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# Pregnancy-Related Deaths, Florida, 1999–2012: Opportunities to Improve Maternal Outcomes

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**Abstract** *Objectives* To examine pregnancy-related deaths (PRDs) in Florida, to identify quality improvement (QI) opportunities, and to recommend strategies aimed at reducing maternal mortality. *Methods* The Florida Pregnancy-Associated Mortality Review (PAMR) Committee reviewed PRDs occurring between 1999 and 2012. The PAMR Committee determined causes of PRDs, identified contributing factors, and generated recommendations for prevention and quality improvement. Information from the PAMR data registry, and live births from Florida vital statistic data were used to calculate pregnancy-related mortality ratios (PRMR) and PRD univariate risk ratios (RR) with 95% confidence intervals (CI). *Results* Between 1999 and 2012, the PRMR fluctuated between 14.7 and 26.2 PRDs per 100,000 live births. The five leading causes of PRD were hypertensive disorders (15.5%), hemorrhage (15.2%), infection (12.7%), cardiomyopathy (11.1%), and thrombotic embolism (10.2%), which accounted for 65% of PRDs. Principal contributing factors were morbid obesity (RR = 7.0, 95% CI 4.9–10.0) and late/no prenatal care (RR = 4.2, 95% CI 3.1–5.6). The PRMR for black women was three-fold higher (RR = 3.3, 95% CI 2.7–4.0) than white women. Among the five leading causes of PRDs, 42.5% had at least one clinical care or health care system QI opportunity. Two-third of these were associated with clinical quality of care, which included standards of care, coordination, collaboration, and communication. The QI opportunities varied by PRD cause, but not by race/ethnicity. *Conclusion* Gaps in clinical care or health care systems were assessed as the primary factors in over 40% of PRDs leading the PAMR Committee to generate QI recommendations for clinical care and health care systems.

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## Significance

Nationally, the contribution of traditional causes of pregnancy-related deaths (hemorrhage, hypertensive disorders of pregnancy, embolism) continued to decline, whereas that of cardiovascular conditions, including cardiomyopathy increased. Evidence shows that when clinical practice guidelines/protocols and policies are implemented systematically, adverse maternal outcomes are reduced significantly. In Florida, hypertensive disorders and hemorrhage remain the leading causes of pregnancy-related deaths. Hence, actions were taken by the Florida Perinatal Quality Collaborative to develop improvement initiatives–obstetric hemorrhage and hypertensive disorders in pregnancy-to educate and promote current evidence based practices with providers and their hospitals teams related to readiness, recognition, response, and reporting.

## Introduction

Although pregnancy-related death (PRD) is uncommon, current trends and evidence suggest that maternal mortality rates may be increasing in the United States (US) (Creanga et al. 2015). Leaders in obstetric medicine and public health have begun to increase the focus on maternal mortality and severe maternal morbidity in the United States (Hankins et al. 2012; D'Alton et al. 2013). One origin of this attention comes from reports comparing rates of maternal mortality and morbidity in the US to maternal mortality and morbidity rates of other developed countries (Kassebaum et al. 2014). The Global Burden Disease Study in 2013 states that during the period 2003 and 2013 only eight countries in the world had increases in maternal mortality and the US was one of them (Kassebaum et al. 2014). The 2010 Amnesty International Report states that black women in the US are three to four times more likely to die from pregnancy complications compared to white women (Amnesty International 2010).

Health care quality improvement (QI) initiatives and patient safety efforts need to focus on the impact of chronic disease on maternal health outcomes. Of special concern are the rising rates of obesity and cardiovascular disease among women of reproductive age (Berg et al. 2010). Yet, California, North Carolina, Illinois, and United Kingdom's maternal mortality reviews have found missed opportunities to make pregnancy and childbirth safer through health care and health care system changes and improvements for one-third to one-half of PRDs (Berg et al. 2005; Main et al. 2015; Cantwell et al. 2011; Geller et al. 2014). The United States Joint Commission on Accreditation of Health Care Organizations considers maternal deaths to be sentinel events that not only call attention to the status of maternal health in the population, but also may indicate gaps in care protocols, patient care coordination and management within health care and health care systems (The Joint Commission 2010). As such, occurrences of PRDs are indicative of the need to review and assess interactions between clinical care, health care systems, and patient/individual/ community that can influence maternal outcomes.

Since 1999, Florida's Pregnancy-Associated Mortality Review (PAMR) has reviewed PRDs and input review data and findings into the Florida PAMR registry (Burch et al. 2012). The purpose of this study was to analyze PRDs in Florida between 1999 and 2012 to identify contributing factors and missed opportunities, and to translate the findings into QI recommendations aimed at reducing maternal mortality.

