Implementing the Risk Identification (RI) and Modified Early Obstetric Warning Signs (MEOWS) tool in district hospitals in Rwanda: A cross-sectional study

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Abstract

Background: Despite reaching Millennium Development Goal (MDG) 3, the maternal mortality rate (MMR) is still high in Rwanda. Most deaths occur after transfer of patients with obstetric complications from district hospitals (DHs) to referral hospitals; timely detection and management may improve these outcomes. The RI and MEOWS tool has been designed to predict morbidity and decrease delay of transfer. Our study aimed: 1) to determine if the use of the RI and MEOWS tool is feasible and acceptable in DHs in Rwanda and 2) to determine the role of the RI and MEOWS tool in predicting morbidity.

Methods: A cross-sectional study enrolled parturient admitted to 4 district hospitals during the study period from April to July 2019. Data was collected on compliance rate to RI and MEOWS tool, acceptability, and prediction of morbidity (hemorrhage, infection, and pre-eclampsia).

Results: Among 798 parturient enrolled in this study, the mean age was 20.3 years (Sd=6.8), most of them had insurance (95%), the mean of length of stay was 3.1 days (Sd=2.08), and the morbidity rate was 10.3%. The RI and MEOWS tool compliance rate was 76.3 and acceptability rate among 22 respondents was 90.9%. The RI and MEOWS tool had accuracy of 14.29%, P value <0.001, relative risk of 0.277 42 (0.1718-0.4487), sensitivity of 73.68%, specificity of 93.86%, positive predictive value of 11.57%, and negative predictive value of 41.67% .

Conclusion: RI and MEOWS tool is a feasible and acceptable in the DHs of Rwanda. In addition, having moderate or high scores on the RI and MEOWS tool predict morbidity. After consideration of local context, this tool can be considered for scale up to other district hospitals in Rwanda or other low resources settings.

Background

Although Rwanda reached Millennium Development Goal (MDG) 3 (Promote gender equality and empower women), the maternal mortality rate (MMR) in the country is still high. MMR has been reduced from almost 500 per 100,000 live births in 2010 to approximately 200 per 100,000, but this is still far from the 2030 target of 140 per 100,000 (MOH, 2015). As in many countries, the hospital system in Rwanda includes District Hospitals (DH, about 40) and central Referral Hospitals (RH, 3). Most maternal deaths occur after transfer of patients with obstetric complications from a DH to a RH (Jackson et al, 2015). This referral system is associated with delays at each level (DH and RH). This suggests that early recognition of patients at high risk of complications might allow earlier transfer before the development of complications and speed up the access to care at higher level by minimizing delays through easy situation awareness, communication, and decision making among teams. For example, studies done in Ireland and Zimbabwe reported an improvement in the time interval between trigger and antibiotic administration, and pre-operative stabilization of women undergoing caesarean section following the implementation of the Early Warning Signs (EWS) tool (Maguire et al, 2015; Merriel et al, 2017).

Multiple effective tools exist to identify parturient at risk, and in other countries have been shown to improve outcomes (Berg et al, 2005; CEMACH, 2007; CMQCC, 2013; NICE, 2015; Main et al, 2017). However, these tools have never been tested in Rwanda, where patient populations and structure of healthcare delivery are quite different from the context of the tool validations.

We therefore wished to determine the effectiveness of one comprehensive tool developed to fit the context of DHs of Rwanda, the RI and Modified Early Obstetric Warning Signs (MEOWS) tool (See table 1) (Berg et al, 2005; CEMACH, 2007; CMQCC, 2013; NICE, 2015; Main et al, 2017). This tool is based on the risk factors of hemorrhage and preeclampsia used by Berger et al, 2005 in California; the risk factors of sepsis used by NICE in 2015, in UK; and regular assessment of 5 physiologic variables: respiratory rate, pulse rate, blood pressure, temperature and mental state (CEMACH, 2007).

Our study had as primary objective to determine if the use of the RI and the MEOWS tool is a feasible and acceptable technique in the setting of DH in Rwanda.

Our secondary goals were to test for association between abnormal RI and MEOWS score and presence of morbidity, and to evaluate the accuracy and the usefulness of the RI and MEOWS tool.

Methods

Aim

This study aimed to evaluate the feasibility of implementing the risk factors identification and MEOWS tool in the setting of DH in Rwanda.

