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Overcoming barriers to the implementation of early warning systems to reduce the maternal mortality rate in the United States of America

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Introduction

Over the past several decades the United States' Healthcare System has made drastic improvements in providing patient care and lowering the overall mortality rate (Center for Disease Control and Prevention (CDC), 2020a, para. 1). However, while the U.S. has drastically decreased the annual death rate for the general population, the Maternal Mortality Rate (MMR) has been increasing steadily since 1987, when the CDC implemented the Pregnancy Mortality Surveillance System (Freidman et al., 2018). Since then, the United States MMR has nearly doubled from 12.4 deaths per 100,000 live births in 1990 (Neggers, 2016) to 29.6 deaths per 100,000 live births in 2019 (United Health Foundation (UHF), 2020).

There is no singular cause for the increase in maternal deaths. Rather, researchers have tied the increase to several medical conditions and external factors such as increased rate of cesarean section deliveries, low socioeconomic status, race, increased maternal age, and improved documentation of maternal death. (Hayes et al., 2019, para. 2). In an effort to combat the rising MMR, researchers began developing obstetric Early Warning Systems (EWS). The purpose of these systems is to use a series of vital sign ranges and assessments to detect the earliest signs that a woman is developing a potentially fatal condition related to her pregnancy, and thereby initiate early intervention to prevent morbidity and mortality (Umar et al., 2019). The EWS have been proven to be beneficial in increasing the successful detection of life-threatening complications and, therefore, lowering the maternal mortality rate in participating facilities (Zuckerwise & Lipkind, 2017). Unfortunately, these influential systems have not been widely implemented in United States hospitals due to barriers such as a lack of administrative support, poor interdisciplinary communication, insufficient education and training of the healthcare team, concerns about the cost of implementations, and lack of access to tools needed

for implementation (Friedman et al., 2018). If a pathway can be opened up to efficiently, affordably, and successfully implement EWS in U.S. hospitals then it is believed that the United States may begin to see a decrease in the nation's MMR.

The purpose of this study is to evaluate the use of obstetric EWS in U.S. hospitals and to identify the barriers that prevent the implementation of these systems. Using a qualitative approach, phone interviews were conducted with six labor and delivery nurses across the United States to evaluate their use of obstetric EWS in current maternal care.

Definitions and Abbreviations

The MMR is often confused with the Pregnancy-Related Mortality Rate. For clarification, the Maternal Mortality Rate, as defined by the World Health Organization, is,

> The death of a woman within 42 days of termination of a pregnancy, irrespective of duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes (World Health Organization [WHO], 2014, para. 2).

Alternatively, the Pregnancy-Related Mortality Rate is,

> The death of a woman while pregnant or within one year of the end of a pregnancy-regardless of the outcome, duration, or site of the pregnancy-from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes (CDC, 2020b, para. 2).

As researchers found new ways to address the rising MMR, they began to create a series of obstetric EWS. Each of these EWS fit under one of two categories: a single parameter system or an aggregate-weighted scoring system. Mhyre et al. (2014) explained that,

> Single parameter systems define abnormal thresholds for a list of physiologic parameters (e.g., heart rate); bedside medical evaluation is indicated when any single parameter is measured as abnormal. In contrast, aggregate-weighted scoring systems are multiparameter assessment tools in which nurses assign a score based on the degree of physiologic derangement for each measured parameter; the total score for all measured parameters is used to determine the likelihood of deterioration and the need for bedside medical evaluation (p. 772).

The three main EWS focused on for this research study includes the Modified Early Obstetric Warning System (MEOWS), the Maternal Early Warning Criteria (MEWC), and the Maternal Early Warning Triggers (MEWT). The *UK Saving Mother's Lives* report proposed the MEOWS, which is a checklist consisting of two sets of vital sign ranges for respiration rate, oxygen saturation, temperature, systolic blood pressure, diastolic blood pressure, heart rate, pain score, and neurologic response (Friedman et al., 2018). The first set of ranges is for a yellow alert, or a moderately concerning measurement (Friedman et al., 2018). The second set of ranges signifies a red alert, or a seriously concerning measurement (Friedman et al., 2018). Either one red alert or two yellow alerts must be present to initiate emergent examination by a clinician (Friedman et al., 2018). MEWC, proposed by the National Partnership for Maternal Safety, is a simplified adaptation of the EWS MEOWS (Friedman et al., 2018). This system uses only red alert triggers, no yellow alerts are included in the scale (Friedman et al., 2018). In order for this EWS to be activated the patient need only have one red alert symptom (Friedman et al., 2018). Finally, Dignity Health System and other United States hospitals use the MEWT system (Friedman et al., 2018). This system separates itself from the other EWS by, "categorize[ing] alerts into diagnostic pathways for conditions such as sepsis, cardiopulmonary conditions,

hypertensive disorders, and obstetric hemorrhage, and provides diagnostic and management recommendations based on parameters" (Friedman et al., 2018, p. 3). While this EWS is activated through one red alert or two yellow alerts, like MEOWS, it is unique in that MEWT requires that an abnormal measurement be sustained for a certain amount of time before the system is activated and a clinician is alerted (Friedman et al., 2018).

Background/ Literature Review

The United States has the highest MMR in the developed world at 29.6 deaths per 100,000 live births (United Health Foundation, 2020). To provide reference for just how high this number is, statistics from *The Lancet* show the MMR for all other developed countries, with Finland having the lowest MMR in the world at 3.8 deaths per 100,000 live births (Alkema, 2016, p. 11). Within the United States, Alaska has the lowest MMR at 12.4 deaths per 100,000 births in 2019 (United Health Foundation [UHF], 2020). The state of Louisiana has the highest MMR in the U.S at 72 deaths per 100,000 live births (UHF, 2020). Tennessee's rate is higher than the national average at 35.8 deaths per 100,000 live births (UHF, 2020). With such staggering differences in MMR between the United States and the rest of the developed world, many have tried to understand why the U.S. MMR is so high. Unfortunately, there is no uniform trend that explains the United States' MMR increase (Callister & Edwards, 2017, p. 57). Each state has unique leading medical causes for maternal mortality as well as disparities in the population of different racial groups and socioeconomic groups. In this literature review it was found that some of the most common factors contributing to the increasing MMR in the United States include race, low socioeconomic status, increasing maternal age, irregular execution of early detection tools, and discrepancies in identification and classification of maternal deaths in the United States (Friedman et al, 2018). Obstetric EWS were created so that, regardless of

background, ability to pay, and race, all patients receive the same level of care and intervention. For the safety of all maternal patients, it is critical that the barriers preventing the implementation of these systems be overcome. The at-risk populations as well as the barriers of implementation must be explored and known in order to begin the process of reducing the overall mortality rate in the United States.

Classifying Maternal Deaths

Prior to 2003, the United States had no established, standardized method for documenting maternal causes of death, and several studies had found significant underreporting of maternal deaths through the National Vital Statistics system (Horon, 2005). To improve the United States' documentation of maternal death and to better understand how the rates are changing, the National Center for Health Statistics developed a revision to the standard death certificate in 2003 (Center for Disease Control and Prevention (CDC), 2001). This revision included a series of checkboxes that categorized a death as, "not pregnant within the past year; pregnant at the time of death; not pregnant, but pregnant 43 days to 1 year before death; or unknown if pregnant within the past year" (CDC, 2001, p. 150).

