

Original Research

Trends in Maternal Mortality by Sociodemographic Characteristics and Cause of Death in 27 States and the District of Columbia

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OBJECTIVE: To analyze recent trends in maternal mortality by sociodemographic characteristics and cause of death and to evaluate data quality.

METHODS: This observational study compared data from 2008–2009 with 2013–2014 for 27 states and the District of Columbia that had comparable reporting of maternal mortality throughout the period. Maternal mortality rates were computed per 100,000 live births. Statistical significance of trends and differentials was evaluated using a two-proportion z-test.

RESULTS: The study population included 1,687 maternal deaths and 7,369,966 live births. The maternal mortality rate increased by 23% from 20.6 maternal deaths per 100,000 live births in 2008–2009 to 25.4 in 2013–2014. However, most of the increase was among women aged 40 years or older and for nonspecific causes of death. From 2008–2009 to 2013–2014, maternal mortality rates increased by 90% for women 40 years of age or older but did not increase significantly for women younger than 40 years. The maternal mortality rate for nonspecific causes of death increased by 48%; however, the rate for specific causes of death did not increase significantly between 2008–2009 (13.5) and 2013–2014 (15.0).

CONCLUSION: Despite the United Nations Millennium Development Goal and a 44% decline in maternal mortality worldwide from 1990 to 2015, maternal mortality has not improved in the United States and appears to be increasing. Maternal mortality rates for women 40 years or older and for nonspecific causes of death were implausibly high and increased rapidly, suggesting possible overreporting of maternal deaths, which may be increasing over time. Efforts to improve reporting for the pregnancy checkbox and to modify coding procedures to place less reliance on the checkbox are essential to improving vital statistics maternal mortality data, the official data source for maternal mortality statistics used to monitor trends, identify at-risk populations, and evaluate the success of prevention efforts.

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Maternal mortality has long been seen as a primary indicator of the quality of health care both in the United States and internationally.^{1–5} The U.S. National Vital Statistics System is the source of official U.S. maternal mortality statistics used for subnational and international comparisons.⁶ To improve the identification of maternal deaths, a pregnancy question was added to the U.S. standard death certificate in 2003.⁷ The question has checkboxes to ascertain whether female decedents were not pregnant within the past year, pregnant at the time of death, not pregnant but pregnant within 42 days of death, not pregnant but pregnant 43 days to 1 year before death, or unknown if pregnant within the past year.⁷ However, delays in states' adoption of the new pregnancy question created problems for maternal mortality analysis, because data from states using the standard pregnancy question were not comparable with data from states with no pregnancy question or a nonstandard pregnancy question.^{7,8}

A previous article provided estimates of U.S. maternal mortality trends from 2000 to 2014 after adjustment for differences in the use of the pregnancy question among states.⁸ This article extends the previous analysis by analyzing trends in maternal mortality for 27 states and Washington, DC, for the most recent 5-year period (2008–2009 to 2013–2014) by maternal age, race and ethnicity, and for detailed causes of death. The purpose was twofold: 1) to identify trends and at-risk populations to assist in targeting prevention efforts; and 2) to begin to evaluate the data quality of vital statistics maternal mortality data, because these data have not been widely used.

MATERIALS AND METHODS

We use the World Health Organization (WHO) definition of maternal death as the death of a woman while pregnant or within 42 days of the end of pregnancy from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.⁹ This is the definition used for international maternal mortality comparisons. Late maternal deaths are pregnancy-related deaths that occurred from 43 days to 1 year after the end of pregnancy.⁹