## Methods

In 1996, the Florida Department of Health (FDOH) initiated the PAMR Committee to improve surveillance and analysis of PRDs in Florida. This study uses information accessed from the PAMR data registry pertaining to PRDs that occurred between January 1999 and December 2012. The purpose of PAMR is to identify QI opportunities in clinical care and/or health care systems, as well as, patient/individual/community factors contributing to PRD, and make recommendations to initiate strategies to improve maternal outcomes (Burch et al. 2012).

The identification of all pregnancy-associated deaths in Florida is the first step in the PAMR review process. Florida PAMR defines a pregnancy-associated death as "the death of a woman while pregnant or within 1 year of termination of pregnancy, irrespective of the cause of death." Details of the process that identifies pregnancy-associated deaths in Florida have been published previously (Burch et al. 2012). After pregnancy-associated deaths are identified, a physician, nurse, and epidemiologist subcommittee subsequently categorizes the cases based on complete information obtained from the woman's death certificate, and if applicable the fetal death or birth certificate. Cases are deemed by Florida PAMR as 'pregnancy-related', 'possibly pregnancy-related', or 'not pregnancy-related.' Only a small percentage of deaths are categorized as 'possibly pregnancy-related' and include deaths where the committee has questions (Burch et al. 2012). A PRD is defined as "a pregnancy-associated death resulting from: (1) complications of the pregnancy, (2) the chain of events initiated by the pregnancy that led to death, or (3) aggravation of an unrelated condition by the physiologic or pharmacologic effects of the pregnancy

that subsequently caused the death (Burch et al. 2012).” All PRDs are reviewed.

The pregnancy-related mortality ratio (PRMR) is defined as the number of PRDs per 100,000 live births (Creanga et al. 2015). Information from the PAMR data registry and live births from routinely reported birth certificate data were used to calculate PRMR by maternal demographics and health characteristics (Florida Department of Health, CHARTS). The PAMR Committee uses the Centers for Disease Control and Prevention’s recommended cause of death categories and assigns a primary cause of death for each reviewed case (Creanga et al. 2015). PRD cases were also classified and examined by available individual-level characteristics, such as race, Hispanic ethnicity, prenatal care history, source of delivery payment, and other factors found to be associated with pregnancy outcomes. Race and Hispanic ethnicity classifications were based on PAMR registry information collected from standard data sources (i.e., death, birth, or fetal death certificates, or prenatal risk screen). For this analysis, race/ethnicity was categorized as non-Hispanic white (hereafter referred to as white), non-Hispanic black (hereafter referred to as black), Hispanic, and non-Hispanic other race (i.e., Asian, Pacific Islander, American Indian, and Alaska Native; hereafter referred to as other race). Maternal age was grouped into four categories: 19 or younger, 20–24, 25–34, and 35 or more. Two individual-level characteristics, obesity status by body mass index (BMI) and delivery payment source were added to the Florida birth record in 2004; therefore, descriptive results for these two characteristics are only provided for the years 2004–2012. Pregnancy outcomes were classified as live birth, stillbirth, ectopic, abortion, molar, undelivered, or unknown. The timing of PRDs was classified as occurring during pregnancy/before delivery, occurring during delivery, or occurring after delivery during the postpartum period.

For each case reviewed, the PAMR Committee identified factors or issues that may have contributed to the woman’s death and proposed recommendations to address these issues where applicable. Some recommendations aligned with existing standards of care while others proposed changes or improvements to health care practice and systems of care. Issues and recommendations were aligned into one of four QI categories: clinical, health care system, individual/community, and death review factors. To identify the PRDs that had potential QI opportunities, the PAMR Committee post-reviews recommendations assigned to the five leading causes of PRD. Two obstetrical authors (KH, ID) independently reviewed identified contributing factors and panel recommendations related to clinical care and health care system QI categories, which applied to the majority PRD case recommendations. Based on their clinical judgment, the obstetrical authors designated committee recommendations that had a potential QI opportunity to prevent the maternal death. A third author (WS) moderated discussions to resolve any differences of opinion.

Data analysis was performed using SPSS version 17 software (SPSS Inc. Chicago, IL., USA). To assess differences between PRMR proportions by individual-level characteristics, Chi square ($\chi^2$) tests for proportions were conducted using the Open Epi-Epidemiologic calculator (Dean et al. 2015). This study did not require review by Florida Department of Health (FDOH) Institutional Review Board.

## Results

Between 1999 and 2012, a total of 2228 pregnancy-associated deaths were identified, and 785 (35.2%) of these cases identified as pregnancy-related and possibly pregnancy-related were forwarded for medical record abstraction. Of these, 12 cases were excluded due to inability to access records. After abstraction and review of 773 cases by the PAMR Committee, 561 deaths were deemed to be pregnancy-related. The remainder of this narrative focuses on the 561 PRD cases.

