

OBSTETRICS

Maternal mortality in the United States: are the high and rising rates due to changes in obstetrical factors, maternal medical conditions, or maternal mortality surveillance?



K. S. Joseph, MD, PhD; Sarka Lisonkova, MD, PhD; Amélie Boutin, MSc, PhD; Giulia M. Muraca, MPH, PhD; Neda Razaz, MPH, PhD; Sid John, MSc; Yasser Sabr, MHSc, MD; Wee-Shian Chan, MSc, MD; Azar Mehrabadi, MSc, PhD; Justin S. Brandt, MD; Enrique F. Schisterman, PhD; Cande V. Ananth, PhD, MPH

BACKGROUND: National Vital Statistics System reports show that maternal mortality rates in the United States have nearly doubled, from 17.4 in 2018 to 32.9 per 100,000 live births in 2021. However, these high and rising rates could reflect issues unrelated to obstetrical factors, such as changes in maternal medical conditions or maternal mortality surveillance (eg, due to introduction of the pregnancy checkbox).

OBJECTIVE: This study aimed to assess if the high and rising rates of maternal mortality in the United States reflect changes in obstetrical factors, maternal medical conditions, or maternal mortality surveillance.

STUDY DESIGN: The study was based on all deaths in the United States from 1999 to 2021. Maternal deaths were identified using the following 2 approaches: (1) per National Vital Statistics System methodology, as deaths in pregnancy or in the postpartum period, including deaths identified solely because of a positive pregnancy checkbox, and (2) under an alternative formulation, as deaths in pregnancy or in the postpartum period, with at least 1 mention of pregnancy among the multiple causes of death on the death certificate. The frequencies of major cause-of-death categories among deaths of female patients aged 15 to 44 years, maternal deaths, deaths due to obstetrical causes (ie, direct obstetrical deaths), and deaths due to maternal medical conditions aggravated by pregnancy or its management (ie, indirect obstetrical deaths) were quantified.

RESULTS: Maternal deaths, per National Vital Statistics System methodology, increased by 144% (95% confidence interval, 130–159) from 9.65 in 1999–2002 (n=1550) to 23.6 per 100,000 live births in 2018–2021 (n=3489), with increases occurring among all race and ethnicity groups. Direct obstetrical deaths increased from 8.41 in 1999–2002 to 14.1 per 100,000 live births in 2018–2021, whereas indirect obstetrical deaths increased from 1.24 to 9.41 per 100,000 live

births: 38% of direct obstetrical deaths and 87% of indirect obstetrical deaths in 2018–2021 were identified because of a positive pregnancy checkbox. The pregnancy checkbox was associated with increases in less specific and incidental causes of death. For example, maternal deaths with malignant neoplasms listed as a multiple cause of death increased 46-fold from 0.03 in 1999–2002 to 1.42 per 100,000 live births in 2018–2021. Under the alternative formulation, the maternal mortality rate was 10.2 in 1999–2002 and 10.4 per 100,000 live births in 2018–2021; deaths from direct obstetrical causes decreased from 7.05 to 5.82 per 100,000 live births. Deaths due to preeclampsia, eclampsia, postpartum hemorrhage, puerperal sepsis, venous complications, and embolism decreased, whereas deaths due to adherent placenta, renal and unspecified causes, cardiomyopathy, and preexisting hypertension increased. Maternal mortality increased among non-Hispanic White women and decreased among non-Hispanic Black and Hispanic women. However, rates were disproportionately higher among non-Hispanic Black women, with large disparities evident in several causes of death (eg, cardiomyopathy).

CONCLUSION: The high and rising rates of maternal mortality in the United States are a consequence of changes in maternal mortality surveillance, with reliance on the pregnancy checkbox leading to an increase in misclassified maternal deaths. Identifying maternal deaths by requiring mention of pregnancy among the multiple causes of death shows lower, stable maternal mortality rates and declines in maternal deaths from direct obstetrical causes.

Key words: cause of death, epidemiology, maternal mortality, surveillance, United States

Cite this article as: Joseph KS, Lisonkova S, Boutin A, et al. Maternal mortality in the United States: are the high and rising rates due to changes in obstetrical factors, maternal medical conditions, or maternal mortality surveillance? *Am J Obstet Gynecol* 2024;230:440.e1-13.

0002-9378

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<https://doi.org/10.1016/j.ajog.2023.12.038>



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Introduction

Commentaries on maternal health in the United States highlight concerns related to the high and rising rates of maternal death.^{1,2} However, doubts linger regarding the accuracy of the maternal mortality estimates.^{3–5} Maternal mortality tends to be underestimated even in countries with good vital registration systems because pregnancy status at the time of death (or in immediate past) is sometimes overlooked. The National Center for Health Statistics (NCHS)

recommended the addition of a pregnancy checkbox to the death certificate in 2003 as a mechanism to improve maternal death ascertainment (Glossary; [Appendix, A and B](#)).

Although the introduction of the pregnancy checkbox led to a rapid increase in reported maternal mortality rates between 2003 and 2017,^{6–8} subsequent studies conducted by the NCHS showed that this increase was an artifact.^{9–11} Use of the pregnancy checkbox resulted in some egregious

GLOSSARY

Maternal death: “Death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.”¹⁵

Direct obstetrical death: Maternal death “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 above.”¹⁵

Indirect obstetrical death: Maternal death “resulting from previous existing disease or disease that developed during pregnancy and which was not due to direct obstetric causes, but which was aggravated by physiologic effects of pregnancy.”¹⁵

Late maternal death: “Death of a woman from direct or indirect obstetric causes more than 42 days but less than one year after termination of pregnancy.”

Incidental cause of death: Death by a cause unrelated to and unaffected by the pregnant state and its management (eg, breast cancer whose course was unaffected by the pregnancy).

Accidental cause of death: Death due to trauma from an accident (including transport or other accident, self-harm, and assault) that was unaffected by the pregnant state.

Pregnancy-related death: Defined by the World Health Organization as the “death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death”¹⁵ and by the Pregnancy Mortality Surveillance System (PMSS; Centers for Disease Control and Prevention) as “death while pregnant or within 1 year of the end of pregnancy from any cause related to or aggravated by the pregnancy.”²⁴

Pregnancy-associated death: A death during or within 1 year of pregnancy, regardless of the cause.¹⁷ Note: In this study, we excluded maternal and late maternal deaths from pregnancy-associated deaths to make the death categories mutually exclusive (for simplicity).

Underlying cause of death: Defined as “(a) the disease or injury which initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury.”^{11,15} The underlying cause of death serves to identify critical conditions and diseases amenable to preventive health interventions.^{11,15}

Multiple causes of death: These refer to all the causes of death listed on the death certificate including the immediate, intermediate, and underlying causes and contributory conditions.

