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Maternal Mortality and Related Concepts



DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

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Maternal Mortality and Related Concepts

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

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Objective

This report presents data on U.S. deaths to pregnant or recently pregnant women, summarizes long-term processing issues, and examines recent changes affecting the data and the impact of the changes on the statistics for these women.

Methods

This report presents descriptive tabulations of information reported on death certificates that are completed by funeral directors, attending physicians, medical examiners, and coroners. The original records are filed in the state registration offices. Statistical information is compiled into a national database through the Vital Statistics Cooperative Program of the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics (NCHS). Causes of death are processed in accordance with the *International Classification of Diseases (ICD)*.

Results

Maternal mortality fluctuates from year to year but was 12.1 deaths per 100,000 live births in 2003. The implementation of the *International Classification of Diseases, Tenth Revision (ICD-10)* in 1999 resulted in about a 13 percent increase in the number of deaths identified as maternal deaths between 1998 and 1999. The rate increased again between 2002 and 2003 after a separate pregnancy question became a standard item on the U.S. Standard Certificate of Death. The adoption of a standard separate question on pregnancy facilitates the identification of late maternal deaths.

Conclusion

Maternal deaths increased with the introduction of the ICD-10 and with changes associated with the addition of a separate pregnancy status question on the U.S. Standard Certificate of Death. These changes may result in better identification of maternal deaths.

Keywords: maternal mortality • maternal mortality rate • vital statistics • U.S. Standard Certificate of Death • ICD

Maternal Mortality and Related Concepts

by Donna L. Hoyert, Ph.D., Division of Vital Statistics

Introduction

In 1915, the maternal mortality rate was 607.9 deaths per 100,000 live births for the birth registration area. In 2003, the maternal mortality rate was 12.1 deaths per 100,000 live births in the United States ([Figure 1](#) and [Tables 1](#) and [2](#)). Despite this tremendous overall improvement, maternal mortality continues to be a significant public health issue and commands an enormous amount of attention. One of the consequences of this intense scrutiny is that enhanced surveillance efforts have been developed to actively identify deaths of women near the time of pregnancy. Death certificates are a common tool for researchers interested in this topic and serve several roles; for example, the source of National Vital Statistics System (NVSS) maternal mortality data and one of the sources used in pregnancy mortality surveillance efforts to identify cases.

Following the rules and regulations of the ICD (1), the NVSS has provided maternal death counts since 1900 and maternal mortality rates since 1915 ([Tables 1](#) and [2](#) and [Figure 1](#)). It remains a valuable source of information on trends and is characterized by universal coverage and consistent data collection. However, the NVSS does not identify as many events as active surveillance efforts. An evaluation study for the

1995–97 period found that 35 percent more maternal deaths are identified through surveillance efforts than solely by the death certificate. A number of explanations account for the under ascertainment including missing information in the cause-of-death section, use of fewer sources, and differences in identification (2).

As alternative data sources have been developed and research groups have focused on this issue in greater detail, there has been interest in improving the information coming from the death certificate. Some longstanding efforts to improve vital statistics data quality include states querying death certificates to get additional information for specific records (3), and the inclusion of a separate question on recent pregnancy history on death certificates in a growing number of states. More states would likely have adopted a separate question if it had been on the U.S. Standard Certificate. Although a question was proposed for the 1979 and 1989 U.S. Standard Certificate of Death (4,5), it was not adopted because of a perception that information on maternal deaths should be reported in the existing cause-of-death section, the space for adding questions on the certificate was limited, and alternative sources measuring deaths around the time of pregnancy existed. The 2003 U.S. Standard Certificate of Death did include a separate question.

This report was prepared in the Division of Vital Statistics (DVS) under the general direction of Charles J. Rothwell, Director of DVS and Robert N. Anderson, Chief, Mortality Statistics Branch (MSB). Arialdi Minino of MSB provided content related to comparability. Registration Methods staff and staff of the Data Acquisition and Evaluation Branch provided consultation to state vital statistics offices regarding collection of the death certificate data on which this report is based. This report was edited by Demarius V. Miller, Office of Information Services, Information Design and Publishing Staff; typeset by Jacqueline M. Davis; and the graphics produced by John Jeter, both of CoCHIS/NCHM/Division of Creative Services.

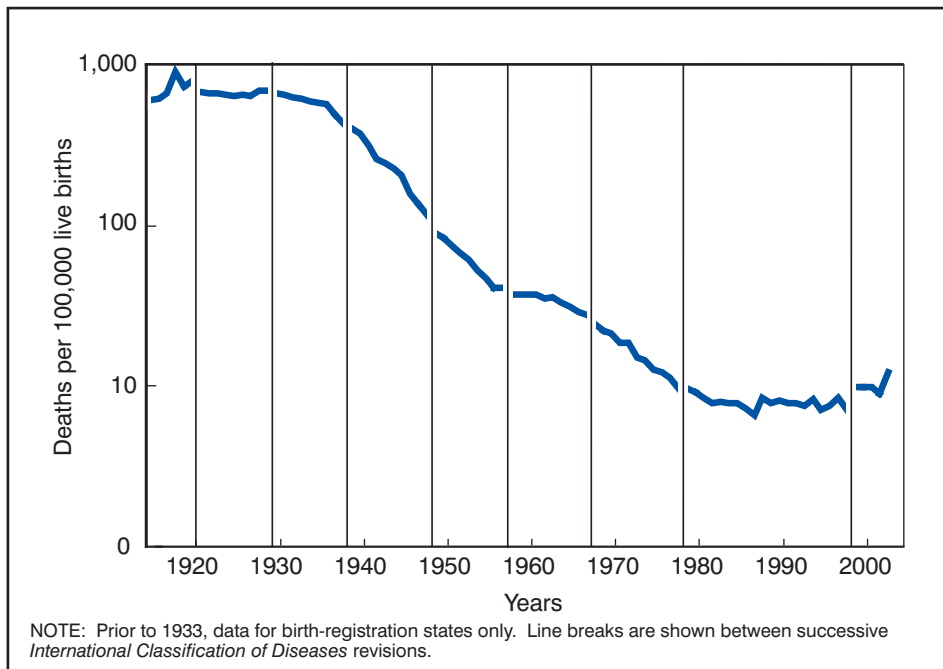


Figure 1. Maternal mortality rates, United States, 1915–2003

This report summarizes processing of maternal mortality in the NVSS and describes some recent changes affecting NVSS data and their impact upon statistics on deaths of pregnant or recently pregnant women. Specifically, the report examines the impact of revision of the death certificate and ICD (6).