Between 1999 and 2012, the PRMR fluctuated between 14.7 and 26.2 PRDs per 100,000 live births. Florida PRMRs by total and race/Hispanic ethnicity are shown in Fig. 1. No significant trends were identified in total, black, and white PRMRs from 1999 to 2012. However, significant changes in single year PRMRs were noted for all three groups from 2008 to 2009 and for black mothers from 2011 to 2012. The higher PRMR in 2009 compared with previous years was associated with the 2009 H1N1 influenza pandemic [Centers for Disease Control and Prevention (CDC) 2011], and a sudden increase in an ectopic PRD [Centers for Disease Control and Prevention (CDC) 2012]. The unadjusted PRMR relative ratios by maternal characteristics of race/ethnicity, age, BMI, prenatal care, and mode of delivery are shown in Table 1. For each characteristic included in Table 1, the PRMR was higher for women who were obese, had received third trimester or no prenatal care, were 35 years or more,

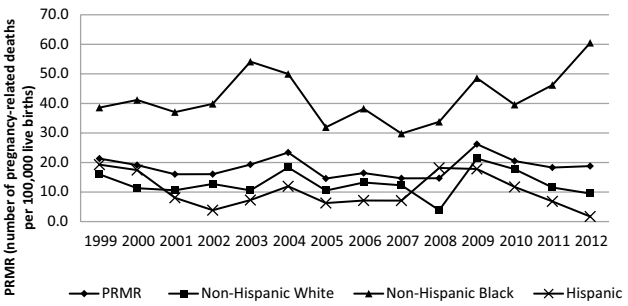


**Fig. 1** Pregnancy-related mortality ratios (PRMRs) by year and race/ethnicity, Florida, 1999–2012

**Table 1** Pregnancy-Related Mortality Ratios (PRMRs—Pregnancy-Related Deaths per 100,000 Live Births) and Unadjusted Relative Ratios, Florida, 1999–2012

| Characteristics | Pregnancy-related deaths | | Live births | | PRMR | Relative ratios | 95% CI |
|---|---|---|---|---|---|---|---|
| | N | % | N | % | | | |
| Race/ethnicity | | | | | | | |
| Non-Hispanic White | 183 | 32.6 | 1,429,521 | 47.6 | 12.8 | Ref | |
| Non-Hispanic Black | 279 | 49.7 | 663,822 | 21.8 | 42.0 | 3.3[d] | 2.7–4.0 |
| Hispanic | 82 | 14.6 | 810,258 | 26.7 | 10.1 | 0.8 | 0.6–1.0 |
| Other | 17 | 3.0 | 122,761 | 3.9 | 13.8 | 1.1 | 0.7–1.8 |
| Age | | | | | | | |
| 19 or younger | 30 | 5.3 | 322,445 | 10.6 | 9.3 | Ref | |
| 20–24 | 114 | 20.3 | 772,624 | 25.4 | 14.8 | 1.6[d] | 1.1–2.4 |
| 25–34 | 252 | 44.9 | 1,502,546 | 49.5 | 16.8 | 1.8[d] | 1.2–2.6 |
| 35 or more | 165 | 29.4 | 440,732 | 14.5 | 37.4 | 4.0[d] | 2.7–5.9 |
| Education | | | | | | | |
| Less than high school | 57 | 10.2 | 591,146 | 19.6 | 9.6 | 0.7[d] | 0.5–0.9 |
| High school | 292 | 52.4 | 978,614 | 32.4 | 29.8 | 2.1[d] | 1.7–2.5 |
| More than high school | 208 | 37.3 | 1,449,036 | 48.0 | 14.4 | Ref | |
| Marital status | | | | | | | |
| Married | 310 | 55.5 | 1,717,097 | 56.5 | 18.1 | Ref | |
| Unmarried | 249 | 44.5 | 1,319,936 | 43.5 | 18.9 | 1.0 | 0.9–1.2 |
| Prenatal care[a] | | | | | | | |
| First trimester | 227 | 61.4 | 2,279,153 | 80.7 | 10.0 | Ref | |
| Second trimester | 91 | 24.6 | 420,273 | 14.9 | 21.7 | 2.2[d] | 1.7–2.8 |
| Third trimester or none | 52 | 14.1 | 125,303 | 4.4 | 41.5 | 4.2[d] | 3.1–5.6 |
| Live birth order | | | | | | | |
| First | 165 | 34.7 | 1,261,640 | 41.7 | 13.1 | Ref | |
| Second | 144 | 30.3 | 972,738 | 32.1 | 14.8 | 1.1 | 0.9–1.4 |
| Third or more | 166 | 34.9 | 791,280 | 26.2 | 21.0 | 1.6[d] | 1.3–2.0 |
| Body Mass Index[b] | | | | | | | |
| Underweight (BMI < 20) | 17 | 4.9 | 94,290 | 5.1 | 18.0 | 1.7[d] | 1.0–2.9 |
| Normal (BMI 20–24.9) | 96 | 27.8 | 926,268 | 50.1 | 10.4 | Ref | |
| Overweight (BMI 25–29.9) | 87 | 25.2 | 453,251 | 24.5 | 19.2 | 1.9[d] | 1.4–2.5 |
| Obese class I (BMI 30–34.9) | 64 | 18.6 | 218,642 | 11.8 | 29.3 | 2.8[d] | 2.1–3.9 |
| Obese class II (BMI 35–39.9) | 36 | 10.4 | 95,250 | 5.1 | 37.8 | 3.6[d] | 2.5–5.3 |
| Obese class III (BMI of 40+) | 45 | 13.0 | 61,824 | 3.3 | 72.8 | 7.0[d] | 4.9–10.0 |
| Mode of delivery | | | | | | | |
| Vaginal | 137 | 33.3 | 2,013,625 | 66.4 | 6.8 | Ref | |
| Cesarean delivery[c] | 275 | 66.7 | 1,020,719 | 33.6 | 26.9 | 4.0[d] | 3.2–4.8 |
| Payment source | | | | | | | |
| Delivery paid by Medicaid[b] | 157 | 55.3 | 912,656 | 46.4 | 17.2 | 1.4[d] | 1.1–1.8 |
| Delivery paid by other sources | 127 | 44.7 | 1,056,251 | 53.6 | 12.0 | Ref | |