Setting

This study was conducted in 4 DH referring to the 2 main RH in Rwanda: the Centre Hospitalier Universitaire de Kigali (CHUK) and the Centre Hospitalier Universitaire de Butare (CHUB). The DH in the study were at Nyanza, Kabutare, Muhima, and Kibagabaga. They are located within 1 hour drive to the Referral hospitals and have a large number of deliveries (Table 2). They were selected to provide representative examples of typical DHs in various parts of the country.

Study design

To assess our primary objective, we retrospectively collected clinical data from the time period after tool implementation to assess how often and how completely the tool was actually used. Also, staff were interviewed about acceptability of the tool and ability to incorporate it into their workflow. Appendix 2 provides the questionnaires and lists the data items collected.

To assess our secondary objective, we retrospectively collected clinical data from time periods both before and after tool implementation to test for association between abnormal RI and MEOWS score and presence of morbidity by calculating the relative risk. Also, in order to evaluate the usefulness of the RI

and MEOWS tool, we calculated the sensitivity, specificity, the accuracy, positive predictive values, negative predictive values, positive and negative likelihood ratios.

Our patient sample size included all parturient presenting at the hospitals between January 1, 2019 and June 30, 2019.

Intervention

From January to March 2019, the RI and MEOWS tool was adapted to Rwanda context using a modified Delphi method, where a team of 2 anesthesiologists and 2 senior anesthesia residents developed suggested changes to fit the context of DHs in Rwanda. The main changes were related to the availability of laboratory tests, the different healthcare providers, and the structure of the Rwandan referral system (Table 1).

Table 1: The Risk identification (RI) and Modified Early Obstetric Warning Score (MEOWS) tool

1.1 Risk identification (RI) tool

	High risk	Moderate risk	Low risk
...hage	**Recognition:** **-On admission:** 1. Placenta previa, low lying placenta 2. Suspected Placenta accreta or percreta 3. Hematocrit < 30, refusal of transfusion, AND other risk factors: 4. Platelets < 100,000 5. Active bleeding (greater than show) 6. Known coagulopathy -Evaluate for development of additional risk factors **in labor and postpartum**: • Prolonged 2nd Stage labor • Prolonged oxytocin use • Active bleeding •Chorioamnionitis • Magnesium sulfate treatment **-1 or more high risk criteria:** **High risk of hemorrhage** **Response:** **-**Consider referral if not in labor -If in labor close monitoring, type and screen, order 2 units of blood, delivery	**Recognition:** **-On admission:** 1. Prior cesarean birth(s) or uterine surgery 2. Multiple gestation 3. > 4 previous vaginal births 4. Chorioamnionitis 5. History of previous PPH 6. Large uterine fibroids -Evaluate for development of additional risk factors **in labor and postpartum**: • Prolonged 2nd Stage labor: • Prolonged oxytocin use • Active bleeding • Magnesium sulfate treatment **-1 or more moderate risk criteria:** **Moderate risk of hemorrhage** **Response:** **-**Consider referral if not in labor (clinical judgment) -If in labor close monitoring, type and screen, book 2 units of blood, delivery	**Recognition:** **-On admission** 1. No previous uterine incision 2. Singleton pregnancy 3. < 4 previous vaginal births 4. No known bleeding disorder -Evaluate for development of additional risk factors **in labor and postpartum**: • Prolonged 2nd Stage labor • Prolonged oxytocin use: • Active bleeding •Chorioamnionitis • Magnesium sulfate treatment **No moderate or high risk of hemorrhage:** **Low risk of hemorrhage** **Response:** **-**Standard of care
...ion			
...mpsia/Eclampsia	**Recognition:** **CNS:** **Awareness:** unresponsive	**Recognition:** **CNS:** **Awareness:**•Agitated/confused • Drowsy	**Recognition:** **CNS:** **Awareness:** Alert/oriented

Headache: Unrelieved headache

Vision: Temporary blindness

CVS:

SBP: ≥160

DBP: 50-89

HR: 61-110

Chest pain

RS:

RR: <10 or >30

GIT:

Nausea and vomiting

Abdominal pain

Renal: u.o in mls: ≤30 (in 2 hrs)

Proteinuria:

Not relevant

Platelet: <50

ASAT/ALAT: >70

Cr: >1.2

MgSO4 toxicity: Respiration <12

1 or more high risk criteria: High risk

of preelampsia/eclampsia

Response:

