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Research Article

A Novel Approach in Advancing Maternal Health: Early Detection of Maternal Deterioration Using The Khoula Saving Mother Score

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Abstract

BACKGROUND: Maternal morbidity and mortality remain significant global health concerns, often resulting from the late detection of clinical deterioration. Early identification and timely intervention are crucial in preventing adverse maternal outcomes. Currently, there is a lack of monitoring systems identify and detect early maternal warning signs in order to expedite the appropriate escalation of care in Directorate General of Khoula Hospital (DGKH). The aim of this study is to design and implement an evidence-based system and observational chart for the early detection of maternal deterioration and timely intervention. This study examines the implementation of the Khoula-Saving Mother Score (K-SMS) within the Directorate General of Khoula Hospital (DGKH) to enhance the early detection of maternal health deterioration, facilitating timely intervention and reducing adverse maternal outcomes.

Methodology: This prospective observational study with a quality improvement approach started from January 2023 to December 2024 and two maternity wards were involved obstetric and gynecological ward. The newly designed system K-SMS, which is as, integrate a structured early warning score chart based on vital signs, clinical symptoms, and risk factors were implemented.

Result: In 2023, 900 patients were classified as low risk, 84 as mild risk, and 8 as high risk, compare to 2024, 812 low risk, 73 medium risk and 5 patient as high risk. In term of pregnancy-associated eclampsia, 40 patients were diagnosed with eclampsia, which was more common than systemic inflammatory response syndrome (SIRS), with only 8 cases. However, in 2024, eclampsia cases remained stable at 39, but SIRS cases increased significantly to 17.

Conclusion: The study anticipates that Khoula Saving Mother Score (K-SMS) and chart enhance early detection of maternal deterioration, leading to timely interventions, improved response times, and better maternal outcomes. The developed standardized early warning system and observational chart for maternal deterioration contribute to timely intervention and has proven the potential improvement in patient safety and reduce preventable maternal complications. This study contributes to evidence-based maternal care and inform future clinical practice guidelines for early recognition and management of maternal health crises.

Keywords: Khoula-Saving Mother Score, Maternal Early Warning System, maternal morbidity, clinical deterioration, early detection, patient outcomes, Directorate General of Khoula Hospital

Introduction

Maternal deterioration events represent a critical global health concern, reflecting instances where a pregnant or postpartum woman experiences a decline in her physical or mental health that could lead to severe morbidity or mortality if not addressed promptly. Globally, maternal deterioration is often linked to preventable conditions such as postpartum hemorrhage, hypertensive disorders, sepsis, and obstructed labor, which collectively account for a significant proportion of maternal deaths. According to the World Health Organization (WHO), approximately 287,000 women died worldwide in 2020 due to pregnancy or childbirth-related complications, with the majority occurring in low- and middle-income countries, particularly in sub-Saharan Africa and Southern Asia [1].

In Oman, a country recognized for its advancements in healthcare within the Middle East, maternal deterioration events are less frequent but still notable. A study by [2], reported an incidence of peripartum cardiomyopathy (PPCM), a rare but severe form of maternal deterioration, at 1.02 per 1,000 deliveries in Oman between 2010 and 2018, highlighting specific risks such as maternal age, singleton pregnancies, and gestational hypertension. Specifically, In Khoula Hospital (KH), the number of maternal transfer cases to the ICU is increasing. Using the manual record of KH-ICU, in 2021, there are 16 cases transferred to the ICU by the end of September. It was founded that most of these cases are suffered due to various antenatal, postnatal, labor or and gynecological compilations like, PPH, Pre-eclampsia, Gestational Diabetic Miletus (GDM), post labor hemorrhage, Long Segment Caesarian Section (LSCS) complications, uterine prolapse, post hysterectomy etc.

The significance of recognizing maternal deterioration events lies in their preventability and the potential to safeguard maternal and neonatal out-

comes. Early identification and intervention can mitigate progression to life-threatening conditions, reducing the global maternal mortality ratio (MMR) towards the Sustainable Development Goal (SDG) target of less than 70 deaths per 100,000 live births by 2030 [1]. In Oman, where the healthcare system has made strides in reducing MMR, understanding, and addressing these events remain crucial for maintaining progress and ensuring equitable care across all regions [2]. Failure to recognize these events can lead to devastating consequences, including maternal death, long-term disability, and adverse neonatal outcomes such as preterm birth or stillbirth, which carry profound social and economic implications.

Administrative leaders and managers play pivotal roles in addressing maternal deterioration events by fostering systemic improvements in healthcare delivery. Their responsibilities include developing and implementing evidence-based protocols, ensuring staff training on early warning signs, and facilitating access to emergency obstetric care. Globally, administrative oversight is essential for integrating quality improvement initiatives, as emphasized by the WHO's Network for Improving Quality of Care for Maternal, Newborn and Child Health, which underscores the need for coordinated efforts to enhance service delivery [3]. In Oman, managers are tasked with establishing national databases and local guidelines, as suggested by [2], to enable early recognition and timely referral of deteriorating cases. By allocating resources effectively and promoting interdisciplinary collaboration, administrative leaders bridge gaps in care, ensuring that maternal deterioration events are not only identified but managed efficiently to improve outcomes worldwide and within specific contexts like Oman.

Background and Definitions

Maternal Early Warning Systems (MEWS) are structured tools designed to facilitate the timely identification and management of maternal deterioration by monitoring vital signs and clinical symptoms during pregnancy, childbirth, and the postpartum period. These systems typically incorporate parameters such as heart rate, blood pressure, respiratory rate, temperature, and level of consciousness, assigning scores to deviations from normal ranges to trigger appropriate interventions. Globally, MEWS are defined as a proactive approach to reduce maternal morbidity and mortality by enabling healthcare providers to recognize early signs of conditions like hemorrhage, sepsis, or preeclampsia before they escalate into life-threatening emergencies [4].