Maternal Mortality and the NVSS, 1900–1998

In the NVSS, deaths of pregnant or recently pregnant women are identified according to the information reported on the women’s death certificates, particularly the causes of death reported by physicians, medical examiners, and coroners. From the beginning, the ICD included maternal causes in the list of causes of death, so deaths from these causes could be distinguished from those due to other causes. Maternal deaths were deaths where the cause-of-death codes were identified as complications of pregnancy, childbirth, and the puerperium in the ICD. The relevant codes for 1900–1998 are shown in Table A (7–12).

Explicit definitions for terms related to mortality around the time of pregnancy (e.g., maternal death) were first included in the ICD in the *International Classification of Diseases*,

Table A. Maternal death cause-of-death codes by the *International Classification of Diseases* (ICD) Revision

Revision	ICD Codes
First	151–159
Second	134–141
Third	143–150
Fourth	140–150
Fifth	140–150
Sixth	640–689
Seventh	640–689
Eighth	630–678
Ninth	630–676

Ninth Revision (ICD–9), implemented with data for 1979 (13). This introduction of definitions clarified what should be included in the maternal mortality measure obtained from vital statistics; however, the maternal death concept according to the ICD–9 was largely consistent with what the National Center for Health Statistics (NCHS) and its predecessor agencies had been using. The main difference in the definition of maternal deaths introduced in the ICD–9 was that the time frame required for designation of a maternal death was restricted to within 42 days of the end of the pregnancy, whereas the earlier interpretation was to include deaths occurring anytime within 1 year of the end of a pregnancy. The maternal conditions making up maternal deaths continued to be grouped under a

heading that referred to pregnancy, childbirth, and the puerperium, and the time frame of 42 days corresponded to common usage of the term of puerperium as the time during which physiologic changes women experience while pregnant revert back to normal (14). Some contend that the 42-day period also reflects cultural practices as not all physiologic changes may be completely resolved in 42 days (15). Nevertheless, the change in time frame was not judged to have a substantial impact on the statistics in the United States around 1979 because most deaths occur within 42 days, and the decreasing influence of changing the time period was overwhelmed by increases resulting from more causes being grouped within the section of the classification dealing with maternal causes (16).

Coding Practices

There was no specific guidance on maternal death coding for most years (17,18). For most of the 1900s, a classification rule limited a maternal death to a death within 1 year after termination of pregnancy from any “maternal cause.” If no duration was specified and the underlying cause of death was a maternal condition, the duration was assumed to be within 1 year and the death was coded by NCHS as a maternal death. If duration was stated, then deaths occurring more than 1 year after the pregnancy ended were not considered maternal deaths regardless of cause (19).

General changes in 1949 had some implications for maternal deaths (16). The adoption of the *International Classification of Diseases, Sixth Revision* (ICD–6) brought about a change in death certificate format and introduced rules for selecting an underlying cause. Previously, a joint cause manual was used to select the cause that would be tabulated. Using the sequential format resulted in selecting a maternal cause 9 percent less often than using the joint cause manual (20).

More guidelines for maternal deaths have been provided in subsequent years (17). The coding guidelines continued to focus on complications of pregnancy, and described when to code the specific

term “pregnancy,” when to use a separate question on pregnancy, and how to code additional available codes. The gradual changes introduced with the *International Classification of Diseases, Seventh Revision* (ICD–7) and the *International Classification of Diseases, Adapted, Eighth Revision* (ICDA–8) had little impact on maternal mortality statistics (16).

In 1979, the ICD–9 (11,13) had two main changes related to maternal deaths (i.e., definitions and additional categories). The impact of implementing this revision resulted in a 10 percent increase in maternal deaths (21). This was the result of additional causes considered to be maternal (indirect obstetric causes such as infective and parasitic conditions and other current conditions in the mother that are classifiable elsewhere but which complicate pregnancy such as syphilis, tuberculosis, diabetes, drug dependence, and congenital cardiovascular disorders). The time period for a maternal death was shortened from 1 year to 42 days; however, this did not offset the impact of including indirect causes.

Separate pregnancy questions introduced by some states were supplemental sources of information but were not used in coding cause of death according to ICD–9 if sufficient information was written in the cause-of-death statement. However, a positive response to the separate question was interpreted as if “pregnant” was reported in Part II of the cause-of-death section of the death certificate if it was not already reported in the cause-of-death section.

In 1992 (17), guidance on the use of separate questions was broadened slightly. In addition to using questions with a specific time, questions referring to the 42-day period could also be used. After meeting with CDC’s Division of Reproductive Health (DRH) in 1997, NCHS implemented the following modifications for the remainder of the time that the ICD–9 was to be used: a) assume that death occurred within 42 days if no specific duration was mentioned and the state did not have a separate question on pregnancy status and b) if a state had a separate question, do not assume that death occurred

within 42 days unless this is specifically reported.

Recent Changes, 1999–2003

Revisions in the latest ICD and the U.S. Standard Certificate of Death both were relevant for maternal mortality. The ICD–10, which provides cause-of-death titles and codes, coding rules and procedures, and definitions, was implemented in the United States in 1999 (1). The following describes modifications between ICD–9 and ICD–10 with respect to cause-of-death titles, coding rules, and definitions. The ICD–9 definitions for maternal deaths, direct obstetric deaths, and indirect obstetric deaths were retained in ICD–10 (1,13). New definitions were introduced for “Late maternal death” and “Pregnancy-related death” (Figure 2). This complicated a pre-existing situation in which programs conducting surveillance efforts such as CDC’s DRH and the ICD (and consequently the NVSS) used different terms for similar concepts (e.g., DRH’s pregnancy-related death term is similar to ICD’s maternal deaths while DRH’s

pregnancy-associated death is similar to ICD’s pregnancy-related death term) (21).

In 1999, the coding guidelines used in the United States (17) were expanded to cover additional categories available in the ICD–10. Furthermore, if only indirect maternal causes of death (i.e., a previously existing disease or a disease that developed during pregnancy that was not due to direct obstetric causes but was aggravated by physiologic effects of pregnancy) were reported in Part I and pregnancy was reported in either Part I or II, the death was classified as a maternal death. In contrast, in the ICD–9, the pregnancy had to be reported in Part I for the death from indirect causes to be considered a maternal death.

