MICHIGAN MATERNAL MORTALITY SURVEILLANCE (MMMS)

1999-2004 REPORT

Michigan Department of Community Health

MDCH

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Special recognition is given to Douglas M. Paterson for his leadership, not only of the Interdisciplinary Committee of Maternal Mortality Surveillance but also of all areas of maternal child health in Michigan. Mr. Paterson served as Director of the Bureau of Family, Maternal and Child Health at the Michigan Department of Community Health until January 27, 2006 when he retired from the state position. He is currently working with Michigan Primary Care Association.

Appreciation is also extended to members of the Medical and Injury Committees for their commitment to reducing maternal deaths in Michigan and consistent work toward that goal (see appendix for members' listings). The Interdisciplinary Committee consists of the combined membership of Injury and Medical Committees.

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EXECUTIVE SUMMARY

This inaugural report is an overview of the current Michigan's Maternal Mortality Surveillance. The maternal deaths review process was organized in Michigan in 1950 as a collaborative effort between the Michigan Department of Community Health (MDCH), the Committee on Maternal and Perinatal Health of the Michigan State Medical Society (MSMS), and the Chairs of the Departments of Obstetrics and Gynecology of the medical schools in Michigan. It was known as the Michigan Maternal Mortality Study until recently (2004), when the new case ascertainment method and adjustments in the overall process necessitated the name change.

The case definitions are identical with the new terms developed in 1986 by the American College of Obstetricians and Gynecologists (ACOG)/Centers for Disease Control and Prevention (CDC) Maternal Mortality Study Group. Therefore, the reviews include all deaths of women while pregnant or within one year of termination of pregnancy, irrespective of cause. The limitations related to access to different information and the resources needed for the review of all deaths are offset by the benefit of understanding the broad array of issues that women experienced and of which professionals were not aware.

The two committees, Medical and Injury, charged with the death reviews meet regularly. The overall goal of a maternal mortality review committees is to identify medical, systems and patient issues that can then be addressed to improve women's health. Recommendations made based on the specific findings are then submitted to the Interdisciplinary Committee for discussion, evaluation and action. As with other mortality reviews, implementing the recommended actions is often quite complex. The diagram of the process is presented on page 7.

You will note that the Maternal Mortality Ratio (MMR) remains high and the Black/White MMRs ratio above two across all of the characteristics analyzed. The findings demonstrate that maternal mortality is an important indicator of the status of health care in Michigan. These findings were used along with other information obtained from reviews to document the recommendations and the proposed strategies were discussed with partners and providers across the state. While some questions were answered, there is still a need for more comprehensive information that only thorough case reviews can provide.

The findings presented in this report are from the analysis of the newly linked file of death records of women aged 10-55 years old with live births, and later with fetal death files. This encompasses only the information from Vital Statistics and not from the case reviews that are being recorded in the special MMMS database recently developed. This information would be available in the near future and used for subsequent biannual reports. Each report will address specific death causes. The topics will be chosen in consensus by the Committee's chairs, the State MCH Epidemiologist and the MMMS Coordinator.

CHAPTER ONE

INTRODUCTION

Maternal and infant mortality are basic health indicators that reflect a nation's health status (1). In the United States, infant mortality has declined steadily; however, this is not true for maternal mortality. The report published in 1998 by the Centers for Disease Control and Prevention (CDC)'s National Center for Health Statistics indicated that in the United States, the annual maternal mortality ratio remained approximately 7.5 maternal deaths per 100,000 live births during 1982-1996 (1). Annual maternal mortality ratios were calculated using information from death certificates filed in state vital statistics offices and compiled by CDC (2, 3). Maternal deaths have been defined as those deaths that occurred during a pregnancy or within 42 days of the end of a pregnancy and for which the cause of death was listed as a complication of pregnancy, childbirth, or the puerperium (International Classification of Diseases, Ninth Revision, codes 630-676). Maternal mortality ratios were calculated as the number of maternal deaths per 100,000 live births (2, 3).

In 1930, the national maternal mortality ratio was 670 maternal deaths per 100,000 live births (4). The ratio declined substantially during the 1940s and 1950s, and continued to decline until 1982 when annual fluctuations between approximately seven and eight maternal deaths per 100,000 live births were seen. This continued until 1996. Maternal mortality ratios remained higher for black women than for white women. Ratios for black women generally fluctuated between 18 and 22 per 100,000 births and for white women between five and six per 100,000 live births.

The Healthy People 2010 goal is to reduce the maternal mortality ratio to 3.3 deaths per 100,000 live births. No progress has been made and the reason for this lack of improvement is not clear. The United States has not reached an irreducible minimum in maternal mortality; WHO estimates demonstrate that 20 countries have reduced maternal mortality levels to below those of the United States (6).

Each maternal death is a sentinel event and thus every death counts and every death should be counted. Many of these deaths could have been prevented through changes in the health and behavior of women before, during and after delivery; the timing of conception; access to health and social services; and better quality of services. Primary prevention of maternal deaths, such as those associated with ectopic pregnancy and some cases of infection and hemorrhage, is possible (1). Some complications that can occur during pregnancy cannot be prevented (e.g., pregnancy-induced hypertension, placenta praevia, retained placenta, and thromboembolism). However, more than half of all maternal deaths can be prevented through early diagnosis and appropriate medical care of pregnancy complications. Hemorrhage, pregnancy-induced hypertension, infection, and ectopic pregnancy continue to account for most (59%) maternal deaths (7, 8).

When compared with white women, black women continue to have four times the risk of dying from complications of pregnancy and childbirth (3), although the risk for

developing maternal complications is less than twice that of white women (9). In 1996, if the maternal mortality ratio for black women were equal to that for white women, the national maternal mortality ratio would have declined by 32%, from 7.6 to 5.1 per 100,000 live births.

For many years, the maternal mortality ratio was based solely on vital statistics data and thus was most likely underestimated because of the misclassification. The number of deaths attributed to pregnancy and its complications is estimated to be 1.3 to three times that reported in vital statistics records (7). Misclassification of maternal deaths occurs when the cause of death on the death certificate does not reflect the relationship between a woman's pregnancy and her death. In addition, the inclusion of deaths causally related to pregnancy that occurred between 43 and 365 days post-pregnancy increased by at least five to ten percent the number of maternal deaths identified (7).