Immediate evaluation (ABCDE approach)

• Transfer to higher acuity level

• 1:1 staff ratio

• Labetalol/hydralazine in 30 min

• In-person evaluation

• Magnesium sulfate loading or

maintenance infusion

O2 at 10 L per rebreather mask

• Difficulty speaking

Headache:

 • Mild headache

• Nausea, vomiting

Vision: Blurred or impaired

CVS:

SBP: 140-159

DBP: 50-89

HR: 111-129

Chest pain

RS:

RR: 25-30

GIT:

Nausea and vomiting

Abdominal pain

Renal: u.o: 30-49

Proteinuria:

• > +1, • 300mg/24 hours

Platelet: 50-100

ASAT/ALAT: >70

Cr: 0.9-1.1

MgSO4 toxicity: Depression of patellar reflexes

1 or more moderate risk criteria: Moderate risk of preeclampsia/eclampsia

Response:

•Notify In charge RN or Midwife

•In-person evaluation

•Order labs/tests

•Anesthesia consult

•Consider magnesium

sulfate

Headache: None

Vision impairment: None

CVS:

SBP: 100-139

DBP: ≥105

HR: > 130

No chest pain

RS:

RR: 11-24

GIT:

None

None

Renal: u.o: ≥50

Proteinuria:

Trace

Platelet: >100

ASAT/ALAT: <70

Cr: <0.8

MgSO4 toxicity:

• DTR +1

• Respiration 16-20

No moderate or high risk criteria: No risk

of preeclampsia /eclampsia

Response:

Proceed with protocol for normal pregnancy

• R/O pulmonary edema • Chest x-ray •Safe referral to tertiary center	•Supplemental oxygen •Physician should be made aware of worsening or new-onset proteinuria	
Recognition for every woman (on admission): Risk factors: 1.gestational diabetes, diabetes or other comorbidities 2.needed invasive procedure such as caesarean section, forceps delivery, removal of retained products of conception within 6 weeks 3.prolonged rupture of membranes 4.continued vaginal bleeding or an offensive vaginal discharge **Diagnosis criteria** 1.**CNS**: new altered mental state on examination 2.**RS:** RR>25 : --------- or need of FiO2> 40% to keep Sat>92%: --------- 3. **CVS:** SBP<90 mmHg: ------ or HR>130: ---------- 4.**Renal:** No urine in 18 hours : ------- or if foley catheter U.O<0.5 ml/kg/h: ---------- 5.**Temperature >39ºC: ————** 6.**Skin:** Mottled appearance, Cyanosis of skin, lips or tongue, Non-blanching rash of skin: --------------	**Recognition for every woman (on admission):** Risk factors: 1.gestational diabetes, diabetes or other comorbidities 2.needed invasive procedure such as caesarean section, forceps delivery, removal of retained products of conception within 6 weeks 3.prolonged rupture of membranes 4.continued vaginal bleeding or an offensive vaginal discharge **Diagnosis criteria** 1.**CNS**: History of new altered mental state: ---------- 2.**RS:** RR>21 -24: ---------- 3.**CVS:** SBP:91-100 mmHg: -----or HR: 100-130: --------- 4.**Renal:** No urine in 12-18 hours: ----- ------ or if foley catheter U.O: 0.5-1 ml/kg/h: -------------- 5.**Temperature <36ºC: ——** 6.**Skin:** Signs of potential infection, including redness, swelling or	**Recognition for every woman (on admission):** Risk factors: 1.gestational diabetes, diabetes or other comorbidities 2.needed invasive procedure such as caesarean section, forceps delivery, removal of retained products of conception within 6 weeks 3.prolonged rupture of membranes 4.continued vaginal bleeding or an offensive vaginal discharge **Diagnosis criteria** No high risk or moderate risk criteria met: -------------

| ion | -

-1 or more high risk criteria: **High risk of sepsis**

Response:
-Immediate review by senior clinical decision maker (ABCDE approach)
-Blood test:
-Blood gas for glucose and lactate.
-Blood culture·
-Full blood count·
-C-reactive protein·
 -Urea and electrolytes·
-Creatinine·
-Clotting screen

- **MEOWS**
-IV antibiotics within 1h
-500 ml bolus every 15 min, repeat up to 3 times, if SBP<90 mmHg give adrenaline 1mg/500 ml NS to keep MAP>65 or SBP>90
-Refer to a tertiary hospital | discharge at surgical site
or breakdown of wound: --------