Along with the new definitions, the ICD–10 introduced new details and categories in the cause-of-death titles associated with pregnancy, childbirth, and the puerperium. For example, the causes O96 Death from any obstetric cause occurring more than 42 days but less than one year after delivery and O97 Death from sequelae of direct obstetric causes were added for deaths that occur beyond the maternal death

Figure 2. Definitions in ICD–10

“Maternal deaths” are 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 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.”

“Late maternal deaths” are defined as “the deaths of a woman from direct or indirect obstetric causes more than 42 days but less than one year after termination of pregnancy.”

“Pregnancy-related deaths” are defined as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death.”

“Direct obstetric deaths: those resulting from obstetric complications of the pregnant state (pregnancy, labour and puerperium), from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above.”

“Indirect obstetric deaths: those 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.”

period. Also, the ICD now recommends that countries include separate questions about recent pregnancies on their death certificates.

Consequently, the 2003 revision of the U.S. Standard Certificate of Death (23) introduced the following standard question format with response categories to take advantage of additional codes in the ICD–10 for deaths with a connection to pregnancy, childbirth, and the puerperium:

36. 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

The detail of the question also facilitates use of new concepts in the ICD–10.

By 2003, 21 states had a separate question related to the pregnancy status of female decedents around the time of their death and two states had a prompt encouraging certifiers to report recent pregnancies on the death certificate; however, there were at least six different questions being used. In 2003, only four states could capture information consistent with the standard. As states revise their certificates, most states are expected to introduce the standard item or replace pre-existing questions with the standard item, so that there will be wider adoption of a pregnancy status item across the country and greater standardization of the particular item used. See “Technical Notes” for a listing of states and their separate questions.

Changes in the coding guidelines on how to use information reported in separate pregnancy questions were slightly more consequential with modifications associated with the implementation of the ICD–10 in 1999 than with modifications associated with the revision of the death certificate in 2003. The guidelines have described the use of separate questions as supplemental information throughout this period. Prior to 1999, if a specified length of time was not provided by the medical certifier, it was assumed that

the pregnancy terminated within 42 days of death if the state did not have a separate question. This assumption was broadened to include states with separate questions in 1999. In 2003, the coding guidelines were modified to reflect the specific wording of the pregnancy status question on the 2003 U.S. Standard Certificate of Death.

Although information from separate questions had been used previously, the inclusion of a question on the U.S. Standard Certificate of Death in 2003 raised the status of the item and resulted in more guidelines for those with nonstandard questions. In addition to the general coding guidelines for the standard questions, instructions for the jurisdictions’ specific questions were developed and distributed to the states beginning in 2003. Data from the states with nonstandard questions were used to the extent possible. If the state question identified any of the specific categories in the standard question, then the information was used in the same way as the standard to assign codes. If the state question collapsed categories, then the information was treated as if the pregnancy occurred for the later category being collapsed. For example, for the states that asked if a pregnancy occurred within the year, this category is equivalent to combining the standard item’s categories of “pregnant at time of death”; “not pregnant, but pregnant within 42 days of death”; and “not pregnant, but pregnant 43 days to 1 year before death.” A positive response to this nonstandard category without further specification of timing in the cause-of-death statement was treated as if the pregnancy occurred between 43 days and 1 year before death.

Following the guidelines for coding, maternal deaths are now identified using the reported causes of death and a separate question if the information captured in the separate question was not already reported in the cause-of-death section. If the woman was pregnant at the time of death, the medical conditions on the death certificate are assigned to one of the categories for conditions related to pregnancy. If the woman was pregnant within 42 days, the medical conditions

on the death certificate are assigned to one of the categories for conditions related to delivery. If the woman was pregnant between 43 days and 1 year, then the medical condition would be assigned to the late maternal death category. If the woman was pregnant more than a year ago, direct maternal medical conditions are assigned the category for sequelae of direct obstetric causes.

Methods

Data presented in this report are based on information from death certificates filed in the 50 states and the District of Columbia that are subsequently compiled into national data, also known as NVSS, by NCHS. Physicians, medical examiners, and coroners are responsible for completing the medical portion of the death certificate.

This report presents the number of maternal and late maternal deaths as well as maternal mortality rates. These rates were computed by dividing the number of deaths (Figure 2) by the number of live births registered for the same period and are presented as rates per 100,000 live births (1). The number of live births used in the denominator is an approximation of the population of pregnant women who are at risk of a maternal death. These have long been defined as rates although other researchers refer to equivalent measures as ratios (22).

To assess the impact of having a separate question on maternal mortality, the states were divided according to whether the state death certificate included any form of a separate pregnancy question. The number with a separate question was 16 in 1996–1998, 17 in 1999–2000, 18 in 2001–2002, and 21 in 2003. The states were not grouped further according to the particular question used because of the small number of deaths involved.

Maternal mortality is a relatively rare event, so the rates fall within fairly wide confidence intervals. Confidence intervals are presented in Tables A and 3 to illustrate the degree of variation. To

increase statistical reliability and assess if any additional patterns emerge, maternal mortality rates were also calculated by combining the number of deaths and births for the following years: 1997–1998, 1999–2000, and 2001–2002.

Comparisons made in the text among rates, unless otherwise specified, are statistically significant at the .05 level of significance. Lack of comment in the text about any two rates does not mean that the difference was tested and found not to be significant at this level. See the “Technical Notes” for further details on random variation and calculations used in this report.

Results

Maternal mortality rates (Tables 1–3) fluctuate considerably from year to year, and the differences have rarely been statistically significant in the last few decades because of the small numbers of events. The rates (see Table II for ICD–9 and ICD–10 codes) did increase between 1998 and 1999 and between 2002 and 2003.

The increase between 1998 and 1999 results from the implementation of the ICD–10. The changes to the ICD and associated coding procedures for maternal deaths account for a 13 percent increase in the number of maternal deaths between ICD–9 and ICD–10 data (i.e., the comparability ratio is 1.1263). This reflects that more indirect deaths are identified as maternal deaths in ICD–10 because the procedures take into account pregnancies reported in both Parts I and II, whereas ICD–9 only considered deaths from indirect causes to be maternal deaths when the pregnancy was reported in Part I. The assumption that pregnancies without specification of timing occur within 42 days being applied for more states may also account for some additional deaths. When the rates are modified to take into account the comparability ratio (Table B), the difference between 1998 and 1999 is no longer statistically significant.

