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Accuracy of the Obstetric Early Warning System in Predicting Maternal Morbidity: Systematic Literature Review

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ABSTRACT

Background: One way to prevent maternal mortality which is quite high in Indonesia is to prevent late diagnosis through proper screening so that it allows faster handling of morbidity which has an impact on reducing maternal mortality cases. Screening that can be used is the Obstetric Early Warning System. This study discusses evidence regarding the implementation of the Obstetric Early Warning System by showing its accuracy in predicting maternal morbidity. **Method:** Systematic Literature Review using the PRISMA approach. Article search through electronic browser databases, namely Pubmed and Google Scholar. This browser was chosen because it was considered to have a more complete source based on the research topic, namely obstetric early warning. The keywords used were MOEWS, MEWT, MEWC, MEWS in the period 2013-2023. **Results:** Our study found that the obstetric early warning evaluated in this study consisted of SOS, MOEWS, MEWT, SI, e-CART, MEWC, and MEWS had good performance in predicting obstetric patients who experienced infection, were admitted to the ICU, bleeding, patient transfer to the ICU and predicting preeclampsia. **Conclusion:** Obstetric early warning systems can predict maternal morbidity, with varying degrees of accuracy. All early warning systems always begin with vital signs examination so this assessment needs to be done carefully to initiate immediate action if necessary.

INTRODUCTION

The success of health programs is measured by the reduction in maternal mortality rates. However, maternal mortality remains an unresolved issue, especially in Indonesia. Therefore, preventing maternal deaths is something that must be given serious attention. Maternal mortality serves as an indicator of improvements in healthcare services in terms of accessibility and quality. The number of maternal deaths from 2019-2021 showed an increasing trend, but in 2022-2023 there was a fluctuation. The recorded number of maternal deaths in Indonesia in 2019 was 4,221, which increased to 4,627 in 2020 and reached the highest number of 7,389 in 2021, then decreased to 3,572 in 2022, and rose again in 2023 to 4,482 (Kementerian Kesehatan, 2024).

Maternal deaths are primarily caused by hypertension, followed by obstetric bleeding, and other obstetric complications, including infections. The 2022 Susenas data showed that one-third of ten mothers experienced health complaints. The percentage of mothers with health complaints was higher in rural areas than in urban areas. The presence of health complaints leads to disruptions in daily activities, which implicates untreated morbidity that can eventually lead to death (Badan Pusat Statistik, 2002).

One of the Sustainable Development Goals (SDGs) targets is to reduce the Maternal Mortality Ratio (MMR) to 131 deaths per 100,000 live births by 2030. Ensuring that all women have timely access to emergency maternal care when considering childbirth is crucial (Kementerian Perencanaan Pembangunan Nasional, 2021). One of the best efforts to achieve this target is ensuring that every healthcare worker is knowledgeable about the appropriate screening to detect early warning signs before an emergency occurs. By providing care that recognizes danger signs accurately, before emergency conditions arise that can cause suffering or even threaten life, it is possible to prevent delays in diagnosis, allowing for faster treatment.

This article discusses evidence regarding proper screening to detect maternal morbidity. This study aims to present several articles on maternal warning protocols used in healthcare facilities, supplemented by accuracy data to reinforce the importance of early warning comprehension in preventing maternal deaths. Through the Obstetric Early Warning System, early signs of patient deterioration can be detected promptly, allowing for immediate management, improving the quality of care for pregnant, laboring, and postpartum women, and reducing the negative impacts of obstetric complications.

A sound understanding of early warning systems enables early referral. Early referral to higher-level healthcare facilities can save mothers from complications during late pregnancy or childbirth that may result in morbidity and mortality for both mother and baby (Ocviyanti, 2019). This study aims to evaluate the accuracy of the Obstetric Early Warning System in predicting maternal morbidity and facilitating the early detection of complications that may contribute to maternal morbidity during pregnancy, childbirth, and the postpartum period.

METHODS

This systematic review was conducted by synthesizing findings from quantitative studies, both prospective and retrospective, by adopting the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. In addition, the studies used in this review had to have ethical approval.

