Original Research

Health Care Disparity and State-Specific Pregnancy-Related Mortality in the United States, 2005–2014

Amirhossein Moaddab, MD*, Gary A. Dildy,* MD*, Haywood L. Brown,* MD*, Zhoobin H. Bateni,* MD*, Michael A. Belfort,* MD*,* PhD*, Haleh Sangi-Haghpeykar,* PhD*, and Steven L. Clark,* MD

OBJECTIVE: To investigate factors associated with differential state maternal mortality ratios and to quantitate the contribution of various demographic factors to such variation.

METHODS: In a population-level analysis study, we analyzed data from the Centers for Disease Control and Prevention National Center for Health Statistics database and the Detailed Mortality Underlying Cause of Death database (CDC WONDER) that contains mortality and population counts for all U.S. counties. Bivariate correlations between maternal mortality ratio and all maternal demographic, lifestyle, health, and medical service utilization characteristics were calculated. We performed a maximum likelihood factor analysis with varimax rotation retaining variables that were significant ($P<.05$) in the univariate analysis to deal with multicollinearity among the existing variables.

RESULTS: The United States has experienced a continued increase in maternal mortality ratio since 2007 with rates of 21–22 per 100,000 live births in 2013 and 2014. This increase in mortality was most dramatic in non-Hispanic black women. There was a significant correlation between state mortality ranking and the percentage of non-Hispanic black women in the delivery population. Cesarean deliveries, unintended births, unmarried status, percentage of non-Hispanic black deliveries, and four or less prenatal visits were significantly ($P<.05$) associated with increased maternal mortality ratio.

CONCLUSION: Interstate differences in maternal mortality ratios largely reflect a different proportion of non-Hispanic black or unmarried patients with unplanned pregnancies. Racial disparities in health care availability, access, or utilization by underserved populations are an important issue faced by states in seeking to decrease maternal mortality.

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From the Departments of Obstetrics and Gynecology, Baylor College of Medicine, Houston, Texas, and Duke University Medical Center, Durham, North Carolina.

Corresponding author: Steven L. Clark, MD, Department of Obstetrics and Gynecology, Baylor College of Medicine, Texas Children's Pavilion for Women, 6651 Main Street, 10th Floor, Suite F.420, Houston, TX 77030; e-mail: Steven.Clark@bcm.edu.

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The United States ranks poorly in pregnancy-related mortality in comparison with most other developed countries.[1] Of equal concern is the observation that this situation is not improving–U.S. maternal mortality ratios have remained stable for several decades and may be increasing.[2,3] Within the United States, significant variation exists in maternal mortality ratios for individual states.[3] Such differences may be the result of variations in funding, oversight, or organization of state health care services and reflect the intrinsic quality of available health care. Alternately this variation may simply be a product of differences in the prevalence of medical risk factors for poor perinatal outcomes or demographic disparities with lack of access to medical or obstetric services.[4,5] We sought to update the available 2006–2010 national mortality report and 2001–2006 state-by-state report on maternal mortality in the United States to investigate factors associated with differential state maternal mortality ratios and to quantitate the contribution of various demographic factors to such variation.

MATERIALS AND METHODS

In a population-level analysis, we used data from the National Vital Statistics System. The births data are published by the Centers for Disease Control and Prevention (CDC) National Center for Health

Table 1. Number of Live Births and Maternal Deaths and Maternal Mortality Ratio (Maternal Deaths/100,000 Live Births) by Age Group: United States, 2005–2014

	No. of Maternal Deaths			No. of Live Births		
Year	Less Than 15	15–44	45 or More	Less Than 15	15–44	45 or More
2005	0	578	45	6,722	4,125,091	6,536
2006	1	532	36	6,396	4,252,185	6,974
2007	1	508	39	6,195	4,302,685	7,353
2008	0	605	55	5,764	4,234,280	7,650
2009	3	601	81	5,029	4,117,747	7,889
2010	1	614	59	4,497	3,987,164	7,725
2011	2	665	98	3,974	3,942,006	7,610
2012	1	656	130	3,674	3,941,512	7,750
2013	0	686	178	3,098	3,920,911	8,172
2014	2	682	171	2,771	3,974,687	8,465
$P^{\dagger}$	.394	.003	.003	.001	<.001	.006

CI, confidence interval.
* Confidence intervals were not calculated and used for ratios based on fewer than 10 events.[33]
† Jonckheere-Terpstra test.