Maternal mortality rates (Tables B and 3) were also affected by the adoption of a separate pregnancy question on the U.S. Standard Certificate of Death. The maternal mortality rate did not increase by a statistically significant margin between 2002 and 2003 for the states without a question, but the maternal mortality rate was 20 percent greater in the states with a separate question than in the areas without a separate question in 2003. Although the maternal mortality rate increased between 2002 and 2003 for the group of states that had the same question in both years (40 percent), it increased by a larger margin when the states that adopted the new standard question were also included (53 percent). For individual years before 2003, the rates for states with a question were not consistently or statistically significantly greater than those for the states without a question. When the data were collapsed across time, there seemed to be a tendency for the states with a question to have higher rates than those without a separate question; however, the differences were still not statistically different.

New Information

The ICD–10 provided categories for late maternal deaths and sequelae of maternal deaths. There are some records

with these new codes. For 1999–2002, an additional 2 to 9 late maternal deaths (O96 Death from any obstetric cause occurring more than 42 days but less than 1 year after delivery) and 6 to 13 sequelae of maternal deaths (O97 Death from sequelae of direct obstetric causes) were reported in the United States each year. In 2003, the respective numbers were 46 and 4. Some records may be coded to these categories, particularly late maternal deaths, instead of as maternal deaths if the only information on the timing of the pregnancy comes from a nonstandard question. For example, if the question refers to death occurring within 12 months, the death might have occurred within 42 days but the question does not distinguish which ones, so the coding procedure conservatively treats the death as having occurred between 43 days and 1 year.

Discussion

The NVSS is a longstanding source of data on maternal mortality. However, research (2,24–26) has demonstrated that additional maternal deaths and other deaths among recently pregnant women can be identified with more effort. For the states that had a separate question on pregnancy status in the early 1990s, a research study (24)

Table B. Maternal mortality rates by question type: United States, 1996–2003

[By state of residence. Rates are the sum of deaths for the time period divided by the sum of the live births for the time period times 100,000. The numbers shown in parentheses are the confidence intervals for the rates]

Year	United States	Areas with a separate question	Areas without a separate question
2003	12.1 (11.0,13.2)	13.0 (11.6,14.4)	10.8 (9.2,12.4)
2002	8.9 (8.0,9.8)	8.5 (7.1,9.8)	9.2 (8.0,10.5)
2001	9.9 (8.9,10.9)	10.3 (8.9,11.8)	9.5 (8.2,10.8)
2000	9.8 (8.8,10.7)	9.6 (8.2,11.1)	9.9 (8.6,11.2)
1999	9.9 (8.9,10.9)	10.7 (9.2,12.3)	9.2 (7.9,10.5)
1998 ¹	8.0 (7.1,9.0)	7.7 (6.3,9.1)	8.3 (7.0,9.5)
1997 ¹	9.5 (8.5,10.5)	10.0 (8.4,11.6)	9.1 (7.8,10.4)
1996 ¹	8.5 (7.5,9.5)	9.2 (7.7,10.8)	8.0 (6.7,9.2)

¹Rates were modified with the comparability ratio of 1.1263.

identified about 29 percent of the events related to pregnancy within 1 year of death solely through the information reported on the checkbox.

In the NVSS, maternal deaths increased with the introduction of the ICD–10 and when the separate pregnancy status question switched from being supplemental information available from some state certificates to an item expected to be included on all state certificates. Maternal mortality rates increased for both of the years when these changes affecting identification of maternal deaths were implemented. Changes with the ICD–10 that resulted in more indirect maternal causes apply more with the increasing use of separate pregnancy questions. Because most states have yet to adopt the standard format of the separate pregnancy question, it is likely that maternal and late maternal death rates in all states will continue to be subject to increases because of the adoption of questions rather than actual increases in maternal mortality. The “pregnancy-related mortality rates” using surveillance data increased between 1991 and 1999 (18). The increase in the surveillance data was attributed in large part to improved identification of “pregnancy-related deaths” (18).

Having supplemental information provided by a separate question potentially results in more death certificates having information on them that can be used in assigning codes in the section of the classification dedicated to complications of pregnancy, childbirth, and the puerperium. The new guidance in the special rules may have been easier for the states with nonstandard questions to follow because the instructions were tailored to the specific question on each state’s certificate. However, the standard question seemed to result in more maternal deaths being identified than other questions do. In part, this reflects that if the timing of the pregnancy is not stated in the cause-of-death statement and an area has nonstandard categories for their separate questions such as pregnant within 12 months, then the medical coders treat this as a death occurring between 43 days and 1 year. As more states adopt separate pregnancy

questions consistent with the standard, the overall maternal mortality rate will likely continue to drift upward because the standard question captures more information.

The increasing use of a pregnancy status checkbox on death certificates and changes in the coding under the ICD–10, particularly of indirect maternal causes, results in the identification of more maternal deaths in the NVSS. Conceivably, the differential between the NVSS and surveillance efforts will decrease as a result. Recent maternal mortality rates appear to be more similar to the “pregnancy-related mortality rates” published using surveillance data through 1999 (18), and the ratio of deaths of recently (i.e., within 42 days) pregnant women from causes unrelated to pregnancy to those from maternal causes in the NVSS is generally similar to that found in a 1993–1998 Maryland study using enhanced surveillance (26). However, the distribution of the timing of deaths suggests differences between NVSS data and Maryland’s enhanced data (26). Furthermore, the newer NVSS procedures are more inclusive of indirect causes than the surveillance efforts (18). Future studies such as MacKay, et al. (2) will be needed to examine the current differential between the NVSS data and pregnancy surveillance efforts. Finally, surveillance efforts should be able to take advantage of this new question to improve the usefulness of the death certificate as one of the sources to identify deaths of interest.

References

1. World Health Organization. International Statistical Classification of Diseases and Related Health Problems, Tenth Revision. Geneva: World Health Organization. 1992.
2. MacKay AP, Berg CJ, Duran C, Chang J, Rosenberg H. An assessment of pregnancy-related mortality in the United States. *Paediatr Perinat Epidemiol* 19(3): 206–14. 2005.
3. National Center for Health Statistics. Vital statistics, ICD–10 cause-of-death querying, 2006. NCHS instruction manual; part 20. Hyattsville, MD: Public Health Service. 2006. Available

from: http://www.cdc.gov/nchs/data/dvs/Instruction%20Manual%202020_%202006%20edition_w.pdf.