[a]Includes only deaths that occurred during the third trimester of the pregnancy, delivery, or postpartum

[b]Includes 2004–2012 data when prepregnancy weight and height and mode of delivery were added to the birth certificate

[c]Excluded 32 emergency cesarean deliveries

[d]$p < 0.05$

had a cesarean delivery, had a high school degree, had a live birth order third or more, and the delivery was paid by Medicaid.

During the 14-year period, five causes accounted for 362 of 561 (64.5%) PRDs (Table 2). The five leading causes of death were hypertensive disorders (15.5%), hemorrhage

**Table 2** Causes of pregnancy-related death by pregnancy outcome, Florida, 1999–2012[a]

| Causes of death | Outcome of pregnancy (% distribution) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total PRDs | PRDs % | PRMR | Live birth (n = 408) (%) | Stillbirth (n = 39) (%) | Ectopic (n = 27) (%) | Abortion (n = 25) (%) | Molar (n = 1) (%) | Undelivered (n = 57) (%) | Unknown (n = 4) (%) |
| Hypertensive disorders | 87 | 15.5 | 2.9 | 17.2 | 23.1 | 0.0 | 4.0 | 0.0 | 12.3 | 0.0 |
| Hemorrhage | 85 | 15.2 | 2.8 | 11.5 | 12.8 | 96.3 | 16.0 | 0.0 | 5.3 | 0.0 |
| Hemorrhage–Intrauterine Gestations | 59 | 10.5 | 1.9 | 11.5 | 12.8 | 0.0 | 16.0 | 0.0 | 5.3 | 0.0 |
| Hemorrhage–Ectopic | 26 | 4.7 | 0.9 | 0.0 | 0.0 | 96.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Infection | 71 | 12.7 | 2.3 | 12.3 | 25.6 | 0.0 | 32.0 | 0.0 | 1.8 | 50.0 |
| Cardiomyopathy | 62 | 11.1 | 2 | 13.2 | 2.6 | 0.0 | 12.0 | 0.0 | 7.0 | 0.0 |
| Thrombotic pulmonary embolism | 57 | 10.2 | 1.9 | 10.3 | 0.0 | 0.0 | 8.0 | 0.0 | 21.1 | 25.0 |
| Cardiovascular conditions | 48 | 8.6 | 1.6 | 8.3 | 7.7 | 0.0 | 4.0 | 0.0 | 17.5 | 0.0 |
| Amniotic fluid embolism | 36 | 6.4 | 1.2 | 8.1 | 5.1 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 |
| Cerebrovascular accident[b] | 18 | 3.2 | 0.6 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 |
| Anesthesia complications | 9 | 1.6 | 0.3 | 1.5 | 0.0 | 0.0 | 12.0 | 0.0 | 0.0 | 0.0 |
| Non-cardiovascular conditions[c] | 65 | 11.6 | 2.1 | 10.5 | 20.5 | 0.0 | 8.0 | 0.0 | 19.3 | 25.0 |
| Unknown | 23 | 4.1 | 0.8 | 2.9 | 2.6 | 3.7 | 4.0 | 100.0 | 12.3 | 0.0 |
| Total | 561 | 100.0 | 18.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

PRD stands for pregnancy-related deaths and PRMR stands for pregnancy related mortality ratio per 100,000 live births

[a]Causes of Death using CDC's defined categories

[b]Cerebrovascular accident without hypertensive disorders

[c]Noncardiovascular conditions comprise other cause of death categories (example: hematopoietic, collagen vascular diseases, metabolic, gastrointestinal disorders and other conditions) with < 3.0% of all PRDs

(15.2%), infection (12.7%), cardiomyopathy (11.1%), and thrombotic pulmonary embolism (10.2%). While hypertensive disorders, infection, and cardiovascular conditions were the leading causes of maternal deaths for white women, black women were more likely to die from hemorrhage, hypertensive disorders, and thrombotic embolism and Hispanic women were more likely to die from hemorrhage, hypertensive disorders, and infection.