-1 or more moderate risk criteria: **Moderate risk of sepsis**

Response:
-Blood test:
-Blood gas for glucose and lactate·
-Blood culture·
-Full blood count·
 -C-reactive protein·
 -Urea and electrolytes·
-Creatinine·
-Clotting screen
-Review by senior clinical decision maker within 1 hour
-IV antibiotics within 1h
-500 ml bolus every 15 min, repeat up to 3 times
-If no definitive condition identified, repeat structured assessment at least **hourly**

- **MEOWS**
-Source control within 6 hours, if deep infection refer to a tertiary hospital | **-no high or moderate risk criteria:** **Low risk of sepsis**

Response:
-Clinical assessment and manage according to clinical judgement |

1.2 Modified Early Obstetric Warning Score (MEOWS) tool

Score	3	2	1	0	1	2	3
Temperature		<35∘ .C		35-37.4∘ .C		37.5-39∘ .C	>39∘ .C
Systolic * BP	≤70	71-79	81-89	90-139	140-149	150-159	≥160
Diastolic * BP			≤45	46-89	90-99	100-109	≥110
Pulse		≤ 40	40-50	51-100	101-110	111-129	≥ 130
Respiratory Rate		≤ 8		9-14	15-20	21-29	≥30
AVPU				Alert	Responds to Voice	Responds to Pain	Unconscious
Urine output mLs/hr	< 10	<30		Not Measured			

If the pulse rate is higher than the systolic blood pressure then score 2 for 'Pulse'

MEOWS less or equal to 2: Current plan

MEOWS =3-5: Repeat observations, Senior midwife to review, Medical review

MEOWS high or equal to 6: Inform Coordinator or Senior Midwife, Medical review, Anesthesia review, Referral

From March to June 2019, the research team implemented the RI and MEOWS tool (Table 1). For each hospital, the research team conducted a 20 min teaching session explaining use of the risk factors identification and MEOWS tool to all maternity staff during the regular morning meeting. In addition, a co-investigator (HI) selected one coach per hospital to ensure the availability of printed forms in each patient's file and to provide mentorship to all maternity staff as needed. Furthermore, the coach was available to support the data collection team.

Statistical analysis and sample size calculation

Our primary endpoint was the fraction of parturient for which the RI and MEOWS tool was fully completed and number of staff that felt it was acceptable as a tool to include in their workflow. Descriptive statistics were used, we reported frequencies and percentages for categorical data, and mean and standard deviation ranges continuous data.

For the secondary outcomes, we tested for association between abnormal RI and MEOWS score at admission and presence of morbidity at discharge by calculating relative risk for individual scores. All statistical tests, we regarded a value of $p < 0.05$ as statistically significant.

Sensitivity, specificity, positive predictive values, negative predictive values, positive and negative likelihood ratios were calculated for the sample. SPSS version 2013 was used for analysis.

As a similar study done in UK had a sample size of 676 (Singh, 2016). In order to have an adequate sample we recruited patients from 4 district hospitals conducting at least 250 deliveries each month.

Results

Among 798 parturient enrolled in this study, the mean age was 20.3 years (Sd=6.8), most of them had insurance (95%), the mean of length of stay was 3.05 days (Sd=2.08), and the morbidity rate was 10.3% 126 (Table 2). Among 478 forms used, 363 (75.9 %) forms were fully completed, 79 (16.5%) partially completed, and 36 (7.5%) were not completed at all.

When asked about their experience during use of the RI and MEOWS tool, most of the respondents reported that the tool was easy or very easy to use (92%), they were willing to use the tool regularly (90.9%), the tool had improved awareness of patient safety (91.3%), and the tool decreased delay in recognition and management of critically ill obstetric patients (86.4%).

When asked about challenges faced during use of the RI and MEOWS tool, common responses included that the tool was long, it was difficult to use with a low staff to patient ratio, English language was a barrier, and there was unavailability of printed forms.

The RI and MEOWS tool had accuracy of 14.29%, P value <0,001, relative risk of 0.277 (0, 1718-0, 4487), sensitivity of 68%, specificity of 86%, positive predictive value of 57%, and negative predictive value of 67%.

