
Isabelle L. Horon, DrPH
Diana Cheng, MD

COMPLETE AND ACCURATE IDENTIFICATION OF ALL DEATHS ASSOCIATED WITH PREGNANCY IS A CRITICAL FIRST STEP IN THE PREVENTION OF SUCH DEATHS. ONLY BY HAVING A CLEAR UNDERSTANDING OF THE MAGNITUDE OF PREGNANCY-ASSOCIATED MORTALITY CAN COMPREHENSIVE PREVENTION STRATEGIES BE FORMULATED TO PREVENT THESE UNANTICIPATED DEATHS AMONG PRIMARILY YOUNG, HEALTHY WOMEN.

Death statistics compiled through the National Vital Statistics System by the National Center for Health Statistics, Centers for Disease Control and Prevention, are a major source of data on deaths occurring during pregnancy and in the postpartum period. Original death certificates from which state and national vital statistics are derived are filed in and maintained by individual states. Causes of death on death certificates are reported by attending physicians or, under certain circumstances such as death from external trauma or unexplained death, by medical examiners or coroners.

The National Center for Health Statistics is required to use the World Health Organization (WHO) definition of a maternal death for preparation and presentation of mortality data. According to the WHO definition, a maternal death is “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.” This definition includes deaths assigned to the cause “complication of pregnancy, childbirth, and the puerperium” (International Classification of Diseases, Ninth Revision [ICD-9] codes 630-676).

Death records are an important source of data on pregnancy mortality because they are routinely collected by the states and are comparable over time and across the nation. However, there are several limitations to using these data to identify all deaths associated with pregnancy. First, the cause-of-death information provided on these records is sometimes not accurate. Previous studies have shown that physicians completing death records following a maternal death fail to report that the woman was pregnant or had a recent pregnancy in 50% or more of these cases, resulting in the misclassification of the underlying cause of death. Since these deaths cannot be identified as maternal deaths through routine surveillance methods, enhanced surveillance techniques are required to use the World Health Organization definition provided on these records.

Context Deaths occurring among women who are pregnant or who have had a recent pregnancy have a devastating impact on the family and community. It is important to understand the magnitude and causes of pregnancy-associated mortality so that comprehensive strategies can be formulated to prevent such deaths.

Objective To ascertain the number and causes of pregnancy-associated deaths using enhanced surveillance techniques.


Main Outcome Measure Number of pregnancy-associated deaths, defined as death from any cause during pregnancy or within 1 year of delivery or pregnancy termination, by source of data and cause of death.

Results A total of 247 pregnancy-associated deaths were ascertained. Twenty-seven percent (n=67) were identified through cause-of-death information obtained from death certificates, 70% (n=174) through linkage of death records with birth and fetal death records, and 47% (n=116) through review of medical examiner records. Homicide was the leading cause of pregnancy-associated death (n=50; 20%), and cardiovascular disorders were the second-leading cause (n=48; 19%).

Conclusions In this Maryland sample, comprehensive identification of pregnancy-associated deaths was accomplished only after collecting information from multiple sources and including all deaths occurring up to 1 year after delivery or pregnancy termination. This enhanced pregnancy mortality surveillance led to the disturbing finding that a pregnant or recently pregnant woman is more likely to be a victim of homicide than to die of any other cause. By broadening pregnancy mortality to include all possible causes, previously neglected factors may assume increased importance in prenatal and postpartum care.

JAMA. 2001;285:1455-1459

©2001 American Medical Association. All rights reserved.

(Reprinted) JAMA, March 21, 2001—Vol 285, No. 11 1455
methods, they are not included in the calculation of maternal mortality rates.

An additional limitation of using death records alone for comprehensive identification of all deaths associated with pregnancy is that the WHO definition of a maternal death limits the temporal and causal scope of pregnancy mortality. As defined by WHO, a maternal death does not include deaths occurring more than 42 days following termination of pregnancy or deaths resulting from causes other than direct complications of pregnancy, labor, and the puerperium.

To address these issues, the term "pregnancy-associated death" was introduced by the Centers for Disease Control and Prevention, in collaboration with the Maternal Mortality Special Interest Group of the American College of Obstetricians and Gynecologists, to define a death from any cause during pregnancy or within 1 calendar year of delivery or pregnancy termination, regardless of the duration or anatomical site of the pregnancy. Pregnancy-associated deaths include not only deaths commonly associated with pregnancy such as hemorrhage, pregnancy-induced hypertension, and embolism—which are captured in the WHO definition—but also deaths not traditionally considered to be related to pregnancy such as accidents, homicide, and suicide. The term also includes deaths occurring 43 to 365 days following termination of pregnancy. Since cause-of-death information on death certificates cannot identify deaths from nonmaternal causes or deaths occurring 43 or more days following termination of pregnancy as associated with pregnancy, additional sources of data must be used for complete ascertainment of all pregnancy-associated deaths.

