



# Seven Year Evaluation of Maternal Mortality: Impact of Maternal and Fetal Disease

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## Abstract

We performed an institutional review of maternal mortality to identify risk factors, improve obstetric safety, and develop a template for institutional maternal death review citywide. There were fourteen cases of maternal mortality between 2008 and 2015. Autopsy reports and electronic medical records were reviewed. Causes of death varied widely, but three main themes arose in our cohort: pulmonary embolus following stillbirth, hemolysis elevated liver enzyme low platelet syndrome with eclampsia, and complications of human immunodeficiency virus. Barriers to institutional review included lack of standardized method of tracking medical records and differences in city, state, and institutional reporting of maternal death. Despite these barriers, with a standardized approach to maternal death review, we were able to identify a potential association between stillbirth, maternal death, and pulmonary embolism. Large, national epidemiological studies are urgently needed, as physicians have an opportunity to intervene with thrombosis prophylaxis after stillbirth if such prevention is indicated.

**Keywords:** Maternal mortality; Pregnancy; Postpartum period; Risk factors; Stillbirth

## Introduction

Maternal mortality, although rare, is a major public health concern. The national maternal mortality ratio (maternal deaths per 100,000 live births) was 17.8 in 2009 [1]. Within the United States there are racial disparities in maternal mortality, including a two to three times higher maternal mortality ratio in black women compared to white women [2-4].

The World Health Organization (WHO) has adopted the International Classification of Disease, 10<sup>th</sup> revision (ICD-10) definition of direct maternal death: death of a woman while pregnant or within 42 days of pregnancy, from any cause related to or aggravated by pregnancy [5]. The American College of Obstetricians and Gynecologists (ACOG) along with the Centers for Disease Control and Prevention (CDC) have suggested other terms for use by individual states or cities to improve surveillance [6]. These terms include pregnancy associated death: death of a woman while pregnant or within one year of termination of pregnancy irrespective of cause, and pregnancy related death: death of a woman while pregnant or within one year of termination of pregnancy from any cause aggravated by her pregnancy [6]. The United States has seen a recent increase in maternal mortality [4]. Current research indicates a larger percentage of pregnant women with hypertensive disorders, diabetes, and chronic heart disease who have increased risk for maternal morbidity and mortality [7-9].

In August of 2014, ACOG called for standardized institutional review of each case of severe maternal morbidity and mortality with the goal of aggregating de-identified data at the national level to implement statistical analysis and identify opportunities for maternal mortality prevention [10]. In fact, surveillance and inquiries into maternal death cases are examined yearly in the United Kingdom [11]. We implemented the ACOG recommendations and ACOG/CDC endorsed definitions for standardized institutional review of each case of maternal death at our institution since 2008. Our goal was to identify common risk factors, facility factors, including modifiable behaviors of health professionals, in order to improve obstetric safety, reduce severe maternal morbidity and mortality, and provide a template for institutional tracking of maternal death.

## Methods

We performed a detailed, retrospective chart review of all cases of maternal mortality at our

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**Table 1:** Cases of pregnancy related death 2008-2015.

