Original Article

Maternal Mortality: 19-Year Experience in an Eastern North Carolina Tertiary Center

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Abstract

Objective: To examine the cases and causes of maternal mortality at a tertiary care center in eastern North Carolina and to identify risk factors associated with maternal deaths.

Design: A retrospective study of hospital records, death certificates, and autopsy reports was done on all obstetrical deaths from 1988 through 2006 at Pitt County Memorial Hospital (PCMH).

Results: Fourteen maternal deaths were identified during this period. Nine deaths were direct maternal deaths, and five were indirect. Nine of the deaths were potentially preventable through proper preconceptional counseling, early identification, and treatment of diseases such as preeclampsia and premature rupture of membranes. The limitations to this study include lack of detail regarding the prenatal care and nonavailability of autopsy reports for several of the patients.

Conclusion: Preconceptional counseling, to educate patients on pregnancy risk and self identification of preeclampsia, prompt medical diagnosis and treatment of preeclampsia and premature rupture of membranes (PROM), and quick transfers to level II or III hospitals with appropriate specialists to care for these patients could reduce maternal mortality in this region. Finally, the risk factors that increase the area's maternal mortality include its rural location, its low socioeconomic status, and the high number of African-American and single women.

Key words: Maternal mortality, preeclampsia, prevention.

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Introduction

The International Classification of Diseases, Tenth Revision (ICD-10) defines maternal death as the death of a woman while pregnant or within 42 days of termination of pregnancy. A direct maternal death is the "death of a mother resulting from obstetrical complications of pregnancy, labor, or the puerperium and from interventions, omissions, incorrect treatment, or a chain of events resulting from any of these factors. An example of a

direct maternal death is exsanguination after uterine rupture."[1] An indirect maternal death is "a maternal death not directly due to an obstetrical cause, but resulting from previously existing disease, or a disease that developed during pregnancy, labor, or the puerperium, which was aggravated by maternal physiological adaptation to pregnancy. An example of an indirect maternal death is complications from mitral valve stenosis."[1] Finally, a nonmaternal death is the "death of the mother resulting from accidental or incidental causes not related to pregnancy. An example is death from an automobile accident or concurrent malignancy."[1]

With recent improvements of the U.S. Standard Certificate of Death, including the addition of a separate pregnancy question along with the introduction of ICD-10, maternal deaths are becoming better identified. Unfortunately, as the methods to identify maternal death improve, the numbers continue to increase. In 2004, maternal mortality in the United States was 13.1 deaths per 100,000 live births. This rate is substantially higher than the goal of 3.3 maternal deaths per 100,000 live births, which the U.S. Department of Health and Human Services established in Healthy People 2010.[3] Efforts must be made to lower maternal mortality through early identification and treatment of preventable disease.

In addition to the high overall maternal mortality rates, the disparity between non-Hispanic African American women and non-Hispanic Caucasian women is even more worrisome. The maternal mortality rate among non-Hispanic African American women (36.1 deaths per 100,000 live births) is about four times the rate among non-Hispanic Caucasian women (9.8 deaths per 100,000 live births). This disparity has widened since 2000.[2]

The results of the North Carolina statewide review of maternal mortality from 1995 to 1999 revealed that 40% of pregnancy-related deaths were potentially preventable.[4] The study concludes that improved quality of care is considered to be the most important factor in preventing maternal deaths. The most common cause of death in this study was cardiomyopathy, followed by hemorrhage, pregnancy-induced hypertension, cerebral vascular accidents, and complications of other medical conditions.[4] Although the leading cause of maternal mortality varies by area of the country and years of data collection, the causes that repeatedly surface include hemorrhage, pulmonary embolism, pregnancy-induced hypertension, and infection.[5]

The purpose of this study was two-fold: (1) to review the cases of maternal mortality at the East Carolina University Brody School of Medicine (BSOM) and in our referrals from eastern North Carolina and (2) to identify risk factors associated with maternal death in order to seek measures to reduce the state's overall maternal mortality.