The literature search was conducted through electronic browser databases, namely PubMed and Google Scholar, in October 2023. These browsers were chosen because they were considered to have more comprehensive sources based on the research topic, which is obstetric early warning. The keywords used were MOEWS, MEWT, MEWC, MEWS during the period from 2013 to October 2023. All articles were selected by reading the titles and abstracts.

The selected articles focused on early warning systems involving obstetric patients. The studies had to meet the following criteria: first, they involved obstetric patients, including pregnant women, women in labor, and postpartum women. Second, they had to be clinical trials and quantitative studies. Third, the selected studies had to include information on the accuracy, sensitivity/specificity, probability, or predictive value of the Obstetric Early Warning System. All selected articles were assessed by all authors. Initially, the researchers identified eligible studies by reading the abstracts and then reviewing the full texts of the papers. Subsequently, the other authors comprehensively examined the final articles and decided which articles should be selected through discussion. Similarly, the review process began by reading all the information available in the studies. The authors then highlighted the relevant data segments to capture the main concepts of each article.

RESULTS

As illustrated in Figure 1, a total of 2,647 articles were identified from the two browsers. After filtering, only 310 full-text articles were selected. Then, 293 articles were excluded based on their titles and abstracts. After screening, 12 articles related to the Obstetric Early Warning System were considered eligible, but only 8 studies were analyzed because they included information on accuracy, sensitivity/specificity, probability, or predictive value of the Obstetric Early Warning System, as shown in Figure 1. The summary of the studies is presented in Table 1.