Approximately half of the PRDs due to hypertensive disorders (n = 87) were caused by cerebrovascular hemorrhage 38/87 (43.7%). These cerebrovascular hemorrhage deaths were further subclassified as preeclampsia 13/38 (34.2%), eclampsia 14/38 (36.8%), and preexisting hypertension in pregnancy 11/38 (29.7%). Most PRDs due to hemorrhage (n = 59) excluding ectopics, were caused by uterine atony/postpartum bleeding 19/59 (32.2%), placenta accreta/increta/percreta 11/59 (18.6%), placental abruption 5/59 (8.5%) and retained placenta 5/59 (8.5%). Of the PRDs caused by infections (n = 71), nearly half were caused by generalized septicemia 33/71 (46.5%) and approximately one-third were caused by non-pelvic infection 21/71 (29.6%) (e.g., pneumonia and influenza).

The distribution of the leading causes of PRD varied by the timing of death (during pregnancy, delivery, or postpartum). Hemorrhage (primarily due to ectopic pregnancy) and thromboembolism were the primary leading causes of PRDs that occurred during pregnancy. Hemorrhage also was a prevalent cause of death for PRD cases that occurred during the delivery. Consistent with previous Florida PAMR reports, the PRDs from 1999 to 2012 that occurred postpartum, but prior to hospital discharge, revealed that the most common causes of death were still hypertensive disorders and hemorrhage. The most common causes of PRDs among women who were discharged from the hospital after delivery were cardiomyopathy, infection, and thrombotic pulmonary embolism (Florida Department of Health, PAMR). The peak time period for PRDs due to infection and thrombotic pulmonary embolism were 8–42 days after delivery. PRDs due to cardiomyopathy were more likely to be remote from delivery, 43–365 days postpartum.

For each case review, the PAMR Committee identified issues and made recommendations aimed at potential reduction and prevention of PRDs. Of the reviewed PRD cases, 76.1% had at least one PAMR Committee recommendation. The majority (59.2%) of PAMR Committee issues and recommendations were associated with clinical quality of care, which includes standards of care, coordination, collaboration, and communication. Fifteen percent (15.0%) of the recommendations were in the health care system category, which relates to the development or implementation of standards of care, policies, and procedures. The individual and community factors category accounted for 9.0% of the PAMR Committee's recommendations (Table 3). Seventeen percent of the PAMR Committee recommendations addressed factors with the death review process, which includes the recommendations to perform an autopsy on all PRDs with unknown or unexplained causes of death and the recommendation for accurate completions of death certificates. Factors associated with death review process are informational and not prevention opportunities.

Of the 362 cases that were attributed to the five leading causes of PRD, 154 cases (42.5%) had at least one identified clinical or health care system quality care issue that was assessed to be potentially preventable. Two-thirds of these cases were associated with clinical quality of care, which includes standards of care, coordination, collaboration, and communication. Although black women have an increased rate of PRD, the proportion of preventable QI opportunities was similar by race/ethnicity. (Table 4).

## Discussion

In Florida, hypertensive disorders, hemorrhage, infection, cardiomyopathy, and thrombotic pulmonary embolism were the five leading causes of PRDs between 1999 and 2012. Among the five leading causes of PRDs, 43% had at least one major health care or system QI opportunity, and in over two-thirds of these cases quality of health care delivery was considered to be the most important factor. The QI opportunity varied by causes of PRD, but not by race/ethnicity.

For the period 1999–2012, the Florida's PRMR of 18.5 per 100,000 live births was higher than the national PRMR of 16.0 per 100,000 live births, from 2006 to 2010 (Creanga et al. 2015). However, both in Florida and nationally, black women had a three-fold higher risk of PRDs compared with other racial and ethnic groups (Creanga et al. 2015, 2012). For specific causes of mortality (e.g., ectopic pregnancy), this gap between racial and ethnic groups appears to be even greater [Centers for Disease Control and Prevention (CDC) 2012, Creanga et al. 2011].