4. Dundon JL, Gay GA, George JL. The 1978 revision of the U.S. standard certificates. National Center for Health Statistics. *Vital Health Stat* 4(23). 1983. Available from: http://www.cdc.gov/nchs/data/series/sr_04/sr04_023.pdf.
5. Tolson GC, Barnes JM, Gay GA, Kowaleski JL. The 1989 revision of the U.S. standard certificates and reports. National Center for Health Statistics. *Vital Health Stat* 4(28). 1991. Available from: http://www.cdc.gov/nchs/data/series/sr_04/sr04_028.pdf.
6. National Center for Health Statistics. Report of the Panel to Evaluate the U.S. Standard Certificates. National Center for Health Statistics. 2000. Available from: http://www.cdc.gov/nchs/data/dvs/panelreport_acc.pdf.
7. Hetzel AM. History and organization of the vital statistics system. National Center for Health Statistics. 1997.
8. U.S. Census Bureau. Mortality Statistics 1900–1904. Special reports of the Census Office. Washington: Government Printing Office. 1906. Available from: http://www.cdc.gov/nchs/data/vsushistorical/mortstatsh_1900-1904.pdf.
9. National Office of Vital Statistics. Maternal Mortality: United States and each state, and Alaska, Hawaii, Puerto Rico, and the Virgin Islands (U.S.), 1955. *Vital Statistics—Special Reports: National Summaries; vol 46 no 17*. 1957.
10. National Office of Vital Statistics. Vital statistics of the United States, 1958. Volume I. Washington: Government Printing Office. 1960. Available from: http://www.cdc.gov/nchs/data/vsus/Vsus_1958_1.pdf.
11. National Center for Health Statistics. Vital statistics of the United States, 1968, vol II part A, mortality. Rockville, MD: Public Health Service. 1972. Available from: http://www.cdc.gov/nchs/data/vsus/mort68_2a.pdf.
12. National Center for Health Statistics. Vital statistics of the United States, 1979, vol II part A, mortality. Washington: Public Health Service. 1984. Available from: http://www.cdc.gov/nchs/data/vsus/mort79_2a.pdf.
13. World Health Organization. Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, based on the

- recommendations of the Ninth Revision Conference, 1975. Geneva: World Health Organization. 1977.
14. Cunningham FG, Williams JW. *Williams Obstetrics*. 21st ed. New York, New York: McGraw-Hill. 2001.
 15. Hoj L, da Silva D, Hedegaard K, Sandstrom A, Aaby P. Maternal mortality: only 42 days? *BJOG: An International Journal of Obstetrics and Gynaecology* 110(11): 995–1000. 2003.
 16. National Center for Health Statistics. *Vital statistics of the United States, 1980, vol II part A, mortality*. Washington: Public Health Service. 1985. Available from: http://www.cdc.gov/nchs/data/vsus/mort80_2a.pdf.
 17. National Center for Health Statistics. *Vital statistics, instructions for classifying multiple causes of death. NCHS instruction manual; part 2b*. Hyattsville, MD: Public Health Service. Published annually.
 18. Chang J, Elam-Evans LD, Berg CJ, Herndon J, Flowers L, Seed KA, Syverson CJ. *Pregnancy-Related Mortality Surveillance—United States, 1991–1999*. *MMWR Surveillance Summaries* 52(SS-2): 1–8. 2003.
 19. Hoyert DL, Arias E, Smith BL, Murphy SL, Kochanek KD. *Deaths: Final data for 1999*. *National vital statistics reports; vol 49 no 8*. Hyattsville, MD: National Center for Health Statistics. 2001. Available from: http://www.cdc.gov/nchs/data/nvsr/nvsr49/nvsr49_08.pdf.
 20. National Office of Vital Statistics. *Vital statistics of the United States, 1950, vol I*. Washington: Public Health Service. 1954. Available from: http://www.cdc.gov/nchs/data/vsus/vsus_1950_1.pdf.
 21. Klebba AJ, Scott JH. Estimates of selected comparability ratios based on dual coding of 1976 death certificates by the Eighth and Ninth Revisions of the International Classification of Diseases. *Monthly vital statistics report; vol 28 no 11, supp*. Hyattsville, MD: Public Health Service. 1980. Available from: http://www.cdc.gov/nchs/data/mvsr/supp/mv28_11s.pdf.
 22. Wilcox LS, Marks JS (eds). *From data to action, CDC's Public Health Surveillance for women, infants, and children*. U.S. Dept of Health and Human Services, CDC Monograph. 1995.
 23. National Center for Health Statistics. *2003 revision of the U.S. Standard Certificate of Death*. 2003. Available from: <http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-acc.pdf>.
 24. MacKay AP, Rochat R, Smith JC, Berg CJ. The check box: Determining pregnancy status to improve maternal mortality surveillance. *Am J Prev Med* 19(1S): 35–9. 2000.
 25. Baker N, Fogarty C, Stroud D, Rochat R. Enhanced pregnancy-associated mortality surveillance: Minnesota, 1990–1999. *Minnesota Medicine* 87(1): 45–7. 2004.
 26. Horon IL, Cheng D. Enhanced surveillance for pregnancy-associated mortality—Maryland, 1993–1998. *JAMA* 285(11): 1455–9. 2001.
 27. National Center for Health Statistics. *Technical appendix. Vital statistics of the United States, vol II part A, mortality*. Washington: Public Health Service. Published annually. Available from: <http://www.cdc.gov/nchs/dataawh/statab/pubd/ta.htm>.
 28. Chiang CL. *Introduction to stochastic processes in biostatistics*. New York: Wiley. 1968.
 29. Brillinger DR. The natural variability of vital rates and associated statistics. *Biometrics* 42: 693–734. 1986.
 30. Hoyert DL, Heron M, Murphy SL, Kung HC. *Deaths: Final data for 2003*. *National vital statistics reports; vol 54 no 13*. Hyattsville, MD: National Center for Health Statistics. 2006.
 31. Schenker N, Gentleman JF. On judging the significance of differences by examining the overlap between confidence intervals. *The American Statistician* 55: 182–6. 2001.

