A Review of Pregnancy-Related Maternal Mortality in Wisconsin, 2006-2010

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ABSTRACT

Introduction: Maternal mortality is a key indicator of maternal health and the general state of health care. This report summarizes maternal deaths in Wisconsin from January 2006 through December 2010.

Methods: Maternal deaths were identified using death certificates and supporting links with infant birth and fetal death certificates. Suspected pregnancy-related maternal deaths were abstracted by a Wisconsin Maternal Mortality Review Team nurse abstractor. The entire team reviewed and analyzed these cases. If the death was deemed pregnancy related, a cause of death was determined, potential factors of avoidability were assessed, and recommendations for possible quality improvement were made.

Results: Fifty cases were reviewed and 21 cases were determined to be pregnancy related. The Wisconsin pregnancy-related maternal mortality ratio was 5.9 deaths per 100,000 live births (3.9-9.0, 95% CI), with markedly higher rates for non-Hispanic black women. The most common cause of death was cardiovascular related, with 5 of the 7 deaths being ascribed to peripartum cardiomyopathy. Chronic medical problems were associated with 55% of pregnancy-related maternal deaths excluding obesity. Nineteen percent of the pregnancy-related deaths reviewed were considered to be avoidable, and almost half (48%) had substantive recommendations made to improve maternal health.

Conclusion: Even though the Wisconsin pregnancy-related maternal mortality ratio is well below the national average, there remain stark racial disparities in maternal deaths and a number of avoidable pregnancy-related deaths that should be targeted for prevention.

INTRODUCTION

Maternal mortality is an indicator of the state of maternal health, and the general state of health care in every country where it is studied.[1] Every maternal death represents not just the loss of a woman's life, but the impact of that loss on her family and community. Although there have been dramatic improvements in maternal mortality over the past century, the most current statistics reported by the Centers for Disease Control and Prevention (CDC) highlight a recent increase in the pregnancy-related maternal mortality ratio to 16.0 deaths per 100,000 live births for 2006-2010.[2] This remains well above the Healthy People 2020 target of 11.4 maternal deaths per 100,000 live births.[3]

In Wisconsin, maternal mortality ratios historically have been well below the national average, and the number of maternal deaths remains relatively small.[4,5] This does not diminish the impact that these deaths have on the affected families and communities in Wisconsin, and each event should be examined to identify opportunities to prevent future maternal deaths. The Wisconsin Maternal Mortality Review Team (MMRT) reviews detailed information of deaths occurring in Wisconsin women while pregnant or within 1 year of pregnancy. The purpose of these reviews is to determine avoidability and make recommendations for changes in health care systems and practices aimed at the prevention of future maternal deaths. This paper reports on maternal deaths occurring from January 2006 through December 2010 and the MMRT findings for these cases.

METHODS

Pregnancy-associated deaths are deaths occurring to women who were pregnant at the time of death or within 1 year of pregnancy, irrespective of cause.[6] These deaths are identified by the pregnancy checkbox on the death certificate. The checkbox identifies whether the decedent was pregnant at the time of death, within 42 days of death, within 43 days to 1 year of death, or not pregnant in the year before death. Linkage analyses also are performed between deaths to women of child-bearing age and

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infant birth and fetal death certificates. This is done to assist in complete case ascertainment and to identify additional pregnancy-associated deaths where the pregnancy checkbox may not have been marked appropriately. All medical records pertinent to the maternal death (eg, hospital, prenatal, specialist) and any autopsy reports are requested and reviewed by a nurse abstractor to verify the need for a formal review by the MMRT. Mental health records generally are not available for review in Wisconsin. This is due to difficulty identifying the mental health provider in other available medical records and to the protected status of these records under Wisconsin law. All data collection is done by the Wisconsin Department of Health Services as public health investigation activities allowed for under Wisconsin state statute to determine potential causes of morbidity and mortality. As this effort was undertaken as part of standard public health practice, Institutional Review Board approval was not required.