U.S. maternal mortality data used for national and international comparisons are based on information reported on death certificates filed in state vital statistics offices and subsequently compiled into national data through the National Vital Statistics System.⁶ Maternal mortality data used in this observational study were derived from the detailed mortality data files publically available from the National Center for Health Statistics and also available through the Centers for Disease Control and Prevention's WONDER database.^{10,11} Physicians, medical examiners, or coroners are responsible for completing the medical portion of the death certificate, including the cause of death. From 1999 to the present, cause-of-death data in the United States have been coded according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10).⁶ Maternal deaths are denoted by codes A34, O00–O95, and O98–O99, whereas late maternal deaths are denoted by codes O96–O97.^{7,9} Maternal deaths are further subdivided into direct and indirect obstetric deaths.⁹ Direct obstetric deaths are deaths resulting from obstetric complications of the pregnant state (pregnancy, labor, and puerperium); from interventions, omissions, incorrect treatment; or from a chain of events resulting from any of the previously mentioned (ICD-10 codes A34, O00–O92).⁹ Indirect obstetric deaths are deaths resulting from previous

existing disease or disease that developed during pregnancy and which was not the result of direct obstetric causes, but which was aggravated by the physiological effects of pregnancy (O98–O99).⁹ Deaths of unknown cause (O95) are not classified as either direct or indirect causes. In the United States, all death certificates of women identified by the pregnancy checkbox question as being pregnant at the time of death or within 42 days before death are coded as maternal deaths, except for deaths resulting from external causes of injury (ie, accidents, homicide, suicide).^{12,13}

We include the complete population of maternal deaths and live births for the 27 states and the District of Columbia that had adopted the U.S. standard pregnancy question by January 1, 2008.⁸ Although revised to the U.S. standard question in 2006, Texas data will be examined in a separate article, because they exhibited very different trends from the other states.⁸ Data from 2008 to 2009 were compared with data from 2013 to 2014 to analyze changes in maternal death during the most recent 5-year period. We analyzed data by maternal age (by 5-year age groups and for women aged younger than 40 years and 40 years or older), race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic), and for detailed causes of death. The less than 0.01% of records with missing age were excluded. Information on race was missing for less than 0.04% of records and was imputed by the National Center for Health Statistics using procedures described elsewhere.⁶ Unknown cause of death (0.4% of cases in this study) is coded to a separate category (O95) and included as a separate category in the analysis.

We also analyzed trends for a grouping of non-specific "other" and unknown causes of death, including "other specified pregnancy-related conditions" (O26.8), "unknown cause" (O95), and "other specified diseases and conditions complicating pregnancy, childbirth, and the puerperium" (O99.8) (Creanga AA, Callaghan WM. Recent increases in the U.S. maternal mortality rate: disentangling trends from measurement issues [letter]. *Obstet Gynecol* 2017;129: 206–7.). These categories are general categories in which deaths that do not easily fit into the ICD maternal mortality coding rubric are classified; thus, it is more difficult from a clinical perspective to determine the specific cause of death for these cases. Two-year averages of data were used to increase the number of cases available for detailed analysis and to increase the reliability of the resulting estimates. Because maternal death is a rare event, the number of cases was not sufficient to support individual state analysis, particularly when stratified by demographic characteristics

and by cause of death. The 27 states and the District of Columbia included 45% of all U.S. births in 2008–2009 and in 2013–2014. Maternal mortality rates were computed per 100,000 live births. A two-proportion z-test was used to test for statistical significance in trends from 2008–2009 to 2013–2014.¹⁴

Finally, because a recent study found evidence of possible overidentification of pregnancy with the pregnancy checkbox,¹⁵ we did a sensitivity analysis to assess the potential effect of a 0.5%, 1%, and 1.5% level of overreporting of pregnancy status with the pregnancy checkbox. We computed the number of nonmaternal deaths of women from natural causes (excluding accidents, homicide, and suicide) by 5-year age groups and estimated how different levels of incorrect reporting of these deaths as maternal deaths would affect maternal mortality rates by age. The study was exempt from requiring institutional review board approval because the study was based on deidentified, aggregated data from U.S. government public-use data sets.

RESULTS

The study population included 1,687 maternal deaths and 7,369,966 live births. The maternal mortality rate increased by 23% during the latest 5-year period in the District of Columbia and the 27 states with the revised pregnancy checkbox item. The maternal mortality rate rose from 20.6 maternal deaths per 100,000 live births in 2008–2009 to 25.4 in 2013–2014 (Fig. 1; $P<.001$).

