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Quality Improvement Opportunities Identified Through Case Review of Pregnancy-Related Deaths From Venous Thromboembolism

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ABSTRACT

Objective: To analyze quality improvement opportunities (QIOs) identified through review of cases of maternal death from venous thromboembolism (VTE) by the California Pregnancy-Associated Mortality Review Committee.

Design: Qualitative, descriptive design using thematic analysis.

Sample: A total of 108 QIOs identified from 29 cases of pregnancy-related deaths from VTE in California from 2002 to 2007.

Methods: We coded and thematically organized the 108 QIOs using three of the four domains commonly applied in quality improvement initiatives for maternal health care: *Readiness*, *Recognition*, and *Response*. Data did not include reporting issues, so the *Reporting* domain was excluded from the analysis.

Results: Women's lack of awareness of the significance of severe VTE symptoms and the lack of a standardized approach to recognize and respond to VTE signs and symptoms were the most prevalent themes in the *Readiness* domain. Missing the signs and symptoms of VTE and the resultant missed or delayed diagnosis were predominant themes in the *Recognition* domain. For *Response*, issues related to lack of VTE prophylaxis were most frequently noted, along with other themes, including timing of treatment and appropriate follow-up after hospital discharge.

Conclusion: To decrease the occurrence of maternal death from VTE in the United States, consistent and thorough education regarding VTE signs and symptoms must be given to all women and their families during pregnancy and the postpartum period. Maternity care facilities and providers should implement preventive measures, including standardized use of VTE prophylaxis, improved methods to recognize the signs and symptoms of VTE, and improved follow-up after hospital discharge.

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Venous thromboembolism (VTE), a serious complication of pregnancy that includes deep vein thrombosis (DVT) and pulmonary embolism (PE), is one of the leading contributors to maternal death in the United States and worldwide (Creanga et al., 2015; Knight et al., 2016). DVT is the formation of a blood clot in the lower extremities that impedes blood flow (Chandrarajan & Nelson-Piercy, 2015). PE, a severe consequence of DVT, occurs when a thrombus from the lower extremities circulates and settles in a lung and restricts circulation and oxygenation (Davidson, London, & Ladewig, 2016). Although VTE risk increases with any hospitalization, pregnant women are 4 to 6 times more likely to develop VTE than nonpregnant women (Sultan et al., 2012). This increased risk results from the normal, hypercoagulable state of pregnancy that protects against hemorrhage, venous stasis that occurs with the enlarging uterus, and vascular damage that occurs with fetal descent or from trauma during birth, especially during cesarean birth (Cunningham et al., 2014). Middeldorp and Bleker (2014) found that the VTE risk for pregnant women was 17.5 times greater in hospital admissions than during pregnancy alone; most VTE events occurred during the postpartum hospital stay, and the risk of VTE increased by 6.27 in the 28 days after childbirth. The incidence of VTE recurrence during a

subsequent pregnancy has been estimated to be between 15% and 25% (A. H. James, 2012).

Risk factors such as advanced age, obesity, and comorbid conditions among pregnant women have increased, as has the incidence of VTE. Among pregnancy-related hospitalizations, Ghaji, Boulet, Tepper, and Hooper (2013) found a 14% increase in VTE rates over a 10-year period. Although the overall incidence of VTE in pregnancy ranges from 1 to 2 per 1,000 births (Heit et al., 2005), VTE is a significant contributor to maternal morbidity and mortality (California Department of Public Health [CDPH], 2018; Creanga, Syverson, Seed, & Callaghan, 2017). Researchers have previously shown that many events leading up to maternal mortality are preventable, including those associated with VTE. The most common types of preventable events are related to inadequate diagnosis or recognition of high-risk status; inappropriate treatment, primarily caused by delay; and inadequate documentation (Kilpatrick, 2015). These events may be interconnected, because a misstep in diagnosis or documentation can cause inappropriate or delayed treatment.

VTE was the fourth-leading cause of pregnancy-related death in California during a 6-year period (2002–2007). Investigators found that women who died of VTE were more likely to be multiparous (≥5 births), to be obese, and to have given birth by repeat cesarean (Main, McCain, Morton, Holtby, & Lawton, 2015). In the early 2000s, VTE risk during pregnancy was underrecognized in U.S. obstetric practice. Although changes occurred in VTE management in nonpregnant women, VTE management during pregnancy remained controversial, largely because of the absence of sufficient clinical trials on the efficacy and safety of anticoagulant medications during pregnancy (Toglia & Weg, 1996). VTE prophylaxis treatment options during pregnancy were limited because of clinical concerns about fetal development (Sellman & Holman, 2000). Thus, no U.S. consensus existed for the treatment of at-risk women during pregnancy or the postpartum period until recently. Newer research evidence and guidelines support standardized risk assessment of and prophylaxis for pregnant women to prevent and/or treat VTE (American College of Obstetricians & Gynecologists, 2018). The purpose of our study was to examine quality improvement opportunities (QIOs) among pregnancy-related deaths caused by VTE to identify themes that could inform and guide changes in obstetric practice to reduce preventable maternal morbidity and mortality.

Venous thromboembolism is a serious and very preventable complication of pregnancy and one of the leading contributors to maternal death in the United States.