The significance of MEWS lies in their potential to address the global burden of maternal mortality, which remains a pressing challenge despite progress. The World Health Organization (WHO) estimates that 287,000 maternal deaths occurred in 2020, with many linked to delays in recognizing and responding to clinical deterioration [1]. MEWS provide a standardized framework to overcome such delays, improving outcomes by ensuring rapid escalation of care, particularly in resource-limited settings where maternal mortality ratios are highest.

Problem Statement

There is lack of standardized policies and procedures for Health Care Workers (HCWs) about early identification and close monitoring and management of deteriorated cases in Maternity Department in Khoula Hospital.

Aim

The aim of this study is to design and implement an evidence-based system and observational chart for the early detection of maternal deterioration and timely intervention. This study examines the implementation of the Khoula-Saving Mother Score (K-SMS) within the Directorate General of Khoula Hospital (DGKH) to enhance the early detection of maternal health deterioration, facilitating timely intervention and reducing adverse maternal outcomes.

Operational Definitions

MEWS defined by [5], as a chart used to monitor the vital signs for all women admitted to Maternity who are pregnant women or up to six weeks postpartum an obstetric. This chart shall monitor the following seven parameters: Respiratory Rate (RR), temperature, systolic BP, pulse rate, consciousness level, urinary output and mode of birth. The sum of these variable scores can "indicate the severity of abnormal vital signs and assist in the identification of deterioration" [6].

In this, Khoula Saving Mother Scores- SMS can be defined as a color-coded system used to close observe, monitor and record the following maternal physiological variables: Respiratory Rate (RR), SPO2, Supplemented Oxygen (SO2), Heart Rate (HR), Systolic BP (SBP), Diastolic BP (DBP), Temperature, Conscious Level (ACVPU), WBC, Urine Protein- dipstick and Pain Level. Meeting criteria for abnormal parameters triggers the identification of a color code threshold score, which aimed to classify level of deterioration and guide the needed frequency of monitoring and the proper escalation of care.

Furthermore, Registered Midwives are a group of specialized independent practitioners who underwent a special training program in midwifery that benefit maternal and child health care service. They will take the role in the recognition and management of any deteriorated maternal case. This group shall be involved also in the role of attending, supporting and advocating the maternal ward nurses for timely management of these deteriorated cases.

Literature Review

Literature reviews and studies evaluate the significance of MEWS as a vital tool for improving maternal health outcomes by enabling early detection and management of clinical deterioration. A systematic review by [7], analyzed the effectiveness of MEWS across various obstetric settings and found that these systems significantly enhance early recognition of deterioration, with a reported improvement in response times by up to 30% in facilities implementing standardized protocols. The review emphasized that MEWS improve communication among healthcare teams and reduce diagnostic errors, particularly in low-resource settings where staff training and resources may be limited. This is crucial given the World Health Organization's (WHO) estimate of 287,000 maternal deaths in 2020, many of which could have been prevented with earlier intervention [1].

In high-income countries, studies have demonstrated tangible reductions in severe maternal morbidity through MEWS implementation. [4], conducted a study in the United States evaluating the impact of MEWS in obstetric units and reported a 20% decrease in severe maternal morbidity rates, including cases of hemorrhage and eclampsia, following the adoption of these systems. The study highlighted that MEWS provide a structured approach to monitoring, enabling clinicians to escalate care swiftly, which is particularly significant in fast-paced hospital environments where subtle signs of deterioration might otherwise be overlooked. This aligns with broader efforts to standardize maternal care and improve patient safety.

In middle-income and resource-constrained contexts, MEWS have been adapted to address local challenges, proving their versatility and significance. A study by [8], in South Africa assessed the feasibility of a modified MEWS in rural maternity units and found that it reduced the incidence of adverse maternal outcomes by 15% over a two-year period. The authors noted that the system's simplicity and reliance on basic vital sign measurements made it practical for settings with limited technology, emphasizing its potential to bridge gaps in care delivery where maternal mortality rates remain high. This adaptability underscores MEWS as a scalable intervention across diverse healthcare systems.

Furthermore, literature reviews have highlighted the systemic benefits of

MEWS beyond immediate clinical outcomes. A narrative review by [9], explored the role of MEWS in quality improvement initiatives, concluding that these systems foster a culture of vigilance and accountability among healthcare providers. The review pointed to evidence that MEWS integration into national guidelines, as seen in countries like the United Kingdom, has led to improved training programs and resource allocation, amplifying their impact on maternal health policy. This systemic significance is echoed in studies like that of [2], in Oman, where MEWS are recommended to complement existing protocols for managing conditions like peripartum cardiomyopathy, reinforcing their relevance in countries with advanced healthcare systems aiming to sustain low maternal mortality rates.

Overall, the implications and the suggestions indicate the importance to implement different variables to ensure a proper management and care of maternal patients. In addition, the review of the literature indicates the value of implementing variables related to sepsis and pre- eclampsia to ensure accurate monitoring, assessment, and management, for such critical conditions. Furthermore, the project name will be identified as "Khoula-Saving Mother Score, K- SMS", in which other international projects identified MEWS as Saving Mother Score (SMS). For the purpose of research aim clarity, the following themes will examine:

- The effectiveness of MEWS.
- Merging MEWS with sepsis for Effective Detection and Management.
- Effectiveness of MEWS in the Determination and Management of pre- Eclampsia.
- Tools used to assess MEWS scores and Escalation of Care.

Effectiveness of MEWS

There are many literatures examined the effectiveness of MEWS among maternity cases. [10], conducted a descriptive study to evaluate the Modified Early Obstetric Warning System (MEOWS) in women after pregnancies in a tertiary hospital in Brazil. As a result, the use of MEOWS showed a significant number of patients had triggered in which the nursing team did not recognize 99.2% of cases. The application of this tool would result in a better care because critical situations would be recognized and corrected quickly, avoiding unfavorable outcomes. Thus, results are similar as in the mixed-method research design study conducted (between 1 August 2018 and 31 March 2019) by [5], in 3 tertiary care hospitals across the northern regions of Nigeria. The study shows also a significant value in the identification of deteriorated cases. Complications also developed during antepartum or during the puerperium (42 days' post-partum) were also monitored and founded to be less after implementation of MEOWS among pregnant and postpartum women admitted to all inpatient wards included in the study.

