

ORIGINAL RESEARCH

A comparison of various obstetric early warning systems to predict maternal morbidity and mortality**¹Poonam Gangwar, ²Richa Kansal, ³Gargi Agarwal, ⁴Isha Bansal**

¹DNB PG Resident, ²Professor and Head, ³Assistant Professor, ⁴Associate Professor, Department of OBG, Kalpana Chawla Government Medical College, Karnal, Haryana, India
Associate Professor, Department of OBG, Kalpana Chawla Government Medical College, Karnal, Haryana, India

Corresponding author: Isha Bansalish21186@gmail.com**Article History:****Received:** 06.06.2023**Revised:** 29.06.2023**Accepted:** 09.07.2023**Abstract**

Different studies of maternal morbidity and mortality have concluded that many cases of maternal morbidity and mortality can be prevented if the timely detection of early deteriorations may be ensured. Therefore, there has been a renewed interest in validation of early warning pregnancy-specific systems for early identification of high risk patients to improve the maternal outcome though the results may vary in different settings depending upon a variety of factors.

Material and methods: This prospective observational study was carried out at Department of Obstetrics & Gynaecology of Kalpana Chawla Medical College, Karnal, Haryana from October 2020 to April 2022 for evaluation of various Early Obstetric Warning Systems available in literature for prediction of high risk clinical scenarios and maternal morbidity and mortality. The objectives of this study was to compare three maternal early warning Systems (EWS) i.e.; Modified early obstetric warning system (MEOWS), Maternal Early Warning Criteria (MEWC), and Saving Mothers Score (SMS) were compared on the basis of sensitivity, specificity and predictive values as bedside screening methods to allow early recognition of physical deterioration in Obstetric patient by monitoring their physiological parameters. According to maternal outcome at time of discharge, study subjects were divided into two categories. The data collected was analyzed using SPSS® software version 25. Descriptive statistics was calculated using Mean \pm SD for quantitative variables and frequency percentage for qualitative variables.

Results: Among 496 patients, maximum patients were in the age group of 21-25 years (40.9%). 75 (15.1%) patients were below 20 years. out of 496 patients, 196 (39.5%) patients were P1 parity, 177 (35.7%) patients were P2 parity, 70 (14.1%) participants were P3 parity and 53 (10.7%) patients were P4 and above parity with maximum patients from IV (Upper Lower) and V (Lower) SES group. During evaluation of MEOWS scores of participants, out of 496 patients, 291 (58.6%) patients in no alert zone, 129 (26.0%) patients in yellow alert zone and 76 (15.3%) patients in red alert zone triggered on admission and during follow up till discharge. While determining the MEWC score, out of 496 patients 205 (41.4%) patients in red zone and 291 (58.6%) patients in no red zone. According to SAVING MOTHERS SCORE, out of 496 patients 289 (58.3%) patients in green zone, 132 (26.6%) patients in orange zone, 75 (15.1%) patients in red zone. In MEOWS the sensitivity

was 87.1%, specificity was 92.7%, PPV was 89.7% and NPV was 90.8%. In MEWC the sensitivity was 86.1%, specificity was 92%, PPV was 88.7% and NPV was 90.1%, where in SMS sensitivity was 87.1%, specificity was 91.6%, PPV was 88.3% and NPV was 90.7%.

Conclusion: MEOWS and MEWC chart may be as a useful bedside screening tool for prediction of obstetric adverse outcomes in a busy tertiary care centers and should be used routinely in every obstetric unit. Strict monitoring and documentation of all the vital parameters should be fundamental part of any patient's assessment to pick up acute illness at very early stage ,early identification of high risk cases and initiation of timely referral from peripheral care centers to higher centers, to make a difference in final outcome .

Introduction

Several cases of severe maternal morbidity and mortality are often preventable and many methods are underway to cause this reduction [1]. Many near miss and mortality case reviews have revealed patterns of delay in early recognition of haemorrhage, hypertensive crisis, sepsis, venous thromboembolism, and heart failure[2]. In most cases the physiological deterioration is progressive. So early identification of abnormal physiological parameters can lead to early intervention and treatment. However, the increasing patient load and resource constraints make it difficult for the health care providers even in tertiary care centers to identify the impending clinical deterioration in many cases.