Only suspected pregnancy-related deaths are reviewed by the MMRT. Pregnancy-related deaths are defined by the CDC and the American Congress of Obstetricians and Gynecologists (ACOG) as "the death of a woman while pregnant or within one year of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by her pregnancy or its management, but not from accidental or incidental causes."[6] Deaths that are not suspected to be pregnancy related include homicides, cancer deaths, automobile crashes, and other unintentional deaths as well as those deaths in which a recent pregnancy could not be corroborated. A comprehensive chart abstraction is performed on all suspected pregnancy-related deaths by the nurse abstractor, and summaries are prepared for formal review by the MMRT. Strict confidentiality is maintained throughout the process, and all information related to each case is deidentified prior to team review.

The MMRT includes a multidisciplinary group of physicians, allied health care professionals, and public health specialists, all with expertise in maternal and child health. The team meets to conduct the reviews at least yearly depending on the number of cases requiring review. Due to the length of time required to identify cases and request, obtain, and abstract large volumes of medical records, the MMRT frequently reviews cases approximately 1 to 2 years after the event. Each member of the MMRT receives deidentified case summaries approximately 1 week before each scheduled meeting. At the meeting the chair provides a brief overview of each case, followed by a group discussion to summarize risk factors, examine findings from the medical records and autopsy, and assess group agreement with the cause of death as noted on the death certificate. The team then determines (1) whether each case was pregnancy related (direct obstetric or indirect obstetric), possibly pregnancy related, or not pregnancy related; and (2) if pregnancy related, whether the death could have been avoided. Decisions are made by simple majority vote if consensus cannot be reached. Cases may be tabled until the next meeting if the team requests that additional information be gathered. Finally, the team identifies possible opportunities and strategies for preventing similar deaths in the future.

Data from the chart abstraction and the review team summary sheets is aggregated and analyzed using SAS 9.2 software (SAS Institute, Cary, North Carolina). Confidence intervals and modified Wald test *P*-values are calculated using the OpenEpi web-based calculator (www.openepi.com). Pregnancy-related mortality ratios are calculated using the number of maternal deaths in a given category as obtained from the maternal mortality database, divided by the number of live births in the same category as provided by the Wisconsin Interactive Statistics on Health (WISH) system. Support for the abstraction and data analysis is provided by the Health Resources and Services Administration (HRSA) Title V Maternal and Child Health Services block grant.

RESULTS

A total of 126 maternal deaths occurring to Wisconsin residents from January 2006 through December 2010 were identified. Fifty of these deaths were abstracted and reviewed as possible pregnancy-related deaths. Of the 50 deaths reviewed, 21 (42%) were determined to be pregnancy related, 4 (8%) to be possibly pregnancy related, and 25 (50%) to not be pregnancy related. The pregnancy-related maternal mortality ratio (PRMR) for 2006-2010 was 5.9 deaths/100,000 live births (3.9-9.0, 95% CI). The PRMR was broken down by demographic groups as noted on the death certificate (Table 1). The statistically significant differences illustrated in Table 1 were the non-Hispanic white/non-Hispanic black racial disparity (4.5 vs 22.5 deaths/100,000 live births), the differences between married and unmarried women (2.2 vs 12.4 deaths/100,000 live births), and the higher ratio of maternal death in women who smoke (17.7 vs 3.9 deaths/100,000 live births). Age was another possible indicator of the risk of maternal mortality, with the youngest (<20) and oldest (35+) mothers exhibiting a higher PRMR than women 20 to 34; however, these differences were not statistically significant. The majority of pregnancy-related maternal deaths occurred in the postpartum period (71.4%) with 57.1% of these deaths being in the first 42 days (Table 2).

Pre-pregnancy chronic medical conditions—such as hypertension, diabetes, or depression—were documented in 55% of pregnancy-related deaths. When obesity was included as a chronic medical condition, the percentage increased to 80% of all pregnancy-related maternal deaths examined. Among all pregnancy-related maternal deaths, 12% were overweight and 65% were obese (total 76.5%) as defined by standard body mass index (BMI) measures (Table 3).