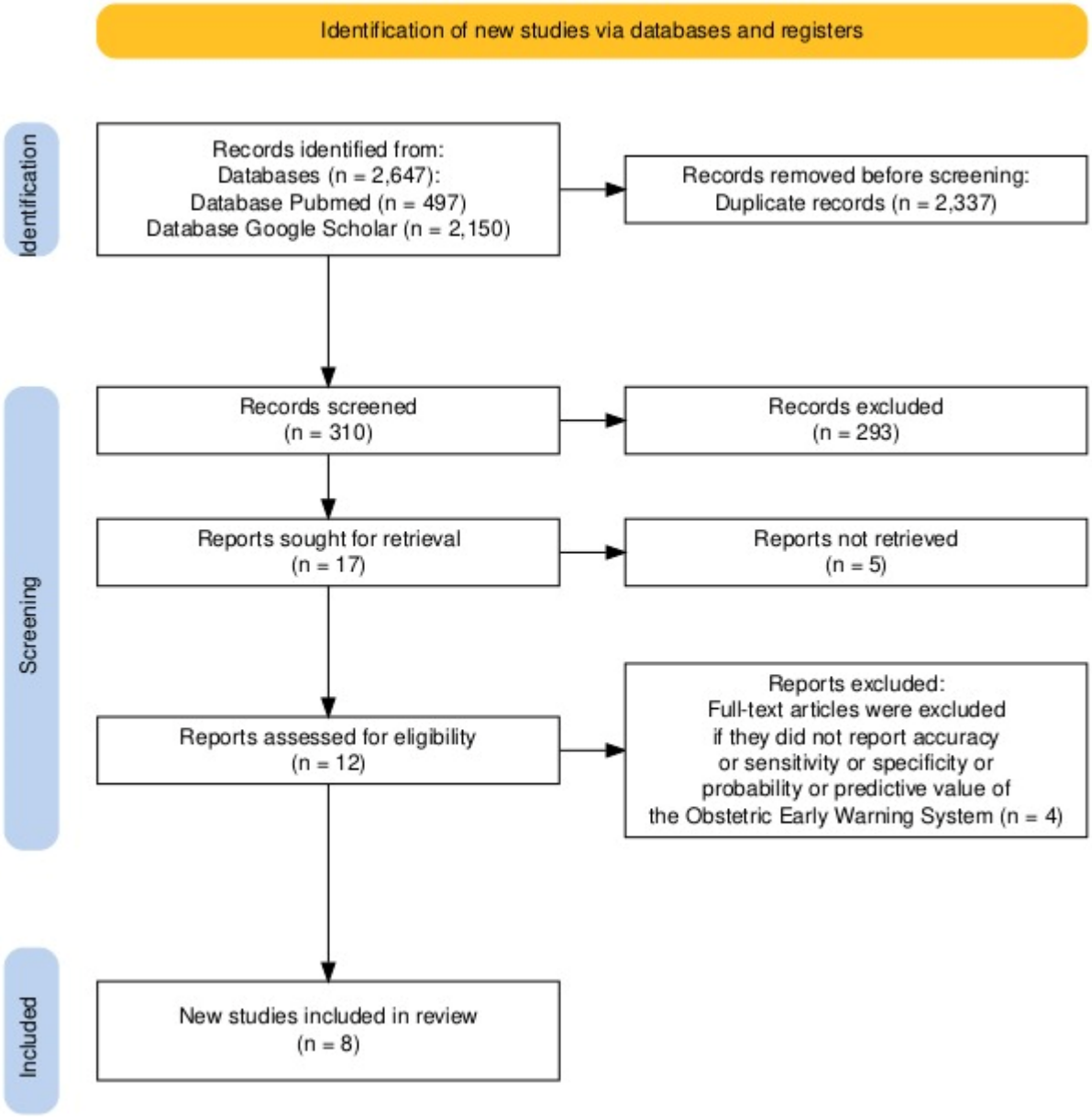

Figure 1. PRISMA Flow Diagram (Page et al., 2021)

Table 1. Summary of The Studies

No	Author	Design	EWS type	Study Population	Types of Morbidity / Risk Factors	Conclusion
1	Catherine M. Albright, MD, Phinnara Has, MS, Dwight J. Rouse, MD, and Brenna L. Hughes, MD (Albright et al., 2017)	Prospective Research	The Sepsis in Obstetrics Score (SOS)	Pregnant or postpartum women who were treated in the emergency department and had systemic inflammation criteria (n= 1250)	Infection, treated in the ICU and antibiotic therapy	SOS performed well (negative prediction of 98.6%).
2	Yonghui Xu, Sha Zhu, Hao Song, Xiaoyuan Lian, Maoni Zeng, Ji He, Lijuan Shu, XingSheng Xue and Fei Xiao (Xu et al., 2022)	Retrospective Research	The New modified obstetric early warning score	women treated in ICU (n=352)	Identifying mothers who were treated 24 hours after entering the ICU	The new MOEWS performs very well (sensitivity 99.3%, specificity 75.8%, positive predictive value 95.1% and negative predictive value 95.9%. The area under the ROC curve is 0.92 and 0.70.
3	Laurence E. Shields, MD; Suzanne Wiesner, RN, MBA; Catherine Klein, RN, CNM; Barbara Pelletreau, RN, MPH; Herman L. Hedriana, MD (Shields et al., 2016)	Prospective Research	Maternal Early Warning Trigger tool	Maternity mothers (n=11,399)	Sepsis, cardiopulmonary dysfunction, preeclampsia-hypertension, and bleeding	MEWT in predicting obstetric patients admitted to the ICU has good performance (sensitivity 96.9%, specificity 99.9%, positive predictive value 12.0%, and negative predictive value 99.99%). In predicting sepsis 38%, cardiopulmonary dysfunction 6%, and 15% hypertension, 31% bleeding, and 6% other obstetric complications

No	Author	Design	EWS type	Study Population	Types of Morbidity / Risk Factors	Conclusion
4	Alice BR Aarvold, MBChB; Helen M. Ryan, MBBChBAO ; Laura A. Magee, MD; Peter von Dadelszen, MBChB; Chris Fjell, PhD ; Keith R. Walley, MD (Aarvold et al., 2017)	Retrospective Research	SOS scores compared APACHE II, SAPS II, SOFA and MODS	Pregnant women and labor up to 6 weeks postpartum (obstetric n=797)	Sepsis	The designed SOS has quite good performance and is on the AUROC curve with a value of around 0.67 in obstetric patients.
5	Varsha Agarwal, Jyotsna Suri, Prerana Agarwal, Supriya Gupta, Pragya K Mishra, Pratima Mittal (Agarwal et al., 2021)	Prospective Research	Shock Index	Women who give birth after 28 weeks gestation with an estimated blood loss of more than 500 mL in vaginal delivery and more than 1000 mL by cesarean section. (n=100)	Bleeding	• The shock index is a simple, non-invasive, and sensitive tool that can be used to triage postpartum hemorrhage. • SI value >1.32 is associated with a blood transfusion of 4 units (product) (AUROC value: 0.88, Sensitivity 82.14%, Specificity 93.06%) • SI value > 1.4 is associated with a blood transfusion of 10 units (product) (AUROC value: 0.91, Sensitivity 91.67%, Specificity 90.91%) • SI value > 1.32 is associated with the need for ICU admission (AUROC value: 0.98, Sensitivity 95.45%, Specificity 92.31%) • SI value >1.65 is associated with maternal death (AUROC value: 0.99, Specificity 98.95%) • SI value >1.32 is associated with the need for hysterectomy