Early Warning Systems (EWSs) are used in obstetrics for timely detection of early clinical deterioration so that maternal morbidity and mortality can be averted. EWSs not only help to improve quality of care by reducing delay but also reduce the maternal near miss cases and deaths. These systems hold special importance in low resource settings as well as in busy hospitals with high patient flow where EWS can draw attention of health staff towards "at-risk" patients. ³

These systems track the basic physiological parameters and some biochemical parameters of the patient over the time period of hospital stay and help in early detection of at-risk patients so that prompt response and treatment can be initiated Successful implementation of such warning systems require support from administration, coordinated effort between health care providers, resources allocation, and collaborated effort to modify hospital working culture.

Material and methods

It was a prospective observational study conducted in the Department of Obstetrics & Gynaecology of Kalpana Chawla Government Medical College, Karnal for evaluation and comparison of the three most popular maternal early warning system namely; Modified early obstetric warning system (MEOWS), Maternal Early Warning Criteria (MEWC) and Saving Mothers Score (SMS) based on their sensitivity, specificity and predictive values. A total of 500 women were included in the study who fulfilled the inclusion criteria. Written and informed consent were taken from all participants. Study was carried out from October 2020 to April 2022 after scientific and ethical committee approval.

Inclusion criteria: All Pregnant women admitted in emergency labour room and up to 6 weeks postpartum were recruited as study subjects. The first five emergency admissions to the labour room were recruited into study depending upon emergency duties of principal investigator.

Exclusion criteria: Those patients who didn't give consent to participate in study.

Measurement of temperature (oral), heart rate, blood pressure, mean arterial pressure, respiratory rate, oxygen saturation (pulse oximeter), conscious level (AVPU: alert, responds to voice or pain and unresponsive), urine output, pain and neurological status, haemoglobin, AST, ALT, S.Bilirubin, S. Creatinine, RBS were documented on admission and during follow up till discharge. Above mentioned physiological parameters were recorded as

normal, yellow or red alert, depending on how abnormal the value was, compared to normal pregnancy physiology. Eight biochemical parameters were identified, color-coded, and given scoring depending on the severity of derangement. These recorded parameters were then used to complete the three early obstetric warning system charts (MEOWS, MEWC and SMS) by the investigator. Subsequent monitoring and charting was done according to the frequency given below from recorded data:

- **Women in labour:** 4 hourly till 24 hours, thereafter once a day till discharge.
- **Postpartum haemorrhage:** 1 hourly for 4 hours, 4 hourly till next 24 h and thereafter once a day till discharge.
- **Caesarean section or other procedure under anaesthesia:** 1 hourly for 6 hours, then 4 hourly for next 48h and then once a day till discharge.
- **Blood transfusion :** Immediately prior to start of transfusion and then after 15 min during transfusion. Biochemical parameters were monitored at the time of admission and on occurrence of event of interest / if physiological parameter triggers were present. Once a daily frequency of monitoring was reached, the study subjects were followed till the time of discharge from hospital.

The **criteria for evaluation** in MEOWS: Either single “Red” trigger (i.e single markedly abnormal observation), OR two “yellow” triggers (the combination of two simultaneously mildly abnormal observations) were used to identify patient at risk of clinical deterioration.

1. Modified early obstetric warning system (MEOWS) [6] :

Physiological Parameters	Yellow Alert	Red Alert
Respiration rate (breaths per minute)	21-30	<10 or >30
Oxygen saturation (% on room air)	96-98	<95
Temperature (degree Centigrade)	35-36	<35 or >38
Systolic blood pressure (mm Hg)	150-160 or 90-100	<90 or >160
Diastolic Blood Pressure (mm Hg)	90-100	>100
Heart rate (beats per minute)	100-120 or 40-50	>120 or <40
*Pain score	2-3	
**Neurological response	Voice	Unresponsive, pain

*Pain -Assess pain on movement deep breathing or coughing.*Pain scores (0 = no pain, 1 = slight pain on movement, 2 =intermittent pain at rest/moderate pain on movement).

**Level of consciousness: based on the Alert Voice Pain Unresponsive (AVPU) scale which assesses four possible outcomes to measure and record a patient’s level of consciousness.