Women aged 40 years and older had the highest maternal mortality rates, and the largest percent increase from 2008–2009 to 2013–2014 (Table 1). In 2008–2009, the maternal mortality rate for women

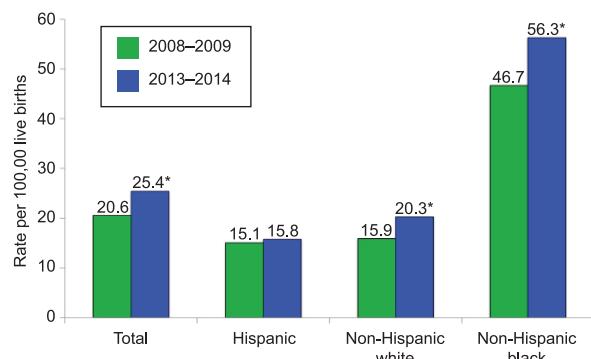


Fig. 1. Maternal mortality rates by race and ethnicity, 27 states and Washington, DC, 2008–2009 and 2013–2014. The 27 states are Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Utah, Washington, and Wyoming. *Statistically significant difference between rates at the $P<.05$ level.

MacDorman. Trends in Maternal Mortality by Cause of Death. Obstet Gynecol 2017.

aged 40 years or older was 141.9 maternal deaths per 100,000 live births, 10 times the rate of 14.1 for women aged 25–29 years, the lowest risk group ($P<.001$). By 2013–2014, the maternal mortality rate for mothers aged 40 years or older was 269.9, 18 times the rate of 14.7 for 25–29 year olds ($P<.001$). This represents a 90% increase in the maternal mortality rate for mothers aged 40 years or older during a 5-year period ($P<.001$). Although rates appeared to decline slightly for women younger than 25 years, and increase slightly for women aged 25–39 years, none of these changes were statistically significant.

Table 1. Maternal Deaths and Mortality Rates by Maternal Age*

| Maternal Age (y) | 2008–2009 | | | 2013–2014 | | | % Change 2008–2009 to 2013–2014 |
|------------------|-----------------|-----------|-------------------|-----------------|-----------|-------------------|---------------------------------------|
| | Maternal Deaths | Births | Rate [†] | Maternal Deaths | Births | Rate [†] | |
| Total | 780 | 3,793,403 | 20.6 | 907 | 3,576,563 | 25.4 | 23.3 [‡] |
| Younger than 40 | 632 | 3,689,111 | 17.1 | 618 | 3,469,489 | 17.8 | 4.1 |
| Younger than 20 | 52 | 367,766 | 14.1 | 26 | 225,902 | 11.5 | -18.4 |
| 20–24 | 141 | 923,577 | 15.3 | 119 | 798,503 | 14.9 | -2.6 |
| 25–29 | 152 | 1,080,462 | 14.1 | 152 | 1,031,402 | 14.7 | 4.3 |
| 30–34 | 156 | 877,975 | 17.8 | 177 | 963,582 | 18.4 | 3.4 |
| 35–39 | 131 | 439,331 | 29.8 | 144 | 450,100 | 32.0 | 7.4 |
| 40 or older | 148 | 104,292 | 141.9 | 289 | 107,074 | 269.9 | 90.2 [‡] |

Data are n unless otherwise specified.

* Including Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Utah, Washington, Wyoming, and Washington, DC.

† Rate per 100,000 live births.

‡ $P\le.001$.

In fact, there was no statistically significant difference in the maternal mortality rate for women younger than 40 years across these two time periods ($P=.38$). The increase for the 40-year or older age group ($P<.001$) accounted for all of the overall increase in maternal deaths between the two time periods.

When examined by race and ethnicity (Fig. 1), the maternal mortality rate increased by 28% for non-Hispanic white women, from 15.9 in 2008–2009 to 20.3 in 2013–2014 ($P<.001$). For non-Hispanic black women, the rate increased from 46.7 in 2008–2009 to 56.3 in 2013–2014, an increase of 20% ($P=.02$). The maternal mortality rate for Hispanic women did not change significantly (15.1 in 2008–2009 and 15.8 in 2013–2014).