No	Author	Design	EWS type	Study Population	Types of Morbidity / Risk Factors	Conclusion
						(AUROC value: 0.91, Sensitivity 90.91%, Specificity 89.74%) • SI value > 1.32 is associated with the need for surgery to repair cervical/vaginal tears (AUROC value: 0.70, Sensitivity 75%, Specificity 78.41%) • SI value > 1.3 is associated with the need for Internal Artery ligation surgery (AUROC value: 0.83, Sensitivity: 90%, specificity 77.78%) • SI value >1.1 is associated with the need for Balloon Tamponade surgery (AUROC value: 0.65, Sensitivity 66.67% and Specificity 71.43%) • SI value > 1.08 is associated with the need for the manual placenta (AUROC value: 0.86, Specificity: 79.38) • SI value > 1.24 is associated with the need for compression sutures (AUROC value: 0.67, Specificity: 58.76)

No	Author	Design	EWS type	Study Population	Types of Morbidity / Risk Factors	Conclusion
6	David E. Arnolds, Kyle A. Carey, Lena Braginsky, Roxane Holt, Dana P. Edelson, Barbara M. Scavone and Matthew Churpek (Arnolds et al., 2019)	Retrospective Cohort Research	The electronic Cardiac Arrest Risk Triage (eCART) score)	Patients treated in the obstetrics ward were (n= 19,611)	ICU transfer and/or death, infection.	An early warning system using machine learning technology, eCART has good accuracy/performance with an AUC of 0.86 and predicts infection with an AUC value of 0.77.
7	Tracey H. DeYoung, Julie R. Whittington, Christopher S. Ennen, Aaron T. Poole, MD (Deyoung et al., 2019)	Retrospective Cohort Research	Maternal Early Warning Criteria (MEWC)	Pregnant women treated with pyelonephritis (n=110)	ICU transfer	A positive MEWC provides a prediction of 16.54 greater for transfer to the ICU.
8	Cristina Iba´ñez-Lorente, Rube´n Casans-France ´s E. Muñoz-Alameda (Ibáñez-Lorente et al., 2021)	Prospective Research	Maternal Early Warning System (MEWS)	P patients first 2 hours after delivery (n=1166)	Preeclampsia, Potential for cesarean birth, multiple pregnancies, potentially fatal disorders (PFD), Transfer to ICU, Bleeding, Emergency surgery within 2 hours postpartum, length of stay >7 days.	MEWS has poor performance at a sensitivity level of 0.28 but has an excellent specificity accuracy of 0.94 in predicting disorders that will have severe consequences.

DISCUSSION

Based on the selected final journals, we evaluated the performance of early warning scores in obstetric patients, consisting of SOS, MOEWS, MEWT, SI, e-CART, MEWC, and MEWS as shown in Table 1. The SOS is a combination of the Rapid Emergency Medicine Score and the Systemic Inflammatory Response Syndrome. Modifications of these two sepsis early warning systems were made because these parameters are expected to change during pregnancy. (Aarvold et al., 2017; Albright et al., 2017) Determining an early warning system for sepsis detection remains challenging due to anatomical and physiological changes during pregnancy. Throughout pregnancy, the cardiovascular system undergoes many changes that contribute to both maternal and fetal physiology. Systemic vasodilation leads to an increase in heart rate by up to 24% by the end of pregnancy and persists for up to two weeks postpartum. A physiological decrease in arterial pressure also occurs. These abnormal baseline changes can obscure the signs of sepsis (Bridwell et al., 2019).