All these limitations highlighted the need for a broad-based surveillance in order to identify the factors, from before pregnancy to puerperium, that affect women's chance of survival. It is anticipated that this will enhance the understanding of the increased risks that minorities and aging women face and thus improve prevention strategies. This surveillance is an ongoing process and includes identifying risk factors, discussing them among the review committee and then recommending strategies for prevention. The CDC definition for surveillance best describes what the process should be: "The ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health." (8)

As with every surveillance system, the case definition must be clear and well understood. The World Health Organization (WHO), in collaboration with official vital registration groups from the member countries, periodically develops and publishes a revision of the International Classification of Diseases (ICD), which is used throughout the world to classify causes of death. ICD-9 CM is a reference classification. It was developed in the United States to provide a way to classify morbidity data for medical records indexing, medical case reviews, ambulatory, in-patient and other health care programs, as well as for basic health statistics and financial studies. The Ninth revision of the International Classification of Diseases was published in 1977 and used by hospitals to tabulate their discharge diagnoses, claims processing, reimbursement and frequently epidemiological and clinical outcomes research. The term traditionally used in this classification to describe deaths caused by pregnancy is maternal mortality, defined in ICD-9 as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by pregnancy or its management but not from accidental or incidental causes". This definition is used by the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics in its calculations of, and official publications on, maternal mortality statistics for the United States.

New terms were developed in 1986 by the American College of Obstetricians and Gynecologists (ACOG)/CDC Maternal Mortality Study Group to expand the prior definition (10). These terms are:

Pregnancy-associated death. The death of a woman while pregnant or within one year of termination of pregnancy, irrespective of cause:

- **Pregnancy-related deaths**. The death of a woman while pregnant or within one year of termination of pregnancy, irrespective of duration and site of pregnancy, from any cause related to or aggravated by her pregnancy or its management, but not from accidental or incidental causes.

- **Non-pregnancy-related death**. The death of a woman while pregnant or within one year of termination of pregnancy, due to a cause unrelated to pregnancy.

The new terms have strength and limitations. They improve the surveillance process by:

- Helping to identify deaths with a temporal relationship with pregnancy (pregnancy-associated) as a group from which to find those deaths caused by pregnancy (pregnancy-related deaths).

- Including deaths caused by pregnancy which occurred more than 42 days after pregnancy ended, which are increasingly common due to improved medical care and changes in demographic characteristics of women who are pregnant at an older age and thus may experience chronic conditions. This offers a more complete picture of the effect of pregnancy on mortality

- Increasing the interest of all professionals involved in perinatal care to better understand women's health and social problems and thus be able to have an effect on them.

The limitation relates to the difficulty in linking some accidental deaths that occurred at the end of the temporal definition of maternal mortality to the pregnancy status. Further, it is difficult to make any recommendations for prevention when causality might not exist. The limitation, however, is offset by the benefit of understanding the broad array of issues that women experienced, of which professionals were not aware.

Michigan uses these new terms in defining maternal deaths.

CHAPTER TWO

MATERNAL MORTALITY SURVEILLANCE IN MICHIGAN

The Michigan Maternal Mortality Study (MMMS) was first organized in 1950. In 1990, it was no longer funded but volunteer committee members continued to review the pregnancy-related deaths and made recommendations for prevention. This Medical Review Committee continued to meet and review cases on a regular basis regardless of the limited resources. The focus was more on pregnancy-related deaths and less on other maternal death causes. Over time, the need to better understand all causes of maternal mortality led to the revision of the entire process and appropriate decisions for improvement.

The first step was to revise and refine the method for ascertainment of maternal deaths. Through collaboration between the MCH epidemiology team and the Division for Vital Records and Health Statistics, an electronic linked file of 1999-2002 deaths of women aged 10 to 50 years old to birth certificate data was developed. All records from the electronic linked file were checked against those reported to the program by hospitals and coroners for accuracy. It was found that it correctly identified cases that were residents of Michigan and met the maternal death definition criteria. The findings showed that non-medical and accidental maternal deaths made up a significant number of the overall cases in Michigan, confirming the need for a non-medical committee to review these deaths. Reviews of non-medical, non-pregnancy-related deaths by the MMMS Injury Committee began on a consistent basis during 2004.

The need for and benefit from adopting the recommendations of both committees, Medical and Injury also became a higher priority. An Interdisciplinary Committee previously created to review the non-medical and non-pregnancy related death, was reactivated and its first meeting was held in 2005. This Committee reviews the recommendations of the other two committees, prioritizes them and makes suggestions for further actions.

The above-described changes in the process demanded a change in the terminology used to designate maternal mortality surveillance work at MDCH. The term “Study” was replaced by “Surveillance” in the project title. Therefore, MMMS now stands for Michigan Maternal Mortality Surveillance. It is the MDCH public health surveillance with responsibilities shared by staff from the Division of Family and Community Health, Bureau of Family, Maternal and Child Health, and the MCH Epidemiology Unit from the Epidemiology Services Division, Bureau of Epidemiology.

The current process uses the case definitions developed by the American College of Obstetricians and Gynecologists and the Centers for Disease Control and Prevention.

The composition and the review process of the two committees, Medical and Injury, share some similarities but each has unique features.

Medical Committee members are obstetricians/gynecologists, maternal/fetal medicine specialists, midwives, pathologists, anesthesiologists, nurses, and an obstetrician/gynecology intensivist with extensive experience working with high-risk pregnancies. For each potential pregnancy-related death, a detailed abstraction of the medical record is prepared for the Medical Committee's review. The program coordinator retrieves and prepares needed documents. The chair of the Medical Committee develops a comprehensive case summary for discussion with the committee. Each member is assigned a case summary to present, followed by interactive discussions and recommendations for prevention whenever it applies. From these reviews, trends in causes of death, avoidable factors, and gaps in service are identified providing a basis for recommendations as well as suggesting the need for further study of specific issues.

The Injury Committee has a diverse membership, including individuals with expertise in motor vehicle safety and injury prevention, intentional and unintentional injury, public health nursing, domestic violence, substance abuse, social work and counseling, the judicial system, midwifery and medical care. For each case, the program coordinator retrieves and prepares a detailed folder with documents related to that cause of maternal death. Each member of the Injury Committee, reflecting the member's expertise and the cause of death in the case under review, is assigned a case to review and present. All members are encouraged to read all cases and thus to prepare for the discussions. Based on these reviews and also through looking at trends, avoidable factors and service gaps, recommendations for prevention are developed by the Injury Committee.