A similar study conducted by [11], to monitor four main causes of morbidity among maternal cases which are: sepsis, cardiovascular dysfunction, severe preeclampsia or hypertension, and severe hemorrhage. They aimed (through a pilot study) to evaluate the use of early warning trigger tool and determine whether it was associated with reduced maternal morbidity compared with those who did not use the tool. They reported a significant reduction in maternal morbidity ($P = 0.01$) compared with another group. This also founded by [12], and stated that "the development of EWS is enough to prevent alarm fatigue and also high enough for clinicians to associate value with the trigger".

In terms of the ability of MEWS in detecting mortality and morbidity rates, a retrospective cohort study conducted by Caisedo et al (2017) to evaluate these outcomes. They founded that, Peripartum women with normal values of OEWS had 0% mortality rate, while those with high OEWS values (>6) had a mortality rate of 6.3%. This validates the performance of OEWS for the prediction of maternal death in peripartum women. Furthermore, the use of early warning scores in obstetrics is a highly useful approach in the early identification of women at "an increased risk of dying". Another study conducted by Tuyishime et al (2020) enrolled parturient admitted to 4 district hospitals in Rwanda during the period from April to July 2019. Among 478 patients, 75% demonstrated a complete MEOWS charts. In addition, MEOWS chart showed to predict morbidity with a sensitivity of 28.9% and a specificity of 93.5%.

In addition to above advantages, the MEWS founded to be effective also in detecting risk of sepsis and eclampsia for this specific population. Below sections examined this advantage.

Merging MEWS with Sepsis for Effective Detection and Management

Worldwide, maternal sepsis represents the third cause of maternal mortality [13]. The WHO estimated that the global prevalence of maternal sepsis is 4.4% among live births, with an incidence of 9–49/ 100 000 deliveries [14]. Additionally, [15], founded that between March 2012 and May 2015, there were 1250 pregnant or postpartum women presented to the A & E with a met Systemic Inflammatory Response Syndrome (SIRS) criteria. Olvera & Dutra (2016) justified that "due to immunological changes associated with pregnancy, the immunological defenses are lowered in order to protect the fetus". All these, led to a focused EWS on maternal sepsis with the publication of updated clinical guidelines. The development of OEWS is essential "to detect critical illness, the application of care bundles, and a growing awareness of the need to treat maternal infection early and appropriately" [14]. Furthermore, [13], added that MEOWS "is an effective early detection tool validated in maternal sepsis scenarios". Additionally, "If early signs of sepsis go unrecognized, septic shock can develop, leading to organ dysfunction and potential death" [16].

The evaluation of the predictive power of MOEWS for the development of severe sepsis in women was evaluated in a retrospective cohort study conducted by [17]. 15,027 births were recorded and 913 cases of sepsis were confirmed (6.1%) in the analysis using 6 MOEWS with different thresholds and clinical triggers. The sensitivities to predict severe deterioration ranged from 40% to 100% and the specificities varied from 4% to 97%. Chakravarty et al (2021) evaluated the use of Saving Mother Scores (SMS) in the detection of sepsis by comparing two groups, A and B. They used APACHE II and Sequential Organ Failure Assessment (SOFA) sepsis scores and being determined along with SMS in eight critically ill patients. There was no maternal mortality in this series. [16], suggested merging temperature, heart rate, respiratory rate and WBC counts to MEOWS. He said that clinical characteristics that consistently appear to be present in maternal sepsis cases include pyrexia (>38 °C) or hypothermia, tachycardia (110/min), tachypnea (>24), and abnormally low or elevated white blood cell (WBC) counts. [18], also supports this. He stated that certain symptoms of sepsis cause abnormal vital signs. When this occurs, MEOWS automatically highlights and alerts the HCWs. This allows for rapid action and providing a clear escalation protocol for deteriorating patients. This early detection is especially crucial due to the rapid spread of maternal sepsis.

Furthermore, the EBP from 2020 onward regarding the integration of Systemic Inflammatory Response Syndrome (SIRS) criteria into Maternity Early Warning System (MEWS) variables for sepsis detection has evolved, reflecting a growing recognition of the unique physiological changes in pregnancy and the need for tailored diagnostic tools. The integration of SIRS into MEWS aims to enhance early sepsis detection in obstetric populations, where normal physiological changes—such as elevated heart rate and white blood cell count—can overlap with sepsis indicators, complicating diagnosis. A 2020 study by Sela et al. explored the proportion of women at risk of intrauterine infection meeting SIRS criteria, finding that while SIRS was sensitive in identifying infection, its specificity was limited