Table 2: Characteristics of the 4 district hospitals involved in the implementation of the RI and MEOWS study

Criteria	Nyanza	Kabutare	Muhima	Kibagabaga
Number of maternity staff				
Midwifes	13	15	48	46
General practitioners	9	3	17	19
Non physician anaesthetists	4	5	8	9
Obstetricians	1	0	2	2
Paediatricians	2	1	4	2
Average number of deliveries per month				
Vaginal deliveries	152	163	505	500
Caesarean sections	133	105	178	200
Total	285	268	683	700

The table 2 describes the capacity (number of staff and deliveries) of the 4 district hospitals selected to be included into our study.

Table 3: Patients' demographics, completeness of the use of the RI and MEOWS tool, and outcome

Variable	Number (%)
Age (Mean, SD)	28.30, 6.38
Gravida (Mean, SD)	2.58, 1.91
Parity (Mean, SD)	1.43, 1.67
ANC (Mean, SD)	2.83, 1.15
Married	
Yes	420 (89.0)
No	52 (11.0)
Insurance	
Yes	450 (95.1)
No	23 (4.9)
Social category	
1	37 (15.7)
2	82 (34.9)
3	115 (48.9)
4	1 (0.4)
District hospital	
Kibagabaga	135 (28.2)
Muhima	136 (28.5)
Kabutare	139 (29.1)
Nyanza	65 (13.6)
Tool use	
Completed	**363 (75.9)**
Partially completed	79 (16.5)
Not completed	36 (7.5)
Morbidity	
Yes	49 (10.3)
No	429 (89.7)
Length of stay (Mean, SD)	3.05 (2.08)
Outcome	
Referral	11 (2.3)
ICU	7 (1.5)
Reoperation	2 (0.4)
Care at DH	458 (95.8)

Table 4: Respondents' demographics

Demographics	Number (%)
Hospital name	
Kibagabaga	14 (56)
Kabutare	11 (44)
Profession	
Midwife	23 (92)
Nurse	2 (8)
Experience	
< 1	8 (32)
2-4	9 (36)
5-7	6 (24)
8-10	1 (4)
>10	1 (4)

Table 5: Respondents' experience during use of the RI and MEOWS tool

ons	Responses			
o you think using the risk factors identification and MEOWS tool within the existing file was ?	Very difficult 0 (0%)	Difficult 2 (8%)	Easy 16 (64%)	Very easy 7(28%)
at extent are you willing to use regularly the Risk identification and MEOWS tool to cility ?	Very resistant 0 (0%)	Resistant 2 (9.1)	Willing 9 (40.9)	Very willing 11 (50%)
at extent do you believe use the risk identification and MEOWS tool has improved ness of patient safety at your health care facility ?	Not at all 0 (0%)	Somewhat significant 2 (8.7%)	Significant 9 (39.1%)	Very significant 12 (52.2%)
at extent do you believe use of the Risk identification and MEOWS tool has sed delay in recognition and management of critically ill obstetric patients to your ?	Not at all 0 (0%)	Somewhat significant 3 (13.6%)	Significant 4 (18.2%)	Very significant 15 (68.2%)

Table 6: Comparison of RI and MEOWS tool scores (Moderate/High versus Low) and Morbidity (Yes versus No)

'S level	Chi-Square (P value)	RR (95% CI)	Sensitivity	Specificity	Accuracy	PPV	NPV
ate or High	< 0.0001	RR: 0,277 {0, 1718-0, 4487}	73, 68%	93, 86%	14, 29%	11, 57%	41, 67%

Morbidity: defined as PPH or Preeclampsia or Infections versus, PPV: Positive predictive value, NPV: Negative Predictive Value

Our study found that the RI and MEOWS tool predict morbidity (P< 0,0001) with a sensitivity of 73.68% and specificity of 93.86%.

Discussion

The completion of the RI and MEOWS tool by 77% of participants suggests an adequate feasibility. Our result was consistent with other previous studies although the level of completeness of our study was not as substantial as in other studies like the study done in UK, Ireland, and Zimbabwe that reported an improvement in the frequency of documentation of vital signs, the time interval between trigger and antibiotic administration, and pre-operative stabilization of women undergoing caesarean section following the implementation of the Early Warning Signs (EWS) tool (Cantwell et al, 2008; Maguire et al, 2015; Merriel et al, 2017).