Case No.	Age at delivery (years)	GA at delivery (weeks)	Gravidity	Parity	Race	Maternal Co-morbidity**	Mode of delivery	EBL (ml)	Type of anesthesia for delivery	ICU admission	Still birth	Placental pathology	Autopsy verified	Presumed Cause of death†
1	40	33	2	0	Black	Eclampsia, HELLP	Cesarean section	2000	General	Yes	No	Un-remarkable	No	DIC, HELLP, frontal lobe herniation
2	22	17	2	1	Black	Drug, tobacco, CHTN	NA	NA	None	Yes	No	NA	No	Wegener's respiratory acidosis
3	26	26/6	2	1	White	Drug, Tobacco, Eclampsia, HELLP	None	NA	None	Yes	Yes	Focal villous infarction, accelerated villous maturation	Yes	Escherichia coli sepsis, DIC, HELLP
4	30	35/0	1	0	Black	Eclampsia	Cesarean section	400	General	Yes	No	Focal villous infarction (20-25%), accelerated villous maturation with hypermature small villi	Yes	Cerebral Hemorrhage, HELLP
5	27	27	4	2	Black	CHTN	Cesarean section	3400	General	Yes	Yes	Focal villous infarction (<10%), focal acute maternal surface hemorrhage	No	Uterine rupture, cardiac arrhythmia, hemorrhagic shock
6	41	27/1	4	2	Black	Tobacco, CHTN	Repeat Cesarean section	800	Epidural	Yes	No	Chorio-amnionitis, accelerated villous maturation	No	Respiratory failure/ ARDS
7	49	26/0	2	0	Black	CHTN, Severe Pre-E	Vaginal Delivery	300	None	Yes	Yes	NA	No	Pulmonary embolus
8	19	NA	2	0	Black	Tobacco	NA	NA	NA	No	NA	NA	No	Thyroid storm
9	23	38/4	4	3	Black	Tobacco, HIV, HELLP	Repeat cesarean section	500	Epidural	Yes	No	Un-remarkable	Yes	Pulmonary arteriopathy from HIV, HELLP
10	34	39/1	11	4	Black	None	Repeat cesarean section	800	Epidural	No	No	Un-remarkable	Yes	Postpartum cardiomyopathy
11	37	27	3	2	Hispanic	None	Vaginal delivery	400	Epidural	No	Yes	Chorio-funicitis	Yes	Pulmonary embolus
12	35	38/2	1	0	White	None	Cesarean section	700	Epidural	No	No	NA	No	Suicide
13	40	39/1	2	0	Black	CHTN	Cesarean section	2500	Epidural	Yes	No	Un-remarkable	No	AFE
14	15	31/3	1	0	Black	Tobacco, HIV	Cesarean section	500	General	Yes	No	Un-remarkable	Green exudate on brain	Acute brainstem herniation secondary to brain edema

**Note:** NA: Not Available; GA: Gestational Age; BMI: Body Mass Index, kg/m<sup>2</sup>; HIV: Human Immunodeficiency Virus; CHTN: Chronic Hypertension; Pre-E: Pre-Eclampsia; HELLP: Hemolysis, Elevated Liver Enzymes, Low Platelets; EBL: Estimated Blood Loss; ICU: Intensive Care Unit; DIC: Disseminated Intravascular Coagulation; AFE: Amniotic Fluid Embolus; ARDS: Acute Respiratory Distress Syndrome

\*Pregnancy related death defined as death 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.

\*\*Co-morbidities include: Drug abuse defined as abuse of illegal drugs or alcohol, tobacco use, HIV, chronic hypertension, pregestational diabetes, pre-eclampsia, eclampsia, and HELLP.

†Cause of death verified with electronic medical record and autopsy report when available.

institution between 2008 and 2015. Our institution is a regional obstetric referral center responsible for over half of the deliveries that occur in the District of Columbia annually with approximately 3,400 deliveries per year. Demographic characteristics and information on intrapartum and postpartum events leading to each case of maternal death were collected from the electronic medical record. Autopsy results from the city Office of the Medical Examiner (ME) were reviewed when available. A single investigator served as a point of contact for collecting medical records and autopsy reports. Institutional review board approval was obtained prior to electronic medical record review.

Cases were included if maternal death occurred within our institution or documented within one year after a delivery of a live or stillborn infant regardless of the location of residence of the patient according to the ACOG/CDC definition of pregnancy associated death. We have an institutional practice of notification of maternal death through our risk management program with cases tracked by the department chairman. Included subjects were identified within the existing departmental database. Confirmation of mortality with the inpatient electronic medical record or autopsy report was required to be included in our review.

In order to statistically determine which pregnancy characteristics

were shared by the majority of subjects, we performed a two-tailed binomial test to examine if there was more than a 50% chance of a particular characteristic present among our cases of maternal death. The following pregnancy characteristics were examined: stillbirth, advanced maternal age, obesity defined as body mass index (BMI) over 30, pulmonary embolus, and history of drug abuse. A *p*-value <0.05 was considered significant.

### Case Series

We identified fourteen cases of pregnancy associated death between 2008 and 2015, ten of the fourteen cases were determined to be pregnancy related (case number 1, 3 through 7, and 10 through 13). Demographic characteristics, information on intrapartum and postpartum factors, and autopsy results from the Office of the Medical Examiner (ME) are presented in Table 1.