National and state-level maternal death reviews report the percentage of PRDs caused by hemorrhage and hypertensive disorders of pregnancy have decreased, while PRDs attributable to cardiovascular conditions (including cardiomyopathy), have increased (Creanga et al. 2015; Berg et al. 2005; New Jersey Maternal Mortality Review 2009–2013). However, a 2014 study conducted by the Hospital Corporation of America, an entity that operates a large number of acute care facilities in the United States, reported that disease-specific protocols were favorable in the reduction of maternal death due to hypertensive disorders and postoperative pulmonary embolism, but not from hemorrhage, suggesting that additional efforts are necessary (Clark et al. 2014). In the United States, the most striking decrease for a specific pregnancy-related cause of death has been for deaths caused by

**Table 3** PAMR Committee Recommendations for the five leading causes of pregnancy-related death by quality improvement category, Florida, 1999–2012

| Prevention category | Recommendations |
|---|---|
| Hypertensive disorders | |
| Clinical factors | All pregnant women with preeclampsia and a systolic blood pressure of 160 mmHg or more, a diastolic blood pressure 110 mmHg or more, require urgent and effective anti-hypertensive treatment in line with the recent guidelines from ACOG Task Force on Hypertension in Pregnancy 2013 |
| | Maintain vigilance in monitoring for pulmonary edema in patients with preeclampsia and treat these patients aggressively |
| | Assure that patients placed on hypertensive medication during a hospitalization demonstrate a stable blood pressure prior to discharge |
| | Consider low dose of Aspirin (ASA) 81 mg a day for pregnant women with high risk of developing preeclampsia |
| | Screen women for a previous history of preeclampsia, pre-existing diabetes, high blood pressure, advanced maternal age, and obesity to recognize a patient at risk for hypertensive disorders |
| Systems factors | ACOG District XII and Florida's Perinatal Quality Collaborative should consider developing and implementing a quality improvement project aimed at treatment of hypertensive disorders |
| Individual and community factors | Medical providers should increase patient awareness about the significance of shortness of breath and headache by including this as a warning sign in postpartum discharge instructions |
| Hemorrhage (intrauterine gestations) | |
| Clinical factors | Develop a comprehensive hemorrhage protocol including a hemorrhage cart with key equipment and a massive transfusion protocol in every birthing facility. Medical personnel should practice hemorrhage drills on labor and delivery and promote a team approach. Implemented through statewide Obstetric Hemorrhage Initiative (OHI) |
| | Prepare the multidisciplinary medical team for planned delivery of patients with potential for placenta accreta, placenta previa, and previous cesareans delivery. Patients/family should be educated about the increased risk of hemorrhage |
| | Provide specialized counseling to patients and family members with religious views against blood transfusions |
| | Florida's Perinatal Quality Collaborative should consider developing and implementing a quality improvement project aimed at treatment of obstetric hemorrhage. Implemented through statewide Obstetric Hemorrhage Initiative (OHI) |
| Hemorrhage (ectopic) | |
| System factors | Establish protocols for women presenting to the emergency room with abdominal pain and anemia to be evaluated for ectopic pregnancy |
| Individual and community factors | Raise community awareness about the need to seek prompt medical attention for women of reproductive age experiencing abdominal pain |
| Infection | |
| Clinical factors | Be aware that a change in mental status in pregnant and postpartum women may be a sign of sepsis or hypoxia |
| | High dose intravenous broad-spectrum antibiotic therapy should be started within the first hour of recognition of septic shock and severe sepsis without septic shock, as each hour of delay in achieving administration of effective antibiotics is associated with a measurable increase in mortality |
| | Perform electrolyte studies in patients with gastrointestinal problems |
| System factors | Ensure all pregnant women are immunized for influenza. Establish practice standards for assessment and treatment of patients suspected of having influenza |
| Death review factors | Perform an autopsy on cases of complicated sepsis with unknown trigger |

**Table 3** (continued)

| Prevention category | Recommendations |
|---|---|
| Cardiomyopathy | |
| Clinical factors | Perform cardiac evaluations of pregnancy or postpartum women with shortness of breath, including echocardiography and chest x-rays. |
| | Educate emergency department staff to recognize postpartum cardiomyopathy. |
| | Improve awareness of symptoms related to cardiac disorders in high-risk patients, especially those with a personal or family history of cardiac disease. |
| | Increase access to preconception care for women with peripartum cardiomyopathy |
| Thrombotic pulmonary embolism | |
| Clinical factors | VTE prophylaxis for all patients undergoing cesarean delivery with pneumatic compression devices, or low molecular weight heparin in high-risk patients |
| | Consider VTE prophylaxis during pregnancy in some high-risk patients who have chronic illnesses associated with an increased risk of thrombosis, such as the morbidly obese |
| General | |
| Clinical factors | Raise awareness among health providers on the importance of screening and educating all women of childbearing age at every health care visit for risk factors that may affect pregnancy outcomes |
| | Promote family planning services especially among those with chronic illnesses to optimally time pregnancy to reduce morbidity and mortality |
| | Establish guidelines for safe parameters of exercise among morbidly obese pregnant and postpartum women |
| | Screen all pregnant women for substance abuse, partner violence, and depression |
| | Perform baseline cardiac and respiratory assessment at the initial prenatal visit to identify women at risk for potential pregnancy complications |
| | Providers should be aware of the risks associated with induction of labor and cesarean delivery with special consideration to co-morbid factors of obesity and chronic illnesses |
| | Consider planned delivery of patients with cardiac disease |
| | Importance of a delivery care plan for high risk women with the potential for cesarean, hysterectomy, and hemorrhage due to factors such as extensive fibroids and prior uterine rupture |
| | Improve linkage and coordination of care between tertiary hospitals and smaller hospitals |
| | Raise awareness among health providers of the importance of postpartum management of diabetes. |
| | Women on seizure medications should be made aware that dosages might require alteration during pregnancy |