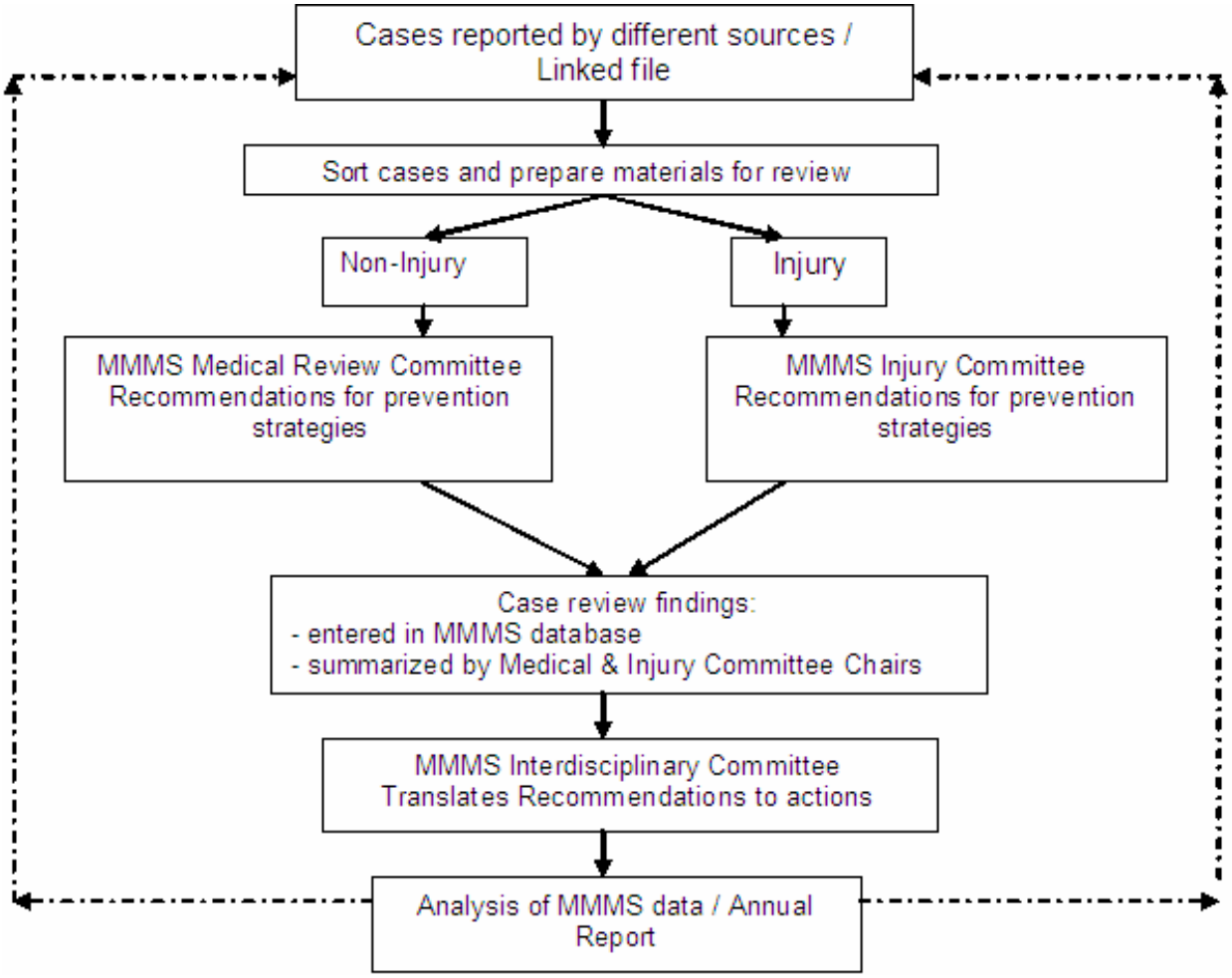
The Interdisciplinary Committee includes all members of the Medical and Injury Committees. This Committee's role is specifically to identify further steps and translate the recommendations into actions.

In addition to comprehensively reviewing cases, improving surveillance activities and achieving consensus from the two expert committees on recommendations were goals for MMMS in 2005.

By improving the Maternal Mortality Surveillance process and thus translating the recommendations into actions, Michigan strives to meet the Healthy People 2010 goals of reducing maternal mortality, maternal illness and complications:

- Goal 16-4: Reduce maternal deaths,
- Goal 16-5: Reduce Maternal Illness and Complications: maternal complications during hospitalized labor and deliveries, ectopic pregnancies, and postpartum complications including postpartum depression.

The following diagram is the graphical representation of the MMMS process:



CHAPTER THREE

LINKED DATA SET:

CASE ASCERTAINMENT METHOD AND DATA SOURCE FOR THIS REPORT

By a collaborative effort between the MCH epidemiology team and the Division of Health Records and Vital Statistics (DHRVS), an electronic linked file of 1999-2002 death to birth certificates data was developed in 2003. The linkage process occurs in the DHRVS Office through the following methodology:

1. Create a subset from the master death registry files for years 1999 through 2002 of females between the ages of 10 and 55 years including only those variables meeting the project criteria.

2. Prepare the subset to resolve the inconsistency of Social Security number encoding for missing numbers. All missing Social Security numbers were converted to “999999999”.

3. Repeat the process by using the master birth registry files from 1998-2002. Create a subset for every year of data that includes only those variables that met the project criteria and resolve the inconsistency of Social Security number encoding for missing numbers.

4. Individually link the birth file subset for each year to the 1999-2002 death file subset using a selection program that matched the mothers who gave birth to those deceased through their names at the time of occurrence, dates of birth, Social Security numbers, maiden names, spouse names, and parent names.

5. Filter all potential matches against the date criteria of the birth occurring prior to death and the date of death, not exceeding the date of the birth by more than one year.

6. Hand-check the final matched file to verify true linked records.

Routines are completed for each birth year and the linked records are archived to the final dataset.

The cause of death is coded based on the International Classification of Diseases 10 revision (ICD10). The “O” codes are specific for pregnancy-related deaths and thus, any death records coded as such that did not link to a birth are also added to the final death set and identified as not having a birth link.

The linked file is updated with new information once a year when the final version of the annual death records file is released. The MCH Epidemiology Unit then tests the linked file for accuracy. When all the questions are answered and both the Vital Statistics and MCH Epidemiology Unit agree upon the completion of the final version of the linked

file, it is matched against the log that reflects the hospital reporting to the MMMS Coordinator at MDCH. Thus, those deaths in which pregnancy ended in a fetal death are identified and reported by hospitals and then added to the linked file.

Michigan did not have a fetal death file for use in linking until 2004, so the log of reported cases was the only source to identify these deaths. Also, the log was used as the case ascertainment method before the linked file was developed. The log is a good tool for tracking reported cases but is not a good ascertainment method, as seen by the significant number of additional cases identified annually using the linked file.

The 1999-2004 linked file was the data source for this report. Excel and SAS 9.1 were used for statistical analysis. The overall as well as race-specific (White and Black) maternal deaths are reported as numbers and ratios per 100,000 live births (Maternal Mortality Ratio: MMR). Further analysis was conducted by demographic characteristics (age, education), pregnancy characteristics (smoking, trimester when prenatal care began, preterm as pregnancy outcomes), interval from delivery to death when pregnancy ended in live birth (less than 43 days, 43-365 days) as well as by causes based on ICD10 codes reported on the death file.

To understand racial differences, the Black/White MMRs ratios are reported for the overall maternal mortality as well as for different strata with the 95% confidence limits used for significance. For continuous variables such as age, education and weeks of gestation at delivery, t-test was used to analyze the racial disparities and a p-value<0.05 was considered significant, unless specified otherwise.

OTHER CASE IDENTIFICATION METHODS

Case reporting from hospitals is still used as an ascertainment method. However, the matching process with the newly created linked file has shown that less than half of the maternal death cases are identified through this mechanism. It must be noted that maternal death reporting is voluntary and not mandatory in Michigan. Maternal death reporting is encouraged through an annual fact sheet mailing. The fact sheet describes the process and progress made through work by the Michigan Department of Community Health and its strong partner, the Maternal Perinatal Health Committee of the Michigan State Medical Society.