Pregnancy checkbox: The 2003 revision of the U.S. Standard Certificate of Death included the following pregnancy question in the form of a checkbox item:

“IF FEMALE:

- Not pregnant within past year
- Pregnant at time of death
- Not pregnant, but pregnant within 42 days of death
- Not pregnant, but pregnant 43 days to 1 year before death
- Unknown if pregnant within the past year”

Note: “Pregnancy within 42 days of death is not in itself an indication of maternal death. The pregnancy must be related to the death, ...”¹⁰ and death should not be from incidental or accidental causes.

Maternal mortality: The population counterpart of maternal death. The maternal mortality rate is expressed as a ratio of maternal deaths to live births (ie, maternal deaths per 100,000 live births).

National maternal mortality rate: The National Center for Health Statistics’ National Vital Statistics System estimates maternal mortality rates in the United States on the basis of cause of death and pregnancy checkbox information on death certificates. Rates are expressed as maternal deaths in pregnancy or within 42 days of termination of the pregnancy per 100,000 live births.

National pregnancy-related mortality ratio: The PMSS uses vital records, linkages of death records to birth and fetal death records, media searches, and reporting from public health agencies, health care providers, and the public to identify maternal deaths. Pregnancy-related mortality ratios are expressed as pregnancy-related deaths in pregnancy or within 1 year of termination of the pregnancy per 100,000 live births.

Nonmaternal deaths: Deaths of nonpregnant women.

CI: Confidence interval.

ICD-10: International Classification of Diseases, 10th Revision.

NCHS: National Center for Health Statistics, CDC.

NVSS: National Vital Statistics System, CDC.

PMSS: Pregnancy Mortality Surveillance System, CDC.

MMRC: Maternal Mortality Review Committees. These Committees function at the state level to comprehensively review pregnancy-associated deaths (based on clinical and non-clinical information), identify pregnancy-related deaths, and develop recommendations to prevent such deaths.

AJOG at a Glance

Why was this study conducted?

This study aimed to assess if the high and rising rates of maternal mortality in the United States reflect changes in obstetrical factors, maternal medical conditions, or methods of maternal mortality surveillance.

Key findings

Identifying maternal deaths on the basis of the current National Vital Statistics System and National Center for Health Statistics' method (which includes identifying maternal deaths on the basis of information from the pregnancy checkbox on the death certificate) shows a high and rising rate of maternal mortality due to less specific and incidental causes of death. A definition-based approach to identifying maternal deaths, which requires at least 1 mention of pregnancy among the multiple causes of death, shows lower, stable maternal mortality rates in the United States and a temporal reduction in deaths due to direct obstetrical causes.

What does this add to what is known?

Recent changes in maternal mortality surveillance, such as maternal death identification based solely on pregnancy checkbox information on death certificates, have led to an overestimation of maternal mortality. A definition-based approach, which requires the mention of pregnancy among the multiple causes of death on the death certificate, shows lower, stable maternal mortality rates in the United States and a temporal decline in deaths due to direct obstetrical causes. However, large racial and ethnic disparities in maternal mortality persist. Identifying maternal deaths by requiring mention of pregnancy among the multiple causes of death provides insights into cause- and race- and ethnicity-specific rates of maternal death, and this can inform clinical care and public health initiatives.

identified solely because of a positive pregnancy checkbox on the death certificate among women aged 15 to 44 years; and (2) under an alternative definition-based premise, requiring at least 1 mention of pregnancy among the immediate, intermediate, or underlying causes of death or contributory conditions on the death certificate. Under this latter formulation, deaths identified as maternal deaths by the NVSS solely because of a positive pregnancy checkbox were deemed to be pregnancy-associated deaths and not maternal deaths. Maternal deaths were categorized as direct obstetrical deaths (ie, those due to obstetrical causes), indirect obstetrical deaths (those due to maternal medical conditions aggravated by pregnancy or its management), late maternal deaths (deaths due to direct or indirect obstetrical causes occurring between 43 and 364 days after termination of pregnancy), and pregnancy-associated deaths (including incidental and accidental deaths in pregnancy) (Glossary).

Materials and Methods

We conducted a descriptive study involving a census of all maternal and pregnancy-associated deaths in the United States from 1999 to 2021, with data obtained from the NCHS (multiple causes-of-death) mortality and natality files. Multiple causes-of-death files contain information transcribed from death certificates and include a single underlying cause of death,¹⁸ and up to 20 multiple causes of death (Glossary; Appendix, A and B include a copy of the death certificate).¹⁹

Since 2003, maternal death identification has been facilitated by a pregnancy checkbox on the death certificate (Glossary; Appendix, B), and this led to changes in the underlying cause-of-death assignment between 2003 and 2017. Women with a positive pregnancy checkbox received an International Classification of Diseases, 10th Revision (ICD-10) Pregnancy Chapter O code as the underlying cause of death and were identified as maternal deaths, irrespective of whether pregnancy was mentioned among the multiple causes of death. In addition, all cause-of-death

errors, including hundreds of decedents, aged ≥ 70 years, being certified as pregnant at the time of death or in the year before death (eg, in 2013, checkbox entries indicated that 147 women aged ≥ 85 years had been pregnant at the time of death or in the 1 year prior).¹¹ In response, the NCHS proposed new guidelines, such as a restriction on the use of the pregnancy checkbox to deaths of pregnant women and people (hereafter abbreviated as "women") aged 15 to 44 years (with the understanding that this would minimize errors).¹¹

Despite these changes in surveillance methods, National Vital Statistics System (NVSS) reports show that maternal mortality rates in the United States have continued to increase from 17.4 in 2018, to 20.1 in 2019, 23.8 in 2020, and 32.9 per 100,000 live births in 2021.^{11–14} Do these relatively high and rising rates of maternal death indicate changes in obstetrical factors, maternal medical conditions, or

maternal mortality surveillance? Addressing this question requires clarity with regard to definitions,^{11,15–18} especially the distinction between maternal death and pregnancy-associated death. Maternal death refers to the "death of a woman while pregnant or within 42 days of termination of pregnancy, ... from any cause related to or aggravated by the pregnancy or its management,"^{11,15,16} whereas pregnancy-associated death refers to all deaths during or within 1 year of termination of pregnancy, including deaths from "accidental or incidental causes"¹⁷ (Glossary).

We conducted a study attempting to quantify rates and temporal trends in maternal and pregnancy-associated death in the United States. Maternal deaths were identified under the following 2 formulations: (1) per current NVSS and NCHS methodology, as deaths in pregnancy or in the postpartum period, including deaths

codes were replaced with Pregnancy Chapter (ICD-10 O) codes for such deaths. Unfortunately, this overwriting of the original causes of death precludes identification and correction of pregnancy checkbox errors, and maternal death data from 2003 to 2017 cannot be taken at face value. From 2018 onward, only decedents aged 15 to 44 years with a positive pregnancy checkbox were identified as maternal deaths and assigned a Pregnancy Chapter code for the underlying cause of death, although their multiple causes of death were not converted to Pregnancy Chapter codes.