During both time periods, the maternal mortality rate for non-Hispanic black women was nearly three times the rate for non-Hispanic white women. In contrast, rates for Hispanic women were similar to those for non-Hispanic white women in 2008–2009. However, by 2013–2014, the rate for Hispanic women was 22% lower ($P=.02$) than for non-Hispanic white women, attributable mostly to a large increase for non-Hispanic white women. When examined by maternal age, we found that almost all of the increase in maternal mortality for non-Hispanic white and non-Hispanic black women was among women aged 40 years or older (data not shown).

From 2008–2009 to 2013–2014, maternal mortality rates increased by 19.7% for direct obstetric causes ($P=.003$) and by 56.7% for indirect obstetric causes ($P<.001$; Table 2). Direct obstetric causes accounted for two thirds (65.6%) and indirect causes one third (32.4%) of maternal deaths in 2013–2014. When the subcategories of direct obstetric deaths were examined, the only significant increases were for diabetes mellitus in pregnancy, from a rate of 0.5–1.0 per 100,000 ($P<.05$), and for other specified pregnancy-related conditions (O26.8), from a rate of 3.4–5.9 ($P<.001$). The subtotal category “other obstetric complications” (which includes the two categories listed previously) also showed an increase, but once the nonspecific (O26.8) category was subtracted out, the rate was unchanged at 5.6 during both time periods. The increase of 82 maternal deaths in the nonspecific O26.8 category accounted for almost two thirds of the overall increase in maternal deaths (127) between 2008–2009 and 2013–2014.

Indirect obstetric causes increased by 54.4% from 2008–2009 to 2013–2014 ($P<.001$). However, the only specific subcategory under indirect obstetric causes that showed a statistically significant increase was

“other specified diseases and conditions” (O99.8), which increased by 75.9% during the 5-year period ($P<.001$) and accounted for more than one third of the increase in maternal deaths between the two time periods.

To further examine data quality issues, we developed a grouping of maternal deaths assigned to nonspecific “other” causes combining other specified pregnancy-related conditions (O26.8), other specific diseases and conditions (O99.8), and obstetric death of unspecified cause (O95). Maternal mortality rates for this cause-of-death grouping increased by 47.9% from 7.0 in 2008–2009 to 10.4 in 2013–2014 ($P<.001$; Table 3). There was an overall increase of 127 maternal deaths across the two time periods, and the non-specific causes accounted for 105 (83%) of them. When this group is subtracted out from the total maternal deaths, the increase in maternal mortality between 2008–2009 (13.5/100,000) and 2013–2014 (15.0/100,000) was not statistically significant ($P=.10$).

Direct obstetric deaths increased by 19.7% from 2008–2009 to 2013–2014 ($P=.003$). However, when the nonspecific category (O26.8) was subtracted out, the remaining category also did not increase significantly from 2008–2009 (10.5/100,000) to 2013–2014 (10.7/100,000; $P=.75$; Table 3).

Indirect obstetric deaths increased by 56.7% from 2008–2009 to 2013–2014. When the nonspecific (O99.8) category was subtracted out, in this case, the remaining category still increased by 42.3% from 2008–2009 (3.0/100,000) to 2013–2014 (4.3/100,000; $P<.01$).

From 2008–2009 to 2013–2014, maternal mortality rates for women aged 40 years or older nearly doubled among both specific and nonspecific causes of death. For women younger than 40 years, maternal mortality rates from nonspecific causes increased by 26% during the period, whereas the rates for specific causes did not change significantly. In 2013–2014, maternal mortality rates from nonspecific causes were 20 times higher for women 40 years or older than for women younger than 40 years, whereas among specific causes, rates were 12 times higher. In fact, for women aged 40 years or older, half of all maternal deaths were the result of nonspecific causes in 2013–2014 (Fig. 2).