Materials and Methods

The Brody School of Medicine at East Carolina University provides high-risk perinatal care for 29 counties in eastern North Carolina at its clinics and at Pitt County Memorial Hospital (PCMH). Following approval by the Institutional Review Board, all cases of maternal death between 1988 and 2006 at PCMH were identified. These patients were those with discharge dispositions that included the death code D7-Z and billing code ICD-9 and ICD-10 for obstetrics. Data sets reviewed included hospital records, death certificates, and autopsy reports of mother and neonate when available. The data collected on each patient included patient's age, race, marital status, highest level of education, parity, gestational age, location of prenatal care, medical conditions, type of delivery, and cause of death. Neonatal data including Apgar scores, gestational age, fetal sex, fetal weight, and gross abnormalities were also recorded.

Death was classified as a direct or indirect maternal death or a nonmaternal death using the aforementioned definitions.[1] Nonmaternal deaths, such as death from a malignancy, were not used in the maternal mortality calculation because they are excluded by the ICD-10 definition: "Maternal death, as defined by the World Health Organization (WHO), 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."[1]

The circumstances regarding each death were then reviewed to decide whether it was potentially preventable, and discussion was made about how to prevent these deaths.

Results

Between 1988 and 2006 at PCMH, 50,764 live births occurred, and 16 potential maternal deaths were identified, of which 14 were maternal deaths and 2 were nonmaternal deaths. Five of these women

received prenatal care at BSOM, and 11 women were transferred to PCMH late in pregnancy. The overall maternal mortality ratio was 27.6 maternal deaths to 100,000 live births. In our referral population, 81% of the pregnancies were in Caucasians, and the remaining cases were in minorities. In the cases for this study, 78% of the mortality cases involved minorities, and 22% were in Caucasians. In our region of North Carolina, the overall incidence of preeclampsia is about 10%, and the incidence of premature rupture of membranes (PROM) is about 4%, which is about the national average. In the cases reviewed for this report, preeclampsia occurred in 31% of the maternal deaths, and PROM occurred in 6% of the maternal deaths. Of the 14 maternal deaths, 9 deaths were direct, and 5 were indirect. Direct, indirect, and non-maternal deaths are shown in Tables 1, 2, and 3.

The direct maternal deaths resulted from the following causes: 56% (5/9) involved preeclampsia, and 3 of those patients had eclampsia; 22% (2/9) were patients with PROM, and 1 of those developed septic shock; and 22% (2/9) of the deaths involved anesthesia complications. Each of these maternal deaths was found to be presumably preventable. Early detection and treatment of diseases such as preeclampsia and PROM could have prevented these deaths. Of the five cases of preeclampsia, three were patients transferred from outside hospitals, and two were BSOM and PCMH patients.

Case number 2 was a patient who developed superimposed preeclampsia on preexisting chronic hypertension. She developed eclampsia that then led to aspiration pneumonia, and finally she expired from adult respiratory distress syndrome.

Case number 3 was a patient who developed severe preeclampsia, which then developed into eclampsia accompanied by severe pulmonary edema. She became comatose, suffered a stroke, and subsequently expired.

Case number 6 was a patient who developed severe preeclampsia, hemolysis, elevated liver enzymes and low platelet count syndrome (HELLP), and finally eclampsia, which led to an intrauterine fetal demise. She arrested at the induction of anesthesia; the autopsy report revealed disseminated intravascular coagulation (DIC) and changes of preeclampsia.

Case number 9 was a morbidly obese woman who had chronic hypertension and developed superimposed preeclampsia. She developed pulmonary edema and expired during attempts at intubation.

Case number 14 was an obese patient who expired from anoxic brain injury. She suffered from chronic hypertension with superimposed preeclampsia. Anesthesia for a Cesarean section delivery was induced, but repeated intubation attempts were not successful. The patient died despite an emergent cricothyrotomy and endotracheal intubation to restore respiration.

The two patients who suffered from PROM came to PCMH from outside locations. Early diagnosis and treatment of this condition might have prevented the deaths.