Despite this addendum being put into effect in 2003, only four states revised their death certificates to include the revision in that year (MacDorman et al., 2016). By the end of 2014 only 46 states and Washington D.C. had adopted the revised death certificate (MacDorman et al., 2016). The states not using the revised death certificate include Alabama, Colorado, Maryland, and California (MacDorman et al., 2016). California decided to use a single question asking about pregnancy of the deceased within the past year instead of the revised death certificate (MacDorman et al., 2016).

To better illustrate how improved documentation of maternal death can impact the national MMR, MacDorman et al. (2016) calculated the unadjusted MMR and adjusted MMR. The unadjusted calculation resulted in numbers that did not have the underreporting factors included whereas the adjusted calculation shows what the MMR would have been with the revised death certificate in the years prior to its implementation (MacDorman et al., 2016). The unadjusted data showed an increase in MMR from 9.8 deaths per 100,000 live births in 2000 to 21.5 deaths per 100,000 live births in 2014 (MacDorman et al., 2016). The adjusted data showed an increase in MMR from 18.2 deaths per 100,000 live births in 2000 to 22.8 deaths per 100,000 live births in 2014 (MacDorman et al., 2016). The researchers estimate that 20.1% of the increase was due to a real increase in maternal mortality and that the other 79.9% of increase was due to more accurate recording of maternal death (MacDorman et al., 2016). Though the increase is smaller for the adjusted calculation, it shows that the MMR in the United States prior to the broader implementation of the revision was significantly lower than the adjusted data. It also shows that, though the rise in MMR is smaller for the adjusted rate, the MMR is increasing and that maternal deaths over the past several years have been seriously underreported.

Some states showed drastic increases in MMR following the implementation of the revised birth certificate. For example, Texas adopted the revised death certificate in 2006 and its MMR rose only slightly from 17.7 in 2000 to 18.6 in 2010 (MacDorman et al., 2016). However, from 2010-2012, Texas saw its MMR nearly double moving from 18.6 in 2010 to 35.8 in 2012 (MacDorman et al., 2016). The researchers are not entirely sure why such an unprecedented increase in MMR occurred in Texas over these two years, but they believe improved documentation of maternal death played a large role, as did the closure of several maternal health clinics in 2011 (MacDorman et al., 2016).

It is essential that the entirety of the United States follow an established, standardized method for documenting maternal death. Proper documentation allows researchers and healthcare professionals to better understand the severity of the issue and the main causes of maternal death. It also demonstrates to healthcare personnel and hospital administrators the dire need for the establishment of obstetric EWS in U.S. hospitals and birthing centers. Understanding the causes of death and identifying the at-risk populations will aid in the development and implementation obstetric EWS, which can play a major role in changing the narrative of maternal death in the United States.

Race

Race is one of the most prominent discrepancies found when investigating maternal mortality within the United States. According to the National Partnership for Women and Families (NPWF) (2018), "black women are more likely to experience preventable maternal death compared with white women" (p. 2). This is due to several contributing factors such as black women's predisposition to certain health conditions, racism and sexism that black women experience throughout their lives, and access to healthcare and education (NPWF, 2018). It has been found that, "black women are three times more likely to have fibroids…than white women, and the fibroids occur at younger ages and grow more quickly for black women. Black women display signs of preeclampsia earlier in pregnancy that white women" (NPWF, 2018, p. 2). Coupled with black women's predisposition to certain health deviations is the reality that the stresses faced uniquely by black women further deteriorate their health and their access to health care. Through their research, the NPWF found that, "black women experience physical 'weathering,' meaning their bodies age faster than white women's due to exposure to chronic stress linked to socioeconomic disadvantage and discrimination over the life course, thus making

pregnancy riskier at an earlier age" (NPWF, 2018, p. 2). Unfortunately, research has found that black women are receiving a significantly lower quality of care than their white counterparts, with 22% reporting discrimination in a healthcare facility (NPWF, 2018). This feeling of discrimination and judgement has led to 75% of the black maternal population giving birth at hospitals with a predominantly black patient populous (NPWF, 2018). This becomes a problem because, "black- serving hospitals have higher rates of maternal complications than other hospitals," and thus expose black women in the maternal period to even greater risk of morbidity and mortality (NPWF, 2018, p. 2).

To better understand how disparities in care for black women during the maternal period compare to other racial groups, MacDorman et al. (2017) conducted research on the deaths of 1,687 women in the maternal period out of 7,369,966 live births over the five-year period between 2008-2009 and 2013-2014. This study found that the MMR for non-Hispanic white women increased 28% from 15.9 to 20.3 deaths per 100,000 live births during this five-year period (Macdorman et al., 2017). The increase in MMR for Hispanic women was deemed unremarkable, as the rate only increased from 15.1 deaths in 2008-2009 to 15.8 deaths in 2013-2014 (MacDorman, 2017, p. 4). From 2008-2009 to 2013-2014 the MMR of the non-Hispanic black women increased by 20% from 46.7 to 56.3 deaths per 100,000 live births (MacDorman, 2017, p.4). Though the overall percentage increase in MMR was lower for the non-Hispanic black women than it was for the non-Hispanic white women, the drastic difference between the overall MMR between these two race classes is extremely concerning.

Socioeconomic Status

There is currently very little data on how socioeconomic status differences in the United States have impacted the usage of prenatal care. An individual's socioeconomic status can be

impacted by several personal and external factors. Personal factors may include education level, income, insurance coverage, and age (Osterman & Martin, 2016). External factors may include proximity of prenatal care centers, transit access, operating hours, and wait times. A 2016 study investigated the timing and adequacy of prenatal care provided to women in the United States (Osterman & Martin, 2016). It defined care as being inadequate (care that began after the fourth month of pregnancy and included lass than 50% or recommended prenatal visits), intermediate (the patient attended 50-79% of recommended prenatal visits), adequate (the patient attended 80-109% of recommended prenatal visits), and adequate plus (the patient attended at least 110% of the recommended prenatal visits) (Osterman & Martin, 2016). Data was gathered from the records of all births to registered citizens of the United States and the District of Columbia. The results showed that age, race, education level, and source of payment lead to severe discrepancies in the level of prenatal care obtained.

When looking at age, this study found that the highest percentage mothers receiving late or no prenatal care were in their teens (25.7% <15 years old and 11% between 15-19 years old) (Osterman & Martin, 2016). The study also found that, “mothers under age 20 were least likely to receive first trimester PNC [prenatal care] (61.2%),” (Osterman & Martin, 2016, p. 2). Unfortunately, given the limited finances and education of these young mothers, it is unsurprising that women under age 20 have the poorest prenatal care attendance. When examining how race impacts usage of prenatal care, this study found that, regardless of age, “non-Hispanic NHOPI [Native Hawaiian or Other Pacific Islander] women were the least likely to have first trimester PNC,” (Osterman &Martin, 2016, p. 3).