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Statistics and include all events occurring between 2005 and 2014 for all 50 states and the District of Columbia.[6–16] Maternal demographic characteristics (age, marital status, education, state of residence, and race), lifestyle and health characteristics (tobacco use, previous cesarean delivery, prepregnancy diabetes, gestational diabetes, prepregnancy hypertension, pregnancy-induced hypertension, prepregnancy obesity [body mass index (calculated as weight (kg)/[height (m)]^2) 25 or greater], and eclampsia), and medical service utilization (method of delivery, source of payment, and number of prenatal visits) were extracted from this same CDC database.[16]

Maternal death data are based on the Detailed Mortality Underlying Cause of Death database (CDC WONDER) that contains mortality and population counts for all U.S. counties.[17] These data are based on death certificates for U.S. residents. Each death certificate identifies a single underlying cause of death (four-digit International Classification of Diseases, 10th Revision [ICD-10] code) and associated demographic data. When more than one cause or condition was entered by the physician, the underlying cause was determined by the sequence of conditions specified on the certificate.[17] Maternal causes are those assigned to categories A34, O00–O95, and O98–O99 of the ICD–10, Second Edition.[18–20] The CDC WONDER data set does not report individual state-specific natal statistics for categories in which the number is nine or less. For such smaller states, these data were extracted by pairing queries regarding combination data for two states (for example, Texas and Vermont) with a single state query for a large state (Texas) and then subtracting.

Data on urban percentage of the population, percentage of unintended pregnancies, health insurance coverage of women aged 15–49 years, and adult woman poverty rate were also collected.[21,22] The number of missing values used in the final analysis was less than 1% of all data in aggregate; in terms of the data representing the primary focus of this study, only 22 of 7,031 (0.3%) total maternal deaths were not associated with a specific ethnic status.

We used publically available data that do not contain any individual identifiers; thus, this study was exempt from human subject research regulatory and institutional review board approval.

Bivariate correlations between maternal mortality ratio and all maternal demographic, lifestyle, health, and medical service utilization characteristics were calculated. We also performed a maximum likelihood factor analysis with varimax rotation retaining variables that were significant (P<.05) in the univariate analysis. Factor analysis was done to deal with multicollinearity among the existing variables and to better identify variables that most closely and independently predicted maternal mortality ratio. We assessed the association between the extracted factors and maternal mortality ratio by correlation and regression analyses and used the Jouckheera-Terpska test to determine the presence or absence of a trend, either increasing or decreasing. A P value of <.05 was considered statistically significant. In all cases, ethnic designation is as reported in the original CDC

Maternal Mortality Ratio (95% CI)			
Less Than 15	15–44	45 or Greater	All Ages
0*	14.0 (12.9–15.2)	688.5 (487.3–889.7)	15.1 (13.9–16.2)
15.6	12.5 (11.4–13.6)	516.2 (347.6–684.8)	13.3 (12.2–14.4)
16.1	11.8 (0.8–12.8)	530.4 (363.9–696.9)	12.7 (11.6–13.8)
0	14.3 (13.1–15.4)	719.0 (528.9–909.0)	15.5 (14.4–16.7)
59.7	14.6 (13.4–15.8)	1,026.7 (803.1–1,250.3)	16.9 (15.6–18.1)
22.2	15.4 (14.2–16.6)	763.8 (568.9–958.6)	16.9 (15.6–18.1)
50.3	16.9 (15.6–18.2)	1,287.8 (1,032.8–1,542.7)	19.3 (18.0–20.7)
27.2	16.9 (15.4–17.9)	1,677.4 (1,389.1–1,965.8)	19.9 (18.5–21.3)
0	17.5 (16.2–18.8)	2,178.2 (1,858.2–2,498)	22.0 (20.5–23.4)
72.2	17.2 (15.9–18.4)	2,020.1 (1,717.3–2,322.9)	21.5 (20.0–22.9)
.121	.003	.001	.001

data. All analyses were performed in SAS 9.4 and statistical software package SPSS 21.0.