Table 1. Maternal mortality rates by race, birth-registration states, or United States, 1915–2003

[Beginning in 1989, race for live births is tabulated according to race of mother. Data are for a registration area for 1915–1932 and for the United States since 1933. Beginning 1970 excludes deaths of nonresidents of the United States. Rates per 100,000 live births in specified group. Deaths are classified according to the *International Classification of Diseases* in use at the time]

Year	All races ¹	White	Black
Race of mother²			
2003	12.1	8.7	30.5
2002	8.9	6.0	24.9
2001	9.9	7.2	24.7
2000	9.8	7.5	22.0
1999	9.9	6.8	25.4
1998	7.1	5.1	17.1
1997	8.4	5.8	20.8
1996	7.6	5.1	20.3
1995	7.1	4.2	22.1
1994	8.3	6.2	18.5
1993	7.5	4.8	20.5
1992	7.8	5.0	20.8
1991	7.9	5.8	18.3
1990	8.2	5.4	22.4
1989	7.9	5.6	18.4
Race of child³			
1993	7.5	4.9	19.1
1992	7.8	5.1	19.5
1991	7.9	5.9	17.2
1990	8.2	5.5	21.1
1989	7.9	5.7	17.5
1988	8.4	5.9	19.5
1987	6.6	5.1	14.2
1986	7.2	4.9	18.8
1985	7.8	5.2	20.4
1984	7.8	5.4	19.7
1983	8.0	5.9	18.3
1982	7.9	5.8	18.2
1981	8.5	6.3	20.4
1980	9.2	6.7	21.5
1979	9.6	6.4	25.1
1978	9.6	6.4	25.0
1977	11.2	7.7	29.2
1976	12.3	9.0	29.5
1975	12.8	9.1	31.3
1974	14.6	10.0	38.3
1973	15.2	10.7	38.4
1972 ⁴	18.8	14.3	40.7
1971	18.8	13.0	48.3
1970	21.5	14.4	59.8
1969	22.2	15.5	59.5
1968	24.5	16.6	65.9
1967	28.0	19.5	72.6
1966	29.1	20.2	74.2
1965	31.6	21.0	88.3
1964	33.3	22.3	93.8
1963 ⁵	35.8	24.0	101.1
1962 ⁵	35.2	23.8	99.4
1961	36.9	24.9	105.4
1960	37.1	26.0	103.6
1959	37.4	25.8	105.0
1958	37.6	26.3	104.5
1957	41.0	27.5	121.6
1956	40.9	28.7	114.3
1955	47.0	32.8	134.3
1954	52.4	37.2	145.9
1953	61.1	44.1	168.3
1952	67.8	48.9	189.2
1951	75.0	54.9	204.2

See footnotes at end of table.

Table 1. Maternal mortality rates by race, birth-registration states, or United States, 1915–2003—Con.

[Beginning in 1989, race for live births is tabulated according to race of mother. Data are for a registration area for 1915–1932 and for the United States since 1933. Beginning 1970 excludes deaths of nonresidents of the United States. Rates per 100,000 live births in specified group. Deaths are classified according to the *International Classification of Diseases* in use at the time]

Year	All races ¹	White	Black
Race of child ³ —Con.			
1950	83.3	61.1	223.0
1949	90.3	68.1	237.6
1948	116.6	89.4	303.6
1947	134.5	108.6	336.2
1946	156.7	130.7	363.6
1945	207.2	172.1	456.7
1944	227.9	189.4	513.9
1943	245.2	210.5	512.8
1942	258.7	221.8	549.1
1941	316.5	266.0	690.2
1940	376.0	319.8	781.7
1939	403.9	352.8	771.3
1938	435.2	377.2	861.0
1937	488.8	436.1	862.2
1936	568.0	511.6	980.9
1935	582.1	530.6	954.8
1934 ^{6,7}	593.2	544	---
1933 ^{6,7}	619.1	564	---
1932 ^{6,7}	632.6	581	---
1931 ⁷	660.9	601	---
1930 ⁷	673.2	609	---
1929 ⁷	695.1	631	---
1928 ⁷	692.3	627	---
1927 ⁷	647.2	594	---
1926 ⁷	655.6	619	---
1925 ⁷	647.1	603	---
1924 ⁷	656.4	607	---
1923 ⁷	665.1	626	---
1922 ⁷	664.4	628	---
1921 ⁷	681.8	644	---
1920 ⁷	799.1	760	---
1919 ⁷	737.3	696	---
1918 ⁷	916.4	889	---
1917 ⁷	661.7	632	---
1916 ⁷	621.6	608	---
1915 ⁷	607.9	601	---

--- Data not available.

¹Includes races other than white and black.

²Maternal deaths based on race of decedent; live births based on race of mother.

³Maternal deaths based on race of decedent; live births based on race of child.

⁴Deaths based on a 50 percent sample.

⁵Figures by race exclude data for residents of New Jersey.

⁶For 1932–1934, Mexicans are included with All other.

⁷For 1915–1934, the rate for white decedents was from published figures.

Table 2. Maternal mortality rates by Hispanic origin and race for non-Hispanic population: United States, 1997–2003

[Race for live births is tabulated according to race of mother. Excludes deaths of nonresidents of the United States. Rates per 100,000 live births in specified group. Deaths are classified according to the *International Classification of Diseases* in use at the time]

Year	All origins ¹	Hispanic	Non-Hispanic ²	Non-Hispanic white	Non-Hispanic black
Race of mother ³					
2003	12.1	10.1	12.7	8.1	31.2
2002	8.9	7.1	9.3	5.6	24.9
2001	9.9	9.5	10.1	6.5	24.7
2000	9.8	9.9	9.8	6.8	22.3
1999	9.9	8.8	10.2	6.4	25.5
1998	7.1	5.7	7.5	4.9	17.4
1997	8.4	8.0	8.8	5.2	21.5

¹All origins includes origin not stated.

²Includes races other than white and black.

³Maternal deaths based on race of decedent; live births based on race of mother.