Osterman and Martin also found that women who had had four or more children were more likely to seek little or no prenatal care (Osterman & Martin, 2016). In addition, mothers

who had received less than a high school education were the most likely to receive late or no prenatal care (Osterman & Martin, 2016). The mothers in this educational group are most likely to be teenagers, which further contributes to the low rate of care among mothers under age 20. When examining how payment method impacted frequency of care, the researchers found that 54.8% of women who self-paid received prenatal care in the first trimester and 19.8% of women who self-paid received late or no prenatal care (Osterman & Martin, 2016). After combining all of these factors, Osterman and Martin found that 88.1% of mothers who received prenatal care in the first trimester received at least adequate care. 46.1% of mothers who initiated care in the second trimester received at least adequate care and 46.7% received inadequate care (Osterman & Martin, 2016). Unfortunately, the national percentage of women receiving prenatal care in the first semester is 77.1%, which is below the Healthy People 2020 goal of 84.8% (Office of Disease Prevention and Health Promotion, 2019).

With so many groups receiving late or no prenatal care, it is important to understand how this lack of care impacts the potential maternal outcomes. A 2019 study investigated the pregnancies and deliveries of 7,086 mothers who had received delayed prenatal care at Oregon Health and Science University (Sarker et al., 2019). In this study, delayed prenatal care was defined as care provided later than 20 weeks of gestation (Sarker et al., 2019). The mothers were split into two groups: an obese group (3,895 mothers) and a non-obese group (3,191 mothers) (Sarker et al., 2019). The study found that mothers in the obese group experienced higher rates of cesarean section deliveries and gestational diabetes (Sarker et al., 2019). The mothers in the non-obese group experienced an increased rate of preterm birth as well as an increased rate of cesarean section deliveries (Sarker et al., 2019). Cesarean section deliveries were a common dangerous outcome between the two groups of mothers who received delayed prenatal care.

Delivering via cesarean section increases the mothers' risk of hemorrhaging and developing a postoperative infection and sepsis, both of which are leading causes of maternal mortality in the United States (Agarwal et al., 2019).

Advanced Maternal Age

Advanced maternal age is defined as a woman who is greater than or equal to 35 years old at the time of delivery (Ladewig et al., 2017). The number of women delivering at or after age 35 in the United States has been steadily increasing over the last several years (Ladewig et al., 2017). Researchers believe that this maternal age increase is occurring because more women are pursuing higher education and career advancements before starting a family (Ladewig et al., 2017). Unfortunately, pregnancy at an advanced age can prove to be very dangerous. A literature review by Ruth Fretts summarized some of the major contributing factors of morbidity and mortality for women of advanced maternal age. These factors include ectopic pregnancy, amniotic fluid embolism, obstetric shock, renal failure, delivery via cesarean section, hypertension, diabetes mellitus, and other coexisting medical conditions (Fretts, 2018).

Ectopic pregnancy, a dangerous condition in which the fertilized egg implants itself in an area outside of the uterus, is four to eight times more likely to occur in women greater than or equal to 35 years (Anderson et al., 2000). A retrospective study by Lisonkova et al. (2017) examined 830,000 births from Washington State and found that women aged 40 and older were eight times more likely to develop an amniotic fluid embolus than women aged 25-29 (Lisonkova et al, 2017). An amniotic fluid embolus occurs when, "a bolus of amniotic fluid, fetal cells, hair, or other debris enters the maternal circulation and then the maternal lungs…[this] has a 60% to 80% mortality rate," (Ladewig et al., 2017, p. 778). The researchers also found that women of the same age group were three times more likely to develop shock than women aged

25-29 (Lisonkova et al., 2017). A study by Sheen et al. (2018) found that women aged 45-49 were at a 16 times higher risk for renal failure and five times more likely to receive obstetric intervention and be admitted to the intensive care unit. Obstetric intervention includes, "induction, epidural use, episiotomy, instrumental delivery (requiring the use of forceps or vacuum), and delivery via cesarean section" (Dahlen et al, 2014, p. 6).

Cesarean section deliveries are becoming increasingly common for women of advanced maternal age in the United States. A study by Leonard, Main and Carmichael (2019) examined 47, 973 cases of severe maternal morbidity in the state of California between 2007-2014. The study found that 37% of the population experienced severe morbidity from a cesarean section and that women were 2.7 times more likely to experience severe maternal morbidity with a cesarean section compared to a vaginal delivery (Leonard et al., 2019). The study also found that the reason for the increase in cesarean section deliveries was the increasing prevalence of advanced maternal age women, which rose 15% from 2007 to 2014 (Leonard, 2019). One study found that older women often had an abnormal progression of labor, which led to longer stages of labor and a large number of operative deliveries (Greenburg et al., 2007). The risks for infection and hemorrhage associated with cesarean delivery increases the likelihood of maternal mortality, especially for women of advanced maternal age.

The health disparities that often come with aging add to the danger associated with advanced maternal age. Yogev et al. (2010) found that women over age 40 were 5-10% more likely to develop preeclampsia than the general obstetric population. Hypertension can develop before or during pregnancy and can continue after (Ladwig et al., 2017). It is not uncommon for women of advanced maternal age to have preexisting hypertension, known as chronic hypertension (Ladewig et al., 2017). Unfortunately, these women are also at an increased risk for

developing superimposed preeclampsia, a dangerous complication of pregnancy that can cause hyperreflexia, headache, seizures, and thrombocytopenia (Ladewig et al., 2017). In severe cases, this may also lead to renal failure, abruptio placentae, disseminated intravascular coagulation, ruptured liver, and pulmonary embolism (Ladewig et al., 2017). Women in this age group are also at an increased likelihood of having preexisting diabetes mellitus and for developing gestational diabetes mellitus (Yogev et al., 2010). Preexisting diabetes mellitus can be difficult to manage during pregnancy due to the hormone changes, appetite changes from the nausea and vomiting, and energy requirements during labor (Ladewig et al., 2017). Gestational diabetes mellitus (GDM) is the onset of glucose intolerance during pregnancy (Ladewig et al., 2017). It is critical that GDM is diagnosed as early as possible because, "even mild diabetes causes increased risk for perinatal morbidity and mortality," (Ladewig et al., 2017, p. 251). GDM also places the mother at risk for hydramnios (excess amniotic fluid), preeclampsia-eclampsia, hyperglycemia, dystocia due to fetopelvic disproportion, retinopathy, monilial vaginitis, and urinary tract infections (Ladewig et al., 2017). The risk for developing gestational diabetes is 12% higher for women over 40 and 20% higher for women over 50 (Yogev et al., 2010). As more research surfaces, it is evident that advanced maternal age significantly increases a woman's risk of maternal mortality.

Implementation of Early Warning Systems

One major factor contributing to the rise in maternal deaths in the United States is the lack of standardization of protocols and detection checklists. Hospitals across the nation use vastly different detection methods on their labor and delivery floors. Each healthcare facility puts together a care bundle or protocol with its own unique set of acceptable parameters or they utilize a pre-programed early warning system in their felicity's electronic health record (EHR)

(Joint Commission on Accreditation of Healthcare Organizations, 2010). Unfortunately, one 2017 study found that, of the 222 maternity units evaluated, 96% used non-obstetric EWS (Zuckerwise and Lipkind). Only 23% of participants in this study reported that these non-obstetric EWS provided relevant flags for the obstetric patients being evaluated (Zuckerwise and Lipkind, 2017). Likely, these EWS were not considered relevant or useful because the ranges on the checklists that are considered normal for the general population are often not within the normal range for the obstetric population. For example, the Systemic Inflammatory Response (SIRS) criteria is used frequently in general medicine to detect the development of sepsis in at risk patients (Ladewig, 2017). This system, however, is not useful in the obstetric population because it is not uncommon for a mother's temperature to reach up to 100.4 F after childbirth and 102.2 F in the 24 hours after the mother begins lactating (Ladewig, 2017). This common rise in temperature caused SIRS to have a very low positive predictive rate in the obstetric population (0.09%) (Lappen et al., 2010). The Modified Early Warning System (MEWS), another generalized system used to detect sepsis, had a positive predictive rate for sepsis of 0.05% (Lappen et al., 2010). Another scale that assesses a person's risk for death secondary to sepsis is the Sequential Organ Failure Assessment (SOFA) or the quick SOFA (qSOFA). This assessment has three evaluatory components: increased respiratory rate, altered mentation, and decreased blood pressure (Baptiste & D'Alton, 2019). Many women experience a drop in their systolic blood pressure following delivery due to the sudden decrease in pelvic pressure, which leads to a false triggering of the system rendering it useless in the obstetric population (Baptiste & D'Alton, 2019).