Other reporting sources include private physicians, Medical Examiners, medical record and nursing staff of hospitals, and law enforcement agencies (Michigan State Police, county sheriff's Departments, and city police departments).

MICHIGAN MATERNAL MORTALITY SURVEILLANCE DATABASE

The information collected during the initial review process of the documents available as well as a result of discussions and recommendations will, to the extent possible, be collected in the recently developed MMMS database.

CHAPTER FOUR

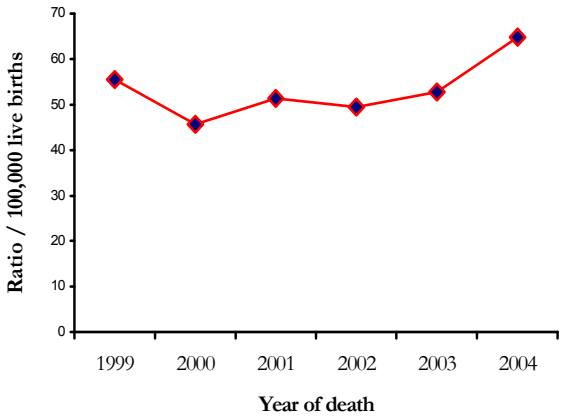
DATA ANALYSIS FINDINGS

There were 424 pregnancy-associated maternal death cases identified during the specified period that translated into an overall ratio of 53.5 (deaths/100,000 live births). These deaths were further categorized as pregnancy-related and non-pregnancy related. When stratified by year of death, MMRs varied from the lowest of 45.7 (95%CI: 34.2, 57.2) in 2000 to the highest of 64.8 (95%CI: 50.9, 78.7) in 2004 but this difference is not statistically significant (Table 1; Figure 1).

Table 1: Numbers and Maternal Mortality Ratio (MMR) by year of death

Year of death	Number of cases	MMR (95%CI)
1999	74	55.5 (42.9-68.1)
2000	61	45.7 (34.2-57.2)
2001	70	51.4 (39.4-63.4)
2002	66	49.5 (37.6-61.4)
2003	69	52.8 (40.3-65.3)
2004	84	64.8 (50.9-78.7)
Total	**424**	**53.5 (48.4, 58.6)**

Figure 1: Trend of the MMR by year of death



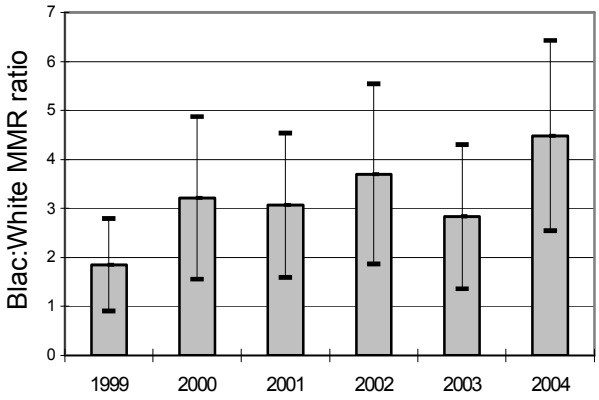
Over half (56.1%) of maternal deaths occurred to White women, 39.2% to Black women, and 2.8 % were in "other" ethnic groups (American Indian, Asian and Pacific Islander, Filipino). Race/ethnicity was missing in eight cases (1.9%). The MMR was significantly different in the White (MMR: 38.4) compared to the Black population (119.8) (Table 2).

Table 2: Numbers and Maternal Mortality Ratio (MMR) by race and by year of death

	White		Black		Black/White
Year	**Number**	**MMR (95%CI)**	**Number**	**MMR (95% CI)**	**MMRs ratio (95% CI)**
1999	50	47.7 (34.5,60.9)	21	88.1 (50.4,125.8)	1.8 (0.9, 2.8)
2000	34	32.3 (21.4, 43.2)	25	103.9 (63.2, 144.6)	3.2 (1.6, 4.9)
2001	41	38.9 (27.0,50.8	28	119.2 (75.0, 163.4)	3.1 (1.6, 4.5)
2002	35	34.0 (22.7,45.3)	28	125.9 (79.3, 172.5)	3.7 (1.9, 5.5)
2003	37	36.3 (24.6,48.0)	23	102.8 (60.8, 144.8)	2.8 (1.4, 4.3)
2004	41	40.7 (28.2, 53.2)	41	182.5 (126.6, 238.4)	4.5 (2.5, 6.4)
Total	**238**	**38.4 (33.5, 43.3)**	**166**	**119.8 (101.6, 138.1)**	**3.1 (2.5, 3.7)**

Figure 2: Black/White MMRs ratio by year of death

The Black/White MMRs ratios varied from the lowest of 1.8 (95%CI: 0.9, 2.8) in 1999 to the highest of 4.5 (95%CI: 2.5, 6.4) in 2004 but no statistically significant difference was found (Table 2; Figure 2).



The mean age at death was 28.9 (95% CI: 28.3, 29.6; Std. deviation=6.9) with 25 being the most frequent (the mode). Age at death was further categorized into four groups. While the percent of deaths by age groups mirrored the above findings (the highest percent was in the age group of 25-29 years old), the maternal mortality ratio calculated per 100,000 live births was the highest in the last two groups of 30-39 and 40 or more years of age (Table 3). The 95% CI limits for the age group of 40+ do not overlap with other groups and thus we can conclude that the ratio is significantly higher in this age group compared to other age groups.

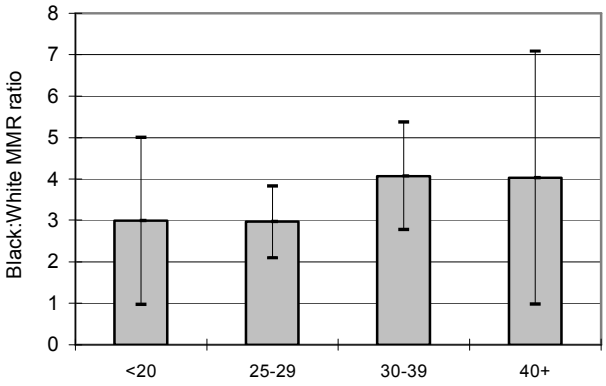
It is important to note the number of deaths in the extreme age groups (less than 20 and 40+) is close (35 and 29 respectively), but the number of live births is different (almost five times higher in the age group of less than 20 compared to 40+ years old: 80,045 compared to just 17,059, respectively, in the same six year time frame). In other words, given the lower number of live births, there are proportionally more deaths in the oldest age group. Considering the continuing increase in the age of women giving birth, there is concern that the number of maternal deaths in this age group increase due to the associated risks unless the findings from maternal death reviews are translated into effective actions/strategies.