due to these overlaps. The authors suggested that combining SIRS with MEWS could improve early warning capabilities, though they emphasized the need for obstetric-specific adjustments [19]. In 2021, research by Ackermann et al. reviewed computerized clinical decision support systems, including those merging SIRS with MEWS, for early sepsis detection in maternal inpatients. The study highlighted that integrating SIRS variables, like temperature, heart rate, respiratory rate, and leukocyte count, into MEWS increased sensitivity for detecting sepsis compared to standalone tools. However, it also noted a trade-off with specificity, as many healthy pregnant women triggered alerts due to normal physiological variations [20]. This underscores the challenge of balancing early detection with avoiding over-diagnosis in maternity settings. A 2022 prospective cohort study by Sharma et al. investigated physiological and immune-metabolic biomarkers in septic and healthy pregnant women, incorporating SIRS criteria into a modified MEWS framework. The results indicated that merging SIRS variables with MEWS improved the prediction of feto-maternal immune health outcomes, with a sensitivity of 85% for sepsis detection when adjusted cutoffs (e.g., heart rate >120 bpm, temperature >38.2°C) were used. The study advocated for customized thresholds to account for pregnancy-related changes, suggesting this hybrid approach could reduce delays in sepsis management [21]. Further evidence emerged in [22], who validated sepsis screening tools in patients with clinical chorioamnionitis. Their findings showed that a combined SIRS-MEWS model outperformed standalone SIRS or quick Sequential Organ Failure Assessment (qSOFA) tools, achieving a sensitivity of 90% and specificity of 70% when tailored to obstetric parameters. The study emphasized that integrating SIRS into MEWS allowed for earlier identification of at-risk patients, particularly when paired with clinical judgment, though it cautioned against relying solely on these scores due to variable positive predictive values [22]. Moreover, A systematic review and meta-analysis by [23], evaluated early warning scores, including SIRS-integrated MEWS, for sepsis identification in adults, with a subgroup analysis on obstetric patients. The review found that SIRS-MEWS hybrids had a pooled sensitivity of 88% and specificity of 65% in maternity settings, outperforming traditional SIRS alone (sensitivity 88%, specificity 26%). The authors concluded that merging SIRS with MEWS variables offers a practical, evidence-based approach for maternity care, though they recommended ongoing validation to refine thresholds and reduce false positives [23].

For this, the new tool of K- SMS will explain the consideration about patient as at risk for SIRS, if a combination of abnormalities in the following variables will be met HR, RR, Temp, WBC count, hypotension, and level conscious level. In addition, other considerations like FHR ≥160 or RBS is ≥ 7.7ml/l in the absence of Gestational Diabetic Mellitus (GDM), will be ensured.

Effectiveness of MEWS in the Determination and Management of pre- Eclampsia

Another crucial element in the development of the scoring tool of MEWS is detection of the risk of pre- eclampsia through MEWS. Preeclampsia, characterized by hypertension, proteinuria, and organ dysfunction, shares overlapping clinical features with maternal deterioration that MEWS aims to identify, such as elevated blood pressure, altered mental status, and abnormal vital signs. Research since 2020 has explored how integrating preeclampsia-specific variables into MEWS can improve timely intervention. A [24,25], evaluated the predictive validity of MEWS in obstetric patients, finding that adding preeclampsia markers, like systolic blood pressure >160 mmHg and proteinuria, enhanced the system's sensitivity for identifying at-risk patients from 78% to 87%. However, the authors noted that specificity slightly decreased, suggesting a need for refined thresholds [24,25]. In 2021, Johnson and colleagues conducted a retrospective cohort study examining the integration of preeclampsia variables (e.g., headache, epigastric pain, and hypertension) into MEWS to detect maternal morbidity. Their findings indicated that this hybrid approach reduced the time to intervention by an average of 2.4 hours compared to standard MEWS alone, with a sensitivity of 91% for detecting severe preeclampsia cases. The study highlighted the importance of including symptoms alongside vital signs to capture the full spectrum of preeclampsia-related deterioration [26]. Furthermore, a systematic review conducted by [27], analyzed early warning systems in maternity care, including those merging preeclampsia variables with MEWS. The review found that incorporating preeclampsia-specific triggers, such as diastolic blood pressure >90 mmHg and visual disturbances, into MEWS increased the area under the receiver operating characteristic curve (AUC) from 0.75 to 0.82, indicating improved discriminatory power. The authors recommended standardizing these variables across healthcare settings to ensure consistency, though they acknowledged variability in implementation as a limitation [27]. Further evidence emerged in 2023 from a prospective study by Lee et al., which tested a modified MEWS incorporating preeclampsia parameters like platelet count <100,000/μL and liver enzyme elevation. The study reported a sensitivity of 93% and specificity of 68% for predicting adverse maternal outcomes, such as eclampsia, when these variables were included. The authors argued that this approach better captured the multisystem nature of preeclampsia, though they cautioned that training staff to recognize these additional triggers was essential for success [28].

As a result, the proposed tool will ensure that staff must consider the patient for risk of Pre- eclampsia, if a combination in the following variables is met: SBP≥ 140, DBP ≥90 and urine dipstick of protein reading as +1. In addition, the following features must be assessed to consider risk for eclampsia headache, blurred vision, epigastric pain, urine output ≤ 30/ 2hrs for catheterized patient and generalized edema.

Tools and specific variables used to assess MEWS scores & Escalation of Care

Internationally, there are several tools and charts used in the detection of maternal deterioration and developing its escalation of care. In this section, a summary of most MEWS and its protocols presented in many literatures used will be discussed.

In terms of tool variables, [11] discussed MEOWS with its four main causes of maternal morbidity, which are potential sepsis, cardiopulmonary disorders, hypertension, and hemorrhage. [29], also outlined these four causes or diagnosis.

The EMC Guidelines (2018) suggested setting Respiratory Rate (RR), oxygen saturation (SPO2), Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), temperature, Reduced/altered level of consciousness and Urine Output (UO). Additional supplementary observations (such as lochia) should be recorded separately from the early warning observations. Similarly, [16] stated the same variables to be included. They added that, with abnormal values of these vital signs, a Fetal Heart Rate (FHR) greater than 160 BPM can be added as an indicator score for sepsis. [15], suggested also the same with inclusion of SOFA scores to predict sepsis. In another review, [14] stated that the SIRS criteria used to diagnose sepsis in the non-pregnant adult appropriate for use especially in diagnosing of a maternal sepsis as RR, PaCO2, HR, and WBC count during a normal healthy pregnancy might meet the criteria for SIRS.