When asked about challenges faced during use of the RI and MEOWS tool, most of the respondents reported that the tool was long, the staff to patient ratio was low, the English language was a barrier, and the printed forms were sometimes unavailable. These are challenges that need to be addressed for a successful implementation of the RI and MEOWS tool (Mhyre et al, 2014; Knight et al, 2014).

There are other challenges to be considered for the successful implementation of the MEOWS tool which have been reported in the literature. These include the lack of multidisciplinary coordination and buy-in, inadequate education about the tool, suboptimal integration within the hospital culture, lack of leadership support, and suboptimal alignment with other quality improvement projects (Friedman et al, 2018).

Our study found that the abnormal RI and MEOWS tool predicted morbidity (P < 0,0001) with a high sensitivity of 73.68%, a high specificity of 93.86%, but with a low accuracy of 14.29%, a low positive predictive value of 11.57%, and a low negative predictive value of 41.67% .

These findings are also similar to the results from other multiple studies conducted in different settings. For example, Singh S et al., (2012 and 2016), did 2 studies implementing the MEOWS with more than 1600 patients in total; the results showed a high sensitivity (89%) and (86.4%), high specificity (79%) and (85.2%), an acceptable PPV (39%) and (53.9%), and a high NPV (98%) and (96.9%) for both studies respectively (Singh S et al., 2012), (Singh S et al., 2016).

In addition, the Obstetric EWS tool has been found to be effective in predicting severe morbidity (in general obstetric population) and mortality (in critically ill obstetric patients) (Umar et al, 2019).

Furthermore, the implementation of the Obstetric EWS has been found to contribute to improved quality of care, prevent progressive obstetric morbidity and improve health outcomes (Umar et al, 2019). However, there is limited evidence of the effectiveness of the Obstetric EWS in reducing maternal death across all settings (Umar et al, 2019).

There are several limitations to consider while interpreting the results of this study. Firstly, our study was conducted in only 4 district hospitals and the results and conclusions may not be applicable to other hospital settings. These hospitals, however, are representative of the country of Rwanda, and the results of this study could be applied to the remaining hospital systems within this country and similar other countries. Secondly, the sample size was small; the study was not powered to determine a difference in

mortality. Some data were missing as they were collected retrospectively; therefore this study was unable to determine the actual difference in interval time from admission to care which would have demonstrated if the use of the MEOWS tool improves the quality of care.

Conclusion

The RI and MEOWS tool is a feasible and acceptable in the DHs of Rwanda. In addition, having moderate or high scores on the RI and MEOWS tool predict morbidity. After consideration of local context, this tool can be considered for scale up to the rest of district hospitals of Rwanda or other low resources settings. Further studies are needed to evaluate the impact of the RI and MEOWS tool on maternal mortality in low resources settings.

Abbreviations

RI and MEOWS Risk Identification and Modified Early Obstetric Warning Signs

MMR   Maternal Mortality Rate

MDG   Millennium Development Goal

UK   United Kingdom

MOH   Ministry of health

DH   District Hospital

RH   Referral Hospital

CEMACH Confidential Enquiry into Maternal and Child Health

CMQCC   California Maternal Quality Care Collaborative

NICE   National Institute for Health and Care Excellence

CHUK   University Teaching Hospital of Kigali

CHUK   University Teaching Hospital of Butare

SPSS   Statistical Package for the Social Sciences

WFSA World Federation Society of Anesthesiologists

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the University of Rwanda College of Medicine and Health Sciences Institutional Review Board (Reference number No 157/CMHS IRB/2019). Informed consents were obtained from the maternity staff involved in the study.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ET and HI led the study design, protocol development, data analysis and manuscript writing. JPM, TT and MD contributed to study design, protocol development and results interpretation. ET and HI led and supervised data collection and led data cleaning. All authors critically reviewed and approved the final manuscript.