By race, the mean age at death was lower in Black compared to White women (27.0 versus 28.6 respectively; t-test p-value=0.07). The same age group of 40+ and the 30-39 years old had the highest Black/White MMRs ratios of 4.0 (95%CI: 1.0, 7.1 and 2.7, 5.3 respectively) (Figure 3).

Table 3: Maternal deaths (numbers and MMR) by age

Age at death	Number	Percent	MMR	(95%CI)	
<20	35	8.3	43.7	29.2	58.2
20-29	190	44.8	45.7	39.5	51.8
30-39	170	40.1	60.9	52.2	69.5
40+	29	6.8	170.0	111.3	228.7
Total	**424**	**100.0**	**53.5**	**48.4**	**58.6**

Figure 3: Black/White MMRs ratio by age



Maternal education was used as a proxy measure for socioeconomic status and a predictor of the patients' understanding of the importance of early and comprehensive prenatal care, delivery and post-partum follow-up. We speculated that the level of maternal education between the end of the pregnancy and the death (up to one year) would not significantly change. There were 417 cases with documented number of years of education (98.3%). The mean was 12.4 (95%CI: 12.2, 12.6; Std. deviation=2.3), with the most frequent being 12 years (the mode) and the maximum being 17 years. Black women had significantly less years of education than White women (mean of 11.5 vs. 12.3 respectively, with t-test p-value=0.01).

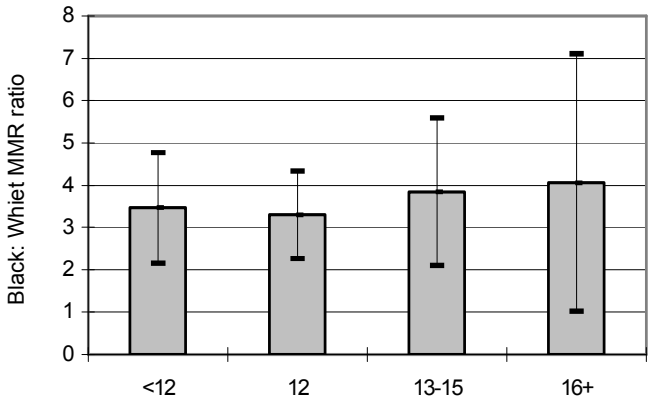
Maternal education was further categorized in four groups (<12, 12, 13-15, 16+). The highest MMR was recorded in those having less than 12 years of education (82.4; 95%CI: 67.0, 97.8) (Table 4). The same distribution of educational status was present in both, White and Black populations, with the highest Black/White MMRs ratio recorded in the group of women with 16+ years of education (4.1: 95% CI: 1.0, 7.1) followed by the group of 13-15 years of education (3.8; 95% CI: 2.1, 5.6). The disparities are present across the education groups but more in the highly educated women (16+ years of education) (Figure 4). While this is just a crude analysis, it mirrors other previous study findings that showed higher disparities in this highly educated group of women.

Table 4: Maternal deaths by education

Years of Education at death	Number	Percent	MMR	(95%CI)	
<12	110	25.9	82.4	67.0	97.8
12	163	38.4	64.1	54.3	74.0
13-15	83	19.6	45.1	35.4	54.8
16+	61	10.1	34.7	22.6	37.7
Unknown	7	1.7	37.5	9.7*	65.2*
Total	424	100.0	53.5	48.4	58.6

* Wide CI due to small number

Figure 4: Black/White MMR ratio by education



The MMR was higher in mothers who smoked during pregnancy (19.5; 95% CI 15.6-23.4) than among those that were non-smokers (8.5; 95% CI: 7.5, 9.6). The percent distribution by race of the smoking status during pregnancy reflects the previous findings that smoking alone is less frequent in the Black population (higher percent of non-smokers in Black women compared to Whites). However, the race-specific MMR was higher in the smoking group, highlighting that this is a risk factor that should be continuously addressed. The racial disparity measured as Black/White MMRs ratio was observed in both groups although higher in the non-smoking group (Black/White MMRs ratio in the non-smoking group was 3.3 compared to 2.1 in the smoking group) (Table 5).

More than 50% of women initiated prenatal care in the first trimester (53.8%) but the highest MMR was found in those who entered care in the third trimester (MMR=62.3;

95%CI: 44.3, 80.3) followed by those who did not have any prenatal care (MMR=47.3; 95%CI: 25.5, 69.2). Both were significantly different compared to the initiation of prenatal care in the first trimester. The significantly higher MMR in women who sought prenatal care either late or never illustrates the need for timely and comprehensive prenatal visits, especially for women exposed to different factors that put them at risk of dying if not counseled, screened or treated appropriately. As for the Black/White MMRs ratios, the highest (6.8) was in those who initiated prenatal care in the first trimester followed by those with no prenatal care (5.1) (Table 5). Prenatal care is usually self-reported, so it is difficult to explain the findings. The number of visits and the services received during prenatal care need to be further explored and correctly measured before making further conclusions.

Maternal mortality is not usually analyzed in association with pregnancy outcomes. However, preterm births could be associated with high-risk pregnancies as well as complications at labor and delivery that put at risk the lives of both baby and mother. This study was not intended to thoroughly analyze these risks. However, MMRs were calculated and found to be significantly higher when pregnancies ended in preterm births.

The majority of pregnancies that ended in live births were term (37+ weeks gestation). The MMR was 34.5 (95%CI: 30.0, 39.0). The MMR for those pregnancies, that ended as preterm births (less than 37 weeks gestation) was 82.1 (95% CI: 63.0, 101.3), significantly higher compared to term births (Table 5). Only five percent were very preterm (<=31 weeks gestation) and 11.8% moderate preterm (32-36 weeks gestation). The MMRs were 139.7 (95%CI: 80.0-199.5) and 70.0 respectively (95%CI: 50.6, 89.4). The same distribution of the gestational weeks at delivery was found in both White and Black populations with insignificant difference between means (37.5 vs. 36.2 respectively; t-test p-value=0.06). The Black/White disparities exist regardless of the weeks of gestation. As for Black/White MMRs ratios, the highest was for term (2.8) births followed by preterm (2.7).

For those pregnancies resulting in live births and thus having the date of delivery recorded, the interval to death was calculated as the first 42 days (below 43 days) and from 43 to 365 days. More women died after the first 42 days (59.7%), which reflects a significantly higher maternal mortality ratio of 31.9 (95%CI: 28.0, 35.8) when compared to 12.9 (95%CI: 10.4, 15.4) for those who died within the first 42 days. The same distribution was observed by race and the Black/White MMRs ratio showed higher but not statistically significant disparity in those who died within the first 43 days from delivery (3.7 vs. 3.1).