Study period and deaths among women aged 15 to 44 years

All years during which ICD-10 codes were used for categorizing causes of death were included in the study (1999–2021). However, most temporal contrasts were restricted to 1999–2002 vs 2018–2021 because, as mentioned, all causes of death from 2003 to 2017 had been replaced with Pregnancy Chapter codes if the pregnancy checkbox had been checked.¹¹ We first quantified the frequency of each major cause-of-death category among deaths of all women aged 15 to 44 years in the 1999–2002 and 2018–2021 periods based on the underlying cause of death (Supplement S1), with the number of women aged 15 to 44 years at the beginning of each period serving as the rate denominator.

Maternal death identification based on National Vital Statistics System and National Center for Health Statistics methodology

Maternal and late maternal deaths were identified without any age restriction, using appropriate ICD-10 Pregnancy Chapter underlying cause-of-death codes (namely, A34, O00–O95, O98, and O99; and O96 and O97; respectively). Such deaths included maternal and late maternal deaths identified solely on the basis of a positive pregnancy checkbox. Death rates were calculated using women aged 15 to 44 years at the beginning of the period of interest, and also live births during the period of interest as denominators.

Deaths were categorized on the basis of the underlying cause-of-death categories used by NCHS,¹¹ namely: (1) direct obstetrical deaths (A34, O00–O95); (2) indirect obstetrical deaths (O98, O99); (3) late maternal deaths (O96, O97); (4) pregnancy-associated deaths¹⁷; and (5) other nonmaternal deaths. For simplicity, we made the groups mutually exclusive by restricting pregnancy-associated deaths to accidental or incidental deaths (eg, transport accident) and excluding maternal and late maternal deaths from this category (Supplement S1). Analyses by race and ethnicity were based on race categories specified by the NCHS.^{9–11}

Analyses were performed to assess temporal changes in death certificate completion by quantifying the average number of multiple causes of death in the 1999–2002 and 2018–2021 periods. Potential artifacts associated with pregnancy checkbox use were examined by (1) estimating changes in maternal deaths with malignant neoplasms listed among the multiple causes of death and (2) contrasting temporal trends in case fatality rates among women with preexisting hypertension in pregnancy with those of women with hypertensive disorders of pregnancy (using data from the mortality and natality files).

Maternal death identification based on an alternative, definition-based formulation

Deaths in the 1999–2002 and 2018–2021 periods were identified as maternal deaths or late maternal deaths if at least 1 of the multiple causes of death on the death certificate mentioned pregnancy (ie, if an ICD-10 Pregnancy Chapter code was included) *and* the underlying cause of death was not a transport accident, other accidental injury, self-harm, or assault. Deaths were identified as pregnancy-associated deaths if they included (1) a positive pregnancy checkbox (identified by a specific variable on the NCHS mortality file)¹¹ but did not include any (multiple) cause of death from the Pregnancy Chapter, or (2) transport accident, other

accidental injury, self-harm, or assault as the underlying cause of death and a Pregnancy Chapter code among the multiple causes of death. Maternal deaths among women with chronic disease (ie, preexisting hypertension, preexisting diabetes, cardiomyopathy, and liver, renal, or other disease) were classified as indirect obstetrical deaths (Supplement S1).^{16,20,21}

Statistical analyses were carried out using SAS 9.4 (SAS Institute, Cary, NC). Ethics approval was not sought because the anonymized data used in the study are publicly available.

Results

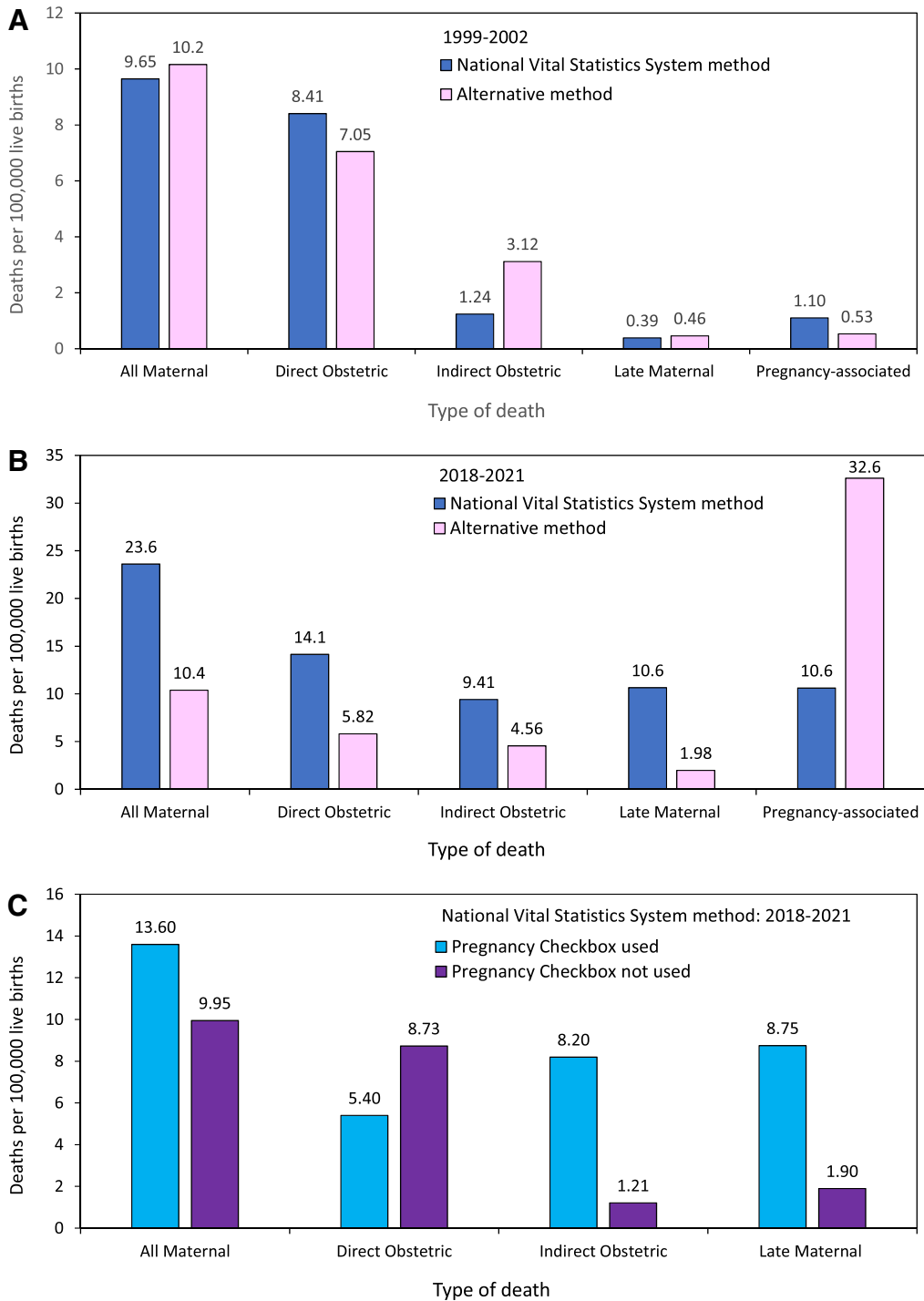
Deaths of women aged 15 to 44 years

Deaths among women aged 15 to 44 years increased from 216,888 (3528.1 per million) in the 1999–2002 period to 256,785 (4001.5 per million) in the 2018–2021 period. Death rates increased among non-Hispanic White and Hispanic women and decreased among non-Hispanic Black women. Death rates in several cause-of-death categories decreased substantially (eg, infectious and parasitic diseases, neoplasms, circulatory system diseases, and transport accidents), whereas deaths from other accidental injury, self-harm, or assault increased. Mostly similar patterns were observed by race/ethnicity (Supplement S2–S10).