RESULTS

Between 2005 and 2014, there were 40,922,512 live births and 7,031 maternal deaths in the United States. Live births, maternal deaths, and maternal death by age group are presented in Table 1. State-by-state maternal mortality ratios by year and ethnicity are presented in Table 2 and Appendix 1 (Appendix 1 is available online at http://links.lww.com/AOG/A860). Appendix 2, available online at http://links.lww.com/AOG/A861, represents state-by-state maternal mortality rankings as well as rankings of percentage of deliveries for non-Hispanic black and non-Hispanic white mothers. For example, Massachusetts has the lowest maternal mortality ratio (5.6) and ranks 25th for the percentage of non-Hispanic black births and 27th for the percentage of non-Hispanic white births. The District of Columbia ranks last with the highest maternal mortality ratio (38.8) as well as the highest percentage of non-Hispanic black births and lowest percentage of non-Hispanic white births. Table 3 details correlation coefficients between state-specific demographic, lifestyle, health, and socioeconomic characteristics and maternal mortality ratios.

As demonstrated in Table 1, there has been a continued increase in maternal mortality ratio since 2007 with a rate of 21–22 per 100,000 live births in 2013 and 2014. This trend was most pronounced in women aged 45 years and older, although the numbers are small in this subgroup. Appendix 1 (http://links.lww.com/AOG/A860) demonstrates large differences in state maternal mortality ratios, ranging from 6 per 100,000 (Alaska and Massachusetts) to 40 per 100,000 (District of Columbia). As demonstrated in Figure 1, the recent increase in mortality was most dramatic in non-Hispanic black women, of lesser magnitude in Native American and non-Hispanic white women, and was not seen in Asian or Hispanic women after 2008. Table 2 demonstrates disparities between statewide maternal mortality ratios among women of different ethnic groups; in most states, rates of mortality rations were at least twice as high in the non-Hispanic black as in the non-Hispanic white populations. As indicated in Table 3, there was a significant correlation between state mortality ranking and the proportion of non-Hispanic black women in the delivery population and an inverse correlation with non-Hispanic white deliveries. Of all risk factors examined (Table 3), only gestational diabetes, cesarean deliveries, unintended births, unmarried status, percentage of non-Hispanic black deliveries, and four or less prenatal visits were significantly ($P<.05$) associated with maternal mortality ratio. The probability levels for the χ^2 test was $P>.05$ for the hypothesis of one common factor, indicating the one-factor model was an adequate representation. On this factor the highest loading, based on standardized regression coefficients, was seen on the variable of black deliveries (0.39) (Table 4). Unmarried status and caesarean deliveries had weaker coefficients (0.25), and the remainder of the variables had negligible contributions (Table 4). This factor (black deliveries) had a Pearson's correlation coefficient of 0.51 with maternal mortality ratio ($P=.001$). The presence of both unmarried status and caesarean delivery on this factor is expected because black ethnicity had a high association with both unmarried status ($r=0.65$) and caesarean delivery ($r=0.66$) ($P<.001$).