2. Maternal Early Warning Criteria (MEWC) [2] :

Physiological Parameters	Red Zone
Systolic blood pressure (mm Hg)	<90 or >160
Diastolic Blood Pressure (mm Hg)	>100
Heart rate (beats per minute)	<50 or >120
Respiration rate (breaths per minute)	<10 or >30
Oxygen saturation (% on room air)	<95
Oliguria(ml/hour) for >2 hours	<35
Maternal agitation, confusion, or unresponsiveness; Patient with pre-eclampsia reporting a non-remitting headache or shortness of breath	

The **criteria for evaluation** in SMS:

1. Saving Mothers Score (SMS): takes into account three parameters: pregnancy-related riskfactors, physiological variables and biochemical tests [7].

A. Pregnancy related risk factors: A bicolour coding is used & a simple yes(orange) or no (green colour) was noted as the potential response. An orange colour denotes the presence of a risk factor and a green colour indicates no risk. Each parameter was given a score of 1.

B. The presence of ≥ 4 oranges at any time during pregnancy indicates a high-risk pregnancy.

		Yes (Orange)	No (Green)
1	Age of the mother <19 and >35 yrs		
2	Body weight <40 kg or >90 kg		
3	Body height <145 cms		
4	Interpregnancy interval <18 months		
5	Illiterate/Low socioeconomic status		
6	Parity >2/BOH/Previous LSCS		
7	Significant surgical history		
8	Pre-existing Medical Disorders		
9	Complication in previous pregnancy (Eclampsia, PPH or Transfusion)		
10	Complication in present pregnancy, if any (Anaemia/Oedema/PIH/Twins/Breech/Placenta previa/Diabetes/Thyroid problem/Abruption/IUFD/others-specify)		

C. Physiological Parameters: General condition of the patient was noted :

	Parameters	Weight age	Normal Score 0 (Green)	Needs Observation Score 1 (Orange)	Sick Mother Score 2 (Red)
1	Systolic/Diastolic BP (mmHg)	1	100-140/ <90	141-160 91-100	<90 or >160 >100
2	Pain (VAS)	1	0	3-5	6 or more
3	Temperature (degree Centigrade)	1	95-98.4	99-100	<95 or .100
4	Pulse rate (beats per minute)	1	60-99	100-120 or 52-59	<52 or >1120
5	Oxygen saturation (% on room air)	1	>95	-	<95
6	Urine output (in pt. with urinary catheter)	1	>30 ml/hr	<30 ml/hr	<30 ml/hr
7	Respiration rate (breaths per minute)	2	12-18	19-25	<12 or >25
8	Neurological response	2	A-alert	V-voice responsive	Irritable/ Response to pain/ Unresponsive

Biochemical parameters were suggested if the patient triggers >2 orange/ 1 red condition OR ascore is >3.

D. Biochemical parameters:

	Parameter	Normal/ Score 0 (GREEN)	Needs Observation/ Score 1 (ORANGE)	Sick Mother/ Score 2 (RED)
1	Complete blood count: Hb-m% WBC-10 ³ Platelets in lakhs	10 3-9x10 ³ 1.5-3	8-10 9-18x10 ³ 1.0-1.5	<8 <3/>18x10 ³ <1.0
2	S. Creatinine	<1.0	1.0-1.2	>1.2
3	Random blood sugars	70-120	120-180	<70/>180
4	LFT Total bilirubin SGPT/SGOT	<1.2 <40	1.2-3 40-80	>3 >2x Normal
5	LDH	<200	200-600	>600
6	CUE Urine albumin Pus cells	Nil- + Nil- Few	++	>++ Plenty
7	Serum Potassium(mEq/L)	3-4.5	4.5-5	>5
8	*ABG: pH PF Ratio	7.35-7.45 >400	7.2-7.35/7.45-7.5 200-400	<7.2->7.5 <200

*Where ABG can be done if/or physiological score is ≥ 6

Interpretation:

- Green Zone- score of 0-3 ; low risk/Healthy mothers
- Orange Zone- score of 3-5 ; moderate risk/need further management
- Red Zone-score of more than or equal to 6; High risk/Sick mother/Needs immediate ICU care.

However, appropriate management was done based on triggers and patients were managed according to the hospital protocol. According to maternal outcome at time of discharge, study subjects were divided into two categories:

Category 1 (Normal and those recovered without morbidity)

Category 2 (recovered with morbidity, near miss or maternal mortality).