To combat the lack of consistency in obstetric detection devices, the Joint Commission (2010) required childbirth facilities to develop their own obstetric specific early warning systems

(Joint Commission on Accreditation of Healthcare Organizations, 2010). Unfortunately, having each birthing facility create its own warning system potentiated the lack of consistency in maternal care from facility to facility. Each system has different parameters and procedures for when the system is triggered, which leads to extreme inconsistencies as to how and when care is provided. As previously mentioned, researchers have created three prominent obstetric EWS in an effort to provide greater consistency in care: Maternal Early Obstetric Warning Systems (MEOWS), Maternal Early Warning Criteria (MEWC), and Maternal Early Warning Triggers (MEWT).

MEOWS is an obstetric EWS that was validated in 2012 by the Confidential Enquiry into Maternal and Child Health (CEMACH) (Singh, McGlennan, England, & Simons, 2012). This EWS was utilized for two months in several birthing facilities and was included in 673 cases (Singh et al., 2012). The warning system checklist included temperature, blood pressure, heart rate, respiratory rate, oxygen saturation, consciousness level (evaluated with the AVPU tool: Alert, responds to Voice or Pain, and Unresponsive), and pain score, all of which were evaluated at least every 12 hours (Singh et al., 2012). Throughout the two months 30% of the women triggered the EWS and 13% suffered morbidity (Singh et al., 2012). Hemorrhage was the most common morbidity (43%) followed by hypertension (31%) and possible infection (20%) (Singh et al., 2012). This study found that the women that triggered MEOWS were more likely to develop morbidity (39%), experience prolonged hospital stay of at least 3 days, and undergo an obstetric emergency procedure (Singh et al., 2012). However, none of these women were admitted to the intensive care units and none of them suffered from cardiopulmonary arrest or death (Singh et al., 2012). Upon review of the cases that activated MEOWS, Singh et al. (2012) found that increased blood pressure, tachycardia, tachypnea, and increased temperature were the

best indicators of morbidity in these obstetric patients. The most important indicators of the validity of the MEOWS trigger tool is specificity, sensitivity, positive predictive value, and negative predictive value (Singh et al. 2012). The specificity was 79%, sensitivity was 89%, positive predictive value was 39%, and the negative predictive value was 98% (Singh et al. 2012, p. 14). Singh et al. (2012) stated that, "the specificity of MEOWS is reasonable and comparable to other adult early warning systems, though there is scope for further refinement" (p. 14).

The National Partnership for Maternal Safety proposed MEWC in 2014 (Mhyre et al., 2014). The evaluation criteria for this trigger tool was pulled from the red trigger list, or very serious warning signs, of the MOEWS alert system (Mhyre et al., 2014). The creators decided to remove the temperature and pain parameters, add oliguria measurements, and increase the bradycardia parameter from 40 beats per minute (bpm) to 50 bpm (Mhyre et al., 2014). They also expanded the neurologic evaluation to include agitation, confusion, and unrelieved headache with hypertension (Mhyre et al., 2014). In addition, the frequency of evaluation of these vital sign parameters was adjusted according to the patient's medical condition and to meet the existing clinical guidelines of the healthcare facility (Mhyre et al., 2014). MEWC requests that nurses reevaluate abnormal measurements to ensure that they are sustained before contacting a clinician, however this is not required (Mhyre et al., 2014). A study by Arnolds et al. (2019) evaluated the validity of the MEWC system. They found that, of the 400 patients evaluated, 70% triggered the MEWC system once and 50% triggered the MEWC system multiple times or recurrently (Arnolds et al., 2019). 25% of the patients experienced morbidity, the most common of which were hemorrhage, suspected infection, and severe preeclampsia (Arnolds et al., 2019). This study expressed the validity of the MEWC using a 95% confidence interval. The sensitivity of the MEWC system's ability to predict morbidity was 0.97 (0.92-0.99) when only triggered

once and 0.84 (0.75-0.90) when triggered multiple times or recurrently (Arnolds et al., 2019). The specificity of this system was 0.39 (0.33-0.44) when triggered once and was 0.62 (0.56-0.67) when triggered multiple times or recurrently (Arnolds et al., 2019). The positive predictive value of the MEWC system in this patient population was 0.34 (0.29-0.40) and the negative predictive value was 0.97 (0.93-0.99) (Arnolds et al., 2019). The researchers of this study found that the MEWC system is able to detect maternal morbidity, but they also found that, "additional efforts to improve the specificity of MEWC, with a focus on identifying sustained or recurrent patterns of abnormal vital signs, may be necessary before their widespread implementation" (Arnolds et al., 2019, p. 3).

The MEWT tool was developed to address the four most common causes of maternal morbidity (Shields et al., 2016). These include sepsis, cardiopulmonary dysfunction, preeclampsia-hypertension, and hemorrhage (Shields et al., 2016). This trigger tool is also unique in that it requires an abnormal vital sign be maintained for at least 20 minutes before the alarm is triggered (Shields et al., 2016). The pilot study for the MEWT tool was conducted in 6 of 29 hospitals within a large hospital system and included 11,399 cases (Shields et al., 2016). A positive screen occurred in 260 of the 11, 399 patients and the most common triggers were maternal heart rate greater than 130 bpm and the nurse being concerned about the patient's medical presentation/status (Shields et al., 2016). The physician arrived within 60 minutes of the MEWT tool being triggered in 82.3% of triggering cases (Shields etal., 2016). Of the 47 patients admitted to the ICU, 32 were screened using the MEWT tool and 31 resulted in positive screenings (Shields et al., 2016). After evaluating the population that had a positive screening, the researchers found that the MEWT tool's sensitivity for ICU admissions was 96.9 %, the specificity was 99.9%, the positive predictive value was 12%, and the negative predictive value

was 99.99% (Shields et al., 2016). This study also found that there was a statistically significant reduction in severe maternal morbidity and composite maternal morbidity (Shields et al., 2016). The benefits of this system are that the alarm rates are low because of the sustained abnormality requirement, it has a good predictive value for patient ultimately admitted to the ICU, and it was tested in birthing facilities with a relatively high delivery volume so it should be well suited for use in birthing centers across the country (Shields et al., 2016).

Despite having EWS that could play a major role in decreasing the maternal mortality rate in the United States, these obstetric trigger systems are used in very few birthing facilities throughout the country. A study by Friedman et al. (2018) examined the key barriers that hindered the mass implementation of obstetric EWS throughout the United States. They found that the most common barriers included: lack of multidisciplinary coordination and buy-in, inadequate education on the use of the EWS, poor integration of the EWS in hospital culture and practice, and lack of leadership support (Friedman et al., 2018).