Methods

Design, Setting, and Analytic Approach

The study design and thematic analysis were based on three of the four domains commonly applied in quality improvement initiatives for maternal health care: *Readiness*, *Recognition*, and *Response*. QIO data did not include reporting issues, so the *Reporting* domain was excluded from the analysis. These domains were introduced in the first version of the *Obstetric Hemorrhage Toolkit* published by the California Maternal Quality Care Collaborative (Lyndon et al., 2010). They have since been widely adopted, most notably in the patient safety bundles published by the National Partnership for Maternal Safety (Council on Patient Safety in Women's Health Care, 2019). In this series, we refer to the domains collectively as the *4R Framework*. Further details regarding the methodology for our study are described in the introductory article to this series (Morton, VanOtterloo, Seacrist, & Main, 2019).

Sample

The sample for this analysis included 108 QIOs from the California Pregnancy-Associated Mortality Review (CA-PAMR) committee's analysis of 29 cases of pregnancy-related mortality from VTE from 2002 through 2007 in California. These cases were identified from the CA-PAMR data set described elsewhere (Morton et al., 2019). The QIO data were derived from committee members' open-ended responses to the following question: *In this particular case, what alternative approaches to recognition, diagnosis, treatment, or follow-up at the system, provider, and/or patient levels may have led to better patient care and/or a better outcome?*

Results

Characteristics of Women Who Died of VTE in California

Of the 333 pregnancy-related deaths that occurred from 2002 to 2007 in California, VTE accounted for 9% (n = 29), and the overall

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pregnancy-related VTE mortality rate was 0.9/100,000 live births (CDPH, 2018). More than half of VTE deaths occurred among women younger than 30 years ($n = 15$). Nearly three fourths of the women who died of VTE were multiparous (73%, $n = 21$). Most (66%, $n = 19$) had adequate prenatal care: nearly 60% ($n = 17$) had public insurance, and 38% ($n = 11$) had private insurance. Almost half of the women who died of VTE were Hispanic (48%, $n = 14$; eight were born in the United States, and six were born elsewhere). Another seven women (24%) were White, and seven (24%) were Black. The California birth population in 2010 was 37% Hispanic, 58% White, and 6% Black (CDPH, 2018).

Women who died of VTE were less likely to experience preterm birth than other women who gave birth in California ($p < .05$). More than half of the women who died of VTE (55%, $n = 16$) gave birth at greater than 37 weeks gestation. Among women who died of VTE, 10 (35%) gave birth by unplanned cesarean, five (17%) by planned cesarean, two (7%) by emergency cesarean, three (10%) by perimortem cesarean, and nine (31%) gave birth vaginally (CDPH, 2018).

Of the 29 women who died of VTE, 89% ($n = 24$) had documented general or pregnancy-related risk factors when they entered prenatal care, and 93% ($n = 25$) had documented risk factors at the childbirth hospital admission. The most common VTE risk factor was prepregnancy body mass index (BMI): 64% ($n = 19$) were obese (BMI > 30 kg/m^2) and 25% ($n = 7$) were severely obese (BMIs > 40 kg/m^2). Six of the seven Black women who died of VTE had BMIs greater than 35 kg/m^2, and five of the seven had BMIs greater than 40 kg/m^2. The mean BMI among Black women who died of VTE was 48 kg/m^2, compared with 35 kg/m^2 for White women and 30 kg/m^2 for Hispanic women who died (CDPH, 2018). Regardless of the high-risk status of the women who died of VTE, all but one of the deaths were deemed preventable. For more than half of the women ($n = 15$, 52%), the CA-PAMR committee determined that there was a good to strong chance that the outcome could have been altered (CDPH, 2018).

Relationships of QIOs to the 4R Framework

Three domains (*Readiness*, *Recognition*, and *Response*) of the 4R Framework were used to categorize the themes extracted from the QIO data collected from pregnancy-related VTE mortality case review. The goals for the project and for this analysis were to affirm and contribute to current and future action recommendations for quality-of-care improvement to prevent women's deaths from VTE. The themes, QIOs, and action recommendations for each domain are summarized in Table 1. No QIO themes were specific to the *Reporting* domain.

Readiness Domain

Readiness, or the preparation required to respond adequately and immediately to any woman during pregnancy or the postpartum period who presents with complications, is a key element to reduce maternal morbidity and mortality. From the 33 VTE QIOs identified under the *Readiness* domain, two major themes emerged that reflected the need for education strategies to improve outcomes related to VTE: *Women's Knowledge* and *Facility Preparation*. Two additional themes included *Location of Care* and *Clinician Preparation*.

Women's Knowledge. Women's or their families' lack of awareness of the significance of severe VTE symptoms was the most prevalent theme in the *Readiness* domain. Many QIOs reflected perceptions of the committee members that there was "apparent lack of understanding by the woman regarding her condition and medication needs." The committee determined that this lack of understanding regarding risk factors; severity of symptoms; and when to seek medical attention, especially when other comorbidities are present, contributed to VTE-related mortality. The QIOs were suggestive of the need for stronger prenatal counseling on key risk factors: weight gain ("Better prenatal counseling on weight gain. Patient gained 75 lbs. prenatally but scant prenatal care"), mode of birth ("Lack of thorough VBAC [vaginal birth after cesarean] counseling prior to surgery—woman declined"), medication adherence ("Not on anti-coagulant prophylaxis despite counseling"), and need for follow-up ("Postpartum counseling when to return post-discharge with symptoms").