References

1. Ministry of Health (MOH), Rwanda Annual Health Statistics 2015.
2. Jackson JR, Rulisa SR, DecesareJZ. Et al. Maternal Mortality and Near Miss Morbidity at the University Teaching Hospital in Kigali, Rwanda. RMJ Vol.72 (2); June 2015
3. Berg CJ, Harper MA, Atkinson SM, et al. Preventability of pregnancy-related deaths: results of a statewide review. Obstet. Gynecol. Dec 2005; 106(6): 1228-1234.
4. National Institute for Health and Care Excellence (NICE) guideline NG51 https://www.nice.org.uk/guidance/ng51, March 2015

5. Lewis G. (ed) 2007. The Confidential Enquiry into Maternal and Child Health (CEMACH) Saving Mothers' Lives: reviewing maternal deaths to make motherhood safer - 2003-2005. The Seventh Report on Confidential Enquiries into Maternal Deaths in the United Kingdom. London: CEMACH

6. Lyndon A, Lagrew D, Shields L, Main E, Cape V. Improving Health Care Response to Obstetric Hemorrhage. (California Maternal Quality Care Collaborative (CMQCC) Toolkit to Transform Maternity Care) Developed under contract #11-10006 with the California Department of Public Health; Maternal,Child and Adolescent Health Division; Published by the California Maternal Quality Care Collaborative, November 2013.

7. Maurice L. Druzin, MD; Laurence E. Shields, MD; Nancy L. Peterson, RNC, PNNP, MSN; Valerie Cape, BSBA. Preeclampsia Toolkit: Improving Health Care Response to Preeclampsia (California Maternal Quality Care Collaborative Toolkit to Transform Maternity Care) Developed under contract #11-10006 with the California Department of Public Health; Maternal, Child and Adolescent Health Division; Published by the California Maternal Quality Care Collaborative, November 2013.

8. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving Mothers' Lives: reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. BJOG 2011;118(Suppl 1):1–203

9. Main EK, Cape V, Abreo A, et al. Reduction of severe maternal morbidity from hemorrhage using a state perinatal quality collaborative. Am J Obstet Gynecol 2017;216:298.e1-11.

10. Maguire PJ, O'Higgins AC, Power KA, Daly N, McKeating A, Turner MJ. Maternal bacteremia and the Irish maternity early warning system. Int J Gynecol Obstet. 2015; https://doi.org/10.1016/j.ijgo.2014.11. 022 PMID: 25670063

11. Merriel A, Murove BT, Merriel SWD, Sibanda T, Moyo S, Crofts J. Implementation of a modified obstetric early warning system to improve the quality of obstetric care in Zimbabwe. Int J Gynecol Obstet. 2017; https://doi.org/10.1002/ijgo.12028 PMID: 28099733

12. Seiger N, Maconochie I, Oostenbrink R, Moll HA. Validity of different pediatric early warning scores in the emergency department. Pediatrics 2013;132(04):e841–e85022

13. Gold DL, Mihalov LK, Cohen DM. Evaluating the Pediatric Early Warning Score (PEWS) system for admitted patients in the pediatric emergency department. Acad Emerg Med 2014;21 (11):1249–1256

14. Bokhari SW, Munir T, Memon S, Byrne JL, Russell NH, Beed M. Impact of critical care reconfiguration and track-and-trigger outreach team intervention on outcomes of haematology patients requiring intensive care admission. Ann Hematol 2010;89(05): 505–512

15. Mhyre JM, D&Oria R, Hameed AB, et al. The maternal early warning criteria: a proposal from the national partnership for maternal safety. Obstet Gynecol 2014;124(04):782–786

16. Knight M, Kenyon S, Brocklehurst P, Neilson J, Shakespeare J, Kurinczuk JJ (Eds.) on behalf of MBRRACEUK. Saving Lives, Improving Mothers' Care - Lessons learned to inform future maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009 -12. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2014

17. Friedman AM, Campbell ML, Kline CR, et al. Implementing Obstetric Early Warning Systems. Am J Perinatol Rep 2018;8:e79–e84.

18. Singh S, McGlennan A, England A, Simons R. A validation study of the CEMACH recommended modified early obstetric warning system (MEOWS)*. Anaesthesia. 2012; 67: 12–1 https://doi.org/10.1111/j.1365-2044.2011.06896.x PMID: 22066604

19. Singh S, Guleria K, Vaid NB, Jain S. Evaluation of maternal early obstetric warning system (MEOWS chart) as a predictor of obstetric morbidity: a prospective observational study. Eur J Obstet Gynecol Reprod Biol. 2016; https://doi.org/10.1016/j.ejogrb.2016.09.014 PMID: 27792988

20. Umar A, Ameh CA, Muriithi F, MathaiM (2019) Early warning systems in obstetrics: A systematic literature review. PLoS ONE 14(5): e0217864. https://doi.org/10.1371/journal.pone.0217864