Category 2 was included, but did not limited to these the following cases [25,26]:

Performance of three charts (MEOWS chart, MEWC chart and SMS chart) were evaluated by calculating their sensitivity, specificity and predictive values. The data collected was analyzed using SPSS® software version 25. Descriptive statistics was calculated using Mean \pm SD for quantitative variables and frequency percentage for qualitative variables. Paired Student T-test was used for intra-group comparison of before and after delivery changes in hemoglobin concentration. Unpaired T-test was used for inter-group comparison.

Results

A total of 500 women were included in the study and fulfilling the inclusion criteria out of which 4 patients lost follow up. The outcomes were as below:

Table 1: Maternal outcomes:

	Participated in study (n=496)
Normal course	287 (57.86%)

Maternal morbidity	135 (21.22%)
Maternal Near miss	62 (12.5%)
Maternal death	12 (2.41%)
ICU stay	73 (14.7%)
Ventilatory support	59 (11.8%)
Inotropic support	47 (9.4%)
Blood transfusion	179 (36%)

Table 2: Participants distribution according to age group:

Age	No of subjects	Percentage
18 to 20	75	15.1
21 to 25 years	203	40.9
26 to 30 years	138	27.8
31 to 35 years	76	15.3
>35 years	4	0.8

Table 3: Participants distribution based on parity:

Parity	No of subjects	Percentage
P 1	196	39.5
P 2	177	35.7
P 3	70	14.1
P4 and above	53	10.7
Total	496	100

Table 4: Socio economic status of Participants (Modified Kuppu Swami Classification) 1:

Socio economic status (SES)	No of subjects	Percentage
I (Upper)	15	3.0
II (Upper Middle)	41	8.2
III (Lower middle)	117	23.5
IV (Upper lower)	184	37.0
V (Lower)	139	28.0
Total	496	100

Table 5: Participants distribution in Modified early obstetric warning system (MEOWS):

Meows Score	No of subjects	Percentage
No Alert	291	58.6
Yellow Alert	129	26.0
Red Alert	76	15.3
Total	496	100

Table 6: Physiological Parameters of participants for Modified early obstetric warning system(MEOWS):

Physiological Parameters	YELLOW ALERT n = 129 (%)	RED ALERT n = 76 (%)	
Respiration rate (breaths per minute)	18 (14%)	5(7%)	
Oxygen saturation (% on room air)	20(15.5%)	12(16%)	

Temperature (degree Centigrade)	19(15%)	7(9%)	
Systolic blood pressure (mm Hg)	34(26.5%)	15(20%)	
Diastolic Blood Pressure (mm Hg)	14(11%)	16(21%)	
Heart rate (beats per minute)	20(15.5%)	16(21%)	
*Pain score	1(<1%)	2(2.5%)	
**Neurological response	3(2%)	3(4%)	

Using the “Chi- Square Test $\{\chi^2\}$ – Test”, the chi-square statistic is 10.14 and p value is 0.18{ $p>0.05$ } (result is not significant at $p < 0.05$) There was statistically no significant difference

Table 7: Participants distribution in Modified Early Warning Criteria (MEWC):

Red Zone	No of subjects	Percentage
No	291	58.6
Yes	205	41.4
Total	496	100

Table 8: Physiological parameters for MEWC score:

Physiological Parameters	Red Zone (N = 205)
Systolic blood pressure (mm Hg) >160	38 (19%)
Systolic blood pressure (mm Hg) <90	43 (21%)
Diastolic Blood Pressure (mm Hg) >100	59 (29%)
Heart rate (beats per minute) >120	63 (31%)
Heart rate (beats per minute) <50	6 (3%)
Respiration rate (breaths per minute) >30	16 (8%)
Respiration rate (breaths per minute) <10	4 (2%)
Oxygen saturation (% on room air) <95	34 (17%)
Oliguria(ml/hour) for ≥ 2 hours	14 (7%)
Maternal agitation, confusion, or unresponsiveness; Patient with preeclampsia reporting a non-remitting headache or shortness of breath	10 (5%)

Table 9: Participants distribution in Saving Mothers Score (SMS):

Indicator	No of patients	Percentage
Green zone	289	58.3
Orange zone	132	26.6
Red zone	75	15.1
Total	496	100

Table 10: Saving Mothers Score (SMS) with pregnancy-related risk factors:

SN	Parameters	Number of subjects n = 496 (%)
1	Age of the mother <19 and >35 yrs	25 (5.0%)
2	Body weight <40 kg or >90 kg	34 (6.8%)
3	Body height <145 cms	28 (5.6%)
4	Interpregnancy interval <18 months	73 (14.6%)
5	Illiterate/Low socioeconomic status	362 (72.4%)

6	Parity>2/BOH/Previous LSCS	128 (25.6%)
7	Significant surgical history	26 (5.2%)
8	Pre-existing Medical Disorders	12 (2.4%)
9	Complication in previous pregnancy (Eclampsia, PPH or Transfusion)	15 (3.2%)
10	Complication in present pregnancy, if any-(Anaemia/Oedema/ PIH/ Twins/ Breech/ Placenta previa/Diabetes/Thyroid problem/ Abruptio/ IUFD/ others-specify)	75(15.2%)

Table 11: Comparison of Maternal Outcome distribution in MEOVS, MEWC and SMS:

Maternal Outcome		MEOVS			MEWC		SMS		
		Red Alert	Yellow Alert	No Alert	Red Zone	No Zone	Red zone	Orange Zone	Green zone
Normal course (n=287)	No.	0	0	287	0	287	0	0	287
Morbidity (n=135)	No.	5	127	3	132	3	2	131	2
Near Miss (n=62)	No.	61	1	0	62	0	62	0	0
Mortality (n=12)	No.	10	1	1	11	1	11	1	0
Total	496	76 (15.3%)	129 (26%)	291 (58.6%)	205 (41.3%)	291 (58.6%)	75 (15.1%)	132 (26.6%)	289 (58.2%)

Comparison of Maternal Outcome distribution in MEOVS, MEWC and SMS

Table 12: Distribution of Morbidity:

Cause	No. of patients with Morbidity by cause (n=496)
Haemorrhage	59(12%)
Suspected Infection	44(9%)
Severe preeclampsia	84(17%)
Pulmonary edema	5(1%)
ICU admission	64(7%)
Diabetic ketoacidosis	1(<1%)
Maternal mortality	12(<1%)

Table 13: Comparison of ICU admission in MEOVS, MEWC and SMS:

ICU Admission (N=73)	MEOVS			MEWC		SMS		
	Red Alert	Yellow Alert	No Alert	Red Zone	No Zone	Red Zone	Orange Zone	Green Zone
Yes	70 (92.1%)	2 (1.5%)	1 (0.3%)	72 (35.1%)	1 (0.3%)	72 (96%)	1 (0.7%)	0 (0%)
No	6 (7.9%)	127 (98.5%)	290 (99.7%)	133 (64.9%)	290 (99.7%)	3 (4%)	131 (99.3%)	289 (100%)
Total	76	129	291	205	291	75	132	289

(n=496)								
---------	--	--	--	--	--	--	--	--

Table 14: Comparison of needs of support for participants in MEOWS, MEWC and SMS:

Maternal Outcome		MEOWS			MEWC		SMS			
		Red Alert (n=76)	Yellow Alert (n=129)	No Alert (n=291)	Red Zone (n=205)	No Zone (n=291)	Red Zone (n=75)	Orange Zone (n=132)	Green Zone (n=289)	
Ventilator support (n=59)	Yes	56	2	1	58	1	58	1	0	
	No	20	127	290	147	290	17	131	289	
Inotropic support (n=47)	Yes	45	1	1	46	1	46	1	0	
	No	31	128	290	159	290	29	131	289	
Blood transfusion (n=179)	Yes	73	102	4	175	4	75	104	0	
	No	3	27	287	131	287	0	28	289	
Total		496	76	129	291	205	291	75	132	289

Table 15: Comparison of Hospital Stay duration in MEOWS, MEWC and SMS:

Duration of Stay	MEOWS			MEWC		SMS		
	Red Alert	Yellow Alert	No Alert	Red Zone	No Zone	Red Zone	Orange Zone	Green Zone
7 days	3 (3.9%)	8 (6.2%)	287 (98.6%)	11 (5.3%)	287 (98.6%)	3 (4.1%)	3 (2.3%)	287 (99.3%)
Above 7 days	73 (96.4%)	121 (93.8%)	4 (1.4%)	194 (94.7%)	4 (1.4%)	72 (95.9%)	129 (97.7%)	2 (0.7%)
Total (n=496)	76	129	291	205	291	75	132	289

Table 16: Comparison of trigger generated at admission, intrapartum and postpartum period in MEOWS, MEWC and SMS