Table 5: Maternal deaths (numbers and MMR) by maternal characteristics

	White			Black			Black:White	
	Percent	MMR	(95%CI)	Percent	MMR	(95%CI)	MMRs Ratio	(95%CI)
Smoking								
Yes	26.9	68.3	(51.5, 85.0)	18.7	144.2	(93.4, 194.9)	2.1	(1.2, 3.0)
No	52.9	25.1	(20.7, 29.5)	62.0	82.1	(66.2, 97.9)	3.3	(2.4, 4.1)
Prenatal Care Began								
1st trimester	59.2	11.4	(9.5, 13.2)	47.6	77.8	(60.6, 94.9)	6.8	(5.0, 8.7)
2nd trimester	12.6	22.8	(14.6, 31.0)	15.7	88.5	(54.5, 122.5)	3.9	(1.8, 5.9)
3rd trimester	8	80.1	(44.1, 116.1)	15.7	391.3	(240.9, 541.8)	4.9	(2.0, 7.8)
None	2.5	56.9	(11.4, 102.4)	7.2	292.5	(127.0, 457.9)	5.1	(0.1, 10.2)
Preterm								
<31 weeks	3.4	89.3	(27.4, 151.3)	7.2	214.0	(92.9, 335.1)	2.4	(0.3, 4.5)
32-36 weeks	11.3	52.3	(32.6, 72.0)	13.9	134.7	(79.7, 189.8)	2.6	(1.1, 4.0)
Term 37+ weeks	58.4	26.3	(21.9, 30.7)	45.8	74.7	(57.9, 91.5)	2.8	(2.0, 3.6)
Interval to death								
<=42 days	22.3	8.6	(6.2, 10.9)	26.5	31.8	(22.4, 41.1)	3.7	(2.2, 5.2)
43-365 days	60.1	23.1	(19.3, 26.9)	60.2	72.2	(58.0, 86.3)	3.1	(2.3, 3.9)

The cases with missing information are not included and thus the percentages may not add up to 100.

When the 42 day interval from delivery to death was further stratified, it was found that almost half (46.1%) of maternal deaths occurred within the first week (0-6 days). More than half of them (55.3%; 26 deaths out of 47 who died within the first week) occurred within the first 24 hours. Those who died between 7 and 30 days followed (42 cases; 41.2%), with only 13 dying between 31 and 42 days (13; 12.7%). This distribution reflects in the highest MMR of 5.9 (95%CI: 4.2, 7.6) during the first week (0-6 days) followed by 5.3 (95%CI: 3.7, 6.9) between 7 and 30 days and the lower of 1.6 (95%CI: 0.7, 2.5) during the last days of the first interval (31-42 days).

The same analysis was performed by race. The distribution was found the same in the Black population with 50% of deaths occurring within the first week (MMR: 15.9; 95%CI: 9.2, 22.5). The majority of these deaths occurred within the first 24 hours (14 deaths out of 22; 63.6%). It was different in the White population: the highest percent of deaths occurred between 7 and 30 days (43.4%; MMR: 3.7 with 95%CI: 2.2, 5.2), followed by 41.5% (MMR: 3.5; 95%CI: 2.1, 5.0) within the first week (0-6 days). Half of the deaths within first week occurred during the first 24 hours after birth (11 out of 22 cases) (Table 6). These findings are reflected in the highest Black/White MMRs ratio of 4.5 (95%CI: 1.1, 7.8) for those who died within the first week followed by a ratio of 3.5 (95%CI: 2.1, 4.9) for those who died between 31 and 42 days. Among those who died within the first 42 days, the highest Black/White MMRs ratio of 5.7 (95%CI: 3.1, 8.3) was recorded for the deaths occurring within the first 24 hours (Table 6).

Table 6: Maternal deaths within the first 42 days by race

	White			Black			Black:White	
	Percent	MMR	(95%CI)	Percent	MMR	(95%CI)	MMRs Ratio	(95%CI)
Interval to death								
0-6 days	**41.5**	3.5	(2.1, 5.0)	50.0	15.9	(9.2, 22.5)	4.5	(1.1, 7.8)
0 days (within 24 hours)	**20.8**	1.8	(0.7, 2.8)	31.8	10.1	(4.8,15.4)	5.7	(3.1, 8.3)
1-6 days	**20.8**	1.8	(0.7, 2.8)	18.2	5.8	(1.8, 9.8)	3.3	(0.1, 6.4)
7-30 days	**43.4**	3.7	(2.2, 5.2)	40.9	13.0	(7.0, 19.0)	3.5	(2.1, 4.9)
31-42 days	**15.1**	1.3	(0.4, 2.2)	*	*	*	*	*
Total	**100.0**	8.6	(6.2, 10.9)	100.0	31.8	(22.4, 41.1)	3.7	(2.2, 5.2)

* Small numbers (below 5); the percent and ratio considered unstable and not reported

The ICD10 classification was utilized to separate patients who experience a pregnancy-related ("0" codes) from non-pregnancy related (all other codes) deaths.

There were 99 cases (23.3%) whose deaths were pregnancy-related (MMR=12.5; 95%CI: 10.0, 14.9). An additional152 cases (35.8%; MMR=19.2; 95%CI: 16.1, 22.2) died from other health conditions (e.g., pre-existing hypertension, cardiac diseases). The remaining 173 deaths (40.8%; MMR=21.8; 95%CI: 18.6, 25.1) consisted mainly of violent deaths (89.6% were motor vehicle accidents, assaults, etc. which represent 36.6% of the total deaths) with a few having uncertain causes. Similar distribution of causes was observed in the White population (22.3% pregnancy-related; 34.9% other health conditions; 39.5% violent deaths). In the Black population, the deaths caused by other health conditions represent a higher percentage compared to violent deaths (38.0% vs. 32.5% respectively). The Black/White MMRs were higher in the pregnancy-related deaths (3.6; 95%CI: 2.2, 5.1) followed by other health conditions (3.4; 95%CI: 2.2, 4.6) and violent deaths (2.6: 95%CI: 1.6, 3.5) but the differences were not significant. Ranked by prevalence, from highest to lowest, the majority of deaths in the White population had violent causes, followed by other health conditions, compared to the Black population who died more frequently of other health conditions followed by violent causes. This reflects the prior knowledge related to the higher prevalence of different health conditions in Black women. Also, it highlights the need for comprehensive health care regardless of race but also the urgent need to explore further and thus better understand the risks that Black population may experience.

The causes of death were further divided into small groups. Among the pregnancy related deaths (ICD10 "O" codes: obstetric causes), the three most prevalent were obstetric embolism (15 cases; 15.2%) followed equally by hypertension during pregnancy and cardiomyopathy in puerperium (13 cases and 13.1% in each group). Hemorrhage and other specified diseases/conditions followed with seven cases each (7.1%) (Table 7). The last group refers to maternal disease/conditions classifiable elsewhere but complicating either the pregnancy, or childbirth or puerperium. Accurate information about these cases could only be found by the thorough reviews during the surveillance process.