Table 2. SOS Criteria

Variables	High Abnormal				Normal	Low Abnormal			
	+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature (°C)	>40.9	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	<30
Systolic Blood Pressure					> 90		70-90		>70
Heart Rate	>179	150-179	130-149	120-129	≤119				
Respiratory Rate	>49	35-49		25-34	12-24	10-11	6-9		≤5
Oxygen Saturation					≥92%	90-91%		85-89%	<85
White Blood Cell Count	39.9		25-39.9	17-24.9	5.7-16.9	3-5.6	1-2.9		<1
% Immature Neutrophils			≥10		<10				
Lactic Acid			≥4		<4				

Source: (Albright et al., 2017)

The new MOEWS demonstrated outstanding performance in the early detection of deteriorating conditions in obstetric patients. This certainly has a positive impact on improving maternal health (Xu et al., 2022). However, MOEWS detected only about half of morbidity cases. Obstetric patients with hemorrhage and preeclampsia benefit the most from this early warning system. The incidence of detected morbidity was 29% using the new MOEWS) (Hoppu et al., 2022).

Table 3. MOEWS Criteria

Physiological Parameter	3	2	1	0	1	2	3
Temperature (°C)	≤35		<36	36–37.4	37.5–38	38.1–38.9	≥39
Respiratory Rate	<10		10–11	12–20		21–29	≥30
SpO2 (%)	≤90	91–93	94–95	≥96			
Any Supplemental Oxygen	Using mask	Using a nasal cannula		Room air			
Heart Rate	<50	50–59		60–99	100–109	110–129	≥130

Physiological Parameter	3	2	1	0	1	2	3
Systolic BP (mmHg)	<90		90–99	100–139	140–149	150–159	≥160
Diastolic BP (mmHg)			≤45	46–89	90–99	100–109	≥110
level of Consciousness			Alert				Voice (V) / Pain (P) / Unresponsive (U)
Pain (excluding labour)				Normal			Abnormal
Discharge/Lochia				Normal			Abnormal
Proteinurea.						+	++>

Source: (Cole, 2014)

MEWT was designed to identify the most common causes of maternal morbidity, namely sepsis, severe cardiovascular dysfunction, preeclampsia-hypertension, and hemorrhage. Another advantage of MEWT is that it provides assessment and management recommendations that significantly improve maternal morbidity outcomes. Variations of this early warning system are used in most labor centers in the United States (Shields et al., 2016). The implementation of MEWT showed a significant reduction in maternal and fetal complications in mothers with hypertensive disorders, highlighting the importance of integrating MEWT into obstetric practice (Yerubandi et al., 2024). Although MEWT was not directly linked to a reduction in maternal morbidity, its application improved clinical care and was sensitive in detecting septic, hypertensive, and cardiopulmonary morbidity (Blumenthal et al., 2021).