In order for an obstetric EWS to be effective, there must be acceptance of the new program by all persons responsible for a patient's care and efficient, effective communication among the entire healthcare team (Friedman et al., 2018). If a nurse tech takes a set of abnormal vital signs it must be reported to the nurse, and the nurse must report these to the physician, who must then respond by assessing the patient at the bedside. A doctor or nurse who refuses to operate using the new EWS will become a break in the chain of communication that is critical to the success the system. Unfortunately, it is not uncommon for nurses and doctors to resist changes to their care routines, and this poses a major healthcare risk to the obstetric patients.

Education can be major barrier to the implementation due to the cost and difficulty of training a healthcare team in the use of obstetric EWS, which in turn can serve as a barrier to

corporate and interdisciplinary buy-in (Friedman et al., 2018). Educating a healthcare team on a new trigger system will involve continuous in-depth training as new employees are brought onto the floor and staff members transfer from other units (Friedman et al., 2018). There is added difficulty when the facility uses physicians and midwives that practice at an external location, which now have to be brought in for additional training on the new system (Friedman et al., 2018). As the new system is implemented, it may clash with current hospital practices and culture (Friedman et al., 2018). For example, the implementation of obstetric EWS would require the documentation of vital signs and patient status as they are observed and no later. This would be a significant change for some facilities that allow a window of time for these things to be documented in the patient's electronic health record (Freidman et al., 2018). Obstetric EWS require meticulous time management and efficient communication, which are essential to maintaining patient safety but are not always carried out in practice (Friedman et al., 2018).

Lack of leadership support is potentially the largest barrier to the implementation of obstetric EWS because they can stop the process of implementation before it even reaches the labor and delivery units. Implementing new assessment systems and software can be a very costly and time-consuming task. It requires the purchase and installation of the software into the hospital's electronic health record, the training of the healthcare team, and the sequential evaluation of the success of the system in the months and years following its implementation. In addition, hospitals often have to employ additional personnel to help navigate the new system, which adds to the additional costs required to deploy an obstetric EWS (Friedman et al., 2018).

Methodology

This qualitative research study was approached with inductive reasoning. The Institutional Review Board granted the researcher permission to explore existing information on

the use and implementation of obstetric Early Warning Systems (EWS), and interview labor and delivery nurses in various roles from several United States hospitals to better understand the current use of obstetric EWS. These interviews also allowed for the exploration of the barriers that these nurses saw as preventing the effective implementation of EWS.

The hospitals chosen for the interview process were selected from the list of facilities that had been granted a Women's Choice Award: America's Best Hospitals Obstetrics. This is the only evidence-based list that focuses of female patient satisfaction and,

> Use[s] the most recent publicly available information from The Centers for Medicare and Medicaid Services (CMS), as well as accreditation information from appropriate sources…Our methodology is objective, replicable and uniform. There are no subjective considerations for any of our awards (Women's Choice Award, 2019).

Each nurse was contacted via email or telephone call and was required to provide a signed written consent form before participating in a telephone interview. The interviews consisted of six structured questions, with the addition of some probing questions, and lasted 10-15 minutes. The results of each interview have been kept anonymous.

The questions asked in the interview can be found in Appendix A. They focused on the nurse's personal experience with obstetric EWS as well as the general use of these EWS on their labor and delivery floor. Each nurse's responses were then analyzed using the NVivo 12 Qualitative Data Analysis Software and compared to the responses of the other participants for similarities and differences in vocabulary and overall experiences. The questions used during each interview can be found in Appendix A.

Results

Use of an Obstetric EWS

This study reached saturation. Of the six facilities interviewed, none of them currently use an obstetric EWS. Instead, each facility used a combination of detection software and hospital-mandated bundles and protocols. When asked if they were satisfied with the current system in use at their facility, five said they were satisfied, and one said that they were not satisfied, as shown in Table 1. Two facilities stated that they had never heard of an obstetric EWS before being contacted.

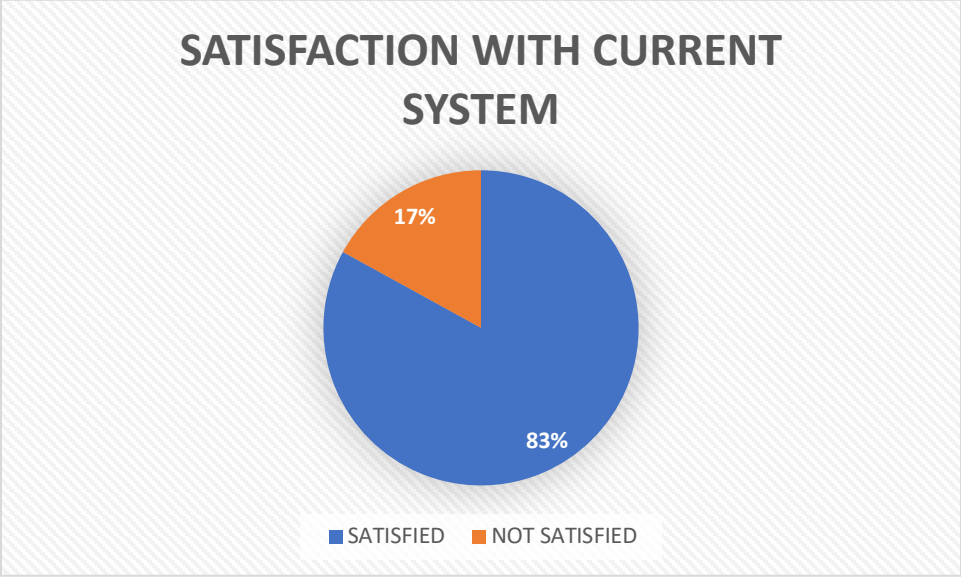

Table 1

While none are currently using obstetric EWS, the unit nurse manager at Facility 1 (F1) stated that they are currently in the process of implementing a postpartum hemorrhage EWS for their postpartum unit, however this is not currently in action and there are no plans in place to implement an obstetric EWS on their labor and delivery unit. F1 states that they do currently have a checklist that pops up on their electronic health record (EHR), EPIC, that is filled out on admission to determine a patient's risk for adverse outcomes, such as low hemoglobin or hematocrit. This initial risk determination helps the nurses and physicians know who to watch

closely due to their increased risk for morbidity and mortality. F1 stated that, given the uniqueness of obstetric patients, their facility has created an obstetric emergency team (OBET). Their rapid response carts are designed and stocked specifically for the obstetric population and they are trained like a trauma team in the emergency room. This means that each member of the OBET has a specific role that they perform, and they organize themselves in the room according to their role. This rapid response team is called using a push and talk phone, similar to a walkie talkie, to avoid having a rush of people from all over the hospital during an emergency. While F1 believes that the system they have in place is very effective, they also think that there is room for improvement and implementing obstetric EWS in their hospital would be a big step forward in decreasing morbidity and mortality.