In a few cases, women refused anticoagulation medication even though they were at very high risk for VTE. Committee members noted, "Poor patient compliance and providers' inability to compel treatment or adequately document patient noncompliance" and "First hospitalization, patient refused treatment, may indicate need for better patient education." The committee

Table 1: Themes Related to the 4R Framework, Quality Improvement Opportunities, and Recommendations Related to Venous Thromboembolism (VTE)

Themes	Quality Improvement Opportunities	Recommendations
Readiness		
Women's Knowledge	Education for woman regarding signs and symptoms of worsening condition[a]	Prenatal and discharge teaching for risk factors, risk-reduction strategies, presence of symptoms, and when to seek care • Weight loss • Medication adherence • Birth plan
Facility Preparation	Well-defined recommendations for VTE prophylaxis in high-risk women[a] Availability of equipment	Standardized approach to thromboprophylaxis • Training for providers • Regional cooperation agreements for smaller hospitals • Availability of appropriate equipment, especially for obese women
Location of Care	Care of women during pregnancy and the postpartum period on the labor and delivery unit	Consultation with an obstetric clinician when a woman arrives in the emergency department • Transfer to appropriate unit or hospital
Clinician Preparation	No prophylaxis or suboptimal dosing of medication Recognize need for deep vein thrombosis prophylaxis	Provider and staff education • Support for low-volume hospitals Routine risk assessment ante-, intra-, and postpartum
Recognition		
Missed Clinical Warning Signs	Missed recognition of clot during initial hospitalization[a] Warning signs ignored: leg pain, shortness of breath[a]	Assess and report abnormal warning signs
Misdiagnosis or Delayed Diagnosis	Delays in diagnostic assessment	Consider VTE when respiratory and cardiac conditions are present
Response		
Type of Treatment	Prophylactic treatment of obese women (sequential compression devices, chemoprophylaxis) and cesarean[a] No prophylaxis for women with prolonged labor and/or bedrest[a]	Standardized use of mechanical and chemical thromboprophylaxis • Sequential compression devices • Antiembolism stockings • Low-molecular-weight heparin • Early ambulation after cesarean
Timing of Treatment	Delayed response in resuscitation	Coordinated team response to critical situations at the bedside, including communication between intensive care unit and labor and delivery unit
Follow-Up Care	Discharged too early without being clinically stable	Use of case management or home visitation with high-risk women with mobility or psychosocial issues

Note. The 4R Framework includes the four domains first identified by Lyndon et al. (2010): *Readiness*, *Recognition*, *Response*, and *Reporting*. Data did not include *Reporting* issues, so that domain was excluded from the analysis. Quality improvement opportunities were identified by the California Pregnancy-Associated Mortality Review Committee.
[a]Indicates the most frequently cited quality improvement opportunities.

members affirmed that all women during pregnancy and the postpartum period have the autonomy to make decisions regarding their care, but they were concerned that lack of documentation about decision-making processes meant that women were likely not adequately informed or counseled about the health consequences of the refusal of VTE prophylaxis or treatment.

Facility Preparation. The second theme in the *Readiness* domain included aspects of facility readiness, specifically a standardized approach for recognizing and responding to VTE signs and symptoms and having appropriate preventive measures in place. Many suggestions by the committee members reflected the need for a "standardized protocol that outlined specific care requirements caused by changes in physiology during pregnancy," especially when caring for women who are obese and experience long labor, have elective induction of labor, or undergo cesarean birth. A QIO indicated that the outcome would have been altered if there were "well-defined recommendations for VTE prophylaxis in an obese woman with a 36-hour induction and prolonged bedrest." Committee members noted the importance of "guidelines for postpartum thromboprophylaxis," including early mobility in women after long periods of immobility or cesarean birth.

In addition to standardized protocols, the committee documented QIOs around the availability of working, appropriate equipment for VTE prevention or cardiopulmonary resuscitation: "Appropriate equipment may not be available for the morbidly obese, including blood pressure cuff, compression stockings in appropriate size." Review of the QIO data highlighted the importance of identifying women with VTE risk and matching the degree of risk with the level of clinical expertise available. Smaller hospitals "not equipped to care for women at greater risk for VTE needed regional cooperation agreements" with higher-level facilities available to receive women or coordinate women's care.

Location of Care. The location of care, especially the emergency department (ED), affected clinicians' abilities to respond immediately and/or adequately to VTE signs and symptoms. When consultation with obstetricians was absent, appropriate assessment for possible VTE was missed: "ED doctor should have called obstetrician for consult, should have done cesarean on his own as soon as patient coded" and "Lack of continuity of care." In a case in which a woman presented with symptoms, and PE was noted as a differential diagnosis, the use of thrombolytics was not considered: "ED doctor should have started heparin since PE in differential, work up to rule out PE." The committee noted a "need for ED clinician education regarding the physiology and complications of pregnancy and postpartum as well as best practices for diagnosing and treating VTE." Additional QIOs included ED protocols for "obtaining timely assessment of recently pregnant woman" and "consultation within the ED or transferring care of pregnant women to the appropriate unit or hospital."

Clinician Preparation. In general, "staff education regarding appropriate dose of medication" was needed when no prophylaxis or suboptimal dosing of medication was noted in the health care record. "Issues of training and experience of staff in low-volume hospitals" was highlighted in one case in which a woman with multiple documented risk factors for VTE was admitted to a facility with 400 births per year. Health care staff in low-volume facilities may not have the ability or training to respond quickly because of limited resources and lack of experience with severe complications of VTE.