Previous studies on pregnancy-associated deaths have relied largely on linkage of records or the use of a check box on the death certificate to identify pregnancy-associated deaths. Only 1 study (Allen et al10) in New York City used death certificates, linkage of records, and review of autopsy reports to identify pregnancy-associated deaths. However, this study did not include all pregnancy-associated deaths since only records for deaths occurring within 6 months of termination of pregnancy were collected, and medical examiner records for only certain causes of death were reviewed.

This article, based on Maryland resident data for the years 1993-1998, presents more comprehensive data on pregnancy-associated deaths since it includes all deaths occurring during pregnancy or within a year of termination of pregnancy. In addition, medical examiner records for all women of reproductive age who died during the study period, regardless of cause of death, were reviewed to identify pregnancy-associated deaths.

METHODS

Data for this analysis were collected from the following 3 sources: (1) review of death certificates to identify those records on which a complication of pregnancy, childbirth, or the puerperium (ICD-9 codes 630-676) was listed as an underlying or contributing cause of death; (2) linkage of death certificates of reproductive-age women with corresponding live birth and fetal death records to identify a pregnancy within the year preceding death; and (3) review of medical examiner records for evidence of pregnancy.

Vital records data were obtained from the Vital Statistics Administration of the Maryland Department of Health and Mental Hygiene. Identification of pregnancy-associated deaths through linkage of vital records was accomplished by matching death certificates for all women of reproductive age against live birth and fetal death records. Successful linkage of records was achieved by matching either mother’s Social Security number or mother’s name and date of birth on the death record with corresponding information on live birth and fetal death records. All linked records were manually reviewed to ensure accurate matching of records.

Medical examiner records, which include autopsy reports and police records, were reviewed for all 4195 women aged 10 to 50 years whose deaths were investigated by the medical examiner during the study period. Maryland law mandates that the medical examiner investigate all deaths that occur by violence, suicide, casualty, unexpectedly, or in any suspicious or unusual manner. Death certificates were obtained for 116 women for whom medical examiner records indicated evidence of pregnancy.

With the exception of 1 death to a 14-year-old adolescent, all deaths identified through medical examiner records occurred among women who were within the traditional reproductive age group of 15 to 44 years. All deaths identified through death certificates and record linkage were among women between the ages of 15 and 44 years.

All death records that did not identify a maternal cause as the underlying cause of death (n=184) were reviewed by trained nosologists to determine the underlying cause of death that would have been assigned if a history of pregnancy had been reported on the death certificate. Nosologists were provided with information on pregnancy outcome and, if available, the date of delivery, date of pregnancy termination, or gestational age. Revised underlying cause-of-death information was used to categorize data by cause of death.

RESULTS

A total of 247 pregnancy-associated deaths occurring between 1993 and 1998 were identified from the 3 data sources. Sixty-seven pregnancy-associated deaths (27.1%) were identified through cause-of-death information obtained from death certificates. Sixty-two of these records listed pregnancy complications as the underlying cause of death; the remaining 5 certificates listed pregnancy complications as a contributing, but not underlying, cause of death. Linkage of records identified 174 (70.4%) of all pregnancy-associated deaths and review of medical examiner records resulted in the identification of 116 (47.0%) deaths (TABLE 1).

Sixty-five percent (n = 160) of pregnancy-associated deaths were identi-
fied through a single surveillance method. One hundred two (41.3%) were identified only through linkage of records, 45 (18.2%) only through review of medical examiner records, and 13 (5.3%) only through cause-of-death information provided on death certificates. Thirty-five percent of pregnancy-associated deaths were identified through more than 1 data source (n=87).

One hundred eighty-two (73.7%) of the 247 pregnancy-associated deaths identified in this study followed a live birth, 5 (2.0%) followed a fetal death, 1 followed a therapeutic abortion, and 53 (21.4%) occurred among women who were pregnant at the time of death. Of the 53 deaths that occurred among pregnant women, 7 were the result of ruptured ectopic pregnancies and 1 resulted from a molar pregnancy (Table 1). Eighty-four (34.0%) deaths occurred within 42 days of delivery or termination of pregnancy, and 103 (41.7%) deaths occurred 43 to 365 days following delivery or termination of pregnancy. The time of death was unknown for 7 women (Table 2).

The leading cause of pregnancy-associated death was homicide (n=50). All homicides were identified through record linkage or review of medical examiner records rather than from death certificates, as would be expected since homicide is not a maternal cause of death. Deaths from cardiovascular disorders, the second leading cause of death (n=48), were identified through all 3 data sources, although no single source was able to identify all deaths. Of the 26 deaths from cardiovascular disorders that occurred during pregnancy or within 42 days of delivery and should therefore have been classified as maternal deaths, only 8 were identified through death certificates. A substantial proportion of deaths from other maternal causes, including embolism and infection, could not be identified from death certificates since the physicians filling out the certificates failed to report that the women were pregnant or had recent pregnancies (Table 2).