The violent deaths were mainly accidents (57.4%), followed by assaults (27.7%). Accidents were mainly caused by motor vehicles; drowning, accidental poisoning, etc. caused only few. With regard to other health conditions, cardiac disease made up the highest percent (24.3%), followed by malignant neoplasm (23.0%) and mental and behavioral disorders due to substance use (7.9%). (Table 7)

Table 7: Maternal deaths by main causes

	Number	Percent
Pregnancy-related (ICD10 'O' codes)		
Obstetric embolism (O881, O882)	15	15.2
Amniotic fluid embolism (O881)	*11*	*11.1*
Obstetric blood-clot embolism (O882)	*4*	*4.0*
Hypertension during pregnancy (O141, O149, O152, O159)	13	13.1
Cardiomyopathy in puerperium (O903)	13	13.1
Hemorrhage (O469, O678, O721)	7	7.1
Other specified diseases and conditions complicating pregnancy, childbirth and puerperium (O998)	7	7.1
Violent deaths		
Accidents (V01-X59)	89	57.4
Motor vehicle accidents (V03, V28-V29, V-40-V49, V50-V59, V86-V87)	*82*	*52.9*
Assaults (X85-Y09)	43	27.7
Intentional self-harm (X60-X84)	17	11.0
Other health conditions		
Cardiac diseases (I20-I52)	37	24.3
Cardiomyopathy (non-pregnancy-related) (I42)	11	7.2
Malignant neoplasms (C00-C97)	35	23.0
Mental and behavioral disorders due to substance use (F10-F19)	12	7.9

The above classification by cause of death is based on the information recorded on the death certificate file and thus is subject to limitations. Autopsy was reported as performed in 297 (70.9%) of cases, with the vast majority of them (74.8%) being in those who died after 42 days (43-365 days). Some of the ICD10 codes should be studied further to better understand the death circumstances (i.e., ICD10 'O96' code). Thorough reviews of maternal deaths are definitely necessary prior to making further recommendations.

This analysis has limitations associated with both the data source and the methodology. The linked file is based solely on the vital statistics data, so there may be some missing and perhaps even misreported information. For instance, marital status use is limited because of the indirect coding (parents' names used for coding the marital status) and thus is not included in this analysis. The proposed new birth certificate will

clarify this coding issue. Another important limitation is that the maternal deaths associated with fetal deaths or abortions/miscarriages were identified only from hospital reporting until 2004, when the fetal death file became available for linkage.

Regardless of these limitations, the linked file proved to be an effective case ascertainment method in Michigan, where maternal mortality reporting is not mandatory. It was also found to be a good data source for maternal mortality analysis.

CHAPTER FIVE

RECOMMENDATIONS

The overall goal of a maternal mortality review committee is to identify medical, systems and patient issues that can then be addressed to improve women's health.

As with other mortality reviews, implementing recommendations is often more difficult than merely disseminating the information.

Findings do not always lead to actions for various reasons including:

- Policy and decision makers are not part of the team and/or have not been engaged in the process;
- Committees want to gather more data before developing recommendations and/or action steps;
- Lack of funding for implementing strategies;
- Lack of staff to oversee strategy implementation and evaluation;
- Lack of jurisdiction to change the official cause of death on the birth certificate to reflect committee findings; and
- Too few channels for disseminating prevention information or guidelines.

Regardless of the barriers to implementation, one of the maternal mortality recommendations led to an important action: the introduction of the pregnancy check box on the new death certificate to better capture these sentinel-events.

The last Interdisciplinary Committee meeting was held in June 2005. The members attending were asked to review, discuss and approve the recommendations suggested by both the Medical and Injury Committees. The following recommendations were endorsed:

1. Mandatory autopsy for each case of maternal death in Michigan.
Medical Committee reviews have established the importance of accurate cause of death information in preventing maternal deaths among reproductive-aged women. It was recommended that meetings with Medical Examiners in Michigan be held, confirming the value of their work toward reducing maternal deaths, sharing data and findings from Maternal Mortality Surveillance, and seeking their assistance in assuring that autopsy is used in all cases of maternal death. Such discussion should include the potential benefits of consistency in the format of autopsy reports (including microscopic exam and toxicology reports).

2. Assure knowledge of brief interventions and available resources to aid in the treatment of depression as an essential component of prenatal care.
It was recommended that health care providers utilize existing resources to aid in identifying depression during pregnancy and the postpartum period, and that a workgroup be appointed to develop an action plan.

3. Work needs be undertaken regarding the special needs of pregnant women in Emergency Department Services. Consideration of the special roles of Emergency Room Nurses as well as Emergency Medical Transport Services must be made.

It was recommended that Emergency Physicians be invited to participate in both Medical and Injury Committees case reviews. Abstracts prepared for case review must show EMS run times, e.g., time shown when call received, EMS arrival time and arrival time in Emergency Department.

4. Develop and implement a public education project regarding the use of seatbelts during pregnancy to prevent maternal deaths associated with motor vehicle accidents.
It was recommended that a workgroup be appointed to develop an action plan. This group should collaborate with ACOG to ensure educational materials are part of this plan.

Recommendations endorsed without a work group included:

1. Two actions need be taken regarding surveillance in the area of management of cardiovascular disease and pregnancy.
The Michigan Department of Community Health recommended developing a case registry. Specialty work currently being done in the management of cardiovascular disease and pregnancy should also be presented. MDCH should identify actions by which this work may be supported.

2. Assure first trimester entry into prenatal care.
First trimester entry into prenatal care offers the health care provider an opportunity for early risk identification. This includes convincing women that early entry to care is important to them and creating a social expectation about this, and convincing providers to take full advantage of opportunities for early entry to care.

3. Additional means must be found to educate health care providers, pregnant women, and organizations which monitor rental property on the need for smoke detectors and home safety to prevent maternal deaths due to home fires. This recommendation will be communicated to the State Fire Marshall.

4. All private providers of prenatal care and health care systems must ensure that health care records are eligible.

5. Michigan Maternal Mortality Surveillance (MMMS) has found that there are multiple ways in which the abuse of either legal or illicit substances contributes to maternal deaths. It is recommended that all health care providers of women of child-bearing age be informed of the importance of documenting known or suspected substance abuse. Clinical observation or lab results confirming substance abuse provide supportive evidence for counseling and referral. It is important that all screening results and referrals to women's substance abuse treatment programs be noted in the health care record.

6. Identification of domestic violence is an issue needing to be addressed in the prevention of maternal deaths. Additional data about deaths where domestic violence is identified should be accumulated and brought to the Injury Committee for action. Review data fields required by the database for domestic violence cases to assure the data fields adequately capture data needed for analysis.

Other general examples for dissemination and implementation of the recommendations:

- Develop performance measures to help keep the issue on the radar screen for policymakers.
- Continue directing attention to observed racial disparities in maternal mortality.
- Assure the provision of care coordination, as lack of coordination is cited as a gap in many cases.
- Ensure that family planning issues are addressed early in care, especially for women with chronic illness.
- Heighten awareness of the importance of management of chronic illnesses during pregnancy, considering the increase in age of pregnant women.
- Identify the factors that contribute to excess mortality among black women and develop appropriate interventions.
- Look at increasing clinical information regarding the prevention of pregnancy-related and associated conditions and make such information available to other practitioners.
- Provide technical assistance to hospitals to help them comply with regulations and laws (e.g., they are required to talk about postpartum depression, but some do not know how to do that).
- Measure progress in achieving necessary changes (in process and systems of care).
- Develop strong partnerships with university research departments of perinatology/obstetrics.