Trigger generated at	MEOWS			MEWC		SMS		
	Red Alert	Yellow Alert	No Alert	Red Zone	No Zone	Red Zone	Orange Zone	Green Zone
Admission	76	127	287	203	287	75	131	287
Intrapartum period	0	1	1	1	1	0	0	1
Postpartum period	0	1	3	1	3	0	1	1
Total	76	129	291	205	291	75	132	289

Table 17: Comparison of scoring system on the basis of sensitivity, specificity and predictive values:

Scoring system	Sensitivity	Specificity	PPV	NPV	p- value	Odds ratio	95% Confidence interval	
MEOWS	87.1%	92.7%	89.7%	90.8%	.0001	85.38	46.83	155.67
MEWC	86.1%	92%	88.7%	90.1%	.0001	71.24	39.92	127.13
SMS	87.1%	91.6%	88.3%	90.7%	.0001	73.86	41.29	132.117

Discussion

In our study out of 496 maximum patients were in the age group of 21-25 years (40.9%). 75 (15.1%) patients were below 20 years indicating that early teenage pregnancy are still prevalent in this area, 4 (0.8%) cases were above 35 years of age. Comparison of observations regarding age distribution as found in other studies is as follows:

S no.	Author	No. of participant	Age
1.	Zohra S ⁴ et al.	205	18-40 years with mean age of 31.585± 3.31 years
2.	Singh A ⁵ et al.	1065	20-30years
3.	schuler L ⁶ et al	705	11-45 years(25.9± 6.9 years)
4.	Our study	496	21-25 years

In our study Table 2 shows that out of 496 patients, 196 (39.5%) patients were P1 parity, 177 (35.7%) patients were P2 parity, 70 (14.1%) participants were P3 parity and 53 (10.7%) patients were P4 and above parity. More subjects were in parity P1 group. Zohra S^[33] et al. reported mean parity was 1.839 ± 1.59 and another previous study tool done by Singh S^[6] et al. also validated MEOWS tool by studying 676 obstetric in patients who were from 20 weeks of gestation and almost similar parity results.

No.	Author	No. Of Participants	Parity
1.	Zohra S ⁴ Et Al.	205	P1 (1.839 ±1.59)
2.	Singh A ⁵ Et Al.	676	P1
3.	Our Study	496	P1

Out of 496 patients, 15 (3.0%) patients were from I (upper) SES group, 41 (8.2%) participants were II (Upper Middle) SES group, 117 (23.5%) patients were from III (Lower middle) SES group, 184 (37.0%) participants were from IV (Upper Lower) SES group and 139 (28.0%) participants were from V (Lower) SES group. In our study most of patients were seen in upper lower and lower SES in this region according to modified Kuppu Swami Classification [32]. These result comparable with Zohra S⁴ et al. study. In our study few factors like elderly age, multi parity and low socio-economic class lead to increased obstetric morbidity which was not comparable with another study done in 2014 by Soubra⁷ et al.

MEOWS scores of participants, out of 496 patients, 291 (58.6%) patients in no alert zone, 129 (26.0%) patients in yellow alert zone and 76 (15.3%) patients in red alert zone triggered on admission and during follow up till discharge.

Mitchell IA⁸ et al. shows that more ICU admission in MEOWES system and more ICU admission of red zone participants. In our study, mostly all of the triggered patients were correctly identified as having morbidity and number of misleading triggers was less. Bajwa SK⁹ et al. reported almost similar mortality and morbidity. Singh S^[6] et al. also observed more mortality in red zone patients.

According to MEWC score, out of 496 patients 205 (41.4%) patients in red zone and 291 (58.6%) patients in no red zone. The “track and trigger” of physiological parameters can reduce morbidity and mortality by early recognition so as to prevent cascade of drastic events ultimately leading to better maternal care, as shown in study done by Paternina-Caicedo¹⁰ et al, who suggested similar results and declared that the Maternal early warning systems align with other major initiatives that are currently being widely disseminated including efforts to improve management of obstetric hemorrhage and severe hypertension.