Recognition Domain

Recognition of women at high risk for VTE and those who exhibit signs and symptoms of VTE complications is important for adequate and immediate clinical response. The predominant themes among the 15 QIOs in the *Recognition* domain were *Missed Clinical Warning Signs* and *Misdiagnosis or Delayed Diagnosis*. The single most missed symptom on admission to the hospital or in the office during the postpartum period was leg pain, which usually was severe (6–8 out of 10 on a pain scale): "Missed trigger: leg pain 8 out of 10 on admission" and "Missed trigger of leg pain in family practice office, 8 days postpartum after induction for fetal demise. She was sent home without further evaluation or treatment." Better recognition would have led to an earlier diagnosis of thrombus and appropriate treatment. Some women experienced severe leg pain at home but did not seek care. Others complained about leg pain during their hospital stay, which "nurses did not report to the physician." In other cases, physicians were "aware of the leg pain but did not follow up with appropriate diagnostics such as Doppler studies." Other missed clinical warning signs and symptoms included

"decreased oxygen saturation, headache, chest pain, altered blood pressure, shortness of breath, and tachycardia." These signs and symptoms are similar for respiratory and cardiac conditions and thus complicate the differential diagnosis, which potentially results in delayed care: "Delay in diagnostic assessment delayed recognition of the need for VTE thrombolytics."

Response Domain

The *Response* domain is focused on appropriate and adequate treatment of women at risk for VTE. From the 69 QIOs in the *Response* domain, three predominant themes emerged that highlighted the need for adequate and timely care in women identified as high risk: *Type of Treatment*, *Timing of Treatment*, and *Follow-Up Care*.

Type of Treatment. Issues related to lack of VTE prophylaxis were most frequently noted. The "lack of utilization of sequential compression devices, heparin/anticoagulant therapy, and early ambulation" was seen in many cases, even when the risk due to prolonged bedrest, obesity, cesarean birth, anesthesia, or lengthy inductions should have been apparent. In several cases, women were "on bedrest for greater than 48 hours without the benefit of prophylactic treatment before or after the birth." Principal issues included "lack of needed VTE prophylaxis and/or workup of comorbidities in obese women."

Timing of Treatment. Inadequate or inappropriate treatment for VTE included QIOs that pertained to "adequate resuscitation and delays in intubation and airway management," especially in obese women. In one case, "resuscitation was delayed, and the woman became hypoxic during the transfer to the intensive care unit," and in another, the "critical care response during a presumed pulmonary embolus, including need to transfuse, deliver the baby, and provide thrombolytics quickly was inadequate." Furthermore, several QIOs addressed resuscitation: "delayed response from respiratory therapy," "phone rather than in-person consultation with the attending physician," and "coordination of care during transport from labor and delivery to the intensive care unit." The need for "more aggressive management of VTE with Enoxaparin" was noted by the reviewers in several cases, as was the "need for adequate treatment for severe hypoxia, anemia, and thrombophilia."

Follow-Up Care. The final theme in the *Response* domain was related to postpartum follow-up for women at risk for VTE. The committee identified that women were "discharged too early without being clinically stable." During the postpartum period, women were "seen in the ED without adequate evaluation of symptoms including leg swelling." It was noted that "case management or home visitation for high-risk women may have benefited" these women.

Missed warning signs and symptoms, such as leg pain and shortness of breath, in the perinatal period were key contributors to pregnancy-related deaths from venous thromboembolism.

Exemplar Cases With QIOs

The following two vignettes were created from a compilation of actual cases reviewed. They represent QIOs that were typically seen in cases of maternal death from VTE. Both deaths were preventable, and the QIOs point to the need for clinicians to recognize the constellation of factors that should require VTE prophylaxis or treatment when indicated. Pseudonyms are used.

Vignette 1. Carolyn was a 33-year-old gravida 2, para 1 woman with a BMI of 36 kg/m^2 and early entry into prenatal care. She was admitted to the labor and delivery unit for induction of labor at 31 2/7 weeks with fetal demise. Intravenous oxytocin was started for induction and was continued for 38 hours until birth of the fetus. Carolyn was discharged the following day with a plan for follow-up in 1 week for grief counseling. On Postpartum Day 8, she complained to her spouse of pain and swelling in her legs. Rest and antiembolism stockings were recommended by phone consultation with the physician, but no further diagnostic evaluation or teaching of danger signs were noted in Carolyn's health care record. On Postpartum Day 11, she experienced sudden, severe difficulty breathing. A family member called emergency 911. Carolyn was intubated by emergency responders during transport, but she rapidly declined after arrival at the hospital and died 4 hours later. An autopsy confirmed the diagnosis of pulmonary embolism.

Quality improvement opportunities:

- No VTE prophylaxis during Carolyn's birth hospitalization
- No clear recognition of risk factors (obesity, prolonged induction, and fetal demise)

To prevent maternal mortality and morbidity from venous thromboembolism, facilities and clinicians need to implement standardized protocols for prophylaxis and treatment.