**Table 3** (continued)

| Prevention category | Recommendations |
|---|---|
| System factors | Be aware of pregnant women not accessing care due to lack of insurance |
| | Prenatal care providers should assess whether transportation barriers may preclude a woman from accessing high-risk specialty care |
| | Birthing facilities should provide comprehensive and effective delivery of postpartum discharge instruction |
| | Birthing facilities should ascertain the adequacy of staff training and equipment to handle medically complicated pregnant patients upon their arrival in labor and delivery and have policies in place for transfer to a higher level of care when indicated |
| | Licensed abortion clinics need to hold drills that address management of complications |
| | Closely monitor a patient's vital signs. Implementing systems such as the United Kingdom's Modified Early Obstetric Warning System (MEOWS) may serve as a quick alert to potential changes in a patient's health status |
| Individual and community factors | Educate women on the optimal inter-birth interval and the risk of short pregnancy intervals |
| | Discharge instructions should be comprehensive, individualized, and offered to mothers/partners/families. |
| | Raise awareness in the community that substance use and abuse can compound physical conditions and may mask signs of serious medical conditions |
| | Women with complex medical issues should be aware of the risk of pregnancy |

hemorrhage, despite an increase in cases of postpartum hemorrhage caused by uterine atony (Berg et al. 2010; Callaghan et al. 2010; Campbell et al. 2013; Creanga et al. 2014). Shifts seen in the US causes of PRD were not observed in Florida; hypertensive disorders and hemorrhage have remained the leading causes of Florida PRDs. The significant increase in ectopic pregnancy-related deaths in 2009 was not mirrored nationally [Centers for Disease Control and Prevention (CDC) 2012, Creanga et al. 2011]. After further study, it was found that the increase in Florida's ectopic mortality in 2009 was associated with drug use and patient delays in accessing health care [Centers for Disease Control and Prevention (CDC) 2012]. In addition, Florida's overall PRMR has not increased significantly between 1999 and 2012.

Reports from various maternal mortality reviews have found that an increasing percentage of PRDs are associated with cardiovascular conditions and other chronic diseases (Berg et al. 2005; Main et al. 2015; Cantwell et al. 2011; Geller et al. 2014, New Jersey Maternal Mortality Review 2009). Similar to select state, national, and international findings, chronic medical conditions contributed greatly to PRD in Florida (Creanga et al. 2015; Berg et al. 2005; Cantwell et al. 2011). The combination of older maternal age (35 or more) and obesity was associated with increased rates of underlying medical problems, especially hypertension, diabetes, and cardiac disease. These underlying medical problems also contributed to the rise in obstetric interventions (e.g., labor inductions, cesarean delivery) and occurrence of obstetric hemorrhage, which in turn additionally contributed to higher risks of maternal mortality (Bodker et al. 2009; Callaghan and Berg 2003; Deneux-Tharaux et al. 2006).

Among Florida reviewed cases due to one of the five leading causes of PRD death, 43% had at least one potential QI opportunity identified. Similarly, population-based studies in North Carolina, California, and the United Kingdom Confidential Enquiry maternal mortality report found 30–40% of maternal deaths identified had one major QI opportunity (Berg et al. 2005; Main et al. 2015; Cantwell et al. 2011; Geller et al. 2014). Despite different review approaches and assessments of identified QI opportunities, all referenced maternal death reviews found that potential QI opportunities varied by PRD cause. PRDs due to intrauterine hemorrhage and preeclampsia presented moderate-to-strong opportunities for QI impact, while PRDs from ectopic hemorrhage, cardiomyopathy, infection, and thrombotic embolism presented good-to-moderate opportunities for QI impact.