Case number 4 was an obese woman who developed preterm labor with PROM of more than 12 hours duration. She had pulmonary artery stenosis and pulmonary hypertension. There was no evidence of chorioamnonitis. After giving birth via a spontaneous vaginal delivery, she suffered from a postpartum hemorrhage. There was retained placenta, and she had developed a severe DIC. Attempts to control her bleeding by an emergent hysterectomy were unsuccessful. Death was a result of adult respiratory distress syndrome (ARDS) secondary to the DIC.

Case number 13 was a patient who had PROM, which led to chorioamnionitis, which then caused septic shock. She expired from DIC.

The final two direct maternal causes of death are described below. Although each death was directly related to obstetrical complications of pregnancy, neither death was preventable.

Case number 1 was a transfer from an outside hospital. She suffered from severe vomiting, nausea, and weight loss. She developed aspiration pneumonia after an endoscopy at PCMH to explore the cause of her symptoms. A pneumothorax occurred following a bronchoscopy to explore airway status after the aspiration. This led to ARDS, followed by respiratory failure, then death.

Case number 8 was a transfer from an outside hospital. She suffered from systemic lupus erythematosus. She did not have hypertension but she developed peripartum cardiomyopathy. This was complicated by pulmonary embolism, and suffered from a cardiopulmonary arrest.

There were 5 indirect deaths over the 19-year study. Previously existing diseases such as sarcoidosis, AIDS, splenic artery aneurysm, diabetes, asthma,

Table 1. Direct maternal deaths.

Case	Age	Race	Gestation	Condition	Cause of Death	Preventable
1	27	AA	32 weeks	nausea/vomiting	ARDS-aspiration pneumonia	yes
2	37	AA	25 weeks	chronic hypertension, superimposed preclampsia	ARDS eclampsia	yes
3	26	AA	38 weeks	severe preeclampsia	coma, CVA, eclampsia	yes
4	27	C	33 weeks	PROM, pulmonary artery stenosis	retained placenta, DIC postpartum hemorrhage	yes
6	25	AA	23 weeks	severe preeclampsia, HELLP	eclampsia, DIC	yes
8	35	AA	20 weeks	SLE, cardiac arrhythmia	pulmonary embolism peripartum cardiomyopathy	no
9	29	AA	38 weeks	hypertension preeclampsia	pulmonary edema	yes
13	35	C	27 weeks	PROM, chorioamniontis	septic shock, DIC	yes
14	35	C	37 weeks	chronic hypertension, superimposed preeclampsia	bilateral uncal herniation, failed anesthesia	yes

Note: AA = African American, C = Caucasian, PROM = premature rupture of membranes, HELLP = HELLP syndrome (hemolysis, elevated liver enzymes, low platelets), SLE = systemic lupus erythematosus, ARDS = adult respiratory distress syndrome , CVA = cerebrovascular accident, DIC = disseminated intravascular coagulation.

and congenital heart disease (anomalous cardiac vessels) were worsened with the pregnancy. Two out of five, or 40% of these deaths, resulted in intrauterine fetal demise. These maternal and fetal deaths may have been prevented with better prenatal counseling and close supervision of the diseases throughout pregnancy. Today, a death associated with AIDS would probably be preventable because of effective antiviral therapy that prevents the progression of HIV infection to AIDS in most cases.

Case number 5 was a BSOM and PCMH patient with sarcoidosis, which led to pulmonary fibrosis and finally respiratory failure. She delivered a live infant by Cesarean section.

Case number 7 was a BSOM and PCMH patient infected with HIV who had developed AIDS. In addition to pneumocystis pneumonia, the patient developed preterm labor and PROM. She eventually expired from pulmonary complications after giving birth to a live infant by Cesarean section.

Case number 10 was a patient transferred to PCMH from an outside hospital. She suffered from severe asthma and chronic hypertension. After delivering a live infant by Cesarean section she had a severe asthma attack and expired from respiratory failure.

Table 2. Indirect maternal deaths.