Maternal death identification based on National Vital Statistics System and National Center for Health Statistics methodology

The number of maternal deaths increased from 1550 in the 1999–2002 period to 3489 in the 2018–2021 period (9.65 and 23.6 per 100,000 live births, respectively), whereas the number of late maternal deaths increased from 62 in 1999–2002 to 1577 in 2018–2021 (0.39 and 10.6 per 100,000 live births, respectively) (Figure 1, A and B; Appendix, C and D; Supplement S11 and S12). Maternal and late maternal death rates increased among all race and ethnicity groups (Appendix, E); such deaths comprised 1.36% and 0.61%, respectively, of all deaths of women aged

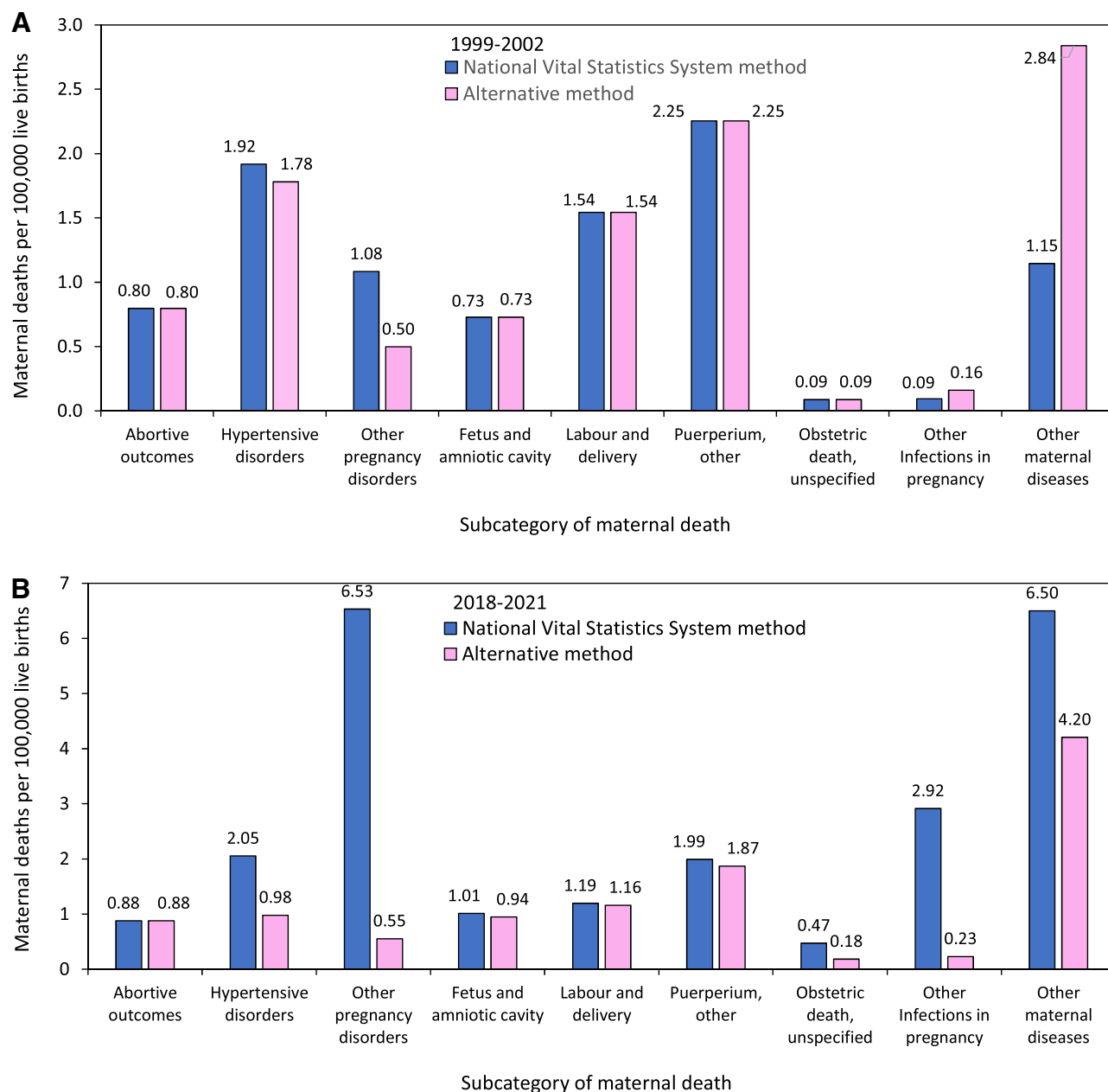
FIGURE 1
Maternal mortality rates using 2 alternative methods for identifying maternal deaths



Rates of maternal death, direct obstetrical death, indirect obstetrical death, late maternal death, and pregnancy-associated death based on the National Vital Statistics System (NVSS)/National Center for Health Statistics methodology (using pregnancy checkbox information), and an alternative method for identifying maternal deaths (not using pregnancy checkbox information), United States, **A**, 1999–2002 and **B**, 2018–2021. **C**, Rates of maternal and late maternal death stratified by use of pregnancy checkbox information under the NVSS method for identifying maternal deaths, United States, 2018–2021.

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FIGURE 2
Maternal mortality subcategories using 2 alternative methods for identifying maternal deaths



Rates of maternal death by maternal death subcategory based on the National Vital Statistics System/National Center for Health Statistics methodology (using pregnancy checkbox information), and an alternative method for identifying maternal deaths (not using pregnancy checkbox information), United States, **A**, 1999–2002 and **B**, 2018–2021.