According to saving mothers score, out of 496 patients 289 (58.3%) patients in green zone, 132 (26.6%) patients in orange zone, 75 (15.1%) patients in red zone.. The significant factors responsible for women to trigger were picked up by SMS score which were included

age <19 and >35 years, rural background, lower socio- economic status, muligravida, illiteracy and absence of antenatal care. It was observed that patients who triggered in red zone had long (>7 days) hospital stay. **Gardner-Thorpe J¹¹ et al.** also consist with our result and reported that more hospital stay duration in red zone participants and high risk patients where **Isaacs RA¹² et al.** also reported more hospital stay duration in red zone participants. In our study follow up was done 4 hourly till 24 hours then once a day till discharge helped to pick up triggered patients who were not triggered during admission.

MOEWS the sensitivity was 87.1%, specificity was 92.7%, PPV was 89.7% and NPV was 90.8%. In MEWC the sensitivity was 86.1%, specificity was 92%, PPV was 88.7% and NPV was 90.1%, where in SMS sensitivity was 87.1%, specificity was 91.6%, PPV was 88.3% and NPV was 90.7%..

Author	MEOWS				MEWC			
	Sen (%)	Sp (%)	PPV (%)	NPV (%)	Sen (%)	Sp (%)	PV (%)	NPV (%)
Ryan¹³etal.	96	54	-	-	-	-	-	-
Singh¹⁴ et al.	86.5	85.2	53.8	96.9	-	-	-	-
Singh S^[6]etal.	89	79	39	98	-	-	-	-
Chakravarthy¹⁵ etal.	-	-	-	-	-	-	-	-
Arnolds DE¹⁶et al.	-	-	-	-	97	39	34	97*
					84	62	42	92**
Our study	87.1	92.7	89.7	90.8	86.1	92	88.7	90.1

Author	SMS			
	Sen(%)	Sp(%)	PPV(%)	NPV(%)
Ryan¹³etal.	-	-	-	-
Singh¹⁴ et al.	-	-	-	-
Singh S^[6]etal.	-	-	-	-
Chakravarthy¹⁵ etal.	56.1	92.4	96.6	80.2
Arnolds DE¹⁶et al.	-	-	-	-
Our study	87.1	91.6	88.3	90.7

In other studies is as follows:

* with single trigger

** with multiple trigger

Sen – sensitivity, Sp – Specificity, PPV- Positive predictive value, NPV- Negative predictivevalue.

A sensitivity and specificity in our study was comparable to the study by **Ryan¹⁷ et al.** apart from few contextual differences. In one of the retrospective studies done on 364 women with clinically diagnosed chorioamnionitis for prediction of sepsis, 6 different MEOWS had variable performance with 40– 100% sensitivity, 4-97% specificity with a low positive predictive value of <2-15% for all. Apart from this, the study **Edwards SE¹⁸et al.** also found simpler designs MEOWS to be more sensitive and useful.

Blumenthal EA et al.¹⁹ resulted MEWS were more specific (88.6% MEWT and 93.5% MEWS vs. 51.2% MEOWS and 60.2% MEWC, $p < 0.001$) in their study. **Mackintosh N²⁰ et al.** reported the higher sensitivity of MEOWS may be related to the use of MEOWS to monitor the sick mothers identified and admitted in the ward, whereas SMS was used as a triage to identify the sick mothers. MEOWS is proposed to be used discreetly to monitor women with established risk of morbidity and has variation in implementation.

There are limited comparative data regarding how early warning systems perform in Indian

population for maternal morbidity. None of the systems performs with high sensitivity and specificity. High-volume, high-acuity units may decide that the lower sensitivity of the MOEWS is relatively acceptable when considering the high false trigger rate of the other more sensitive systems. MEOWS was developed to provide a specific early warning system for the obstetric population, identifying patients at risk on severe obstetric complications and permit intervention in being made at an early stage. These literatures also shows that the specificity of MEOWS for predicting morbidity is 79%, comparable to the early warning systems designed for the non-obstetric adult population with a positive predictive value of 39% and 98% of a negative predictive value

The use of a warning system associated with a predefined time of this alert could be an alternative to increase the positive predictive value of the early obstetric warning system. Studies have reported a sensitivity of 89% for MEOWS, higher than the 43% found for the non-obstetric early warning systems commonly used in the adult population.

Conclusion

MEOWS and MEWC chart emerged as a useful bedside screening tool for prediction of obstetric adverse outcomes in a busy tertiary care centers and should be used routinely in every obstetric unit. Strict monitoring and documentation of all the vital parameters should be fundamental part of any patient's assessment to pick up acute illness at very early stage ,early identification of high risk cases and initiation of timely referral from peripheral care centers to higher centres, to make a difference in final outcome .