Table 2. Maternal Mortality Ratio (Maternal Deaths/100,000 Live Births) by Ethnicity for Mothers: United States, Each State, 2005–2014

State	Total	Hispanic	Non-Hispanic White	Non-Hispanic Black	Native American	Asian
Alabama	10.3 (7.8–11.4)	0	5.2 (1.7–8.7)	23.0 (16.1–29.9)	0	10.2
Alaska	6.2	0	4.8	0	14.5	0
Arizona	13.3 (10.9–13.9)	11.8 (8.4–15.3)	10.7 (7.5–13.9)	19.8	39 (23.4–54.5)	5.8
Arkansas	28.9 (23.6–30.4)	19.5	24.1 (18.2–30.0)	51.8 (35.5–68.0)	0	25
California	8.3 (7.5–8.6)	7.1 (6.1–8.1)	7.1 (5.7–8.5)	28.6 (22.6–34.6)	19.9	6.5 (4.7–8.4)
Colorado	7.8 (5.7–8.6)	7.5 (3.7–11.3)	7.6 (3.4–11.9)	16.0	14	3.8
Connecticut	11.8 (8.4–13.2)	7.2	11.7 (7.3–16.2)	22.5 (9.2–35.9)	0	8.7
Delaware	13.9 (7.1–15.6)	0	8.0	33.0 (12.6–53.5)	0	18.4
District of Columbia	38.8 (25.9–41.0)	7.4	0	70.6 (46.9–94.4)	0	
Florida	21.7 (19.8–22.4)	14.0 (7.0–21.0)	17.2 (14.6–19.7)	41.6 (336.0–47.3)	17.5	17.3 (7.9–26.7)
Georgia	28.4 (25.6–29.2)	13.6 (6.8–20.4)	20.7 (17.2–24.3)	49.9 (43.0–55.8)	31.2	11.9
Hawaii	16.9 (11.1–18.4)	6.7	19.2	0	0	16.1 (9.0–23.1)
Idaho	20.0 (14.3–22.1)	18.7	19.7 (13.3–26.0)	62.5	45.3	0
Illinois	12.4 (10.7–12.9)	7.4 (2.8–11.9)	9.5 (7.5–11.5)	29.9 (23.6–36.2)	0	10.3 (3.9–16.7)
Indiana	21.7 (18.5–22.0)	6.8	21.6 (18.0–25.1)	30.7 (19.9–41.5)	72.8	30.8
Iowa	11.6 (8.3–12.6)	15.8	10.6 (7.1–14.1)	32.0	0	0
Kansas	16.8 (12.8–18.1)	14.0	16.3 (11.7–20.9)	30.2	27.0	7.4
Kentucky	13.5 (10.5–14.4)	7.2	11.5 (8.5–14.6)	34.3 (18.5–50.2)	0	18.4
Louisiana	23.0 (19.3–24.1)	4.7	13.5 (9.6–17.4)	38.5 (30.7–46.2)	23.5	23.5
Maine	8.2 (3.4–8.3)	0	8.1 (3.1–13.1)	27.2	0	0
Maryland	23.8 (20.3–24.8)	9.4 (1.0–17.8)	16.5 (12.2–20.8)	41.8 (33.8–49.9)	0	14.9
Massachusetts	5.6 (3.9–6.3)	6.9	3.9 (2.1–5.6)	17.0 (7.4–26.7)	0	4.9
Michigan	23.3 (20.6–24.6)	13.4 (5.0–21.8)	17.7 (14.7–20.4)	52.6 (43.0–66.1)	26.0	9.5
Minnesota	11.8 (9.2–12.5)	7.4	10.1 (7.3–12.8)	26.9 (14.5–39.3)	25.2	7.6
Mississippi	24.4 (19.6–25.8)	33.7	16.0 (10.6–21.4)	34.2 (25.8–42.7)	0	0