- No response to Carolyn's symptoms of leg pain and swelling with a physical assessment rather than telephone advice
- No evidence of discharge teaching for VTE risks and signs and symptoms of VTE that require a prompt return to a health care facility (hospital or clinic)

Vignette 2. Evelyn was a 22-year-old gravida 1, para 0 woman with a BMI of 31 kg/m^2 and a normal prenatal course but a history of sleep apnea. She presented to the labor and delivery unit at 38 weeks for elective induction of labor. She was given dinoprostone at 7 a.m. and again 8 hours later. On Day 2, she received 12 hours of intravenous oxytocin and then rested for the second night, with a third dose of dinoprostone given at 7 p.m. The following day, she received intravenous oxytocin for 10 hours and then had a cesarean birth for failure to progress. On Day 4 of hospitalization (Day 1 postpartum), she was helped to the bathroom for the first time, where she collapsed and a code was called. Evelyn received cardiopulmonary resuscitation for 45 minutes with no response. An autopsy showed multiple thrombi in Evelyn's lungs, and the pathologist determined that the cause of death was pulmonary emboli.

Quality improvement opportunities:

- No readiness with VTE prophylaxis during or after surgery
- No evidence of recognition of prolonged induction as a risk factor
- No response to VTE risk through early ambulation after cesarean

In many of the VTE cases, clinicians had little time to respond to the rapid deterioration that ensued after a PE event. Nevertheless, early recognition of risk factors and timely, appropriate response with thromboprophylaxis before a PE can decrease VTE maternal deaths.

Discussion

The most common theme in the *Readiness* domain was the importance of education for women about VTE risk during pregnancy and before postpartum discharge. Women were not adequately educated about the significance of their VTE risk; were not provided with compelling rationale for prophylaxis to facilitate adherence; and were not offered strategies to decrease VTE risk, including weight management before or during pregnancy. Alzoubi, Khassawneh, Obeidat, Asfoor, and Al-azzam (2013) noted similar issues with VTE risk awareness in their cross-sectional survey of 230 women who experienced cesarean birth. The majority of women (54%) were not aware of VTE as a complication of cesarean or of other factors that increase VTE risk. Only 25.4% recognized pregnancy as a VTE risk factor.

Despite having several risk factors, including high BMI, long induction of labor, and/or cesarean births, women who died of VTE appeared not to understand the importance of their symptoms and thus did not seek care in a timely manner. In several cases, it was not clear to the CA-PAMR committee whether women received discharge education about VTE signs and symptoms, including how and when to seek care. In a study to assess the quality of postpartum discharge education, Suplee, Kleppel, and Bingham (2016) noted that although nurses provided some form of postpartum discharge education about warning signs and symptoms of postpartum complications to all women, the information was not always consistent or evidence based. Bowman (2005) also noted that elements of discharge education regarding warning signs and symptoms did not occur throughout the hospital stay, when women may be more receptive. Instead, these issues were typically raised on the day of discharge at a time when women receive an abundance of information about other topics, including self- and infant care. In their pilot project to implement standardized discharge teaching education, Suplee, Kleppel, Santa-Donato, and Bingham (2016) found that nurses had positive responses to the use of discharge education tools and reported increased self-efficacy to educate women about VTE risk.

Insights from the analysis of the QIO data on VTE deaths in California informed the development of the *Improving Health Care Response to Maternal Venous Thromboembolism* toolkit (Hameed, Friedman, Peterson, Morton, & Montgomery, 2018). On a national level, the four domains used in this study (4R Framework) have been adopted by the National Partnership for Maternal Safety, which has published multiple patient

safety bundles, one of which addresses VTE (D'Alton et al., 2016). Emphasis in this bundle is placed on education and routine screening for risk factors to identify pregnant women who need preventive or treatment measures. Several risk assessment tools are available for use in the clinical setting (Bennett-Day, 2011; Collins, Bowles, & MacCallum, 2016; Hameed et al., 2018). Women who died of VTE in California and were at risk for VTE due to obesity, cesarean birth, or prolonged labor with induction were not identified as such, and their need for thromboprophylaxis went unrecognized. Bedrest with decreased mobility during pregnancy is harmful in most cases and increases VTE risk (Chunilal & Chan, 2011; Munib & Madlon-Kay, 2012). Similar to the results of other studies (Colmorn, Ladelund, Rasmussen, & Secher, 2014; Main et al., 2015), our findings indicate a strong relationship between VTE, obesity, and cesarean birth, because BMI significantly influences VTE risk after cesarean compared with vaginal birth. Although pregnant women at very high risk for VTE (i.e., thrombophilia or previous VTE) typically receive prophylaxis, Friedman et al. (2015) noted that women with other risk factors are less likely to receive routine prophylaxis.

Clinicians' failure to identify women at risk and to recognize VTE signs and symptoms were common among the case reviews. Despite presenting more than once for severe leg pain, women were not comprehensively evaluated for VTE and, hence, not treated. In cases in which other symptoms were evident, such as tachycardia, shortness of breath, chest pain, and decreased oxygen saturation, women were commonly misdiagnosed with myocardial infarction instead of PE. Clinicians need to know that signs and symptoms have less than 50% specificity for VTE diagnosis, which must be confirmed by ultrasound and D-dimer assays (D. C. James, 2014). Because maternal death related to VTE is uncommon, symptoms can be overlooked and misdiagnosed. Dyspnea from normal pregnancy changes can be differentiated from dyspnea caused by VTE by the severity and related signs and symptoms. Although leg swelling and tachypnea can be attributed to normal physiologic changes in pregnancy, especially in the third trimester (Marshall, 2014), when women report subjective symptoms suggestive of DVT or PE, clinicians should have a high index of suspicion for pregnancy-related VTE, especially in women with known risk factors.