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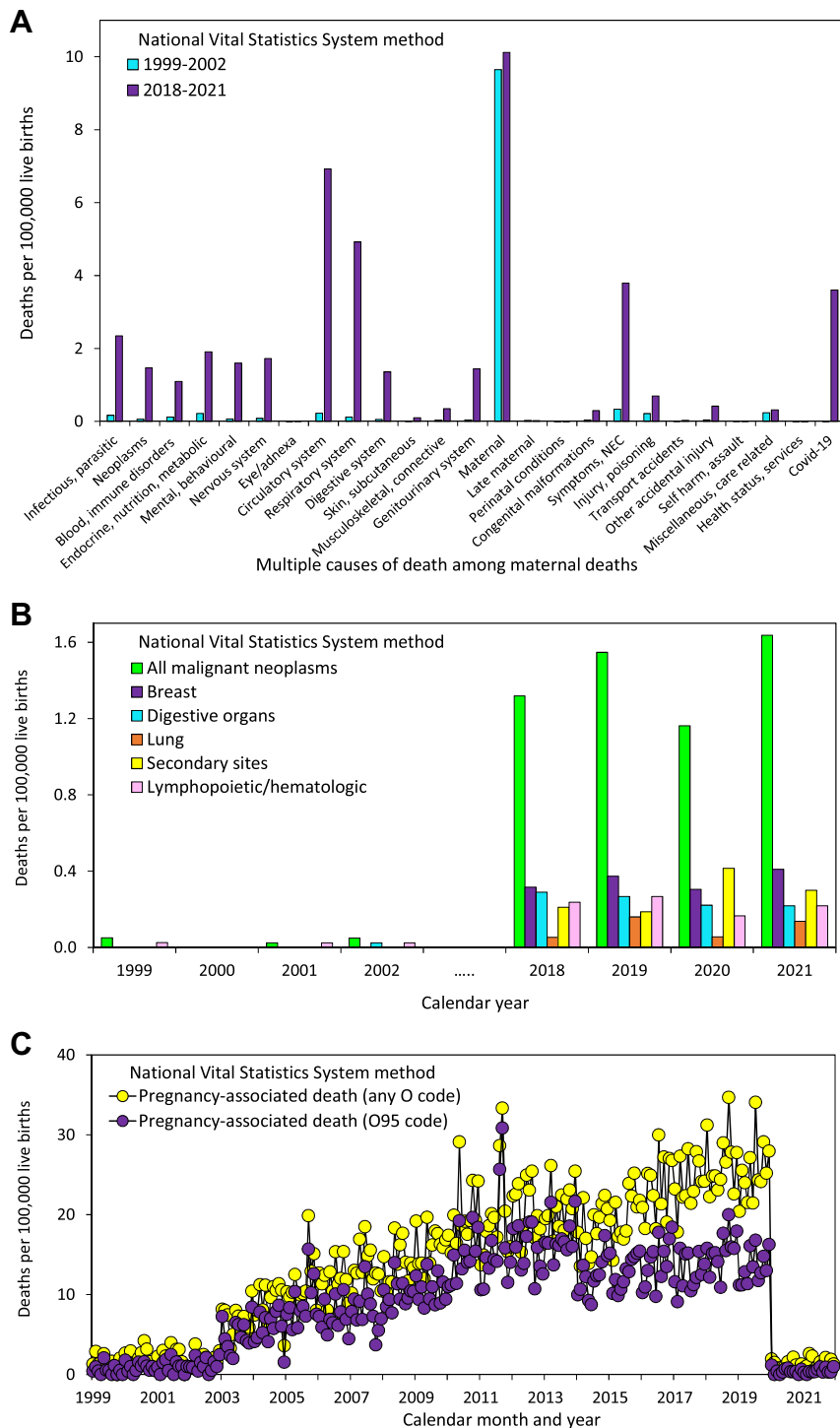
15 to 44 years in the 2018–2021 period (Supplement S13 and S14). The death rate from hypertensive diseases among women aged 15 to 44 years in 2018–2021 was 29-fold higher than the

death rate from preexisting hypertension in pregnancy (Supplement S15 and S16).

Direct obstetrical deaths increased from 8.41 in the 1999–2002 period to 14.1 per 100,000 live births in the

2018–2021 period, whereas indirect obstetrical deaths increased from 1.24 to 9.41 per 100,000 live births (Figure 1, A and B; Supplement S17 and S18). These patterns were observed across all race

FIGURE 3
Causes of maternal death, and frequency of pregnancy-associated death



National Vital Statistics System/National Center for Health Statistics methodology for identifying maternal deaths (using pregnancy checkbox information): rates of **A**, each multiple cause of death among maternal deaths in 1999–2002 and 2018–2021, **B**, maternal deaths with malignancy listed as a (multiple) cause of death in 1999–2002 and 2018–2021, and **C**, pregnancy-associated deaths, United States, 1999–2021.

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and ethnicity groups (Appendix, F and G; Supplement S19 and S20). Most of these increases were due to a positive pregnancy checkbox (Figure 1, C): 38% of direct obstetrical deaths, 87% of indirect obstetrical deaths, and 82% of late maternal deaths in the 2018–2021 period were identified because of a positive pregnancy checkbox.

Subcategories of maternal death (National Vital Statistics System and National Center for Health Statistics methodology)

Direct obstetrical deaths due to labor, delivery, and puerperal complications decreased, whereas there was a large increase in less specific cause-of-death subcategories such as “other maternal disorders predominantly related to pregnancy” (Figure 2). Indirect obstetrical deaths also increased because of less clearly specified conditions such as “other maternal diseases classifiable elsewhere” (Figure 2; Supplement S21–S23). Deaths identified by a positive pregnancy checkbox were responsible for the increase in these less specific causes (Supplement S24–S26), and this affected all race and ethnicity groups (Supplement S27–S30).

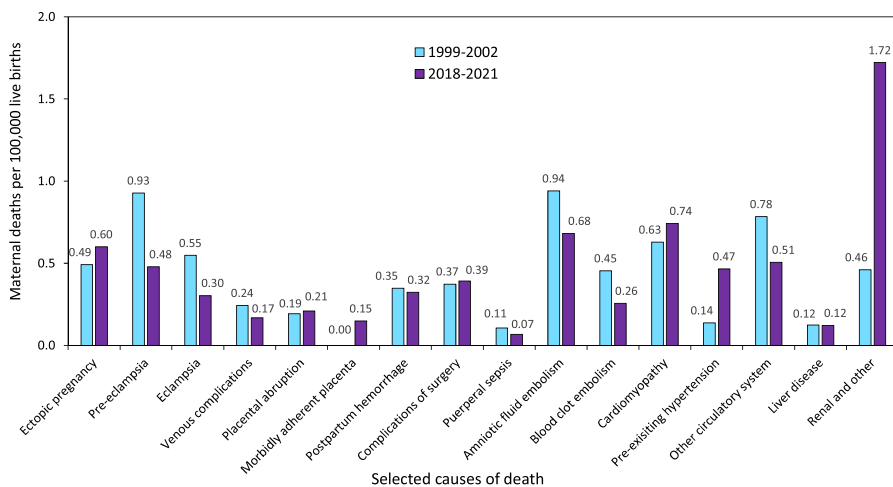
Multiple causes of death (National Vital Statistics System and National Center for Health Statistics methodology)

The pregnancy checkbox accounted for increases in diverse nonpregnancy-related multiple causes of death among maternal deaths (eg, deaths from circulatory and respiratory system diseases, and ill-defined symptoms or signs) (Figure 3, A; Supplement S31–S35). There were 500 maternal and 155 late maternal deaths with COVID-19 included among the multiple causes of death in the 2018–2021 period (394 maternal and 138 late maternal deaths were identified because of the pregnancy checkbox).