Finally, we did a sensitivity analysis to model the effect on maternal mortality rates of different levels of possible overreporting of pregnancy or postpartum status with the pregnancy checkbox (Table 4). For example, we found that a 1% overreporting of pregnancy or postpartum status increased reported maternal mortality rates by 14–23% for women in their 20s and early 30s. In contrast, the maternal mortality rate

Table 2. Maternal and Late Maternal Deaths and Mortality Rates by Cause of Death*

| Underlying Cause of Death (ICD-10 Category) | 2008–2009 | | 2013–2014 | | % Change 2008–2009 to 2013–2014 | | |
|--|------------------|------------------------------------|-------------------|------------------|---------------------------------------|------|--------------------|
| | No. of Deaths | Maternal Deaths (% of Total) | Rate [†] | No. of Deaths | Maternal Deaths (% of Total) | | |
| Total maternal deaths (during pregnancy or within 42 d after the end of pregnancy) (A34, O00–O95, O98–O99) | 780 | 100.0 | 20.6 | 907 | 100.0 | 25.4 | 23.3 [‡] |
| Total direct obstetric causes (A34, O00–O92) | 527 | 67.6 | 13.9 | 595 | 65.6 | 16.6 | 19.7 [§] |
| Pregnancy with abortive outcome (O00–O07)¶ | 51 | 6.5 | 1.3 | 35 | 3.9 | 1.0 | -27.2 |
| Ectopic pregnancy (O00) | 29 | 3.7 | 0.8 | 23 | 2.5 | 0.6 | -15.9 |
| Hypertensive disorders (O10–O16)¶ | 71 | 9.1 | 1.9 | 79 | 8.7 | 2.2 | 18.0 |
| Pre-existing hypertension (O10) | 29 | 3.7 | 0.8 | 32 | 3.5 | 0.9 | 17.0 |
| Eclampsia and preeclampsia (O11, O13–O16) | 42 | 5.4 | 1.1 | 47 | 5.2 | 1.3 | 18.7 |
| Obstetric hemorrhage (O20, O43.2, O44–O46, O67, O71.0–O71.1, O71.3–O71.4, O71.7, O72) | 40 | 5.1 | 1.1 | 43 | 4.7 | 1.2 | 14.0 |
| Pregnancy-related infection (O23, O41.1, O75.3, O85, O86, O91)¶ | 23 | 2.9 | 0.6 | 23 | 2.5 | 0.6 | 6.1 |
| Puerperal sepsis (O85) | 16 | 2.1 | 0.4 | 12 | 1.3 | 0.3 | -20.5 [‡] |
| Other obstetric complications (O21–O22, O24–O41.0, O41.8–O43.1, O43.8–O43.9, O47–O66, O68–O70, O71.2, O71.5, O71.6, O71.8, O71.9, O73–O75.2, O75.4–O75.9, O87–O90, O92)¶ | 342 | 43.8 | 9.0 | 413 | 45.5 | 11.5 | 28.1 [‡] |
| Diabetes mellitus in pregnancy (O24) | 20 | 2.6 | 0.5 | 34 | 3.7 | 1.0 | 80.3 [¶] |
| Liver disorders in pregnancy (O26.6) | 27 | 3.5 | 0.7 | 30 | 3.3 | 0.8 | 17.8 |
| Other specified pregnancy-related conditions (O26.8) | 130 | 16.7 | 3.4 | 212 | 23.4 | 5.9 | 73.0 [‡] |
| Obstetric embolism (O88) | 41 | 5.3 | 1.1 | 42 | 4.6 | 1.2 | 8.6 |
| Cardiomyopathy in the puerperium (O90.3) | 44 | 5.6 | 1.2 | 51 | 5.6 | 1.4 | 22.9 |
| Total indirect causes (O98–O99)¶ | 202 | 25.9 | 5.3 | 294 | 32.4 | 8.2 | 54.4 [‡] |
| Mental disorders and diseases of the nervous system (O99.3) | 15 | 1.9 | 0.4 | 22 | 2.4 | 0.6 | 55.6 |
| Diseases of the circulatory system (O99.4) | 65 | 8.3 | 1.7 | 79 | 8.7 | 2.2 | 28.9 |
| Diseases of the respiratory system (O99.5) | 21 | 2.7 | 0.6 | 18 | 2.0 | 0.5 | -9.1 |
| Other specified diseases and conditions (O99.8) | 85 | 10.9 | 2.2 | 141 | 15.5 | 3.9 | 75.9 [‡] |
| Obstetric death of unspecified cause (O95) | 51 | 6.5 | 1.3 | 18 | 2.0 | 0.5 | -62.6 [‡] |
| Late maternal causes (43 d to 1 y after the end of pregnancy) (O96–O97) | 168 | | 4.4 | 246 | | 6.9 | 55.3 [‡] |

ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision.

* Including Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Utah, Washington, Wyoming, and Washington, DC.

† Rate per 100,000 live births. Denominators were 3,793,403 births in 2008–2009 and 3,576,563 births in 2013–2014.

‡ P≤.001.

§ .001<P≤.01.

¶ Individual cause-of-death categories are shown separately under subtotals when they contained a substantial number of deaths (generally 10 or more in both time periods). However, residual categories are not shown to save space and promote clarity of presentation.

¶ .01<P≤.05.

for women aged 40–54 years more than tripled (232% increase) with a 1% false-positive rate.

DISCUSSION

The maternal mortality rate increased by 23% from 2008–2009 to 2013–2014 for a group of 27 states and

the District of Columbia that used the U.S. standard pregnancy question on their death certificates. From 2008–2009 to 2013–2014, the only significant increases in maternal mortality rates by maternal age groups were for women aged 40 years or older. For these women, maternal mortality rates in 2013–2014

Table 3. Assessing the Effects of Nonspecific Causes on Maternal Deaths and Mortality Rates by Cause of Death*

| Underlying Cause of Death (ICD-10 Category) | 2008–2009 | | 2013–2014 | | % Change 2008–2009 to 2013–2014 |
|--|---------------|-------------------|---------------|-------------------|---------------------------------------|
| | No. of Deaths | Rate [†] | No. of Deaths | Rate [†] | |
| Total maternal (A34, O00–O95, O98–O99) | 780 | 20.6 | 907 | 25.4 | 23.3 [‡] |
| Nonspecific causes (O26.8, O95, O99.8) | 266 | 7.0 | 371 | 10.4 | 47.9 [‡] |
| Total maternal minus nonspecific causes (remainder) | 514 | 13.5 | 536 | 15.0 | 10.6 |
| Total direct obstetric (A34, O00–O92) | 527 | 13.9 | 595 | 16.6 | 19.7 [‡] |
| Other specified pregnancy-related conditions (O26.8) | 130 | 3.4 | 212 | 5.9 | 73.0 [‡] |
| Total direct obstetric minus O26.8 (remainder) | 397 | 10.5 | 383 | 10.7 | 2.3 |
| Total indirect causes (O98–O99) | 202 | 5.3 | 294 | 8.2 | 54.4 [‡] |
| Other specified diseases and conditions (O99.8) | 85 | 2.2 | 141 | 3.9 | 75.9 [‡] |
| Total indirect causes minus O99.8 (remainder) | 117 | 3.1 | 153 | 4.3 | 38.7 [§] |

ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision.

* Including Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Utah, Washington, Wyoming, and Washington, DC.

[†] Rate per 100,000 live births. Denominators were 3,793,403 births in 2008–2009 and 3,576,563 births in 2013–2014.

[‡] $P \leq .001$.

[§] $P \leq .01$.

were 18 times higher than for women aged 25–29 years, the lowest risk group. In contrast, the Confidential Enquiry into Maternal Deaths in Great Britain found maternal mortality rates for women aged 40 years or older to be three to four times higher than for women aged 25–29 years.¹⁶ Approximately one third of maternal deaths in 2013–2014 were of women aged 40 years or older compared with just 3% of live births, suggesting either a much greater mortality risk for women 40 years or older or, more likely given this analysis, possible overreporting of maternal deaths of older women.