Missouri	22.3 (19.0–23.2)	9.5	19.7 (16.1–23.2)	43.3 (25.8–42.7)	24.4	5
Montana	20.4 (12.4–22.0)	0	16.1 (2.1–30.2)	0	58.7	0
Nebraska	14.4 (9.8–15.4)	7.4	13.8 (8.6–19.0)	34.5	0	25.2
Nevada	8.9 (5.8–9.9)	7.2 (3.7–10.7)	8.2 (3.7–12.1)	19.3	19.9	6.4
New Hampshire	15.8 (9.1–17.9)	0	16.1 (8.8–23.3)	47.3	0	18.7
New Jersey	30.2 (27.0–31.1)	21.8 (15.3–28.4)	23.1 (18.3–27.2)	79.8 (66.2–93.3)	53.0	12 (5.7–18.2)
New Mexico	23.0 (17.4–24.2)	25.5 (17.0–34.0)	14.9 (6.5–23.4)	83.0	23.7	0
New York	20.4 (18.6–20.9)	15.9 (12.1–19.6)	11.4 (9.5–13.3)	57.0 (49.6–64.4)	12.4	14.1 (9.4–18.8)
North Carolina	12.0 (10.1–12.7)	4.2	8.1 (6.0–10.2)	26.5 (20.6–32.4)	16.2	8.8
North Dakota	18.0 (9.4–20.1)	0	10.4	0	78.5	56.6
Ohio	18.4 (16.2–18.9)	7.5	15.6 (13.2–17.9)	36.6 (28.9–44.3)	0	13.6
Oklahoma	27.5 (23.0–29.1)	12.9	29.5 (23.7–35.2)	49.0 (29.4–68.6)	21.0 (9.6–32.3)	0
Oregon	11.1 (8.1–11.7)	12.0 (3.5–20.6)	10.4 (6.9–13.9)	8.8	11.1	18.5
Pennsylvania	15.3 (13.3–15.9)	7.1 (1.8–12.4)	12.8 (10.6–15.0)	33.5 (25.6–41.3)	24.5	14.1
Rhode Island	11.2 (5.1–11.2)	16.0	10.7	10.4	0	0
South Carolina	26.1 (22.0–27.4)	12.3	15.8 (11.5–20.0)	48.3 (38.4–58.1)	0	0
South Dakota	18.3 (10.7–20.0)	24.9	13.2 (5.7–20.7)	39.7	34.1	53.7
Tennessee	14.7 (12.1–15.4)	5.5	10.9 (8.2–13.7)	31.0 (22.7–39.4)	37	5.0
Texas	23.9 (22.4–24.3)	15.6 (11.1–20.1)	26.2 (23.5–28.9)	56.5 (49.7–63.6)	26.3	12.3 (7–17.5)
Utah	15.8 (12.4–16.7)	19.1 (9.2–29.0)	14.5 (10.9–18.2)	0	13.5	40.8
Vermont	9.6	0	8.7	0	0	78.2
Virginia	11.7 (9.6–12.8)	4.6	8.2 (5.9–10.5)	25.7 (19.1–32.3)	53.5	7.8
Washington	12.4 (10.0–13.0)	13.0 (8.0–18.1)	10.8 (8.1–13.5)	14.7	26.7	16.0 (7.9–24.1)
West Virginia	11.4 (6.9–13.1)	0	11.7 (6.9–16.4)	13.2	0	0
Wisconsin	14.5 (11.7–15.5)	9.2	13.7 (10.5–16.8)	28.8 (16.2–41.4)	8.8	10
Wyoming	22.2 (11.6–25.8)	10.2	24.2 (12–36.4)	0	31.9	0
United States	17.2 (16.8–17.3)	11.3 (10.1–12.5)	14.1 (13.6–14.6)	40.2 (38.6–41.8)	25.1 (20.6–29.6)	10.6 (9.4–11.9)