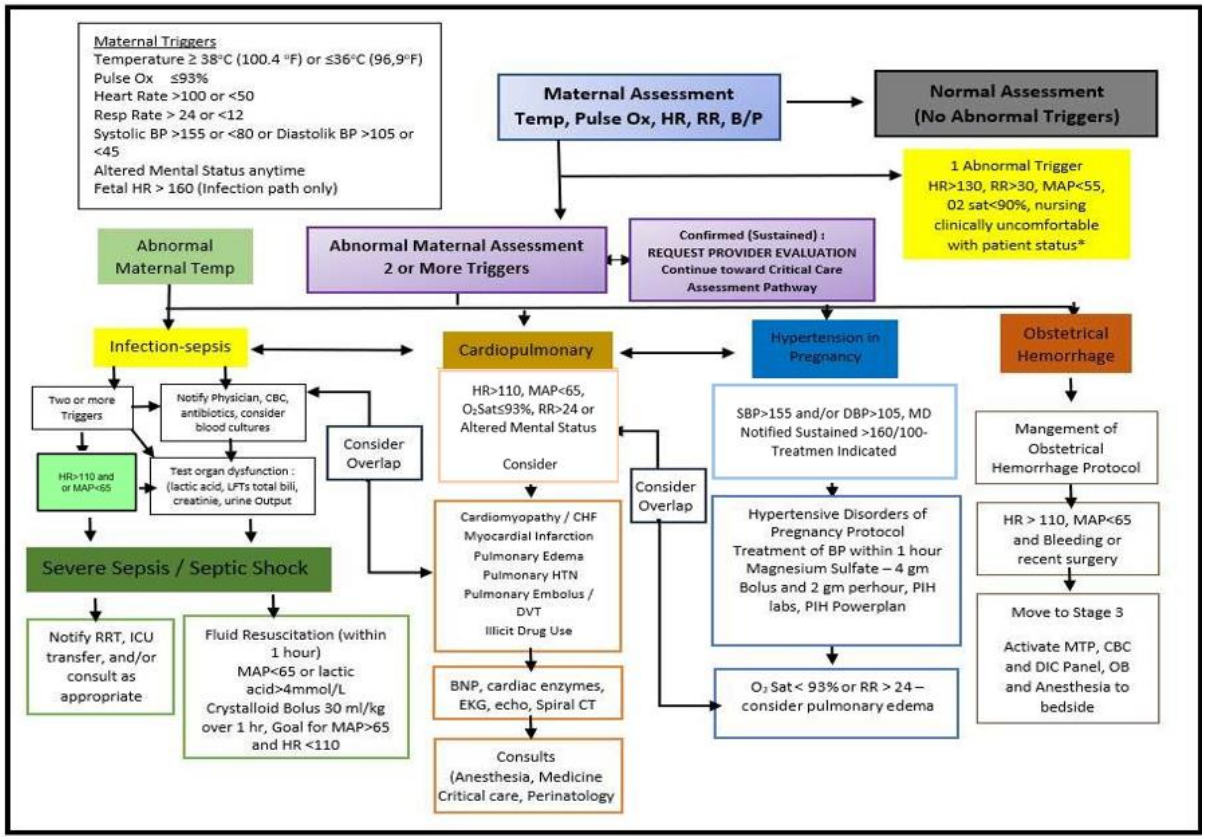

Figure 2. MEWT Flow Diagram (Shields et al., 2016)

The Shock Index (SI), which is the ratio of heart rate to systolic blood pressure, is an indicator of hemodynamic disturbances. Initially, it was used in non-pregnant populations, but later in obstetrics and gynecology, the role of SI was first studied in patients with ectopic pregnancies (Agarwal et al., 2021). For women with hypovolemic shock due to obstetric hemorrhage, the shock index consistently serves as a strong predictor of all adverse outcomes. A shock index value ≥0.9 indicates the need for referral, ≥1.4 indicates urgent intervention at a tertiary facility, and ≥1.7 indicates a high likelihood of adverse outcomes (Ayadi et al., 2016; Nathan et al., 2015, 2016).

The e-CART system was tested in a large population of more than 19,000 inpatients, assessing maternal conditions from mild morbidity to severe cases requiring ICU transfer and estimating mortality. e-CART demonstrated the highest discrimination compared to other predictive tools, but its positive predictive value remained low due to the low incidence rate. Therefore, further research is needed to assess the impact of this score on morbidity, mortality, and early recognition by healthcare providers of women at risk of deterioration. These findings offer opportunities for future efforts to develop machine learning models for predicting deterioration and infection in obstetric populations (Arnolds et al., 2019).

MEWC can be used to identify pregnant patients hospitalized with fever and at higher risk of ICU admission. Pyelonephritis was used as the sample in this study because it complicates about 0.5% of pregnancies and is the most common cause of sepsis. This study concluded that even patients without fever also have significant maternal morbidity risk (Deyoung et al., 2019). MEWC is a maternal morbidity screening tool that prioritizes sensitivity and has an excellent negative predictive value, but it suffers from low sensitivity, making it necessary to identify patterns of recurring abnormal vital signs (Arnolds et al., 2019).