Nonspecific causes of death increased by 48% from 2008–2009 to 2013–2014 and accounted for

83% of the total increase in maternal mortality. In contrast, there was no significant increase among specific causes either for total maternal deaths or for direct obstetric causes, although indirect obstetric causes still increased. Large increases in maternal mortality rates for older women and among nonspecific causes suggest possible data quality problems that may be worsening over time.

Using a checkbox question to report on rare events such as maternal mortality can be problematic because the checkbox might occasionally be inadvertently checked even if the woman is not pregnant or postpartum. The accuracy of the checkbox information is critical because identification of

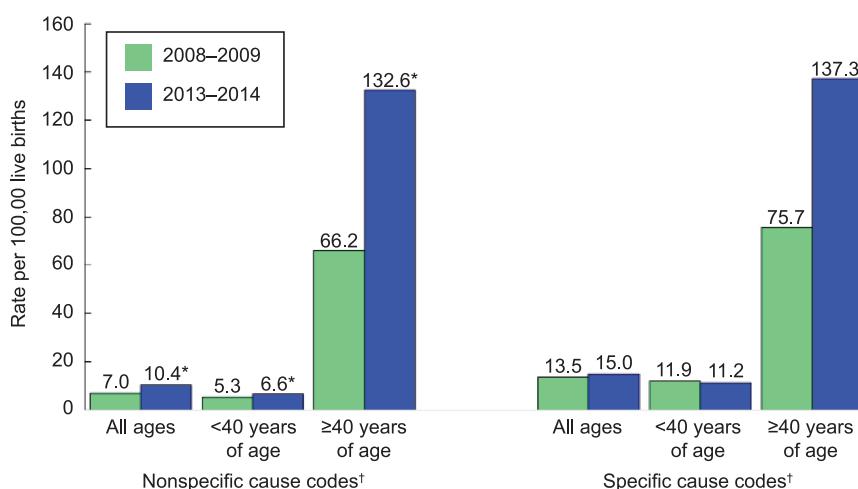


Fig. 2. Maternal mortality rates by age for specific and nonspecific causes of death, 27 states and Washington, DC, 2008–2009 and 2013–2014. The 27 states are Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Utah, Washington, and Wyoming.
*Statistically significant difference between rates at the $P < .05$ level.
[†]Nonspecific cause of death codes are O26.8, O95, and O99.8; specific codes are all others combined.

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Table 4. Sensitivity Analysis of Possible Effects of 0.5%, 1%, and 1.5% Overreporting of the Pregnancy Checkbox on Maternal Mortality Rates

| Age (y) | No. of Maternal Deaths | No. of Female Deaths From Natural Causes (Excludes Maternal Deaths) | No. of Maternal Deaths With 0.5% False-Positives Added to Total | % Increase in MMR With 0.5% False-Positive Rate | No. of Maternal Deaths With 1% False-Positives Added to Total | % Increase in MMR With 1% False-Positive Rate | No. of Maternal Deaths With 1.5% False-Positives Added to Total | % Increase in MMR With 1.5% False-Positive Rate |
|-----------------|------------------------|---|---|---|---|---|---|---|
| Total | 907 | 82,572 | 1,320 | 45.5 | 1,733 | 91.0 | 2,146 | 136.6 |
| Younger than 40 | 618 | 15,553 | 696 | 12.6 | 774 | 25.2 | 851 | 37.8 |
| 15–19 | 26 | 929 | 31 | 17.9 | 35 | 35.7 | 40 | 53.6 |
| 20–24 | 119 | 1,619 | 127 | 6.8 | 135 | 13.6 | 143 | 20.4 |
| 25–29 | 152 | 2,568 | 165 | 8.4 | 178 | 16.9 | 191 | 25.3 |
| 30–34 | 177 | 4,092 | 197 | 11.6 | 218 | 23.1 | 238 | 34.7 |
| 35–39 | 144 | 6,345 | 176 | 22.0 | 207 | 44.1 | 239 | 66.1 |
| 40–54 | 289 | 67,019 | 624 | 115.9 | 959 | 231.9 | 1,294 | 347.8 |