Data are maternal mortality ratio (95% confidence interval).
Confidence intervals were not calculated and used for ratios based on less than 10 events.[33]

Table 3. Correlation Coefficients Between State-Specific Maternal Demographic, Lifestyle, Health, and Socioeconomic Characteristics* and Maternal Mortality in the United States, 2005–2014

Characteristic	Simple Pearson's Correlation Coefficient	*P*
Chronic hypertension	0.069	.627
Pregnancy-induced hypertension	−0.123	.384
Eclampsia	0.003	.982
Diabetes	0.196	.163
Gestational diabetes	−0.319	.021
Tobacco	−0.094	.510
Obesity	0.163	.249
Education of mother less than high school	0.210	.135
Deliveries covered by governmental insurance	0.282	.050
Women with health care coverage	−0.282	.076
Women's poverty	0.214	.128
Unintended pregnancy	0.500	<.001
4 or fewer prenatal visits	0.322	.020
Cesarean delivery	0.288	.047
Unmarried mother	0.423	.002
% of rural population	−0.069	.624
% of Hispanic deliveries	−0.006	.964
% of non-Hispanic white deliveries	−0.254	.069
% of non-Hispanic black deliveries	0.501	<.001
% of Native American deliveries	−0.016	.912
% of Asian deliveries	−0.141	.318
% of pregnancies with maternal age older than 45 y	−0.098	.490

* Raw data are available on request.

DISCUSSION

The U.S. maternal mortality ratio continues to climb and reached a rate of 21–22 per 100,000 in 2013 and 2014. Many explanations for this trend have been offered. Although the United States has a higher rural population than many European nations, such factors are present to an even greater degree in Canada, which is even more rural, yet has a maternal mortality ratio of 10 per 100,000 live births.[23] Furthermore, our data failed to identify a statistical correlation between statewide maternal mortality and either rural status or poverty (Table 3). Immigration has also been cited as a factor in this trend. However we found lower mortality for Hispanic women who make up the majority of recent immigrants (Fig. 1; Table 2). This finding has been noted previously and has been attributed to unique social factors and family support often available to these women.[24] The high U.S. cesarean delivery rate has also been invoked as an explanation for increased mortality, yet our data demonstrate only a weak correlation of mortality with cesarean delivery. Furthermore, previous work has demonstrated that this correlation does not reflect causation–the overwhelming majority of maternal deaths associated with cesarean delivery is a consequence of the indication for the cesarean delivery, not the operation itself.[25] Although medical factors such as hypertensive disease, diabetes, tobacco use, and obesity have been shown to be correlated with increased maternal morbidity, statewide population differences in rates of these conditions were not significantly correlated with mortality ratios (Table 3). The 1999 change in maternal mortality coding practices (ICD-9 to ICD-10) might also be invoked as an explanation for this trend in the United States. However, the continued upward trend in mortality more than a decade later and the absence of such a trend in Canada,[23] which uses the same coding system, casts doubt on this assumption.

Our data suggest that much of the variation in statewide maternal mortality ratios in the United States is accounted for by social rather than medical or geographic factors–unintended pregnancy, unmarried mother, and non-Hispanic black race (Tables 3 and 4) and provide evidence for a strong contribution of racial disparity to maternal mortality ratio in the United States. Particularly striking is the tight correlation between statewide ethnic composition and maternal mortality (Table 4). A factor derived from factor analysis, which primarily represented ethnic background, accounted for 26% of the differences in statewide mortality. We note that although Washington, DC, has the highest maternal mortality ratio in the nation, non-Hispanic white patients in this district have the lowest mortality ratio in the United States. Excellent care is apparently available but is not reaching all the people.

These data support two conclusions. First, states that may pride themselves on the intrinsic quality, leadership, organization, and funding of obstetric health care in their state based on national maternal mortality ratio rankings must realize that in many instances, such favorable rank simply reflects a different proportion of non-Hispanic black patients in the population rather than intrinsically superior medical care. The converse applies as well.

Second, comparative health care statistics that do not adjust for these important demographic factors are of little significance in judging the intrinsic quality of