The clinical resource manager at Facility 2 (F2) also states that they have a checklist built into EPIC. However, F2's system is, "kind of a home grown one I guess you'd say – that would trigger when you needed to call rapid response." While describing the checklist, F2 realized that, following their recent system upgrade, the checklist has not been popping up. F2 also stated that, when the checklist is working, it pops up inconsistently. They also stated that not all of the checklists are maternal-specific, so they often cause false alarms and alarm fatigue among the nurses and physicians. When asked about other protocol used at the facility, F2 stated that they do not use any care bundles to address common life-threatening developments like hemorrhage and sepsis. Instead, they use the checklists built into EPIC to detect adverse outcomes and treat the problem using a physician's unique set of orders. F2 stated that the biggest problem with their current system is the inconsistency in detection software and care provided in an emergency.

The registered nurse at Facility 3 (F3) stated that they do not use an obstetric EWS and was unsure as to whether or not they used bundles when providing care to their patients. F3 stated that they do frequent assessments, and, "if those get out of range then we have to notify the physician. There is not just, like, an early warning system for high blood pressure…It's just kind of like, when you get trained you know that's our protocol." This facility, like F2, also struggles with consistency in detection and treatment.

A nurse midwife at Facility 4 (F4) also stated that their current trigger system is programmed into EPIC. Their alerts appear when vital signs that are out range are entered into the patient's chart. The abnormal readings are highlighted in red and given an exclamation point. If two or more vital signs fall outside of the range, a window will appear and alert the nurse or provider. This facility also reported that they do not have window alerts that appear for hemorrhage. Instead, they have a step-by-step protocol to use once a certain amount of blood has been lost. This does leave a considerable amount of risk, as it depends on the nurse consistently performing frequent, accurate blood loss assessments. F4 stated that the biggest problem with the current system is that some of the alarm systems have vital sign ranges for the general population instead of the obstetric population. The sepsis alarm system has become the biggest problem because it is a generalized system and it triggers for the majority of the obstetric patients, given the high white blood cell counts and increased heart rate that occurs during and after labor. F4 said that the majority of nurses and doctors wind up ignoring this window alert because it is so frequently a false alarm.

The unit nurse manager at Facility 5 (F5) stated that their alert system acts on several different devices on the unit. It highlights abnormal vital signs and lab values in red in the patient's EHR, the monitors are able to send out alerts, and the monitors at the nurses' station

will get warnings when the room monitors have an abnormal reading. Like the other facilities, F5 is does not have a standardized approach for how physicians should address certain situations and emergencies. Instead, the method of treatment is entirely dependent on physician preference and how severe they believe the problem is.

The clinical resource specialist at Facility 6 (F6) stated that they also have their current trigger system built into the EHR EPIC. Like the other facilities, F6's trigger systems are not geared towards the obstetric population, so many of the nurses at this location struggle with alarm fatigue.

While five of the six facilities reported that they are satisfied with the current alarm system that is in place, all six locations agreed that their systems could be improved upon through the implementation of obstetric EWS.

Word Frequency Analysis

Word	Length	Count	Weighted Percentage
communication	13	23	0.58%
financial	9	14	0.35%
hemorrhage	10	13	0.33%
Sepsis	6	13	0.33%
interprofessional	17	10	0.25%
beneficial	10	8	0.20%
Meows	5	8	0.20%
bundles	7	7	0.18%
standardized	12	5	0.13%
eclampsia	9	3	0.08%

Table 2

The words listed in Table 2 are the words that occurred most frequently during the interviews after the removal of filler words such as isn't, that, and, and think. Communication

was the word that was used most frequently during the interviews, occurring 23 times. It was seen by many of the facilities as an interprofessional barrier to the use of their current assessment systems as well as a barrier to the implementation of a new EWS. Each facility agreed that communication between nurses as well as nurses and physicians would improve if obstetric EWS were implemented at their hospitals.

Financial and interprofessional (the second and fifth most frequently occurring words, respectively) were the only barriers to implementation reported by the interviewed facilities. Hemorrhage, sepsis, and eclampsia (the third, fourth, and tenth most frequently occurring words, respectively) were the care bundles most used by the interviewed facilities because they were the most commonly experienced adverse outcomes for the patients at each facility. Each facility used at least one of these conditions when explaining how their current assessment system works and how and obstetric EWS could improve upon their current practice.

Beneficial is the sixth most frequently used word, occurring 8 times in the interviews. This word was used at least once by each interviewee when declaring whether or not they believed that an obstetric EWS would be helpful in improving patient care. Each facility emphasized that they believed an obstetric EWS would be beneficial to patient care. MEOWS, the seventh most used term, was also said 8 times in the interviews. This was a common term because one of the facilities was in the process of exploring this EWS and deciding if it would be a good fit for their facility.

Bundles, the eighth most spoken word, was used frequently because two of the six facilities use bundles to guide their care and they were explaining the process of using said bundles. Finally, standardized was the ninth most frequently used word in the interviews. This is because several of the facilities believed that the implementation of obstetric EWS would create

a standardized practice within their units. This is seen as a positive change because it will improve communication between nurses and physicians and will create a one-track, best practice approach for treating dangerous developments in the obstetric population.

Barriers to Implementation

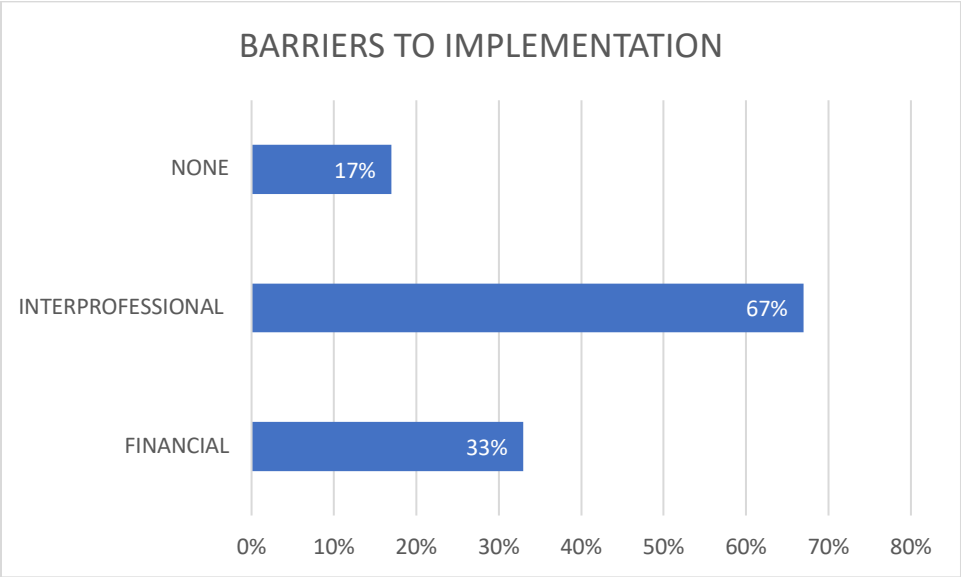

Table 3

Each facility, with the exception of one, felt that there were several barriers to the implementation of obstetric EWS. The most prominent barriers were interprofessional (4/6 or 67%) and finances (2/6 or 33%). None of the facilities reported any political barriers or other barriers besides finances and interprofessional relations.

The majority of facilities interviewed felt that there were significant interprofessional barriers. Several considerations fall under interprofessional barriers such as communication, training methods, willingness to adopt a new method, and proximity of the physicians to the birthing center.