These pregnancy-related deaths occurred in California between 2002 and 2007, when VTE prophylaxis was not universally administered. Current recommendations for VTE prevention include standardization of mechanical and chemical thromboprophylaxis in women identified as being at high risk for VTE based on risk factors and clinical circumstances (D'Alton et al., 2016; Hameed et al., 2018). Although previous researchers noted the need for preconception and early pregnancy assessment of women for VTE risk (McLintock et al., 2012; Okoroh et al., 2012), our findings support the current consensus that every pregnant woman should be assessed for VTE risk on admission to the antepartum, labor and delivery, and postpartum units. Risk assessments should be performed on all women during the first trimester, at each antepartum or intrapartum hospitalization, and again during the postpartum period (Walsh & Malone, 2016).

With this analysis of the lessons learned from fatal consequences of VTE, we show the importance of having and following risk assessment protocols. Several QIOs highlighted lack of appropriate and adequate treatment protocols, and one third (20/60) of the QIOs in the *Response* domain noted the absence of prophylaxis in the presence of major risk factors. Women at risk for VTE have improved outcomes with the use of standardized recommendations for mechanical thromboprophylaxis, including pneumatic compression devices for all women who undergo cesarean birth (Clark, Christmas, Frye, Meyers, & Perlin, 2014) and dosing of prophylactic and therapeutic pharmacologic anticoagulation with low-molecular-weight heparin for women with a history of VTE or thrombophilia (D'Alton et al., 2016). Nursing interventions that can be implemented to mitigate the risk of VTE include early ambulation, hydration, antiembolism stockings, and counseling on prolonged sitting and smoking (Davidson et al., 2016). A standardized approach to assessment (*Recognition*) and treatment (*Response*) has been noted to decrease adverse outcomes related to hemorrhage (Einerson, Miller, & Grobman, 2015; Main et al., 2017; Shields, Wiesner, Fulton, & Pelletreau, 2015), and our findings support this approach to prevent and treat VTE.

In addition to implementing interventions to reduce the risk of VTE in the postpartum period, nurses are also instrumental in advocating for appropriate follow-up after discharge for all women at risk for postpartum VTE. Women with pregnancy complications are at increased risk for early and late

postpartum VTE, and that risk may extend through at least 12 weeks postpartum (Tepper et al., 2014). Therefore, home visitation through community or public health nursing programs could be beneficial to ensure that women's symptoms are identified early, appropriate treatment is begun, and continued support is provided.

Strengths and Limitations

The strengths and limitations of the overall study and methodology are detailed elsewhere (Morton et al., 2019). This was a retrospective view of practice from more than a decade ago, when VTE prophylaxis recommendations were not standard or universally applied, and no maternity care consensus on best practice had been identified. Even so, analysis of the QIO data from 29 maternal deaths due to VTE produced rich insights into optimal clinical and informational processes, which have been incorporated into quality tools for hospitals and clinicians for VTE prevention and treatment (Hameed et al., 2018).

Conclusion

Nurses play a key role in risk assessment, and they are integral to the initiation, implementation, and sustainment of quality improvement in maternity care. As bedside clinicians and usually the first and most frequent providers of hospital-based perinatal care, nurses are vital in identifying women who are at increased risk for VTE due to medical, obstetric, or labor factors; advocating for mechanical and/or chemical prophylaxis; assessing at-risk women for signs and symptoms of VTE or worsening condition; initiating nursing interventions that can mitigate the risk for VTE, including education; and advocating for appropriate, adequate, and timely medical interventions. Because half of pregnancy-related VTE occurs during the postpartum period, nurses in mother–infant units are critical for the success of facility-based quality improvement strategies and should be included in all phases of quality improvement initiatives to reduce women's morbidity and mortality from VTE. Overall, implementation of known strategies, such as those included in the California VTE toolkit and the national maternal safety bundle on VTE, can help reduce rates of maternal mortality.

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REFERENCES

Alzoubi, K. H., Khassawneh, B. Y., Obeidat, B., Asfoor, S. S., & Al-azzam, S. I. (2013). Awareness of patients who undergo cesarean section about venous thromboembolism prophylaxis. *Journal of Vascular Nursing, 31*, 15–20. https://doi.org/10.1016/j.jvn.2012.07.001

American College of Obstetricians and Gynecologists. (2018). ACOG practice bulletin no. 196. Thromboembolism in pregnancy. *Obstetrics & Gynecology, 132*(1), e1–e17. https://doi.org/10.1097/AOG.0000000000002706

Bennett-Day, S. (2011). Universal risk assessments to guide use of thromboprophylaxis. *British Journal of Midwifery, 19*, 778–785. https://doi.org/10.12968/bjom.2011.19.12.778

Bowman, K. G. (2005). Postpartum learning needs. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 34*, 438–443. https://doi.org/10.1177/0884217505276054

California Department of Public Health. (2018). *California Pregnancy-Associated Mortality Review (CA-PAMR)*. Sacramento, CA: Author. Retrieved from https://www.cdph.ca.gov/Programs/CFH/DMCAH/Pages/PAMR.aspx

Chandrarajan, L., & Nelson-Piercy, C. (2015). Risk of venous thromboembolism during pregnancy and birth. *British Journal of Midwifery, 23*, 618–622. https://doi.org/10.12968/bjom.2015.23.9.618