MMR, maternal mortality rate.

a death as maternal or nonmaternal in U.S. vital statistics data is based almost entirely on the checkbox information. The current coding rules are that unless the cause of death is an accident, suicide, or homicide, *if the pregnancy or postpartum within 42 days checkbox is checked, the record is coded as a maternal death, regardless of what is written in the cause-of-death section*.^{12,13} This puts tremendous pressure on the pregnancy question as almost the sole determinant of whether the death is maternal or nonmaternal. However, until recently, there has been little quality control done on this data item.

We modeled the potential effect of overreporting of pregnant or postpartum status with the pregnancy checkbox on maternal mortality rates. We found that a 1% false-positive rate increased reported maternal mortality rates by 26% for women younger than 40 years but more than tripled them (232% increase) for women aged 40–54 years. When compared with younger women, women aged 40–54 years have higher death rates and much lower pregnancy rates, making the effect of false-positives much larger for these women.

U.S. coding practices for maternal deaths vary somewhat from those used in other countries. Although the ICD-10 recommends the use of a pregnancy checkbox, not all countries have adopted it, which can affect maternal mortality comparisons.^{8,17} Also, recent WHO publications include suicides as maternal deaths as a result of the possible etiologic link with depression.^{18,19} Countries also vary in what are considered “incidental causes” in the maternal mortality definition. For example, in the Confidential Enquiry into Maternal Deaths in Great Britain, deaths

from nonhormonally dependent, nonreproductive cancers are considered to be incidental and probably pre-existing and are not classified as maternal deaths (personal communication, M. Knight, 2016). In part to assist in identifying “incidental” causes, beginning in 2016, WHO recommended adding a second pregnancy question, asking whether the pregnancy contributed to the death²⁰; however, there are currently no plans to adopt this question in the United States.

Even if much of the reported increase is the result of overreporting, our core findings reflect several reasons for concern for U.S. policymakers and practitioners. First, even if we examine only direct causes of maternal mortality for mothers of all ages (15.0/100,000), or just women younger than 40 years for any cause (17.8), these rates are much higher than for other industrialized countries.²¹ For example, the 2014 maternal mortality rate was 3.9 in the United Kingdom, 3.5 in France, and 2.2 in Sweden.²¹ Second, even limiting the analysis to women younger than 40 years or deaths from direct causes, we find the mortality rate is not decreasing in contrast to most other countries.^{22–24} In 1990, the United Nations named maternal mortality reduction as a Millennium Development Goal,²² leading to an unprecedented effort to reduce maternal mortality worldwide. Maternal mortality decreased by 44% worldwide from 1990 to 2015, including a 48% decline among developed regions.²³ In contrast, the U.S. maternal mortality rate has not improved and appears to be increasing.⁸

The U.S. vital statistics system provides useful information on maternal mortality. However, high and increasing maternal mortality rates for older mothers and among nonspecific causes of death suggest possible

data problems. Quality improvement efforts need to focus on improving the quality and validity of the pregnancy checkbox data. Periodic validation studies and the implementation of data quality checks at both the state and national levels are essential to improving reporting. State and federal agencies should provide training to persons who complete death certificates, which emphasizes the importance of correct reporting of the pregnancy checkbox information. A percentage of records, including 100% of records for women 40 years or older or coded to nonspecific causes, should be routinely queried back to the certifier to confirm the fact of pregnancy. Given concerns about overreporting with the pregnancy checkbox, it is illogical to continue to use it as the sole means of identifying maternal deaths. Further identifying and excluding incidental causes of death as well as changes to coding to decrease the near exclusive reliance on the checkbox to identify maternal deaths might improve data quality. Finally, the recent growth in state maternal mortality review committees can improve data quality,²⁵ but only if information from maternal mortality reviews is used to update vital statistics information on the cause and circumstances of death.

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