In addition, the ACT Health Policy Register (2021) to record RR, SPO2, HR, SBP, DBP, temperature and sedation score (indicates level of consciousness). The policy added also a specific observation for consideration (to be recorded in the chart separated from total calculated score) for both, antenatal and postnatal periods. These observations include blood loss, Liquor amount and FHR for antenatal population and Fundus, Perineum and Lochia for postnatal patients. Other parameters such as pain and nausea scores are suggested to be either included, in the score or recorded on the chart [30]. The physiological parameters suggested by the ACT Health

Policy Register, are same suggested by the [31], in the development of National Early Warning System (NEWS). The college added also a specific maternal observation like blood sugar, severity of pain, antenatal discharge and/or postnatal lochia. Similarly, the Scottish MEWS- 2018, set same above parameters with Yes or No "looks unwell" column [32]. The Irish MEWS- 2017 added also special attention for monitoring maternal sepsis and that to consider this if two or more criteria of SIRS met [33].

[34], discussed the variables used in SMS as mainly consists of three parameters: pregnancy-related risk factors, physiological variables and biochemical tests. Pregnancy-related risk factors were given a bicolor coding with a simple yes or no as the potential response. Each parameter was given a score of 1. Eight physiological parameters were identified: BP, pain, temperature, HR, RR, SpO2, UO, and neurological status of the patient. A triple color coding, weightage, and score was assigned to each one of them. A color-coded, and given scoring depending on the severity of derangement.

Heart rate is a critical variable in MEWS, with abnormal values (e.g., <50 or >120 beats per minute) signaling potential distress. A study in Canada highlighted its role in detecting maternal sepsis, noting that tachycardia often precedes other symptoms [35]. Similarly, [36], included heart rate in their modified early obstetric warning system chart in India, with thresholds tailored to peripartum morbidity prediction.

Respiratory rate is a sensitive indicator of maternal compromise, with deviations (e.g., <10 or >24 breaths per minute) linked to conditions like pulmonary edema or sepsis. [5], validated its inclusion in an obstetric EWS for low-resource settings, reporting high predictive accuracy when combined with other vital signs.

Blood pressure, particularly systolic values below 90 mmHg or above 160 mmHg, is a cornerstone of MEWS for detecting hemorrhage or pre-eclampsia. [37], emphasized its monitoring in the postpartum period in Spain, where hypotension flagged bleeding risks, while hypertension signaled eclampsia. [38], also incorporated blood pressure in their teleassistance-supported MEWS in rural Colombia.

Temperature abnormalities (e.g., <36°C or >38°C) are used to identify infection or sepsis. [35], underscored its importance in Canada's obstetric EWS, linking fever to early sepsis recognition. [5], similarly included temperature in their model, noting its feasibility in resource-limited environments due to ease of measurement.

Oxygen Saturation measured via pulse oximetry, oxygen saturation (e.g., <95%) is increasingly included in MEWS to detect respiratory compromise. [36], incorporated it into their rural Indian system, associating low levels with peripartum morbidity, though its use depends on equipment availability in some settings.

The Level of Consciousness (LOC) was ssessed using tools like the AVPU scale (Alert, Voice, Pain, Unresponsive), altered consciousness indicates neurological deterioration, often due to eclampsia or hemorrhage. [37], included this variable in their Spanish study, noting its value in escalating care during postpartum monitoring.

Urine Output (Optional). Though less consistently measured internationally, urine output (<30 mL/hour) is sometimes included to assess renal function and hypoperfusion, particularly in high-resource settings. [9], reported its use in some UK systems, but its omission in resource-limited contexts was noted due to monitoring challenges [5].

The specific thresholds and scoring of these variables differ across systems. For instance, the Modified Early Obstetric Warning System (MEOWS) used in the UK and the Maternal Early Warning Trigger (MEWT) in the US adjust ranges based on obstetric norms rather than general adult standards [9]. In low-resource settings, simpler systems prioritize variables like respiratory rate and temperature due to limited access to pulse oximeters or continuous monitoring devices [5]. Despite these variations, the core variables, heart rate, respiratory rate, blood pressure, temperature, oxygen saturation, and consciousness, form the foundation of MEWS globally.

Accordingly, the proposed tool will be modified. It will involve monitoring of the following maternal variables: Blood Pressure (BP), Heart Rate (HR), Respiratory Rate (RR), Temperature, WBC count, Saturated Oxygen (SPO2), Oxygenation Status, General Appearance, Urine Protein dipstick, Sudden Onset of Pain, and level of consciousness. The tool will be designed as a simple, color-coded structure, for each parameter, that used, green to indicate the values within a normal range (scored as 0), blue as low risk (scored as 1), yellow as moderate risk (scored as 2) and red to indicate high risk of deterioration (scored as 3). Respectively, depending on these ranges, staff nurse can score the patient accordingly.

Once calculated the total K- SMS score, the staff nurse must classify patient's clinical risk as if score is 0 indicates normal, score between 1-3 indicates low risk (blue code), score between 4-6 indicates mild risk (yellow code) and score 7 and above indicates high risk (red code). A single score of 3 in any variable is considered as high risk (red code).

In term of tool escalation of care and clinical guidelines, the MEWS got many types. For instance, with MEOWS, there are two moderately abnormal parameters (yellow alerts) or one severely abnormal parameter (red alert) trigger a clinical response [39].

EMC Guidelines (2018) set MEWS scores and its classifications as a score of 5 to 6 indicates medium risk, a score of 7 or more indicates high risk of deterioration. However, The [6], determined that MEWS ≥ 4, this considered as mild risk and score of ≥ 7 indicates high risk [4, 34], explained SMS classifications for each parameter. For instance, pregnancy-related risk factors were given a bicolor coding with a simple yes or no (orange denotes risk factor and green indicates no risk). The presence of ≥4 oranges at any time during pregnancy indicates a high-risk pregnancy. For the 8 physiological parameters/ vital signs, a triple color coding, weightage, and score was assigned to each one of them. Respiratory rate and conscious level were given a weightage of 2. Other parameters were given a weightage of 1. Moderate risk color-coded as orange with score of 3–5. High-risk color-coded red and had a score of ≥6.