The most common cause of pregnancy-related death was cardiovascular disease, specifically cardiomyopathy, followed

Table 1. Pregnancy-Related Mortality Ratios (PRMR) by Selected Demographic Characteristics, Wisconsin, 2006-2010

	Number of Deaths	Number of Live Births	PRMR	
			PRMR	95% CI
Age				
15-19	4	29,518	13.6	3.9-36.2
20-24	4	81,870	4.9	1.4-13.1
25-29	4	111,108	3.6	1.0-9.6
30-34	3	87,087	3.4	0.7-10.6
35-39	5	38,359	13.0	4.6-31.5
40+	1	8,217	12.2	0.0-76.3
Education				
<12 years	5	51,706	9.7	3.4-23.4
12 years	10	99,116	10.1	5.2-18.9
>12 years	6	203,141	3.0	1.2-6.6
Marital Status				
Married	5	226,889	2.2	0.8-5.3
Unmarried[a]	16	129,217	12.4	7.4-20.3
Race/Ethnicity				
White non-Hispanic	12	265,955	4.5	2.5-8.0
Black non-Hispanic[a]	8	35,612	22.5	10.5-45.2
Hispanic	1	34,283	2.9	0.5-16.5
American Indian	0	5,749	0.0	0.0-66.8
Hmong	0	6,531	0.0	0.0-70.9
Other	0	7,907	0.0	0.0-58.6
Smoking status				
Smoker[a]	9	50,725	17.7	8.8-34.3
Nonsmoker	12	304,181	3.9	2.2-7.0
Total[b]	**21**	**356,252**	**5.9**	**3.9-9.0**

[a]Demographic characteristics associated with a higher PRMR ($P < 0.05$).
[b]Totals for demographic characteristics may not add up to total live births because of missing values for certain characteristics.

Table 2. Timing of Death Among Pregnancy-Related Death, Wisconsin, 2006-2010

Timing of death	Frequency	Percent
Antepartum	5	23.8
1st trimester	2	9.5
2nd trimester	0	0.0
3rd trimester	3	14.3
Labor and delivery	1	4.8
Postpartum	15	71.4
<42 days	12	57.1
≥42 days	3	14.3
Total	**21**	**100**

by sepsis, thromboembolic disease, and hemorrhage (Table 4). The most common causes of death for the pregnancy-associated maternal deaths (cases not brought to the committee for review or not deemed by the committee as pregnancy related) were motor vehicle crashes, cancer, and homicide.

Nineteen percent of the pregnancy-related deaths were judged to be avoidable. Substantive recommendations were made in almost half (48%) of the pregnancy-related deaths regarding possible opportunities for quality improvement. These recommendations varied from specific items about a particular case to more general recommendations about improvement in the quality of obstetric care in Wisconsin. Most often recommendations were made for educational efforts in a specific area of obstetric care, but more global recommendations were made regarding management of chronic medical conditions before, during, and after pregnancy. Also, recommendations were made to address promoting research in the area of peripartum cardiomyopathy, as well as continued efforts in the area of patient safety.

Table 3. Body Mass Index in Pregnancy-Related Deaths, Wisconsin, 2006-2010

Body Mass Index	Frequency	Percent
Underweight (<18.5)	0	0.0
Normal (18.5-24.9)	4	23.5
Overweight (25.0-29.9)	2	11.8
Obese (30.0-39.9)	11	64.7
Total	**17**	**100**
Missing	4	-

Table 4. Causes of Death Among Pregnancy-Related Deaths, Wisconsin, 2006-2010

Cause of Death	Frequency
Cardiac	7
Cardiomyopathy	5
Other cardiac	2
Sepsis	4
Thromboembolic disease	4
Amniotic fluid embolism	1
Other thromboembolic	3
Hemorrhage	3
Abnormal placentation	2
Ectopic pregnancy	1
Anesthesia	1
Hypertension/Preeclampsia/Eclampsia	1
Suicide (postpartum depression)	1
Total	**21**

DISCUSSION

As shown in Table 1, the pregnancy-related mortality ratio for 2006-2010 is 5.9 per 100,000 live births. This is a slight decrease, though not statistically significant, from the combined statistics in the last report from 1998-2005 of 9.4 deaths/100,000 live births (7.1-12.3, 95% CI).[5] This is substantially lower than the reported United States rate for the same time period.[2] It is unclear whether this difference indicates that the actual number of pregnancy-related mortality is lower in Wisconsin. The difference might instead be an artifact due to differences in case ascertainment, methods for identification of cases for review, or the distribution of demographic characteristics and risk factors in the population. However, the group-specific pregnancy-related mortality ratios appear to be lower in Wisconsin across all demo-

graphic groups. Confidence intervals do overlap due to the small number of events over the time period of review.