Of the six locations, only two, F1 and F4, have a physician or midwife on the unit 24/7. Every other location either calls their physicians in from another facility or from another part of their own facility. F2 has an average physician arrival time of 10-15 minutes on weekdays and

they have physician on call on the weekends that stays in-house. F3 has a physician arrival time of 5-20 minutes. F5 has a physician arrival time of 8-15 minutes and F6 has a physician arrival time of 2-10 minutes. Though this seems like a relatively short amount of time, it causes a delay in the physician's evaluation of a patient that is deteriorating, thus delaying the initiation of preventative measures that can prevent morbidity and mortality. All facilities agreed that having in-house physicians or physicians that are very close by would be critical to the success of the implementation of an obstetric EWS. Therefore, having out-of-house physicians is seen as a barrier to the implementation of EWS at these facilities.

In addition to physician presence, communication was seen as a prominent barrier to implementation. Four of the six facilities reported that their main form of communication with physicians was a telephone call. Many reported that the urgency of a situation was difficult to convey over the phone, especially for nurses that were new to the floor. Several of the facilities interviewed explained that physicians often ignored alerts from nurses when they were receiving warnings or brushed off nurses' concerns when a patient was presenting abnormal symptoms. Obstetric EWS rely on physicians quickly responding to nurse alerts that the system has been triggered and performing a bedside assessment of the patient in question. When communication breaks down like this, the patient does not get a bedside assessment from the physician and the nurse is left trying to maintain a deteriorating and endangered patient. This ineffective communication has to be resolved so that obstetric EWS can be effectively implemented and utilized.

In addition to the breakdown in communication, four of the six facilities stated that they train the nurses separately from the physicians in annual simulation exercises (Table 4).

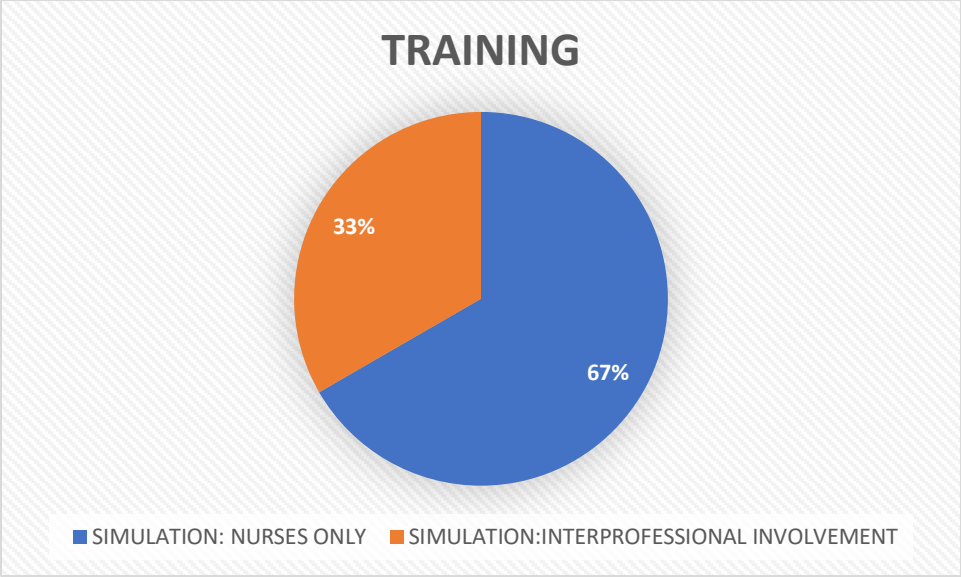

Table 4

The effective implementation of an obstetric EWS relies upon a strong interprofessional team dynamic, which can only be achieved through interprofessional training for obstetric emergencies. If facilities train their nurses and physicians separately, there is a high risk for confusion, miscommunication, and accidents during an emergency situation. When medical professionals are not trained on how to work together when managing an obstetric crisis, it places the patient at a high risk for morbidity and mortality.

Finally, several of the facilities reported that many physicians and senior nurses demonstrated a reluctance to adopt a new system of caring. F5 stated that,

> "it's hard for nurses to change, but it's even harder for physicians because it was how they were trained and how they learned, and it's gotta be the best way. So…they're not always- I can't say all of them, but they're not usually very receptive to change."

F5 also stated that all of the physicians at their facility were not employed by the hospital, so it was hard to get them to conform to a new protocol or policy. While all of the aforementioned components of interprofessional barriers are very important to the implementation of obstetric

EWS, actual, widespread implementation will never be possible if nurses and physicians refuse to comply with an improved system of care.

Two of the six facilities, F1 and F6, also stated that there were financial barriers present as well as interprofessional barriers. F1 explained that it is a major cost to the hospital when a new system like this is implemented because of the amount of training needed for nurses, techs, physicians, and midwives. All members of the healthcare team must be trained on the utilization of the new system. The healthcare team will be paid for the hours they spend training, and the hospital will have to pay stand-in nurses to care for the patient during the training sessions. F1 explained that, "you have to look at just having that non-function time, NFT, of a staff member. So, you're employing them and paying them for a three-hour time period," where they are not caring for patients. In addition, as F6 stated, the cost of purchasing, installing, and then managing the new EWS presents a large cost to the hospital. The expense of implementation can also contribute to interprofessional barriers because it serves as a deterrent to upper level executives within the hospital system.

One of the facilities, F3, claims that the do not believe that there are any interprofessional, financial, or other barriers to the implementation of obstetric EWS. They stated that it sounds like the concept of obstetric EWS is similar to what they are already doing.

Available Resources

When asked if the resources available at each facility would be sufficient for the implementation of obstetric EWS five of the six facilities stated that they did have sufficient resources. The facility that stated it lacked the necessary resources, F5, explained that, "we have 2 OB groups and a lone OB. At least one of the OB providers are often in the hospital, however, we do not have a designated In-House OB." F5 explained that they do have residents in-house

that are under the guidance of a hospitalist, however this hospitalist is not OB specific. They felt that not having an in-house obstetrician would make the execution of an obstetric EWS extremely difficult or impossible.

The facilities that stated that they had EPIC in their interview listed this as a major resource in the implementation of EWS. F2 stated, "I know that the other hospitals that use it [EPIC], some of them have these EWS, especially maternal specific EWS, built in. So, it would not be a hard thing to put into our EMR [electronic medical record]." Other facilities stated that, with the severity of the issue and the urgency presented by a steadily increasing MMR, they are confident that their hospitals would utilize their resources to implement an obstetric EWS in the near future.

Implementation of an Obstetric EWS

When asked if they thought that the implementation of an EWS would be beneficial to their facility, all of the interviewees answered yes. Some of the facilities had specific EWS in mind. For example, F5 has been discussing the possibility of implementing MEWS at their location and F6 is very interested in beginning discussions on implementing MEOWS.

In addition to improving the safety and assessment of mothers admitted to the labor and delivery or mother-baby unit, many of the facilities felt that obstetric EWS could be used to improve communication between nurses and physicians. F4 explained that EWS could help the nurses communicate by,

> kind of giving them a leg to stand on when they are calling… you know rather than just saying 'hey, I've had a couple of [abnormal] blood pressures…' They can call and say, 'I'm having the warning pop up for her blood pressure, can you come evaluate?' So, it

> takes a little of the judgement off of them [the nurses], and maybe a little of the heat of feeling like they are bothering one of the doctors, especially if it's during the night.