The frequency of observation increasing as the level of deterioration is increased. For all other pregnant or recently pregnant women, the minimum frequency of observation should be once every 24 hours. Women assessed to be at high risk of deterioration should have at least four-hourly observations, with more frequent observations as clinically necessary [40]. On the other hand, the [6], suggested frequency of Vital Signs minimum frequency to be performed eight hourly unless otherwise specified in the management plan. The policy added that this frequency performed more frequently as per documented procedures and/or as per the woman's clinical condition.

In general, for the aim of tool development and its Escalation protocol, above discussed parameters and criteria will be considered.

Plan & Methodology

Following a specific method to implement the planned outcomes, will make the process more focused and systematic (Langley et al. 2009). Consequently, the leader can use the Plan, Do, Study, Act (PDSA) cycle as a small testing scale for the proposed change Institute for Health Care Improvement (IHCI. 2018). In addition, the PDSA steps support organizational learning through experimentation to make improvements. In this

model, suggested solutions are tested on a small scale before changes are made to the whole system [29].

Plan

Research approach

Prospective observational study with a quality improvement approach

Research design

An experimental quantitative research study

Settings of the study

Obstetric Ward & Gynecology Ward

Inclusion Criteria

All maternal patients admitted in Obstetrics & Gynecology Wards and found to include the following characteristics:

- **Pregnancy Status:** Women who are pregnant, typically from early pregnancy (e.g., before 20 weeks' gestation) through the postpartum period (up to 6–12 weeks after delivery). This includes antepartum, intrapartum, and postpartum phases.
- **Hospitalized Patients:** Maternal patients admitted to obstetrics and gynecology wards where vital signs are routinely monitored. This includes both low-risk and high-risk pregnancies.
- **Physiological Monitoring Capability:** Patients for whom routine physiological parameters (e.g., heart rate, blood pressure, respiratory rate, temperature, and level of consciousness) can be measured and recorded to assess clinical deterioration.
- **General Health Status:** including healthy pregnancy status and Specific Conditions or Risks.
- **Age:** Typically, maternal patients aged 16 years or older are included, though specific age cutoffs may vary by study or protocol.

Exclusion Criteria

Maternal patients admitted in other wards Antenatal, Labor & Private wards.

Methodology

- Data were gathered about incidents of shifting patients to ICU due to deterioration.
- Maternal Early Warning Score Sheet were developed based on latest evidence-based practices from the year 2016 to 2021.
- Proposal was reviewed & approved by Maternal & Child Health HOD before piloting.
- MERT Team (Maternal Emergency Response Team) were established based on specific criteria.
- Development of Maternal Emergency Response Team (MERT), which is a group of registered midwives from Labor Ward who are specialized independent practitioners underwent a special training program in midwifery that benefit MCH service. They will take the role in the recognition and management of any deteriorated maternal case. This group shall be involved also in the role of attending, supporting, and advocating the maternal ward nurses for timely management of these deteriorated cases.
- Training programs were conducted for nursing staff on the accurate use of K-SMS, standardizing documentation, and establishing escalation protocols based on score thresholds.
- 85% of the staff nurses were covered in the training program.
- Implementation established & data collected utilizing excel sheet.
- Regular monitoring through conduction of audits were done.

Forming the teams

Project Team

Assemble a team that has experience in initiating early warning systems (EWS) and understanding the context of EWS. Team also has to understand consequence of failing to solve further issues. Collaboration skills and treating with respects is essential to ensure successful implementation. Finally, the team has to show commitment to any problem and arrive the best solutions.

Registered Midwives

are a group of specialized independent practitioners who underwent a special training program in midwifery that benefit maternal and child health care service. They will take the role in the recognition and management of any deteriorated maternal case. This group shall be involved also in the role of attending, supporting and advocating the maternal ward nurses for timely management of these deteriorated cases.

Setting aims and objectives

1. To develop and implement an assessment and alert system to identify maternal deterioration and its escalation of care.
2. To enhancing staff awareness about the significance of close monitoring and observation of maternity patient's vital signs in the detection of deterioration.
3. To introduce effective specialized nursing team "Midwives" who are able to assess, manage and support ward staff in attending deteriorated cases.
4. To facilitate staff ability to identify and classify level of patient's deterioration.
5. To evaluate the effectiveness of the system and chart in identifying early warning signs of maternal deterioration (e.g., sepsis, hemorrhage, eclampsia).
6. To assess the impact of the system on clinical response times and maternal outcomes (e.g., reduced ICU admissions, improved survival rates).
7. To explore healthcare providers adherence and perceptions regarding the usability and feasibility of the system in real-world clinical settings.
8. To identify barriers and facilitators affecting the implementation of the system in maternity care units.

Tools/ Charts Development

Based on the above literatures being reviewed regarding MEWS, an evidence-based tool developed, considering the following factors/ criteria:

1. Recent evidence (Based on literatures from 2016-2021).
2. Pregnant and postpartum women admitted to all inpatient maternal wards due to complications developing antepartum, those with gynecological diagnosis/ issue, those in active labor and those during the puerperium period.
3. The ranges of the 11 physiological parameters, SIRS and pre- eclampsia criteria.
4. Special considerations for antenatal, postnatal and gynecology patients.
5. The escalation care protocol (management) was developed based on the organizational standards and protocols.

The new tool (Refer to figure 1) is designed as a simple, color coded structure, for each parameter, that used, green to indicate the values within a normal range, blue as low risk, yellow as moderate risk and red to indicate high risk of deterioration. Respectively, depending on the degree of deviation from the target range. Once calculated the total Khoula- SMS score, the staff nurse has to classify patient's clinical risk as if score is 0 indicates normal, score between 1-3 indicates low risk (blue code), score between 4-6 indicates mild risk (yellow code) and score 7 and above indicates high risk (red code). A single score of 3 in any variable is considered as high risk (red code). the proposed tool will ensure that staff must consider the patient for risk of Pre- eclampsia, if a combination in the following variables is met: SBP≥ 140, DBP ≥90 and urine dipstick of protein reading as +1. In addition, the following features must be assessed to consider risk for ec-

lampsia headache, blurred vision, epigastric pain, urine output ≤ 30/ 2hrs for catheterized patient and generalized edema. Kindly refer to Appendix No. 1. For K- SMS Key Tool.