Maternal deaths with malignant neoplasms (eg, breast neoplasms, cancer of the digestive organs and lungs) listed among the multiple causes of

FIGURE 4

Alternative method for identifying maternal death: Selected causes of death



Alternative method for identifying maternal deaths (not using pregnancy checkbox information): rates of selected causes of maternal death, United States, 1999–2001 and 2018–2021.

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death increased 46-fold from 0.03 in the 1999–2002 period to 1.42 per 100,000 live births in the 2018–2021 period (Figure 3, B; Supplement S36). Similarly, late maternal deaths with malignant neoplasms listed among the multiple causes of death increased from 0.0 in 1999–2002 to 1.87 per 100,000 live births in 2018–2021.

Deaths from hypertension (National Vital Statistics System and National Center for Health Statistics methodology)

From the 1999–2002 to the 2018–2021 period, case fatality rates increased by 130% (95% confidence interval [CI], 47–260) among women with preexisting hypertension complicating pregnancy and decreased by 48% (95% CI, 39–56) among women with hypertensive disorders of pregnancy (not including preexisting hypertension). Excluding deaths identified by a positive pregnancy checkbox substantially reduced the case fatality rate from preexisting hypertension complicating pregnancy in the 2018–2021 period (Supplement S37 and S38).

Pregnancy-associated deaths (National Vital Statistics System and National Center for Health Statistics methodology)

Pregnancy-associated deaths (excluding maternal and late maternal deaths) increased from 1.10 in the 1999–2002 period to 10.6 per 100,000 live births in the 2018–2021 period. The rates showed a progressive increase from 2003 to 2019, followed by a sharp decline from January 2020 onward (Figure 3, C; Supplement S39–S43). The most common underlying causes of death among pregnancy-associated deaths in the 2018–2021 period were other accidental injury, self-harm, assault, and transport accident, whereas the predominant maternal (multiple) cause of death was “obstetric death, unspecified cause” (O95), which decreased dramatically from January 2020.

Completion of death certificates (National Vital Statistics System and National Center for Health Statistics methodology)

The median number of multiple causes of death per death certificate was unchanged from the 1999–2002 to the 2018–2021

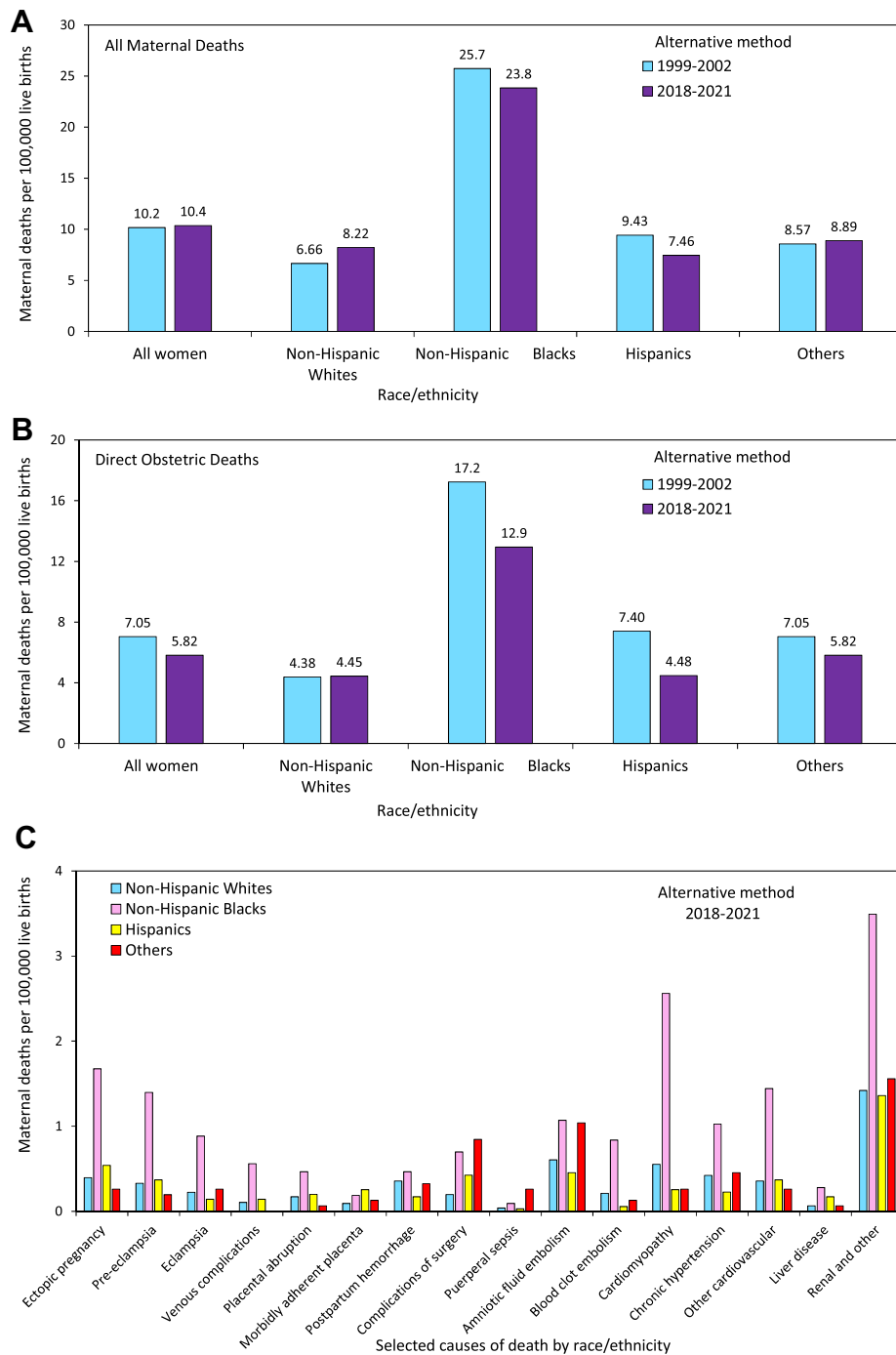
period. However, 14.3% of maternal deaths in the 2018–2021 period with a negative pregnancy checkbox listed a single cause of death (eg, amniotic fluid embolism), whereas this proportion was 22.3% among those with a positive pregnancy checkbox (eg, malignant breast neoplasm) (Supplement S44–S46).