Case	Age	Race	Gestation	Condition	Cause of Death	Preventable
5	38	AA	38 weeks	sarcoidosis	pulmonary fibrosis respiratory failure	no
7	32	AA	31 weeks	AIDS, PCP, PROM	respiratory failure	not at the time
10	34	AA	38 weeks	chronic hypertension severe asthma	respiratory failure	yes
15	35	H	33 weeks	class B diabetes mellitus morbid obesity	ruptured splenic artery aneurysm hemorrhagic shock	no
16	19	AA	38 weeks	congenital heart repair*	sudden cardiac death arterial anomaly**	no

Note: Key: AA = African American, H = Hispanic, AIDS = acquired immunodeficiency syndrome, PROM = premature rupture of membranes, PCP = pneumocystis pneumonia.
*Congenital heart repair: childhood surgically repaired fistula between circumflex and pulmonary arteries
**Arterial anomaly – anomalous origin of left main coronary artery

Table 3. Nonmaternal deaths.

Case	Age	Race	Gestation	Condition	Cause of Death	Preventable
11	30	C	30 weeks	neurofibroma glioblastoma	ruptured cerebral glioblastoma, coma	no
12	33	AA	35 weeks	severe weight loss, IUGR, PTL	metastatic pancreatic carcinoma	no

Note: AA = African American, C = Caucasian, IUGR = intrauterine growth restriction, PTL = preterm labor.

Case number 15 was a morbidly obese female who was transferred from an outside hospital. She suffered from class B diabetes and presented with what was originally thought to have been a placental abruption. However, the autopsy revealed a ruptured splenic artery aneurysm. Her baby was not delivered, and she expired from hemorrhagic shock.

Case number 16 was a PCMH patient who suffered from an unexpected sudden cardiac death. The patient had a congenital anomaly at the origin of the left main coronary artery. This fistula between her circumflex and pulmonary arteries was repaired when the patient was a child. She was cleared by cardiologists as capable of carrying a pregnancy safely.

These indirect maternal deaths were considered not preventable. In four cases the mothers had previously diagnosed medical conditions. Such conditions warrant adequate prenatal counseling on the risks of

pregnancy, but in the end it is the mother's decision to become pregnant or continue the pregnancy. In the splenic artery aneurysm case, there was no way to know of the vasculature defect. Such a defect is rare and while pregnancy worsens the aneurysm, no screening tools exist to detect that condition.

Finally, we found two nonmaternal deaths. Neither patient was counted in the maternal mortality rate as a maternal death. Instead, they are considered pregnancy-related deaths as defined in *Williams Obstetrics* as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death."[1] One patient died of a ruptured cerebral glioblastoma after being in coma, and the other patient died of metastatic pancreatic carcinoma. Neither of these deaths was believed to have been preventable. Case number 11 was transferred to PCMH from an outside hospital. The patient had a history of neurofibromatosis and was in coma due to a ruptured cerebral glioblastoma upon her arrival to the PCMH emergency department. Her fetus was not viable upon arrival at the emergency room and was not delivered. Case number 12 was also transferred from an outside hospital. She later expired from metastatic pancreatic carcinoma. She had suffered severe weight and muscle loss and had gone into preterm labor. Her fetus suffered from intrauterine growth restriction and was delivered live via spontaneous vaginal delivery.

The maternal mortality rate for African Americans was reported to be 30.5 deaths per 100,000 live births in 2003 by the Centers for Disease Control and Prevention (CDC).[6] In our study, 10 of the 14 maternal deaths were African-American patients for a maternal mortality rate of 52.3 deaths per 100,000 live births, roughly 1.7 times the national average. Six out of the 10 African Americans were transferred from outside hospitals, whereas the remaining 4 were PCMH patients.