Our findings and implications for maternity care were similar to both hospital- and population-based studies: (1) most of the deaths occurred soon after delivery and in a health care facility, (2) most women had identifiable contributing risk factors, and (3) one-third to one-half of the deaths had a good-to-strong potential opportunity for QI to improve maternal outcomes. The QI opportunities identified by Florida PAMR were also similar to QI opportunities

**Table 4** The five leading causes of pregnancy-related death and percentage of potential quality improvement opportunities by race/ethnicity, Florida, 1999–2012

| Cause of death | Total | | Non-Hispanic White | | Non-Hispanic Black | | Hispanic | |
|---|---|---|---|---|---|---|---|---|
| | PRDsa | % QI opportunities (%) | PRDs | % QI opportunities (%) | PRDs | % QI opportunities (%) | PRDs | % QI opportunities (%) |
| Total | 362 | 42.5 | 103 | 41.7 | 199 | 43.2 | 53 | 39.6 |
| Hypertensive disorders | 87 | 52.9 | 27 | 51.9 | 46 | 54.3 | 14 | 50.0 |
| Intrauterine Hemorrhage | 59 | 55.9 | 14 | 64.3 | 31 | 51.6 | 11 | 45.5 |
| Hemorrhage-ectopic | 26 | 38.5 | 6 | 33.3 | 15 | 46.7 | 4 | 25.0 |
| Infection | 71 | 33.8 | 25 | 28.0 | 31 | 32.3 | 13 | 46.2 |
| Cardiomyopathy | 62 | 37.1 | 18 | 44.4 | 38 | 34.2 | 6 | 33.3 |
| Thrombotic embolism | 57 | 31.6 | 13 | 23.1 | 38 | 39.5 | 5 | 0.0 |

[a]The total count includes the count of non-Hispanic other and will not equal the sum of the race/ethnicity counts shown on the table. Non-Hispanic other is not shown on the table due to small numbers

identified by other state and United Kingdom maternal death reviews. These QI opportunities include: (1) timely diagnosis and evidence-based treatment of specific clinical conditions; and (2) recognition and response to clinical triggers that show change in clinical status, specified by a need to implement use of a Modified Early Obstetric Warning System (MEOWS) chart for all pregnant or postpartum women, especially those who become ill and require obstetric or emergency services (Cantwell et al. 2011).

The Florida PAMR process has four major strengths. The first strength is that Florida PAMR is based in the Maternal and Child Health (MCH) Title V program within the FDOH and partners with ACOG District XII, which provides structure for the process and promotes implementation of recommendations for QI. PAMR is also now closely tied to Florida's Perinatal Quality Collaborative (FPQC). Second strength is the comprehensive process of case ascertainment (that uses linked prenatal risk screens, birth and death records), medical record abstraction, and case review. Third strength is that over a 14-year period, the Florida PAMR committee has reviewed a relatively large number of deaths compared to other state-based reports (Main et al. 2015; Cantwell et al. 2011). In addition, Florida PAMR-enhanced surveillance presents additional, more recent and consistent data, including data on obesity that is not currently possible with a national report of PRDs (Creanga et al. 2015). Fourth strength of the Florida PAMR process is a review committee that comprises a multidisciplinary team of professionals who are familiar with health care in Florida. During the course of the PAMR reviews, a number of important assessments involve medical, behavioral, economic and social factors.

The limitations of this study are that some PRD cases were not included in the PAMR process due to incomplete information that prevented full medical record abstraction or PAMR review. Examples of information that may have been missing or incomplete include death certificate information; lack of autopsy; in-depth information on preconception health, chronic medical conditions and other life factors due to no or limited data sources, such as family and staff interviews and historical health records.

The Florida PAMR review process confirms the importance of an ongoing, state-based identification and review of PRDs in order to monitor and improve the quality of care (Burch et al. 2012). Findings from maternal mortality reviews have been transformed into QI recommendations as demonstrated in pregnancy-related reports from Florida, California, Illinois, New Jersey, the United Kingdom Confidential Enquiry into Maternal Deaths, and the Joint Commission Sentinel Event Report on Maternal Mortality (Cantwell et al. 2011; Geller et al. 2014; The Joint Commission 2010; Burch et al. 2012; Clark et al. 2014). There is evidence that the recommendations of these maternal mortality reviews are having an impact on clinical practice and that practicing clinicians have adopted many of the suggested changes (Clark et al. 2014). Florida PAMR reviews also have the potential to identify QI opportunities across institutions and settings, and guide obstetric initiatives to reduce maternal mortality. Hence, actions were taken to develop two state-wide initiatives, first obstetric hemorrhage, and then hypertensive disorders in pregnancy by the Florida Perinatal Quality Collaborative (FPQC). The findings from Florida's PAMR were used in selecting these causes of death as priorities to be addressed by the FPQC, planning the initiatives, and educating providers about these issues in Florida.

In conclusion, Florida health care systems need to continue to explore opportunities to reduce pregnancy-related mortality and improve maternal health outcomes based on Florida PAMR and other maternal review findings and recommendations. Florida health care systems also need to explore evidence-based strategies to assure optimal

reproductive and preconception health care for all women, including continuing care beyond the traditional postpartum period, especially for women with chronic medical conditions. There needs to be a strengthening of perinatal systems to provide risk-based maternal care similar to measures being taken to strengthen perinatal care. Of equal importance, there must be continued support of the PRD review process that provides ongoing opportunities to improve maternal outcomes as demonstrated by Florida PAMR.

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**Compliance with Ethical Standards**

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