Funding

No funding sources

Conflict of interest

None declared

Acknowledgments

We would like to thank KCGMC, Karnal for allowing me to conduct this study. Also we would like to thank the study participants, data collectors and supervisors.

References

1. World Health Organization. World health statistics 2016: monitoring health for the SDGs sustainable development goals. World Health Organization; 2016 Jun 8.
2. Isaacs RA et al. A national survey of obstetric early warning systems in the United Kingdom: Five years on. *Anaesthesia* 2014;69:687-92
3. Mhyre JM, D'Oria R, Hameed AB, Lappen JR, Holley SL, Hunter SK, Jones RL, King JC, D'Alton ME. The maternal early warning criteria: a proposal from the national partnership for maternal safety. *Journal of Obstetric, Gynecologic & Neonatal Nursing*. 2014 Nov 1;43(6):771-9
4. Zohra S, et al. Diagnostic Accuracy of Modified Early Obstetric Warning System. *Pak Armed Forces Med J* 2021; 71 (4): 1134-37.
5. Singh S, et al A validation study of the CEMACH recommended modified early obstetric warning system (MEOWS). *Anaesthesia*. 2012 Jan;67(1):12-8
6. Schuler L, et al The use of the Modified Early Obstetric Warning System (MEOWS) in women after pregnancies: a descriptive study. *Revista Brasileira de Saúde Materno Infantil*. 2019 Sep 16;19:545-55
7. Soubra SH, et al. Critical illness in pregnancy: an overview. *Crit Care Med* 2005; 33(10): 48–55.
8. Mitchell IA, , et al. A prospective controlled trial of the effect of a multi-faceted

- intervention on early recognition and intervention in deteriorating hospital patients. *Resuscitation* 2010;81:658-66.
9. Bajwa SK et al. Is intensive care the only answer for high risk pregnancies in developing nations. *J Emergencies, Trauma Shock* 2010; 3(4): 331-3.
 10. Paternina-Caicedo A, et al. Performance of the obstetric early warning score in critically ill patients for the prediction of maternal death. *Am J Obstet Gynecol* 2017; 216(1): 58-1.
 11. Gardner-Thorpe J, et al. The value of modified early warning score (MEWS) in surgical in-patients: A prospective observational study. *Ann R Coll Surg Engl* 2006;88:571-5
 12. Isaacs RA, et al. A national survey of obstetric early warning systems in the United Kingdom: Five years on. *Anaesthesia* 2014;69:687-92
 13. Ryan HM, et al. Validating the performance of the modified early obstetric warning system multivariable model to predict maternal intensive care unit admission. *Journal of Obstetrics and Gynaecology Canada*. 2017 Sep 1;39(9):728-33.
 14. Singh A, et al. Evaluation of maternal early obstetric warning system (MEOWS chart) as a predictor of obstetric morbidity: a prospective observational study. *European Journal of Obstetrics & Gynecology and Reproductive Biology*. 2016 Dec 1;207:11-7
 15. Chakravarthy K, et al. Development and validation of saving mothers score: A comprehensive scoring system for early identification of sick mothers. *Journal of Obstetric Anaesthesia and Critical Care*. 2018 Jul 1;8(2):83.
 16. Arnolds DE, et al. National partnership for maternal safety recommended maternal early warning criteria are associated with maternal morbidity. *Anesthesia & Analgesia*. 2019 Dec 1;129(6):1621-6.
 17. Ryan HM, et al. Validating the performance of the modified early obstetric warning system multivariable model to predict maternal intensive care unit admission. *J Obstet Gynaecol Canada* 2017; 39(9): 728–33.
 18. Edwards SE, et al. Modified obstetric early warning scoring systems (MOEWS): validating the diagnostic performance for severe sepsis in women with chorioamnionitis. *Am J Obstet Gynecol* 2015; 212(4): 536-1.
 19. Blumenthal EA, et al. A Validation Study of Maternal Early Warning Systems: A Retrospective Cohort Study. *Am J Perinatol* 2019; 36(11): 1106-1114
 20. Mackintosh N, et al. Value of a modified early obstetric warning system (MEOWS) in managing maternal complications in the peripartum period: An ethnographic study. *BMJ Qual Saf* 2014;23:26-34.