Table 3. Maternal mortality rates by question type: United States, 1996–2003

[By state of residence. Rates are the sum of deaths for the time period divided by the sum of the live births for the time period times 100,000. The numbers shown in parentheses are the confidence intervals for the rates]

Year	United States	Areas with a separate question	Areas without a separate question
2003	12.1 (11.0,13.2)	13.0 (11.6,14.4)	10.8 (9.2,12.4)
2002	8.9 (8.0,9.8)	8.5 (7.1,9.8)	9.2 (8.0,10.5)
2001	9.9 (8.9,10.9)	10.3 (8.9,11.8)	9.5 (8.2,10.8)
2000	9.8 (8.8,10.7)	9.6 (8.2,11.1)	9.9 (8.6,11.2)
1999	9.9 (8.9,10.9)	10.7 (9.2,12.3)	9.2 (7.9,10.5)
1998	7.1 (6.3,8.0)	6.9 (5.6,8.1)	7.3 (6.2,8.5)
1997	8.4 (7.5,9.3)	8.9 (7.4,10.3)	8.1 (6.9,9.3)
1996	7.6 (6.7,8.4)	8.2 (6.8,9.6)	7.1 (6.0,8.2)

Appendix

Technical Notes

Sources of Data

The National Vital Statistics System (18,27) data shown in this report are based on information from death certificates filed in the 50 states and the District of Columbia. The number of states participating increased from 10 and the District of Columbia in 1900 to 47 and the District of Columbia in 1932. All states have provided these data since 1933.

These mortality statistics were compiled in accordance with World Health Organization (WHO) regulations, which specify that member nations classify and code causes of death in accordance with the current revision of the *International Classification of Diseases* (ICD). To date, 10 revisions have been used successively in the United States (Table I).

Maternal Mortality

Maternal deaths were defined as those encompassing cause-of-death codes (see Table II) associated with complications of pregnancy, childbirth, and the puerperium (7–12). These cause-of-death codes reflect information reported in the cause-of-death section of the death certificates. Explicit definitions for terms related to mortality around the time of pregnancy were introduced in the ICD-9 and expanded in the ICD-10.

Table I. Implementation dates for the *International Classification of Diseases* Revisions

Revision	Years covered
First	1900–09
Second	1910–20
Third	1921–29
Fourth	1930–38
Fifth	1939–48
Sixth	1949–57
Seventh	1958–67
Eighth	1968–78
Ninth	1979–98
Tenth	1999–present

Table II. Maternal death cause-of-death codes by the *International Classification of Diseases* (ICD) Revision

Revision	ICD Codes
First	151–159
Second	134–141
Third	143–150
Fourth	140–150
Fifth	140–150
Sixth	640–689
Seventh	640–689
Eighth	630–678
Ninth	630–676
Tenth	A34, O00–O95, and O98–O99

Separate Questions

In 2003, Idaho, Maryland, Montana, New York City, and New York state had separate questions that could provide the detail captured in the question in the 2003 version of the U.S. Standard Certificate (Table III). Alabama, California, Florida, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, North Dakota, Texas, and Virginia had separate questions; however, they were not consistent with the detail requested in the 2003 U.S. Standard Certificate question. Some states send forward data that differs from what their questions support. For example, California is submitting data for pregnant at the time of death as well as the 43 days to one year category to which deaths within a year are assigned.

Generally, the draft-revised state certificates that have been submitted to NCHS for review have included the standard question. This indicates that in the future, the questions used across states will be more consistent.

Random Variation

Mortality data are not subject to sampling error, but may be affected by random variation. That is, the number of deaths that actually occurred may be considered as one of a large series of possible results that could have arisen under the same circumstances (28,29). When the number of deaths is small (perhaps less than 100), random variation tends to be relatively large.

Therefore, considerable caution must be observed in interpreting statistics based on small numbers of deaths.

Using the properties of the Poisson distribution, the standard error (SE) associated with the number of deaths (D) is

$$1. SE(D) = \sqrt{\text{var}(D)} = \sqrt{D}$$

where $\text{var}(D)$ denotes the variance of D .

For maternal mortality rates based on live births (B) in the denominator, calculation of the SE assumes random variability in both the numerator and denominator. The SE for the maternal mortality rate (MMR) is

$$2. SE(MMR) = \sqrt{\frac{\text{var}(D) + MMR \cdot \text{var}(B)}{E(B)^2}} = \sqrt{\frac{D}{B^2} + \frac{D^2}{B^3}}$$

where the number of births, B , is also assumed to be distributed according to a Poisson distribution and $E(B)$ is the expectation of B .

The relative standard error (RSE) for the MMR is

$$3. RSE(MMR) = 100 \frac{SE(MMR)}{MMR} = 100 \sqrt{\frac{1}{D} + \frac{1}{B}}$$

Suppression of unreliable rates—An asterisk (*) is shown in place of a mortality rate based on fewer than 20 deaths, the equivalent of an RSE of 23 percent or more. The limit of 20 deaths is a convenient, if somewhat arbitrary, benchmark, below which rates are considered to be too statistically unreliable for presentation.

Confidence intervals and statistical tests based on 100 deaths or more—

When the number of deaths is large, a normal approximation may be used in the calculation of confidence intervals and statistical tests. In general, for maternal mortality rates, the normal approximation performs quite well when the number of deaths is 100 or greater. Formula 4 is used to calculate 95 percent confidence limits for the mortality rate when the normal approximation is appropriate.