All maternal deaths, by definition, occurred during pregnancy or within 42 days of delivery or termination of pregnancy. This included most deaths from embolism, hemorrhage, and hypertensive disorders of pregnancy as well as a substantial proportion of deaths resulting from cardiovascular disorders and infection. Homicide was responsible for the majority of deaths during pregnancy (24 [43.4%]) and during the 43- to 365-day period following delivery or termination of pregnancy (24 [23.3%]), but accounted for only a small proportion of deaths occurring within 42 days of pregnancy (3 [3.6%]), when obstetric causes were responsible for most pregnancy-associated deaths. Cardiovascular disorders (n=21) were the leading cause of death in the 42-day period following delivery or termination of pregnancy and the second leading cause of death (n=18), following homicide, in the late postpartum period (Table 2).

Homicide, the leading cause of pregnancy-associated death, was responsible for 20.2% of all pregnancy-associated deaths. By comparison, homicide was the fifth leading cause of death among Maryland women aged 14 to 44 years who had not had a pregnancy in the year preceding death and was responsible for 457 (6.4%) of total deaths among this group (z=7.737, P<.001). The pregnant group was younger and included a higher percentage of African American women than the nonpregnant group, factors that are associated with higher rates of homicide independent of pregnancy. However, these factors did not explain the higher proportion of homicide deaths in the pregnant group. While adjustment for race and maternal age increased the proportion of deaths due to homicide to 11.2% among women who had not been pregnant in the year preceding death, the adjusted figure was still significantly lower than the figure of 20.2% among women who had been pregnant (z=4.349, P<.001).

COMMENT

The use of multiple data sources substantially enhances pregnancy mortality surveillance because no single source can identify all pregnancy-associated deaths. Death certificates are designed to collect only a small subset of pregnancy-associated deaths. Even these deaths are frequently not included in maternal mortality statistics because physicians completing death certificates fail to provide the information needed to correctly classify a maternal death. Analysis of data in this report indicated that 30 (34.5%) of the 87 deaths meeting the WHO definition of a maternal death could not be identified through cause-of-death information reported by physicians on the death certificate. Data linkage is an additional tool for identifying pregnancy-associated deaths, but it is limited to those deaths with a reported outcome, such as a live birth or fetal death. Medical examiner records are the most use-

©2001 American Medical Association. All rights reserved.
ful source for identifying pregnancy-associated deaths among women who have not delivered at the time of death.

Data linkage and review of medical examiner records contribute substantially to identification of pregnancy-associated mortality. In Maryland, this led to the disturbing finding that a pregnant or recently pregnant woman is more likely to be a victim of homicide than to die of any other cause. Other reports have identified homicide as a cause of pregnancy-associated death. However, none of these studies reported on pregnancy-associated deaths from other causes as well, and therefore could not provide a ranking of deaths by cause.

Although we have shown that homicide is responsible for a greater proportion of deaths among pregnant and postpartum women than among women who have not been pregnant in the year preceding death, our findings do not address the issue of whether the homicide rate is higher among pregnant and postpartum women in general than among women who have not had recent pregnancies. This highlights a well-recognized limitation of proportional mortality statistics, ie, that these statistics include only individuals who die, not those at risk of dying. Therefore, no direct inferences regarding increased homicide rates for all pregnant women can be made using only proportional mortality statistics.

The question of whether the homicide rate is higher among pregnant and postpartum women than among women who have not had recent pregnancies could be answered by comparing mortality rates in the 2 groups. However, a methodology for computing pregnancy-associated mortality rates and mortality rates for nonpregnant women has not yet been established because of complexities in determining the number of pregnant women in a population. Since a woman may experience more than 1 pregnancy and more than 1 pregnancy outcome (live birth, fetal loss, or induced abortion) in a given time period, the number of pregnant women cannot be computed by summing the number of pregnancy outcomes. Even if the number of pregnant women could be estimated, an additional issue that would have to be addressed is how to adjust mortality rates to account for differences in the time period of risk of death in the 2 populations. It is important that increased efforts be placed on development of appropriate methodologies for calculating pregnancy-associated mortality rates so that the questions raised by this article may be addressed.

The findings of this article also suggest that maternal mortality review committees should investigate homicides occurring during pregnancy and in the postpartum period to determine potential relationships between these events. For example, a homicide resulting from domestic violence may be related to the stress of pregnancy. Similarly, a suicide soon after delivery may result from postpartum depression. By broadening pregnancy mortality to include all possible causes, factors previously neglected may assume increased importance in prenatal and postpartum care.