Another tool which will be utilized through this change is Khoula SMS Escalation Protocol Tool, to explain the clinical guidelines and protocols for health care workers in MCH department that supports their management for maternal deterioration, organize, and facilitate response process quickly and effectively. These guidelines adapted from above EBP and will be reviewed also by concerned doctors and consultants in the hospital to set a reliable tool. Kindly refer to Appendix No.2. for K- SMS Escalation Protocol.

Finally, A 24-hour Observation Chart will be used to ensure monitoring and documentation of K- SMS for each patient. The staff nurse will utilize the provided key of K- SMS, and the escalation protocol throughout her documentation of the observation chart, to guide her on the frequency of monitoring and escalation needed (Refer to Appendix No. 3, for K- SMS 24-hour Observation Chart).

Furthermore, consider the patient as SIRS if a combination of the following variables is met: HR, RR, Temp, WBC count, hypotension and altered conscious level. In this Total SIRS Score will trigger as orange, indicates patient as SIRS. Consider also FHR ≥160 or RBS is ≥ 7.7mml/l in the absence of GDM.

Moreover, staff has to consider the patient for risk of Pre- eclampsia, if a combination in the following variables is met: SBP≥ 140, DBP ≥90 and urine dipstick of protein reading as +1. In addition, the following features must be assessed to consider risk for eclampsia headache, blurred vision, epigastric pain, urine output ≤ 30/ 2hrs for catheterized patient and generalized edema.

In addition to the above findings, staff has to consider additional measures like blood loss, liquor amount and FHR for antenatal and labor in progress patients and fundus, perineum and lochia for postnatal patients. Other factors/ variables, like RBS, serum lactate and nausea score has to be measured as per indicated and advised to role out causes of variations in patient's vital signs.

Do

Project Team

- Conduct awareness for all nurses and doctors in MCH department.
- Emphasize to the nurses about the importance of adherence to the implementation of K- SMS guidelines.
- Follow the progress and statistics of K- SMS implementation and report to the DNA.

Director of Nursing Affairs (DNA)

- Emphasize to the head of section /unit supervisors, the importance of adherence to K- SMS implementation.
- Follow the progress and statistics of K- SMS implementation.

The MCH Head of Section /MCH Supervisor/ Shift Duty

- Reinforce all the staff about the implementation of K- SMS and the importance of updating their knowledge and skill on the procedure.
- Follow their department's progress on project implementation, overall audit and communicate all findings to their ward's in-charges and departmental HOSs.

The Ward In-charges /Shift In-charges

- Adhere and implement the policy and procedure of K- SMS.
- Monitor the use of K- SMS tools and compliance with the triggering system.
- Ensure proper supervision is given to all staff particularly new staff regarding K- SMS.
- Ensure the availability of fully equipped HD in her/his ward.

The Ward In charge of Labor Ward

- Ensure that the Duty Rota is arranged properly for the MERT nurses.
- Consider the MERT nurses' responsibility while assigning patients for them. E.g., number of patients assigned.
- Arrange essential courses and training programs for MERT Leader and team members.
- Review the MERT statistics monthly and to verify the accuracy of the data.

The MERT Nurse Leader

- Arrange the Duty Rota of MERT nurses with the Labor Ward In-charge and differentiate MERT Nurse in each shift by color code for assigning the responsibility and to notify the ward nurse and On-call of admitting specialty to coordinate the escalation pathway.
- Ensure proper handover between the team members in each shift.
- Take the roles and responsibility in identifying, analyzing and solving any issue related to MERT members or ward-staff nurse in regard to K- SMS implementation and report to the concerned person to ensure smooth communication.
- Support the team members in attending and following-up the deteriorated cases.
- Work with others in developing and delivering a skill-based education aimed at improving the identification and management of patient's requiring critical care.
- Orient, educate and support new MERT member.
- Participate in the audit and evaluation of K- SMS services in MCH department.
- Submit on-going monthly K- SMS statistics and audit reports to Director of Nursing Affair through her supervisor.

The MERT Nurse

- Receive referrals from the maternal wards directly for assistance and to provide an expert initial assessment of any patient meeting the calling criteria for the MERT team, as per K- SMS escalation protocol.
- Based on the patient's assessment, initiate the level of support required.
- Collaborate with Intensivist (anesthetist)/ or on-call doctors in MCH department for making decision regarding the transfer of patients to HD/ ICU whenever required.
- Maintain 24hrs MERT handover sheet for attended cases (Refer to Appendix No. 4).
- If MERT nurse at the scene of cardiac arrest event, she/he must work with members of the ward and cardiac arrest team to provide expert nursing intervention and to provide support for ward nurses.
- Support and orient new members of MERT.
- Be responsible for developing and sustaining own knowledge, clinical skills, and professional awareness.
- Participate in the audit and evaluation of the K- SMS service.

All MCH wards Staff Nurses

- Adhere and implement the procedure of K- SMS.
- Initiate appropriate early interventions for patients who are deteriorating.
- Maintain patient comfort during and after the procedure.
- Document all the details about patient condition and management recommended by MERT in nursing progress report.

Intensivist (Anaesthetist) / On call doctor

- Adhere and implement the procedure of K- SMS.
- Liaise with the MERT nurse, in attending of MERT nurse calls, plan-

ning, and implementing appropriate care for clinically deteriorated patients.

Resources Needed

- Support from DNA, HODs, supervisors and ward in charges for the implementation of K- SMS. For instance, support needed to develop MERT from labor ward, and considerations for MERT nurse who will be responsible to attend the calls of deterioration events, in terms of her assignment and allocation in her ward.
- Awareness and training sessions for nurses, MERT, doctors and any new staff.
- Support from IT department for computerizing, modifications of the tool and follow up with the project team.
- Providing of extra equipment like portable monitors and saturation probes, for best utilization of both normal beds, and HD settings in the department. This important to ensure complete and efficient monitoring of K- SMS variables.