Maternal death identification based on an alternative, definition-based formulation

Requiring maternal and late maternal deaths to mention pregnancy among at least 1 of the multiple causes of death showed that the maternal mortality rates in the United States were 10.2 in the 1999–2002 period (n=1633) and 10.4 per 100,000 live births in the 2018–2021 period (n=1537), representing a 2% increase (95% CI, –5% to +9%). Direct obstetrical deaths decreased by 17% from 7.05 in 1999–2002 to 5.82 in 2018–2021, whereas indirect obstetrical deaths and late maternal deaths increased by 46% and 329%, respectively (Figure 1, A and B; Appendix, F and G; Supplement S47). Deaths due to hypertensive disorders of pregnancy and complications of labor, delivery, and the puerperium declined, whereas deaths due to complications involving the fetus and amniotic cavity, obstetrical deaths from unspecified causes, and deaths due to circulatory system diseases (including preexisting hypertension) and renal and unspecified diseases increased (Figure 2; Supplement S48). Specifically, deaths due to preeclampsia, eclampsia, venous complications, amniotic fluid embolism, thromboembolism, and other circulatory system diseases decreased, whereas deaths due to placental abruption, morbidly adherent placenta, cardiomyopathy, and preexisting hypertension increased (Figure 4; Supplement S49).

Although maternal death rates increased among non-Hispanic White patients from the 1999–2002 to the 2018–2021 period, and decreased among non-Hispanic Black and Hispanic patients, maternal mortality rates were disproportionately higher among non-Hispanic Black patients (Figure 5, A;

FIGURE 5
Alternative method for identifying maternal death: Selected types and causes



Alternative method for identifying maternal deaths (not using pregnancy checkbox information): rates of **A**, maternal death and **B**, direct obstetrical death by race/ethnicity, United States, 1999–2002 and 2018–2021. **C**, Rates of selected causes of maternal death by race/ethnicity, United States, 2018–2021.

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Appendix, E–G). Direct obstetrical death rates were essentially unchanged among non-Hispanic White women but decreased substantially among non-Hispanic Black and Hispanic women and women of other races and ethnicities (Figure 5, B). Non-Hispanic Black women had higher rates of maternal death from several causes, with striking disparities in deaths due to ectopic pregnancy, hypertensive disorders, embolism, cardiomyopathy, other cardiovascular diseases, and renal and unspecified diseases (Figure 5, C; Supplement S50–S57).

Pregnancy-associated deaths increased from 1999 to 2021, with a steady increase from 2003, a surge from 2018 to 2019, and a sharp decline from January 2020 onward. Obstetrical deaths from unspecified cause (O95) decreased dramatically from January 2020 onward (Supplement S58–S63). The common multiple causes of death among such deaths included deaths from circulatory and respiratory system disorders, injury, poisoning, accidents, and ill-defined symptoms.

Comment

Principal findings

The frequency of nonmaternal deaths among women aged 15 to 44 years far exceeded maternal and late maternal deaths. Direct obstetrical, indirect obstetrical, and late maternal death rates increased substantially between the 1999–2002 and 2018–2021 periods under the NVSS and NCHS method for identifying maternal deaths, with increases observed in all race and ethnicity groups. These increases were mainly due to deaths from less specific causes identified solely because of a positive pregnancy checkbox. There was a substantial increase in the misclassification of maternal deaths, including a large increase in deaths with malignancy listed among the multiple causes of death. The alternative formulation, which required maternal deaths to mention pregnancy among the multiple causes of death, revealed lower, stable maternal mortality rates and a temporal reduction in direct obstetrical deaths. Deaths from preeclampsia; eclampsia; venous complications; labor, delivery, and puerperal complications; and embolism decreased, whereas deaths from placental

abruption, morbidly adherent placenta, renal and unspecified diseases, cardiomyopathy, and preexisting hypertension in pregnancy increased. Maternal mortality rates among non-Hispanic Black women, especially direct obstetrical deaths, decreased between the 1999–2002 and the 2018–2021 periods, but rates remained disproportionately high compared with other race and ethnicity groups.

Results in the context of what is known

Several of our findings suggest that the pregnancy checkbox is responsible for a substantial misclassification of nonmaternal and incidental deaths (as maternal deaths), and a consequent overestimation of maternal mortality. Deaths with a positive pregnancy checkbox included a higher proportion of cases with a single cause of death, suggesting a less thorough approach to death certification in such cases. The 46-fold temporal increase in maternal deaths with malignancies listed among the multiple causes of death suggests misclassification of nonmaternal and incidental deaths among pregnant and postpartum women. The observed temporal reduction in case fatality among women with hypertensive disorders of pregnancy is consistent with improvements in obstetrical care,^{24–26} whereas the observed temporal increase in case fatality among women with preexisting hypertension in pregnancy is unexpected. Possible explanations for the latter include an increase in pregnancies among women with severe chronic hypertension and hypertensive heart disease,^{27,28} or more likely, a checkbox-aided misclassification of nonmaternal and incidental deaths due to preexisting hypertension (as maternal deaths). Although the reason for such pregnancy checkbox errors is unclear, possible causes could include misunderstanding regarding the utility and importance of death certificate information on the part of the certifying physician, competing priorities on physician time, or inexperience.

A large fraction of pregnancy-associated deaths (from accidents, etc.) had “obstetric death, unspecified cause”

(O95) as a multiple cause of death (Figure 3; Supplement S58). However, listing “obstetric death” as a cause for incidental or accidental death in pregnancy represents a contradiction in terms. Furthermore, the virtual disappearance of such deaths from January 2020 suggests a change in surveillance procedures and requires investigation.

Maternal and late maternal deaths comprised <2% of deaths among women aged 15 to 44 years in the 2018–2021 period. Although society has traditionally placed a premium on preventing maternal death, the current disparity between maternal and other causes of death among women aged 15 to 44 years may warrant some reconsideration of public health priorities. For example, the 29-fold higher rate of nonmaternal vs maternal death from hypertension among women aged 15 to 44 years calls for an increased emphasis on preventing and treating hypertension among all women of reproductive age. This finding also highlights the potential for a substantial (artificial) increase in maternal deaths due to misclassification of a small fraction of nonmaternal deaths (eg, deaths due to hypertension among nonpregnant women).