Table 4. MEWC Criteria

Variables	Parameter
Systolic BP (mmHg)	<90 atau >160
Diastolic BP (mmHg)	>100
Pulse	<50 atau >120
Respiratory Rate	<10 atau >30
SpO2 on room air (%)	<95
Oliguria (mL/h for ≥2h)	<35
Maternal restlessness, confusion, unresponsiveness, persistent headache, or dyspnea in preeclampsia	Yes

Source: (Mhyre et al., 2014)

This article reviews that MEWS has very low sensitivity but very high specificity and negative predictive value. The low sensitivity and positive predictive value were due to MEWS failing to detect many patients with potentially fatal disorders, identifying only about 28 (71.1%) out of 39 cases (Ibáñez-Lorente et al., 2021). Adding obstetric parameters may complicate the protocol, as complex MEWS protocols cause professional fatigue, increasing specificity but reducing sensitivity. Another study also concluded that simpler MEWS tools tend to be more sensitive, while more complex tools tend to be more specific (Friedman, 2015).

The Obstetric Early Warning Systems evaluated, namely SOS, MOEWS, MEWT, SI, e-CART, MEWC, and MEWS, have diverse focuses and specificities in detecting emergency conditions in each obstetric patient. Each early warning system has strengths and weaknesses in detecting critical conditions in obstetric patients. SOS

excels in predicting sepsis, a serious cause of maternal death, but is somewhat difficult to apply due to physiological changes during pregnancy. MOEWS is specific for detecting deterioration in obstetric patients, particularly hemorrhage and preeclampsia. SI is the ratio of heart rate to systolic blood pressure used to detect hemodynamic disturbances leading to hemorrhage. e-CART excels in predicting the risk of cardiac arrest in obstetric patients and infection. MEWC is used to identify pregnant women at high risk of ICU admission, particularly in cases of sepsis due to pyelonephritis. MEWS identifies preeclampsia and hemorrhage. Only MEWT was specifically designed to identify the most common causes of maternal morbidity: sepsis, severe cardiovascular dysfunction, preeclampsia-hypertension, and hemorrhage.

MOEWS, MEWT, and SI are early warning systems with sensitivity and accuracy rates of 95% or higher. Meanwhile, four other early warning systems—SOS, e-CART, MEWC, and MEWS—each have their strengths but also limitations. SOS has a strong negative predictive value (98.6%), e-CART has an accuracy of 86% but low positive predictive value, MEWC can only predict with an odds ratio of 16.54, and MEWS excels only in specificity (94%). Therefore, combining or modifying these systems is expected to enhance early detection and timely intervention to reduce maternal morbidity and mortality.

Substantial research implications could be considered for future exploration of this topic, such as continuing meta-analysis research or applied research to develop technological products that can strengthen early warning systems to assess maternal health conditions, thereby helping reduce mortality and morbidity. Across the various Obstetric Early Warning Systems, the assessment of vital signs is consistently the most frequently used indicator. Thus, trained healthcare providers must be supported with reliable and accurate equipment to enable prompt action or treatment (Vousden et al., 2018).

CONCLUSION

This systematic review identifies the Obstetric Early Warning System as an initial effort to identify mothers, particularly those who may require immediate action or treatment, in order to minimize maternal morbidity and mortality. The early warning systems discussed in this study have diverse focuses and specificities in detecting emergency conditions in each obstetric patient. Of the seven types of early warning systems evaluated, only the Maternal Early Warning Trigger Tool (MEWT) is capable of assessing the three leading causes of maternal mortality, namely hemorrhage, preeclampsia or hypertension during pregnancy, and infection. The advantage of early warning systems with the best accuracy, such as MOEWS, MEWT, and SI, opens opportunities for the application of new technologies to enhance their utility through automated calculations and by providing alerts/alarms to users when abnormalities are detected.The evaluated early warning systems have been used for the early detection of the most common causes of maternal death: hemorrhage, preeclampsia, and infection. Therefore, it is hoped that healthcare providers and medical personnel have a good understanding of their application. Among the various early warning system variations, the examination of vital signs is the most frequently used indicator. The evaluated Obstetric Early Warning Systems demonstrate different levels of accuracy; however, a sound understanding of these systems remains essential, particularly the assessment of vital signs, which may trigger the need for immediate action when necessary. This can be input so that routine monitoring of vital signs needs to be carried out carefully.

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