Chunilal, S. D., & Chan, W. S. (2011). Critical illness in obstetric patients: Venous thromboembolism in pregnancy. *Current Women's Health Reviews, 7*, 189–202. https://doi.org/10.2174/157340411795445749

Clark, S. L., Christmas, J. T., Frye, D. R., Meyers, J. A., & Perlin, J. B. (2014). Maternal mortality in the United States: Predictability and the impact of protocols on fatal post-cesarean pulmonary embolism and hypertension-related intracranial hemorrhage. *American Journal of Obstetrics and Gynecology, 211*(1), 32.e1–32.e9. https://doi.org/10.1016/j.ajog.2014.03.031

Collins, J., Bowles, L., & MacCallum, P. K. (2016). Prevention and management of venous thromboembolism in pregnancy. *British Journal of Hospital Medicine, 77*(12), C194–C200. https://doi.org/10.1016/j.amjmed.2007.08.011

Colmorn, L. B., Ladelund, S., Rasmussen, S., & Secher, N. J. (2014). Risk of venous thromboembolic episode due to caesarean section and BMI: A study in northern Denmark covering 2000–2010. *Journal of Obstetrics and Gynaecology, 34*, 313–316. https://doi.org/10.3109/01443615.2013.873775

Council on Patient Safety in Women's Health Care. (2019). *Patient safety bundles*. Washington, DC: Author. Retrieved from https://safehealthcareforeverywoman.org/patient-safety-bundles/

Creanga, A. A., Berg, C. J., Syverson, C., Seed, K., Bruce, F. C., & Callaghan, W. M. (2015). Pregnancy-related mortality in the United States, 2006–2010. *Obstetrics & Gynecology, 125*, 5–12. https://doi.org/10.1097/AOG.0000000000000564

Creanga, A. A., Syverson, C., Seed, K., & Callaghan, W. M. (2017). Pregnancy-related mortality in the United States, 2011–2013. *Obstetrics & Gynecology, 130*, 366–373. https://doi.org/10.1097/AOG.0000000000002114

Cunningham, F. G., Leveno, K. J., Bloom, S. L., Spong, C. Y., Dashe, J. S., Hoffman, B. L., … Sheffield, J. S. (2014). *Williams obstetrics* (24th ed.). New York, NY: McGraw-Hill.

D'Alton, M. E., Friedman, A. M., Smiley, R. M., Montgomery, D. M., Paidas, M. J., D'Oria, R., … Clark, S. L. (2016). National Partnership for Maternal Safety: Consensus bundle on venous thromboembolism. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 45*, 706–717. https://doi.org/10.1016/j.jogn.2016.07.001

Davidson, M., London, M., & Ladewig, P. (2016). *Olds' maternal-newborn nursing & women's health across the lifespan* (10th ed.). New York, NY: Pearson.

Einerson, B. D., Miller, E. S., & Grobman, W. A. (2015). Does a postpartum hemorrhage patient safety program result in sustained changes in management and outcomes? *American Journal of Obstetrics & Gynecology, 212*, 140–144. https://doi.org/10.1016/j.ajog.2014.07.004

Friedman, A. M., Ananth, C. V., Prendergast, E., Chauhan, S. P., D'Alton, M. E., & Wright, J. D. (2015). Thromboembolism incidence and prophylaxis during vaginal delivery hospitalizations. *American Journal of Obstetrics & Gynecology, 212*(2), 221.e1–221.e12. https://doi.org/10.1016/j.ajog.2014.09.017

Ghaji, N., Boulet, S. L., Tepper, N., & Hooper, W. C. (2013). Trends in venous thromboembolism among pregnancy-related hospitalizations: United States, 1994–2009. *American Journal of Obstetrics & Gynecology, 209*(5), 433.e1–433.e8. https://doi.org/10.1016/j.ajog.2013.06.039

Hameed, A. B., Friedman, A., Peterson, N., Morton, C. H., & Montgomery, D. (2018). *Improving health care response to maternal venous thromboembolism*. Stanford, CA: California Maternal Quality Care Collaborative. Retrieved from https://www.cmqcc.org/resources-toolkits/toolkits/improving-health-care-response-maternal-venous-thromboembolism

Heit, J., Kobbervig, C., James, A., Petterson, T., Bailey, K. R., & Melton, L. J., III (2005). Trends in the incidence of venous thromboembolism during pregnancy or postpartum: A 30-year population-based study. *Annals of Internal Medicine, 143*, 697–706. https://doi.org/10.7326/0003-4819-143-10-200511150-00006

James, A. H. (2012). Prevention and treatment of venous thromboembolism in pregnancy. *Clinical Obstetrics and Gynecology, 55*, 774–787. https://doi.org/10.1080/14779072.2017.1319279

James, D. C. (2014). Postpartum care. In K. R. Simson & P. A. Creehan (Eds.), *AWHONN's perinatal nursing* (4th ed., pp. 530–580). Philadelphia, PA: Lippincott Williams & Wilkins.