F5 had a very similar thought process and explained that, with an EWS,

> she [the nurse] has something to lean on and say, 'this is not a nursing judgement, this…the guidelines, the warning signs…' When it comes to less experienced nurses, they may or may not have a good solid repertoire with the physician or may not have developed an ability to communicate their need, their urgency, and so a protocol kind of backs them up and gives them a leg to stand on when you are dealing with a physician. And typically, our newer nurses are on the night shift, and you're dealing with a sleepy or tired physician.

It seems that one of the biggest draws towards the implementation of obstetric EWS, aside from earlier detection of maternal adverse outcomes, is the protocol that supports nurses alerting the physicians of abnormal assessments and requires bedside action by the clinician. Many of the facilities also agreed that the implementation of an obstetric EWS would provide standardization of care for all members of the healthcare team. F5 explained that having a standardized method of care would eliminate the idea that, "well, Dr. So-and-So does it this way and Dr. – you know? That's [the EWS are] supposed to make things safer if everybody's on the same page." In all, every facility that was interviewed was in support if the implementation of obstetric EWS at their hospitals.

Discussion

The results of this study have shown that the implementation of obstetric EWS could greatly improve the outcome for maternal patients in the United States by offering standardization of care. Though each EWS is different, if a facility or state decides to operate

using a specific system, it provides consistency in care for each patient and eliminates the confusion and communication barriers that exist across professions within the healthcare system. Having a system like MEOWS, MEWT, or MEWC requires all nurses and physicians to comply with a set method of assessment, intervention, and initiation of emergency management. As the interviewed nurses stated, the guidelines of the EWS provide the nurses with a concrete reason for the provider to come assess the patient and requires that the physician investigate any changes in patient status or nursing concerns.

With the improved communication that these EWS bring, the healthcare team will be required to practice using a standardized method of care. This means that each patient will undergo repeated, in-depth assessments that have been designed for the unique conditions seen in the obstetric population. It also requires that all clinicians and nurses be trained in how to handle every kind of obstetric emergency. This will eliminate the current custom of nurses choosing which physician to call based on their preferred methods of practice.

The implementation of an obstetric EWS also presents the opportunity for the hospital to change and improve its training practices. As stated in the results section, only two out of the six interviewed facilities use an interprofessional approach when training the healthcare team. The training required when implementing a new system of assessment and action gives facilities the opportunity to adopt the interprofessional training method and improve the efficiency and effectiveness of the care provided, especially during an emergency situation. For example, one of the interviewed facilities recently had a patient begin hemorrhaging and her physician did not know how to use the Bakri Balloon to stop the bleeding. The nurses had to find another physician within the facility that knew how to deploy the device. Unequal training among team members creates a dangerous situation for the patients they are treating. It is imperative that

hospitals seize the opportunity to improve training practices during the implementation of obstetric EWS.

In addition to improving the team operating dynamic, implementing an EWS geared towards the obstetric population will decrease the number of false alarms, which frequently occur with the use of a non-obstetric EWS. As these false alarms sound every shift, sometimes multiple times a shift, nurses and physicians become indifferent to the trigger. Several nurses stated that the healthcare members at their facility often ignore these alerts because they are so frequently a false alarm. This poses a great risk to the patients who are not being evaluated because the nurses and doctors consider the alert an inconvenient error. Obstetric EWS help eliminate this risk by utilizing alert systems with parameters designed to detect vital signs and blood levels that fall outside of the accepted range for the obstetric population, rather than the general population. Trigger systems that issue an alert only when the patient's levels fall outside of the obstetric range will greatly reduce the number of false alerts, improve patient assessment rates, and decrease alarm fatigue.

As obstetric EWS improve the initiation of the chain of care for patients showing signs of an adverse outcome, they can also greatly improve the care provided to at-risk populations such as people of color and those living in rural areas. People of color, black women in particular, are at a shockingly high risk for maternal mortality and the implementation of obstetric EWS may help reduce this risk through standardization of care. Should an alarm sound for increased blood pressure in a black woman, healthcare providers are no longer allowed to categorize this as normal for a person in this patient population. Instead they must go and perform a bedside assessment of the patient to ensure that she is safe and is not developing and adverse maternal outcomes. In addition, healthcare providers in rural facilities often have not had a great deal of

experience with obstetric emergencies and have very limited resources at their disposal. Implementing EWS in rural birthing facilities will offer guidance to nurses and physicians about how to address obstetric emergencies and how to care for women at risk for morbidity and mortality. As they learn how to use EWS in everyday practice, the nurses and physicians will learn how to use the resources available at their facility to care for their patients.

Limitations/Future Research

Despite reaching saturation, this study is limited because the data was gathered from only six facilities, and the results are most likely not transferable to the general population. This study would need to be repeated on a much larger scale in order to better reflect the use of obstetric EWS within the United States. In addition, background information available on the accuracy and utilization of obstetric EWS in the United States is extremely limited. More research is needed to determine the accuracy of each system and to better understand which system will be best suited for each facility. In addition, the majority of the facilities interviewed are in the Southeastern United States. Therefore, a similar study that covers more regions of the U.S. will provide more accurate national results.

Given that some facilities see finances as a barrier to the implementation, it may be beneficial to perform studies that examine the financial outcome of implementing an EWS. For example, a long-term study could show the initial cost and possible financial benefit of an obstetric EWS. It should look at how much money a birthing facility can save through early detection of adverse outcomes and prevention of mortality. Evidence of cost reduction through implementation would offer further incentive for the implementation of EWS in U.S. hospitals.

Conclusion

The results of the interview analysis were saturated and revealed that zero out of the six facilities interviewed currently use obstetric EWS, and two of the six facilities had never heard of obstetric EWS before the interview. Despite their lack of use, all six of the interviewed facilities felt that the implementation of obstetric EWS would be beneficial to their practice. The barriers of greatest concern are interprofessional barriers, including communication, training, and physician compliance and presence, and financial barriers. Though these barriers make the implementation and initiation of EWS more challenging, the interviewed nurses did not believe that it would prevent the facility from eventually adopting this assessment method. Several facilities explained that the executives of their facilities are eager to utilize systems that improve patient outcomes and safety and they foresee the implementation of obstetric EWS within their facilities sooner rather than later. Eliminating the barriers that are preventing the use of obstetric EWS in U.S. would aid in protecting the maternal population and could greatly decrease the nation's MMR.

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Appendix A

Interview Questions:

1. To your knowledge, does this establishment use an Early Warning System?
    a. If yes, what is the name of the Early Warning System, and what are its parameters?
    b. If no, what measures are being taken to monitor women during the maternal period and to detect when an adverse effect of the pregnancy is developing?
2. In your experience, has the Early Warning System been an effective tool in caring for women during the maternal period?
    a. If yes, please explain.
    b. If no, please describe the issues you have noticed.
        i. What do you believe would be a more effective method for detecting risk factors for impending mortality during the maternal period?
3. Are there any interprofessional barriers, financial, political, or otherwise, preventing the implementation of Early Warning Systems?
    a. If yes, please explain.
    b. How is your facility working towards overcoming these barriers?
4. Do you have the resources necessary to implement the Early Warning System?
    a. If yes, please describe them.
    b. If no, what resources are you lacking? What are the barriers preventing your facility from acquiring those resources?
5. If the facility does not have an Early Warning System, what is the interprofessional communication and alert procedure used when adverse effects are observed?

If the facility does not have an Early Warning System, do you think the implementation of one would be beneficial to patient care? Please explain.