**Case 1:** Case 1 was a 40-year-old parida 0 at 33 weeks gestation, who presented by ambulance with slurred speech and change in mental status. She had eclampsia and head computer topography (CT) confirmed right frontal lobe hemorrhage with herniation. She underwent a stat cesarean section for fetal distress and developed disseminated intravascular coagulopathy (DIC) and hemolysis elevated liver enzyme low platelet (HELLP) syndrome; support was withdrawn at request of the family.

**Table 2:** Pregnancy characteristics present for fourteen cases of maternal mortality.

Pregnancy characteristic	Present	Not present	Unknown	p-value <sup>1</sup>
Stillbirth	4	9	1	0.267
AMA	6	8	0	0.791
BMI over 30	3	3	8	1.000
PE	2	12	0	0.013
History of drug abuse <sup>2</sup>	3	8	3	0.227

**Note:** AMA: Advanced Maternal Age; BMI: Body Mass Index, kg/m<sup>2</sup>; PE, Pulmonary Embolus

<sup>1</sup>Exact binomial probability from the two-tailed binomial test with 50% of chance to be the positive event.

<sup>2</sup>Drug abuse defined as abuse of illegal drugs or alcohol.

**Case 2:** Case 2 was a 22-year-old parida 1 at 17 weeks gestation with a history of chronic hypertension, drug and tobacco use, and Wegener’s granulomatosis who presented with chest pain, shortness of breath, and hemoptysis. She developed pulmonary hemorrhage, hypoxic respiratory failure, and shock during treatment for her underlying disease.

**Case 3, 5, 7, and 11:** Case 3, 5, 7, and 11 were all preceded by stillbirth. Case 3 was a 26-year-old parida 1 at 26 6/7 weeks gestation. She was found unresponsive by her spouse after 2 days of flu-like symptoms. Fetal demise was confirmed and the patient had an eclamptic seizure. She developed DIC, HELLP, and septic shock. Case 5 was a 27-year-old parida 2 at 27 weeks gestation with a history of morbid obesity, cesarean delivery, chronic hypertension, and deep vein thrombosis on therapeutic heparin who presented with sharp lower abdominal pain. There was no fetal cardiac activity, and she was taken to the operating room where uterine rupture was diagnosed. She developed peripartum hemorrhage and cardiac arrest. Case 7 was a 49-year-old parida 0 at 23 6/7 weeks gestation admitted for severe intrauterine growth restriction (IUGR) and absent umbilical artery end diastolic flow due to pre-eclampsia with severe features. She subsequently had a fetal demise at 25 5/7 weeks and delivered at 26 weeks gestation. The patient died of massive pulmonary embolus on the same day as delivery. Case 11 was a 37-year-old parida 2 at 27 weeks gestation who presented with decreased fetal movement and fetal demise. She had an induction of labor, vaginal delivery, and was discharged home. She was found unconscious by family four days after discharge. She had pulseless electrical activity and cardiopulmonary resuscitation was attempted. The patient was dead on arrival to the hospital with autopsy report confirming pulmonary embolus.

**Case 4:** Case 4 was a 30-year-old parida 0 at 35 weeks gestation who presented with eclampsia and HELLP syndrome and was brought by ambulance directly to labor and delivery. The patient was intubated and underwent stat cesarean section. Head CT confirmed brain herniation and there was absent cerebral flow on brain perfusion study; further resuscitation was declined by the family.

**Case 6:** Case 6 was a 41-year-old parida 2 who had an urgent cesarean section at 27 1/7 weeks gestation for chorioamnionitis, breech presentation, and preterm premature rupture of membranes. Her post-operative course was complicated by pneumonia. On post-operative day six she became hypoxic, requiring intubation and intensive care unit (ICU) admission. She developed pulmonary embolism, renal failure, and acute respiratory distress syndrome (ARDS). Care was withdrawn on post-operative day fifty-two.

**Case 8:** Case 8 was a 19-year-old parida 0 at 9 1/7 weeks gestation

who was admitted to the ICU with thyroid storm. She was treated and discharged home after four days on propylthiouracil and propranolol. Maternal death was secondary to thyroid storm at home on an unclear date.