Clinical implications

Implications for surveillance

Although the pregnancy checkbox can improve the detection of maternal deaths, it can also lead to the misclassification of nonmaternal and incidental deaths as maternal deaths. A study of maternal deaths from 2016 to 2017, which required mention of pregnancy among the multiple causes of death on the death certificate, yielded a maternal mortality rate of 7.88, as opposed to the NCHS estimate of 21.7 per 100,000 live births.²⁹ Another study that investigated 650 potentially pregnancy-related deaths found that 97 had no evidence of pregnancy in the year before death (mostly pregnancy checkbox errors), 378 were pregnancy-associated deaths, 136 were maternal deaths, and 39 were late maternal deaths; 38 of 136 maternal deaths and 3 of 39 late maternal deaths were identified because of the pregnancy checkbox.³⁰ Other studies have shown

false-positive error rates of 50% among decedents aged 15 to 44 years who were identified as pregnant at the time of death or in the previous year by the pregnancy checkbox.^{9,11,31} However, even correct identification of decedents as pregnant does not satisfy the definition of maternal death, which requires that death be due to a “cause related to or aggravated by the pregnancy or its management.”^{10,11,15,16}

Although the pregnancy checkbox has the potential to improve the sensitivity of maternal mortality surveillance, it has to be used as a first-step screen, with an assessment of the clinical circumstances required before such deaths are deemed to be maternal deaths. The Pregnancy Mortality Surveillance System (PMSS), which uses multiple sources of information to identify and confirm maternal deaths, estimated that the maternal mortality rate in the United States was 12.1 in 2018 and 12.3 per 100,000 live births in 2019 (as opposed to the NVSS rates of 17.4 in 2018 and 20.1 per 100,000 live births in 2019).³² The PMSS also reported pregnancy-related mortality ratios (ie, including maternal and late maternal deaths) of 13.2, 14.5, and 17.6 per 100,000 live births in 1999, 2007, and 2019, respectively.³³ Estimates of maternal and pregnancy-related mortality rates compiled by the NVSS, the PMSS, and the state Maternal Mortality Review Committees differ substantially,³² whereas studies based on large hospital discharge databases show lower rates and temporal reductions in maternal mortality.³⁴ One potential solution for improving pregnancy checkbox-aided maternal death identification would be to require certifying physicians who tick the checkbox to specify the pregnancy-related cause of death.

Requiring the mention of pregnancy among the multiple causes of death for identifying maternal death yields decreasing temporal patterns of maternal mortality, which are congruent with the recent advances in obstetrical care, including improvements in the management of hypertensive disorders of pregnancy,^{24–26} venous complications,^{35–37} postpartum hemorr-

hage,^{38–40} puerperal sepsis,^{41,42} and embolism.^{35,43,44} Temporal increases in maternal deaths from placenta accreta spectrum disorder are also consistent with increases in deliveries to women with previous cesarean deliveries.⁴⁵ The alternative formulation for identifying maternal deaths also eliminated a large fraction of opaque, less specific subcategories of maternal death. Furthermore, the cause-specific pattern of maternal death under this formulation provides a clear agenda for clinical and public health action both in the overall population and in specific subpopulations. For instance, racial disparities in direct and indirect causes of death (eg, preeclampsia and circulatory system deaths) highlight the need for specific preconceptional health and clinical care initiatives among non-Hispanic Black women.

Implications for research

Research is needed to provide insights into the causes of pregnancy checkbox errors, and to identify barriers impeding the correct completion of death certificates. There is also a pressing need for studies regarding effective methods to improve the accuracy of death certificate information.

Strengths and limitations

The strengths of our study included a comprehensive analysis of maternal mortality using 2 different approaches for identifying maternal deaths. Weaknesses of the study included a reliance on cause-of-death data from death certificates, which can lead to an underestimation of maternal mortality.²² In addition, causes of death based on abstracted and coded diagnoses and procedures differ substantially from causes of death ascertained by an expert review of medical records.²³ Calculating case fatality rates for women with hypertension based on information from unlinked mortality and birth files was another potential limitation.

Conclusion

Maternal mortality surveillance presents a serious challenge even in countries with good civil registration systems, and differences in surveillance methods

likely underlie some of the international variation in reported maternal mortality rates. Our study, which identified maternal deaths using a definition-based methodology, shows stable rates of maternal mortality in the United States between the 1999–2002 and 2018–2021 periods, decreases in maternal deaths due to direct obstetrical causes, increases in maternal deaths due to indirect obstetrical causes, and large increases in the misclassification of nonmaternal and incidental deaths due to the use of the pregnancy checkbox. Identifying maternal deaths by requiring the mention of pregnancy among the multiple causes of death provides a more accurate, clinically coherent and compelling perspective on maternal mortality in the United States, and can serve as the evidentiary basis for clinical and public health initiatives. ■

Acknowledgments

K.S.J. is supported by an Investigator award from the BC Children’s Hospital Research Institute. A.B. is supported by a Junior 1 Research Scholar Award from the Fonds de recherche du Québec - Santé. C.V.A. is supported, in part, by the National Heart, Lung, and Blood Institute (grant R01-HL150065) and the National Institute of Environmental Health Sciences (grant R01-ES033190), National Institutes of Health.

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Author and article information

From the Department of Obstetrics and Gynaecology, University of British Columbia, BC Children's and Women's Hospital and Health Centre, Vancouver, Canada (Drs Joseph, Lisonkova and Sabr and Mr John); School of Population and Public Health, University of British Columbia, Vancouver, Canada (Drs Joseph and Lisonkova); Department of Pediatrics, Faculty of Medicine, Université Laval, CHU de Québec-Université Laval Research Center, Québec City, Canada (Dr Boutin); Department of Obstetrics and Gynecology and Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, Canada (Dr Muraca); Division of Clinical Epidemiology,

Department of Medicine Solna, Karolinska Institutet, Stockholm, Sweden (Dr Razaz); Department of Obstetrics and Gynecology, College of Medicine, King Saud University, Riyadh, Saudi Arabia (Dr Sabr); Department of Medicine, University of British Columbia, Vancouver, Canada (Dr Chan); Perinatal Epidemiology Research Unit, Department of Obstetrics and Gynaecology and Department of Pediatrics, Dalhousie University, Halifax, Canada (Dr Mehrabadi); Department of Obstetrics, Gynecology and Reproductive Sciences, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ (Dr Brandt); Division of Maternal—Fetal Medicine, Department of Obstetrics and

Gynecology, NYU Grossman School of Medicine, New York, NY (Dr Brandt); Department of Biostatistics, Epidemiology and Informatics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA (Dr Schisterman); Division of Epidemiology and Biostatistics, Department of Obstetrics, Gynecology and Reproductive Sciences, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ (Dr Ananth); Cardiovascular Research Institute, Department of Medicine, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ (Dr Ananth); Department of Biostatistics and Epidemiology, Rutgers School of Public Health, Piscataway, NJ (Dr Ananth); and

Environmental and Occupational Health Sciences Institute, Rutgers Robert Wood Johnson Medical School, Piscataway, NJ (Dr Ananth).

Received May 15, 2023; revised Nov. 30, 2023; accepted Dec. 21, 2023.

The authors report no conflict of interest.

The authors report no funding for this study.

Data sharing agreement: The data used in this study are publicly available at https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm.

Corresponding author: K.S. Joseph, MD, PhD. ksjoseph@bcchr.ca