$$4. Lower = MMR - 1.96(SE(MMR)) \text{ and } Upper = MMR + 1.96(SE(MMR))$$

Table III. Separate questions related to pregnancy on state certificates in 2003

Alabama	Was there a pregnancy in last 42 days? (Specify Yes, No, or Unknown)
California	If female, pregnant in last year? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Florida	If female, was there a pregnancy in the past 3 months? <input type="checkbox"/> Yes <input type="checkbox"/> No If female aged 10–54: <input type="checkbox"/> not pregnant within past year <input type="checkbox"/> pregnant at time of death <input type="checkbox"/> not pregnant, but pregnant within 42 days of death <input type="checkbox"/> not pregnant, but pregnant 43 days to 1 year before death <input type="checkbox"/> unknown if pregnant within the past year
Idaho	If female, was there a pregnancy in past three months? <input type="checkbox"/> Yes <input type="checkbox"/> No
Indiana	Was decedent pregnant or 90 days postpartum? (Yes or no)
Iowa	If female, was there a pregnancy in the past 12 months? (Specify yes or no)
Kentucky	If female, was there a pregnancy in the past 12 months? <input type="checkbox"/> Yes <input type="checkbox"/> No
Louisiana	If deceased was female 10–49, was she pregnant in the last 90 days? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If female: Was decedent pregnant in the past 12 months? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Maryland	<i>Separate fields on dates of death and delivery support capability to compute the other categories in the standard.</i> Was female pregnant: At death? <input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> unknown In last 12 months? <input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> unknown
Minnesota	Had decedent been pregnant within 90 days prior to death? <input type="checkbox"/> Yes <input type="checkbox"/> No
Mississippi	If deceased was female 10–49, was she pregnant in the last 90 days? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Missouri	If female: <input type="checkbox"/> not pregnant within past year <input type="checkbox"/> not pregnant but pregnant with 42 days of death <input type="checkbox"/> not pregnant but pregnant 43 days to 1 year before death <input type="checkbox"/> pregnant at time of death <input type="checkbox"/> unknown if pregnant within past year
Montana	If female, was there a pregnancy in the past 3 months? <input type="checkbox"/> Yes <input type="checkbox"/> No
Nebraska	If female, was she pregnant at death, or any time 90 days prior to death? <input type="checkbox"/> Yes <input type="checkbox"/> No
New Jersey	Was decedent pregnant within last 6 weeks? <input type="checkbox"/> Yes <input type="checkbox"/> No
New Mexico	If female: <input type="checkbox"/> not pregnant within 1 year of death <input type="checkbox"/> pregnant at time of death <input type="checkbox"/> not pregnant at death, but pregnant within 42 days of death <input type="checkbox"/> not pregnant at death, but pregnant 43 days to 1 year before death <input type="checkbox"/> unknown if pregnant within 1 year of death
New York City	<i>Also have date of outcome, so could compute intervals if needed.</i> If female: <input type="checkbox"/> not pregnant within last year <input type="checkbox"/> pregnant at time of death <input type="checkbox"/> not pregnant, but pregnant within 42 days of death <input type="checkbox"/> not pregnant, but pregnant 43 days to 1 year before death <input type="checkbox"/> unknown if pregnant within past year
New York State	<i>Also have date of delivery, so could compute intervals if needed.</i>
North Dakota	Was deceased pregnant within 18 months of death? <input type="checkbox"/> Yes <input type="checkbox"/> No
Texas	Was decedent pregnant at time of death <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown within last 12 months <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Virginia	If female, was there a pregnancy in past 3 months? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown

The resulting 95 percent confidence interval can be interpreted to mean that the chances are 95 out of 100 that the “true” mortality rate falls between the lower and upper limits. For example, suppose that the mortality rate is 3.9 per 100,000 live births based on 112 deaths and 28,560 births. Lower and upper 95 percent confidence limits using formula 4 are calculated as

$$\text{Lower} = 3.9 - 1.96(.37) = 3.2 \text{ and}$$

$$\text{Upper} = 3.9 + 1.96(.37) = 4.6$$

Thus, the chances are 95 in 100 that the true mortality rate is between 3.2 and 4.6.

When testing the difference between two rates, MMR_1 and MMR_2 (each based on 100 or more deaths), the normal approximation may be used to calculate a test statistic, z , such that

$$5. \quad z = \frac{MMR_1 - MMR_2}{\sqrt{SE(MMR_1)^2 + SE(MMR_2)^2}}$$

If $|z| \geq 1.96$ then the difference between the rates is statistically significant at the 0.05 level. If $|z| < 1.96$ then the difference is not statistically significant. Suppose that the mortality rate is 9.9 per 100,000 live births in 2002 (MMR_1) and 8.9 per 100,000 live births in 2003 (MMR_2). The SE for each of these figures, $SE(MMR_1)$ and $SE(MMR_2)$, is calculated using formula 2. Using formula 5, one can test if the decrease in the rate is statistically significant.

$$z = \frac{9.9 - 8.9}{\sqrt{(0.246)^2 + (0.222)^2}} = 1.46$$

Because $z = 1.46 < 1.96$, the increase from 2002 to 2003 in the mortality rate is not statistically significant.

Confidence intervals and statistical tests based on fewer than 100 deaths—When the number of deaths is not large

(fewer than 100), the Poisson distribution cannot be approximated by the normal distribution. A method based on the more general family of gamma distributions, of which the Poisson is a member, can be used to approximate confidence intervals for deaths and mortality rates when the number of deaths is small (30).

The 95 percent confidence limits can be estimated using the lower and upper confidence limit factors shown in the “Technical Notes” of “Deaths: Final Data for 2003” (30) or obtained using the function “gammainv(probability, alpha,beta)” in Excel. For the mortality rate, MMR , the lower and upper confidence limit factors that correspond to the adjusted number of maternal

$$6. \quad \text{Lower} = L(1 - \alpha, D_{adj}) \cdot MMR \text{ and}$$

$$\text{Upper} = U(1 - \alpha, D_{adj}) \cdot MMR$$

deaths, D_{adj} , are calculated using formula 6. The adjusted number of

maternal deaths take into account the RSE of the number of maternal deaths and live births.

$$D_{\text{adj}} = \frac{D \cdot B}{D + B}$$

For example, suppose that the mortality rate for American Indian or Alaska Native (AIAN) persons is 5.9 per 100,000 and based on 58 deaths and 9,801 births.

$$D_{\text{adj}} = \frac{58 \cdot 9,801}{58 + 9,801} = 58$$

Applying formula 7, values for L and U for 58 deaths are multiplied by the mortality rate, 5.9, such that

$$\begin{aligned} \text{Lower} &= 0.75934 \cdot 5.9 = 4.5 \quad \text{and} \\ \text{Upper} &= 1.29273 \cdot 5.9 = 7.6 \end{aligned}$$

These confidence limits indicate that the chances are 95 out of 100 that the actual mortality rate for AIAN persons is between 4.5 and 7.6 per 100,000.

When comparing the difference between two rates, MMR_1 and MMR_2 where one or both of the rates are based on fewer than 100 deaths, a comparison of 95 percent confidence intervals may be used as a statistical test. If the 95 percent confidence intervals do not overlap, then the difference can be said to be statistically significant at the 0.05 level. A simple rule of thumb is: if MMR_1 is greater than MMR_2 then test if $L(MMR_1)$ is greater than $U(MMR_2)$ or if MMR_2 is greater than MMR_1 then test if $L(MMR_2)$ is greater than $U(MMR_1)$. Positive tests denote statistical significance at the 0.05 level.

Users of the method of comparing confidence intervals should be aware that this method is a conservative test for statistical significance. That is, the difference between two rates may, in fact, be statistically significant even though confidence intervals for the two rates overlap (31). Thus, caution should be observed when interpreting a nonsignificant difference between two rates, especially when the lower and upper limits being compared overlap only slightly.

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For answers to questions about this report or for a list of reports published in these series, contact:

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