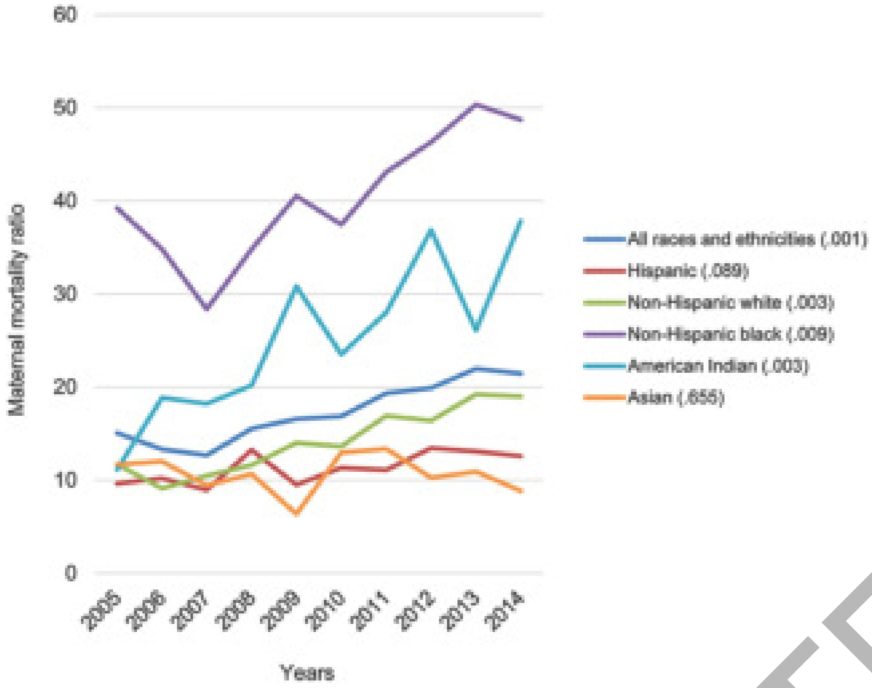

Fig. 1. Trends in maternal mortality ratio (maternal deaths/100,000 live births) by ethnic group and race: United States, 2005–2014. Numbers in parentheses represent *P* values for the Jonckheere-Terpstra test.
Moaddab. Trends in Maternal Mortality: 2005 to 2014. Obstet Gynecol 2016.

available health care in an individual state. Most importantly, these data strongly suggest that racial disparities in health care availability, access, or utilization by underserved populations are important issues faced by states in seeking to decrease maternal mortality. Ethnic genetic differences may also be involved. In addition, the potential role of unconscious (implicit) bias in this significant racial disparity must be considered.[25]

Finally, available publications consistently document relatively good maternal outcomes for select groups of otherwise healthy older women undertaking pregnancy.[26,27] Such data, coupled with the national age-related mortality ratios presented in Table 1, suggest that many older mothers in the United States are not healthy. The mortality ratio in women 45 years of age or older surpasses those in many low-resource nations. Again, these numbers are small, suggesting caution in interpretation of these data. However, careful health screening and preconception counseling are recommended before undertaking pregnancy in such women, especially among those who plan to conceive after assisted reproductive technologies for whom such screening should always be possible.

Table 4. Standardized Regression Coefficients for Primary Factor in Factor Analysis

Variable	Standardized Regression Coefficient
Black mother	0.39
Unmarried status	0.25
Unintended birth	0.17
Cesarean delivery	0.25
Gestational diabetes mellitus	−0.05
4 or fewer prenatal visits	0.04
Variance explained by factor (weighted)	7.33
Correlation with maternal mortality ratio (*R*)	0.51
P	.001

Standardized regression coefficients express the correlation between each variable with the corresponding factor.

There are several limitations to this study. First, it is recognized that there exists significant underreporting of maternal mortality in the United States when data are obtained based on ICD cause-of-death codes.[28,29] Actual maternal mortality rates are therefore likely to be higher than those reported here. However, no data exist to document either differential accuracy of coding based on ethnic background or among different states. Thus, errors so introduced are likely to be random rather than systematic and similar for all states and would not significantly alter our fundamental conclusions. In addition, our data sets do not allow a precise determination of the causes of death, although such data have been extensively reported in other recent series from the United States.[30–32]

We conclude that the increased mortality ratios seen in the United States in recent years reflect significant social as well as medical challenges and are closely related to lack of access to health care in the non-Hispanic black population. Our results provide evidence for the strong contribution of racial disparity to maternal mortality ratio in the United States and to interstate differences in maternal mortality ratio and suggest that addressing issues related to health care disparity and access for this population will play an important role in national attempts to reverse this mortality trend.[30–32]

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