Despite the use of enhanced surveillance techniques, it is likely that some pregnancy-associated deaths remain undetected, particularly those occurring in

---

Table 2. Number of Pregnancy-Associated Deaths by Cause of Death, Source of Data, and Time of Death, Maryland, 1993-1998*

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>All Sources</th>
<th>Death Certificates</th>
<th>Record Linkage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total†</td>
<td>During Pregnancy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤42 d</td>
<td>43-365 d</td>
<td></td>
</tr>
<tr>
<td>All causes</td>
<td>247</td>
<td>53</td>
<td>84</td>
</tr>
<tr>
<td>Homicide</td>
<td>50</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Cardiovascular disorders</td>
<td>48</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Embolism</td>
<td>21</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Accidents‡</td>
<td>18</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>17</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Hypertensive disorders of pregnancy</td>
<td>16</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Infection</td>
<td>16</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Substance abuse</td>
<td>13</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Suicide</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>All other causes</td>
<td>26</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

*Deaths from any cause during pregnancy or within 1 calendar year of delivery or termination of pregnancy, regardless of the duration or anatomical site of the pregnancy.
†Includes deaths from motor vehicle collisions, falls, drowning, and other unintentional injuries.
‡Deaths from any cause during pregnancy or within 1 calendar year of delivery or termination of pregnancy, regardless of the duration or anatomical site of the pregnancy.
A single death may have been ascertained from more than 1 source, therefore columns do not sum to the total number of deaths ascertained from all sources.
†Includes deaths from motor vehicle collisions, falls, drowning, and other unintentional injuries.
women who were pregnant at the time of death. Since autopsies are performed on all homicide victims, it is more likely that pregnancy would be detected among these women than among women dying from other causes, who are less likely to be autopsied. Since Maryland law mandates that the medical examiner investigate deaths among individuals who were in apparent good health at the time of death, which describes most pregnant women, the majority of deaths among these women should have been investigated by the medical examiner. Autopsies were in fact performed more frequently among women with recognized pregnancy-associated deaths who died from causes other than homicide (123 [62.4%]) than among women of reproductive age without recognized pregnancies (6969 [30.6%]). However, it is still possible that some pregnancies remain undetected, which could have an impact on the total number of pregnancy-associated deaths as well as on the distribution of deaths by pregnancy outcome, time of death, or cause of death.

Efforts are being made in Maryland to improve the identification of pregnancy-associated deaths. Recent legislation mandates that health care professionals and facilities report all pregnancy-associated deaths to the Maryland Maternal Mortality Review Program. In addition, the Maryland death certificate was revised in 2001 to include questions about current or recent pregnancies. Currently, only 17 states and New York City have a pregnancy check box or ask about pregnancy status on their death certificates. Use of a pregnancy question by all states on the revised US Standard Certificate of Death has been recommended to the National Center for Health Statistics by the Panel to Evaluate the US Standard Certificates and Reports. Such a change, which would be consistent with a recommendation of the World Health Assembly in the International Classification of Diseases, 10th Revision (ICD-10), would substantially improve ascertainment of pregnancy on death certificates. If approved by the US Department of Health and Human Services, states could adopt the pregnancy question in the 2003 revision of their death certificates. This change should help to identify deaths that remain difficult to detect, such as deaths that cannot be identified through linkage of records and deaths among women who had not delivered that are not reported to the medical examiner. However, it would be a service, as well as good medical practice, if physicians made a greater effort to report pregnancy as a factor contributing to death when appropriate.

Comprehensive identification of pregnancy-associated deaths can only be accomplished by collecting information from multiple data sources and including all deaths occurring up to 1 year after pregnancy termination. Through such enhanced surveillance, the Maryland Department of Health and Mental Hygiene has shown that the number of pregnancy-associated deaths is substantially higher and causes of death substantially broader than previously believed. Enhanced surveillance of pregnancy-associated deaths is necessary to accurately document the magnitude of pregnancy mortality, identify groups at increased risk of death, review factors leading to the death, and plan prevention strategies. It is therefore a critical step in the reduction of pregnancy-associated mortality.

**Author Contributions:** Study concept and design: Horon, Cheng. Acquisition of data: Horon, Cheng. Analysis and interpretation of data: Horon, Cheng. Drafting of the manuscript: Horon, Cheng. Critical review of the manuscript for important intellectual content: Horon, Cheng. Statistical expertise: Horon.

**Administrative, technical, or material support:** Horon, Cheng.

**Acknowledgment:** The authors gratefully acknowledge Robert L. Hayman, PhD, of the Maryland Vital Statistics Administration, for his assistance with data linkage; John E. Smialek, MD, Chief Medical Examiner for the state of Maryland, for graciously providing access to medical examiner records; and members of the Maryland Maternal Mortality Review Program for their commitment to improving maternal health.

**REFERENCES**