Kilpatrick, S. (2015). Next steps to reduce maternal morbidity and mortality in the USA. *Women's Health, 11*, 193–199. https://doi.org/10.2217/WHE.14.80

Knight, M., Nair, M., Tuffnell, D., Kenyon, S., Shakespeare, J., Brocklehurst, P., & Kurinczuk, J. J. (Eds.). (2016). *Saving lives, improving mothers' care. Surveillance of maternal deaths in the UK 2012–14 and lessons learned to inform maternity care from the UK and Ireland confidential enquiries into maternal deaths and morbidity 2009–14*. Oxford, UK: National Perinatal Epidemiology Unit, University of Oxford. Retrieved from https://www.npeu.ox.ac.uk/downloads/files/mbrrace-uk/reports/MBRRACE-UK%20Maternal%20Report%202016%20-%20website.pdf

Lyndon, A., Lagrew, D., Shields, L., Melsop, K., Bingham, D., & Main, E. (Eds.). (2010). *Improving health care response to obstetric hemorrhage version 1.0. California Maternal Quality Care Collaborative toolkit to transform maternity care*. Stanford, CA: California Maternal Quality Care Collaborative.

Main, E. K., Cape, V., Abreo, A., Vasher, J., Woods, A., Carpenter, A., & Gould, J. B. (2017). Reduction of severe maternal morbidity from hemorrhage using a state perinatal quality collaborative. *American Journal of Obstetrics & Gynecology, 216*(3), 298.e1–298.e11. https://doi.org/10.1016/j.ajog.2017.01.017

Main, E. K., McCain, C. L., Morton, C. H., Holtby, S., & Lawton, E. S. (2015). Pregnancy-related mortality in California: Causes, characteristics, and improvement opportunities. *Obstetrics & Gynecology, 125*, 938–947. https://doi.org/10.1097/AOG.0000000000000746

Marshall, A. (2014). Diagnosis, treatment, and prevention of venous thromboembolism in pregnancy. *Postgraduate Medicine, 126*, 25–34. https://doi.org/10.3810/pgm.2014.11.2830

McLintock, C., Brighton, T., Chunilal, S., Dekker, G., McDonnell, N., McRae, S., … Young, L. (2012). Recommendations for the prevention of pregnancy-associated venous thromboembolism. *Australian and New Zealand Journal of Obstetrics and Gynecology, 52*, 3–13. https://doi.org/10.1111/j.1479-828X.2011.01357.x

Middeldorp, S., & Bleker, S. M. (2014). Women admitted to hospital during pregnancy have increased risk of venous thromboembolism that persists up to 28 days post discharge. *Evidence-Based Nursing, 17*, 103. https://doi.org/10.1136/eb-2013-101706

Morton, C. H., VanOtterloo, L. R., Seacrist, M. J., & Main, E. K. (2019). Translating maternal mortality review into quality improvement opportunities in response to pregnancy-related deaths in California. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 48*, 252–262. https://doi.org/10.1016/j.jogn.2019.03.003

Munib, S., & Madlon-Kay, D. J. (2012). What are the benefits and harms of bedrest for complications of pregnancy? *Evidence-Based Practice, 15*(12), 1–2.

Okoroh, E. M., Azonobi, I. C., Grosse, S. D., Grant, A. M., Atrash, H. K., & James, A. H. (2012). Prevention of venous thromboembolism in pregnancy: A review of guidelines, 2000–2011. *Journal of Women's Health, 21*, 611–615. https://doi.org/10.1089/jwh.2012.3600

Sellman, J. S., & Holman, R. L. (2000). Thromboembolism during pregnancy: Risks, challenges, and recommendations. *Postgraduate Medicine, 108*(4), 71–84.

Shields, L. E., Wiesner, S., Fulton, J., & Pelletreau, B. (2015). Comprehensive maternal hemorrhage protocols reduce the use of blood products and improve patient safety. *American Journal of Obstetrics & Gynecology, 212*, 272–280. https://doi.org/10.1016/j.ajog.2014.07.012

Sultan, A. A., West, J., Tata, L. J., Fleming, K. M., Nelson-Piercy, C., & Grainge, M. J. (2012). Risk of first venous thromboembolism in and around pregnancy: A population-based cohort study. *British Journal of Haematology, 156*, 366–373. https://doi.org/10.1111/j.1365-2141.2011.08956.x

Suplee, P. D., Kleppel, L., & Bingham, D. (2016). Discharge education on maternal morbidity and mortality provided by nurses to women in the postpartum period. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 45*, 894–904. https://doi.org/10.1016/j.jogn.2016.07.006

Suplee, P. D., Kleppel, L., Santa-Donato, A., & Bingham, D. (2016). Improving postpartum education about warning signs of maternal morbidity and mortality. *Nursing for Women's Health, 20*, 553–567. https://doi.org/10.1016/j.nwh.2016.10.009

Tepper, N. K., Boulet, S. L., Whiteman, M. K., Monsour, M., Marchbanks, P. A., Hooper, W. C., & Curtis, K. M. (2014). Postpartum venous thromboembolism: Incidence and risk factors.

Obstetrics & Gynecology, 123, 987–996. https://doi.org/10.1097/AOG.0000000000000230

Toglia, M. R., & Weg, J. G. (1996). Venous thromboembolism during pregnancy. *New England Journal of Medicine, 335*, 108–114. https://doi.org/10.1056/NEJM199607113350207

Walsh, J. M., & Malone, F. D. (2016). Reducing the risk of venous thromboembolism in pregnancy—The safe motherhood initiative thromboembolism bundle. *Seminars in Perinatology, 40*, 93–95. https://doi.org/10.1053/j.semperi.2015.11.013