Several demographic disparities associated with pregnancy-related deaths are again noted in this report as they were in the 2 previous reports, most notably a greater than 4-fold difference in the PRMR between non-Hispanic black and non-Hispanic white mothers. This association is likely complex and related to a number of other social, economic, and medical factors. One key concept focused on addressing these disparities is the "life-course" perspective introduced in 2002.[7] This approach suggests that health outcomes across the life span are influenced by a complex interplay of biological, behavioral, psychological, and social protective factors as well as risk factors.[8,9] Many state and local public health initiatives in Wisconsin and throughout the country now include this concept in all of their programming efforts and aim to understand and address the many risk and protective factors that play a role in outcomes even before a woman becomes pregnant.[10]

Chronic medical conditions appear to play an important part in a number of maternal deaths. A significantly higher proportion of the pregnancy-related deaths reported in Wisconsin occured in obese women (65%) compared to all births in Wisconsin (28%; 2011-2013).[11] Recent data published by the California Maternal Mortality Review Team found that this association remained only for certain causes of death.[12] In Wisconsin, in many cases, chart reviews fail to provide enough details about the course of the medical condition to allow for a complete understanding of the role that chronic conditions may have played in contributing to the death. The MMRT discussion frequently includes concern that many of the women who died as a result of being pregnant enter pregnancy with medical conditions not optimally treated, end pregnancy without coordinated and consistent postpartum care for these conditions, or are inadequately counseled regarding the risks of becoming pregnant with a serious medical condition. Nationally, the current (2006) unintended pregnancy rate in the United States is 49%.[13] The Wisconsin Pregnancy Risk Assessment Monitoring System (PRAMS) shows that mothers who gave birth in 2009-2011 who did not intend pregnancy, as opposed to mothers who intended pregnancy, were more likely to suffer from chronic medical conditions, as well as engage in behaviors and life experiences that increase risk for poor infant and maternal outcomes.[14] A maternal comorbidity index was recently developed as a tool to better assess pregnancy risk based upon chronic medical conditions, but it has not yet been tested prospectively.[15]

The observation that the most common causes of pregnancy-related deaths in Wisconsin are cardiac in nature is a change from the 1998-2005 data in which the most common cause of death was thromboembolic disease, with a substantial number of those deaths caused by amniotic fluid embolism (AFE). The most recent US statistics also reflect this change, with a steady increase in cardiomyopathy deaths.[2] There appears to be a decline in the incidence of thromboembolic disease and AFE as a cause of maternal mortality since the last report, and there has been a concerted national effort in the United States to prevent postsurgical thromboembolic disease.[16] There also is evidence that the mortality rate from AFE is declining due to more rapid and effective diagnosis and management.[17,18] The Wisconsin data may be a reflection of these efforts.

Hemorrhage continues to be a leading cause of obstetric morbidity and mortality, however, none of the hemorrhage deaths from the current study were due to the most common cause of maternal hemorrhage, uterine atony. Two deaths were due to abnormal placentation. Nationally, increasing Cesarean section rates are thought to be directly related to this infrequent but significant iatrogenic problem causing obstetrical hemorrhage.[19] Unfortunately, effective treatment of abnormal placentation, in many cases, is highly problematic. It requires early and accurate diagnosis and appropriate planning for delivery in a facility with proper equipment, personnel, and experience to deal with the problems associated with this condition. Even in the most optimum circumstances, these women still can experience severe morbidities and mortality.