Discussion

Our study of maternal deaths in eastern North Carolina showed a gross maternal mortality rate of 31 deaths per 100,000 live births. The adjusted maternal mortality rate following exclusion of nonmaternal deaths was 27.6 deaths per 100,000 live births, which is still two times higher than the national rate of 13.1 deaths per 100,000 live births.[2] The inclusion of late transfers to PCMH undoubtedly increased the mortality rate at our facility. Since we know only the birth figures and not the maternal mortality figures in our referring counties we cannot correct the data to obtain a regional maternal mortality rate. For the five subjects cared for at BSOM and PCMH, the mortality rate is 10 deaths per 100,000, slightly below the national rate. Also, the maternal mortality rate in our study may reflect a more precise method of finding maternal deaths. Several studies reported deficiencies in the use of the death certificate and vital statistics data alone in the calculation of maternal mortality rates.[7-9] The high maternal mortality in our population is also related to a high incidence of indigent pregnant women with less-than-optimal social, racial, and educational factors. Previous studies reported higher maternal mortality among indigent, African American, single women with <12 years of education than among middle-class, married, college-educated Caucasian women.[7-11] In this study the maternal mortality rate was 3.8 times higher in African American women than in Caucasian women. Lack of prenatal care was reported to be associated with increased maternal mortality in minority populations in one previous study.[12]

The leading causes of maternal mortality in the United States reported by the CDC between 1989 and 1990 were hemorrhage, pregnancy-induced hypertension, and infection.[11,12] A more recent report suggests a trend in which pulmonary embolism and cardiac disease are emerging as leading causes of maternal mortality.[13]

Improving maternal and perinatal outcome in severe preeclampsia and eclampsia requires prompt diagnosis and treatment. Also, outcomes are dependent on the severity of the disease and gestational age at the onset. Severe preeclampsia was a major cause of maternal morbidity and mortality in our region. Complicated or mismanaged cases caused most of the deaths. Patients with onset in the mid trimester and those with HELLP (hemolysis, elevated liver enzymes, and low platelet) syndrome and pulmonary edema are at significant risk for maternal morbidity and mortality.[14] Among the 9 direct maternal deaths in our study, 5 (56%) were related to preeclampsia, a treatable disease. Analysis of the records reveal that these women were not promptly diagnosed, medically managed, or had unnecessarily delayed delivery. This report calls for a need for establishment of more expeditious and aggressive management strategy for

treatment of pregnancy-induced hypertension.

In summary, it is clear that maternal mortality rate in this high-risk rural population with many African American and single women of lower socio-economic status is much higher than the mortality rate for patients receiving care at BSOM and PCMH. This study also confirms the previous reports that detailed review of maternal records reveals a much higher maternal mortality rate than that reported in vital statistics records.[7] It is also evident that misdiagnosis and mismanagement of serious conditions such as severe preeclampsia and eclampsia significantly contribute to increased maternal mortality rates. In this report we found the major problem was failure to diagnose and treat preeclampsia promptly. Because management of the severely preeclamptic or eclamptic patient requires the availability of neonatal and obstetric intensive care units and personnel with special expertise, we believe that severe preeclamptic and eclamptic patients should not be managed by health departments or at level I hospitals. These patients should be cared for only at level II or III hospitals with adequate facilities and with consultants from other specialties available. The referring physician should stabilize the patient's blood pressure and administer prophylactic measures for convulsions. Patients should be sent to the tertiary medical center in an ambulance with medical personnel in attendance. All maternal records, including prenatal data, should be sent with the patient. Some reports indicate that occurrence of eclampsia is not preventable in 30-40% of cases.[15] However; death from severe forms of preeclampsia should be preventable with appropriate care. Convulsions should not occur once the women with preeclampsia are admitted to the hospital and receive intravenous magnesium sulfate to lower blood pressure and are delivered expeditiously.[16] This therapeutic guideline remains the cornerstone in prevention of maternal mortality in women with severe preeclampsia and eclampsia. Most recent data from the largest collaborative trial supports the concept that magnesium sulfate therapy in women with preeclampsia reduces the risk of eclampsia and probably reduces the risk of maternal death.[17]

In conclusion, this study showed that many of the maternal deaths occurring in eastern North Carolina can be prevented. Greater effort to give appropriate prenatal counseling about the signs and symptoms of preeclampsia could help patients seek medical care earlier. Area practitioners should be more vigilant about early identification and treatment of women with preeclampsia and those with PROM to prevent maternal deaths.

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