CHAPTER SIX

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

The high MMMR as well as Black/White MMRs ratios above two across all of the characteristics used in this report, demonstrate that maternal mortality remains an important indicator of the status of health care in the U.S. These findings were used with other information obtained from reviews to document the recommendations, as well as the proposed strategies discussed with partners and providers across the state. While some questions were answered, there is still a need for more detailed and comprehensive information that only thorough case reviews will provide.

Previous main strategies suggested for reducing maternal mortality were (13):

a) Prenatal care

b) Preconception Counseling—A Role for All Physicians

c) Addressing Cultural Differences

d) Education, Documentation, Participation and Collaboration

a) Prenatal care became a mainstream intervention in the 1980s and has since succeeded in reaching most women in the US. However, improvements in maternal and infant health have slowed significantly or worsened in recent years. Prenatal care, which usually begins at week 11 or 12 of a pregnancy, comes too late to prevent a number of serious maternal and child health problems. Also, adverse pregnancy outcomes remain a prevalent health problem suggesting that an improved national approach to ensuring healthy birth outcomes is needed.

b) There are multitudes of different factors that interact to increase the risk of death in a pregnant woman. The information from reviews was used to minimize these risks and thus further alleviate the burden of maternal deaths on families and the entire society. However, after so many years of effort, the impact is not as great as expected as the actions were often reactive rather then proactive. Ideally, the social, financial, and medical problems that can affect a pregnant woman's health should be addressed prior to pregnancy. Preconception is also the best time to address emotional issues surrounding past poor outcomes or difficult pregnancies.

As described in the American College of Obstetricians and Gynecologists in Technical Bulletin 205, 1995, the goals of preconception counseling are basically fourfold: (1) to identify any preexisting conditions that may affect an anticipated pregnancy; (2) to allow time for interventions that could lead to more favorable outcomes; (3) to educate the patient about the importance of prenatal care and overall good health; and (4) to address home, social, financial and emotional issues that could affect attitudes toward pregnancy and prenatal care (11,13).

Preconception care is a set of interventions that identify and modify biomedical, behavioral, and social risks to a woman's health and future pregnancies. It includes both

prevention and management, emphasizing health issues that require action before conception or very early in pregnancy for maximal impact (12).

Preconception care is mainly targeted to women of reproductive age, but it also includes specific components for men. The overarching goal of preconception care, as described in reports and recommendations of the American Academy of Pediatrics (AAP), American Academy of Family Physicians (AAFP), and the American College of Obstetricians and Gynecologists (ACOG) is to provide: 1) screening for risks, 2) health promotion and education, and 3) interventions to address identified risks (12).

Health conditions amenable to preconception care include hypertension, thrombo-embolic disease, substance abuse and domestic violence, all identified as being prevalent among the maternal deaths reviewed by MMMS. Addressing these problems before pregnancy not only yields known benefits to women's health but also can positively impact later pregnancy outcomes (including the reduction of maternal deaths). "Preconception health promotion should be directed toward healthy women as well as women with known health risks" (12).

Specific issues should be addressed with all women before pregnancy, including nutrition and weight, depression, tobacco, alcohol, medications, illicit drug use, occupational and environmental hazards, domestic violence, infections, immunization, screening for medical disease, family planning, and genetic risks. "The challenge for preconception health is to reach all women with these interventions in time for them to be effective in reducing risks to women and their pregnancies" (12).

"Optimizing a woman's health before and between pregnancies is an ongoing process that requires access to the full participation of all segments of the health care system." Committee Opinion, Number 31. American College of Obstetricians and Gynecologists, September 2005.

"Preconception care could succeed in improving maternal and child health where the current paradigm is failing, but most providers don't provide it, most insurers don't pay for it, and most consumers don't ask for it". (12)

The Centers for Disease Control and Prevention (CDC) has successfully aligned the efforts of a number of its external partners and internal programs through a two-year collaborative effort (12). In 2003-2004, an internal workgroup on preconception care with participants representing 22 programs from across CDC was convened. Also, in 2005 CDC convened a Select Panel on Preconception Care. It included experts from a variety of national organizations concerned about the health of women, infants, and families. The CDC internal workgroup and the Select Panel developed ten recommendations designed to achieve four goals that guarantee optimal reproductive health outcomes for all women and couples:

Goal 1. To improve the knowledge, attitudes, and behaviors of men and women related to preconception health.

Goal 2. To assure that all U.S. women of childbearing age receive preconception care services – screening, health promotion, and interventions -- that will enable them to enter pregnancy in optimal health.

Goal 3. To reduce risks indicated by a prior adverse pregnancy outcome through interventions in the interconception (inter-pregnancy) period that can prevent or minimize health problems for a mother and her future children.

Goal 4. To reduce the disparities in adverse pregnancy outcomes.

This last goal will address cultural differences. The question of whether a woman's cultural background affects the content of her interactions with health care providers and influences the interventional strategies and preventive care services offered (as well as her attitude toward them) remains to be answered. More studies are needed to determine to what extent the content and quality of prenatal care affect the racial disparity seen with maternal mortality rates.

Developing educational programs on health maintenance and prenatal care within the community, disseminating information through the news media and the Internet, educating all patients of reproductive age on the benefits of family planning, and promoting research in areas such as women's health, cultural competency, and maternal mortality remain important. Improvements must be made in the documentation of maternal deaths.

Each of these strategies for reducing maternal mortality leads to preconception as the most efficient time for understanding the women's needs. A targeted health care plan and the ability to develop targeted prevention strategies will results in better pregnancy outcomes.

Establishment of maternal mortality surveillance systems and review committees will enhance collaboration between physicians and other organizations within the health care field. Physicians in specialties other than obstetrics should participate in educational conferences on women's reproductive health issues and on obstetric care and complications.

It is important to remember that the continued evaluation of the implemented maternal mortality surveillance is key for improvement.

In conclusion, if the goal is to improve mothers' and infants' health in Michigan, the focus should be on the two indispensable and interchangeable components in the medical and prenatal care of pregnant women, preconception care and racial and cultural disparities.

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APPENDICES

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INTERDISCIPLINARY COMMITTEE MEMBERS

Currently, all members of the other two committees could serve on the Interdisciplinary Committee. This process is under revision and a new method to assign the participating members will be developed by the other two committees' chairs in collaboration with the MMMS Coordinator and the state MCH Epidemiologist. The process will then be finalized based on consensus of both committees' members.

The MDCH Bureau of Family, Maternal and Child Health's Director will chair this Committee. Dr. Gary Kirk replaced Douglas Paterson in this position.