Two other pregnancy-related deaths illustrate points worth emphasizing in this report. The first is an overdose of local anesthesia with a labor epidural. Immediate public attention surrounding this case prior to the MMRT review resulted in major changes in hospital pharmacy policies, as well as labor and delivery nurse staffing throughout the United States.[20] The second case involves an infection with *Clostridium sordellii* after a medical termination of pregnancy. This type of infection is rare but almost uniformly lethal. Cases of this sort are still reportable. To date, only 1 case of survival with this specific type of infection has been reported in the literature.[21] Although cases of *C sordellii* do occur with normal vaginal deliveries and with spontaneous pregnancy losses, this infection seems to be associated more frequently with intravaginal prostaglandin use and its possible immune-suppressive effects.[22,23]

In the past, recommendations and action plans resulting from MMRT review have been carried forward through an invaluable partnership with the Wisconsin Association for Perinatal Care (WAPC) and the Wisconsin Section of the ACOG. Together they have translated MMRT findings into prevention projects and initiatives concerning maternal hemorrhage, maternal depression screening, maternal obesity, and maternal substance abuse. In addition, groups including the Wisconsin Chapter of the Association of Women's Health, Obstetric, and Neonatal Nurses (AWHONN) and the Wisconsin Chapter of the American Academy of Family Physicians (AAFP) have used this information as a springboard for their educational efforts. However, the

processes and partnerships necessary to fully realize the potential of maternal mortality reviews to inform public health systems, health care delivery systems, and state and local government agencies have not yet been fully realized. The Wisconsin Perinatal Quality Collaborative was formed recently and will implement quality improvement strategies to reduce maternal deaths and morbidities, as has been done successfully in California and other states. The MMRT is committed to collaborating with this group to more efficiently translate team findings and recommendations to quality improvement action for prevention of maternal deaths.

Looking to the future, maternal mortalities are but the tip of the iceberg in terms of adverse outcomes. Severe maternal morbidities or so-called "near misses" make up a much larger portion of adverse maternal outcomes; however, the study of these morbidities has been limited. Until recently, most hospitals had no mandates to do such reviews, compared to many states that require maternal mortality reviews. However, the Joint Commission for Hospital Accreditation recently mandated a review of all maternal intensive care unit (ICU) admissions and transfusions over 4 units.[24] Interest is also increasing among ACOG and the Society for Maternal Fetal Medicine (SMFM) with initiatives to investigate and analyze these events on a nationwide basis.[25,26] Efforts are underway to create standardized means of performing these investigations at a local level with the aim of more rapidly and efficiently addressing quality-of-care issues.[27] Review of these larger numbers of severe maternal morbidities could complement maternal mortality reviews and allow more evidence-based recommendations to be made. Finally, the MMRT hopes to build relationships with other state mortality review and reporting systems to obtain more complete records concerning homicide, cancer, and motor vehicle deaths to incorporate these cases into its formal maternal mortality review process.

The maternal mortality review process and the resulting data are not without limitations. Identification and proper review of maternal mortalities is highly dependent on complete case ascertainment, the availability of high-quality source data, and the composition and perspectives of the review team. Specific to pregnancy-related mortalities, Wisconsin's ratio may well be artificially low due to possible underreporting of maternal deaths related to nonobstetric causes using the pregnancy checkbox, by the exclusion of certain causes and manners of death from review, by lack of availability of records, or by insufficient documentation on available records. In addition, the determination of avoidability can be subjective and may be influenced by the composition of the team and the perspectives and personalities of its members. As a consequence, it also may be difficult to make direct comparisons between states or across time within an individual state. Lastly, it may be difficult to identify statistically significant differences or trends when the number of events is relatively small.

CONCLUSION

Maternal mortality reviews continue to be a vital and necessary means of assessing maternal health and health care. In Wisconsin, there is a lower than average pregnancy-related maternal mortality ratio, but this is not a reason for complacency. There continue to be many challenges in women's health that are illustrated in sharp relief by maternal death reviews. It is imperative that the next steps forward by the MMRT should include initiation of reviews of severe maternal morbidities, closer scrutiny of chronic medical conditions causing maternal morbidities and mortalities, and re-examination of pregnancy-associated deaths.

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