**Case 9 and 14:** Case 9 and 14 were women with poorly controlled human immunodeficiency virus (HIV). Case 9 was a 23-year-old parida 3 at 38 4/7 weeks gestation who underwent scheduled repeat cesarean section. On post-operative day three, she developed lethargy and HELLP syndrome. She had an acute desaturation followed by seizure and asystole. She was unresponsive to attempts at resuscitation. Autopsy confirmed HIV related pulmonary arteriopathy. Case 14 was a 15-year-old parida 0 at 30 6/7 weeks gestation with a history of congenital HIV who presented with fever, mental status changes, and leukocytosis. She was started on ceftriaxone and vancomycin for presumed diagnosis of meningitis. Blood cultures grew *Streptococcus pneumoniae*. She later became unresponsive and was diagnosed with brainstem herniation. She had a peri-mortem emergent cesarean section productive of a viable infant.

**Case 10:** Case 10 was a 34-year-old parida 4 who underwent scheduled repeat cesarean at 39 1/7 weeks gestation with an uncomplicated postpartum course. She collapsed at home on post-operative day five and was found unresponsive; autopsy demonstrated unrecognized cardiomyopathy.

**Case 12:** Case 12 was a 35-year-old parida 0 with a history of severe depression on medication and receiving counseling who presented at 38 1/7 weeks gestation in active labor. She had a cesarean section for arrest of descent and was discharged on post op day three. Her cause of death was suicide at home on the day of discharge.

**Case 13:** Case 13 was a 40-year-old parida 0 at 39 1/7 weeks gestation presenting in active labor requiring an emergent cesarean delivery for fetal bradycardia. During the delivery, the patient became hypotensive with ventricular tachycardia and then pulseless electrical activity (PEA) with signs of DIC. She was transferred to the intensive care unit and underwent multiple episodes of cardiac arrest before becoming unresponsive to resuscitative measures. Final clinical diagnosis was amniotic fluid embolism.

Table 2 contains the results of statistical testing to determine whether any pregnancy characteristic occurred in the significant majority of our maternal mortality cases. None of the risk factors we evaluated were present more often among cases of maternal mortality.

## Discussion

During our standardized institutional review of maternal mortality, we found causes of maternal death varied widely. However, the following medical complications were identified as common themes in our case series: pulmonary embolus following stillbirth, HELLP syndrome with eclampsia, and complications of HIV. Without a previous structured system of retrieving records or appropriate tracking within our institution, much of the information surrounding each case of maternal death was either missing or unavailable.

Tracking maternal mortality is difficult in the District of Columbia (DC), where home of residence (Maryland or Virginia) rather than location of demise may be used to report maternal death. Mortality may also be underreported if pregnancy is not recognized as part of the patient’s recent care. For example, we were unable to include two cases of maternal mortality from our institutional risk management records since the report of maternal death could not be validated by

public record.

Four cases of maternal death were preceded by stillbirth, and two of these four deaths were due to pulmonary embolism. The clinical application of this finding is still in question. Numerous causes of stillbirth have been proposed including infection and acquired thrombophilia, which may predispose to thrombosis [12]. In one review of risk factors precipitating postpartum pulmonary embolism (PE), stillbirth had a strong association with PE (adjusted odds ratio 5.97) [13]. The etiology for increased risk of PE after stillbirth is unknown. Large epidemiological studies are lacking in the United States to confirm an association between stillbirth and maternal death.

We found several barriers to implementing a citywide standardized institutional review of maternal deaths. Differences in city and state reporting of maternal death make it difficult to track appropriate risk factors. Standardized institutional review of maternal death is limited without development of a systematic approach to obtain and query hospital records in a non-attribution fashion. Development of city or state maternal mortality committees, presently underway in DC, can facilitate record review and present guidance to the region on common themes or “red flags” concerning for potential mortality risk. We are currently working to improve maternal mortality review in DC by establishing standardized institutional maternal death tracking, addressing each case of maternal death with a multi-disciplinary root cause analysis, and establishing an institutional point of contact responsible for obtaining all available medical records for review by the institution and the Medical Examiner. It is important to note, even during implementation of our own institutional review, we were able to identify a potential association between stillbirth, pulmonary embolism, and maternal death. Larger, national epidemiological studies are urgently needed to investigate this association as we have ample opportunity to intervene after stillbirth with thrombosis prophylaxis to prevent postpartum pulmonary embolus.

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