Time Needed

The overall estimated time needed to accomplish this project will be 9 months. Below table. No. 2, shows the detailed of interventions to be done with their estimated time needed.

Time Needed.	Interventions to be done.
1 month.	Writing a proposal to the DNA and getting feedback for approval.
1 month.	The HODs and consultants of MCH department and anesthetist will review the newly developed tools and will give feedback.
2 weeks.	Modifying the tools according to consultant's review and developing the manual observation chart.
1 week.	Discussing of the proposal with the stakeholders and preparing them for the change.
2 months.	Awareness session will be initiated for both, MERT nurses and other nursing staff working in MCH department. To ensure a good coverage of staff, a plan will be scheduled based on their duty Rota.
1 month.	The charts will be piloted in antenatal ward and in gynaecology ward to examine the validity and feasibility of the tools.
2 months	Measuring the outcomes of the pilot study, and then to proceed the computerization process of the tools and observation chart in Al Shifa 3 Plus, in collaboration with IT department in the hospital and in MOH.
1 month.	Generalizing of the project to other MCH wards, the Labor ward, and the obstetric ward. Training the staff of MCH department on the use of the system in Al Shifa 3 Plus and encourage to teach each other during the shift.

Study (Pilot)

In study stage, the charts will be piloted/ examined for implementation. The pilot study will be carried for one month. The following outcomes will be measured:

Patient's Demographical Data

1. Age group.
2. Gavida.
3. Para.
4. Live.
5. Abortion.
6. Dead.

Maternal mortality and morbidity aspects/ risk factors

1. Maternal complications (preeclampsia/ eclampsia, antepartum haemorrhage, postpartum haemorrhage, sepsis, prolonged/obstructed labour, abortions, and thromboembolism.

Kindly refer to Appendix 1 for description and definition of above complications.

2. Maternal death.

Obstetric Interventions

1. SVD.
2. Forceps.
3. Elective LSCS.
4. Emergency LSCS.

Essential components of early warning system

1. Total No. of 24 hours Khoula SMS Observation charts collected.
2. Total No. of charts not Maintained.
3. Total No. of Patients at Normal Khoula SMS Score.
4. Total No. of Patients at Low Risk.
5. Total No. of Patients at Medium Risk.
6. Total No. of Patients at High Risk.
7. Total No. of Patients at Risk of sepsis.
8. Total No. of Patients at Risk of Eclampsia.
9. Total No. of Visits Informed and seen by Maternity PART Nurses.
10. Total No. of Visits not informed and seen by Maternity PART Nurses.
11. Total No. of Visits Informed and not seen by Maternity PART Nurses.
12. Total No. of Patients Shifted to Higher Level of Care (HD).
13. Total No. of Patients Trans in to ICU.
14. 24 hrs. Re-admission.
15. Length of Stay (LOS).

Act

Following the piloting, the outcomes will be reviewed. Recommendations from nurses will be also collected and analyzed. Based on these data, the tools will be revised and planned to implement through Al Shifa 3 Plus.

Conduction of the study and sampling. In the year of 2023 a total of 14021 Khoula SMS observation charts being collected from both wards.

Escalation of care.

Total cases informed and seen by MERT is 39 and there is a total of 43 case which not being informed to MERT. All deteriorated cases filled under mild or high risk category, improved to normal SMS score. The MERT nurse and bedside staff demonstrated effective management in following of SMS escalation of care guidelines. For instance, close monitoring and management of acute symptoms.

Score Interpretation:

The K SMS escalation protocol is categorized in to different levels based on score as normal, low, mild & high and it was signified with a color coding for each category as following:

Normal: Green
Low: Blue
Mild: Yellow
High: Red
Maternal SIRS: Orange
Pre -Eclampsia: Purple

This can enhance clarity for healthcare providers and facilitate rapid decision-making. Staff training on how to interpret each category correctly and take appropriate actions is essential. Developing an alerting mechanism tied to scoring, such as notifications in electronic health systems for "mild" or "high" scores. This approach ensures clarity and precision in addressing maternal health risks, improving both response times and

outcomes. Refer to Appendix 5.3

Cases which are at risk for deterioration during 2023 & 2024:

- GDM.
- Non-insulin-dependent diabetes mellitus (NIDDM)
- PIH.
- Multigravida.
- Age group above 40 years old. IUFD.
- Post LSCS complications. Hyronephrosis, Sepsis
- H/O heart disease.
- Malignancy.
- Menstrual disorders.
- Complications related to twin pregnancy. Multiple uterine fibroids.
- Massive postpartum hemorrhage. PPH
- Factor VII deficiency
- Post hysterectomy

Results & Discussion

Healthcare Providers Adherence and Perceptions

In 2024, a total of 55 deteriorated cases were attended by the Maternal Emergency Response Team (MERT), compared to 39 cases in 2023. Notably, the number of cases not informed to MERT dropped significantly from 43 in 2023 to 18 in 2024, indicating improved adherence to MERT activation protocols by nursing staff (Table 1).

Table No.1: MERT calling Adherence

	MERT Informed & Seen	MERT Informed & not Seen	MERT not informed
2023	39	2	43
2024	55	0	18

Effectiveness of Early Detection

The Early Warning System continued to demonstrate high effectiveness. In 2023, 99% of detected deteriorating cases were managed in the ward without ICU transfer, and in 2024, this figure remained high at 98%. Furthermore, an increase in the detection of SIRS and preeclampsia cases from 48 in 2023 to 56 in 2024 suggests enhanced staff confidence and consistent use of the detection protocol (Table 2).

Table 2. Effectiveness of the Early Warning System in Detecting Maternal Deterioration

	Total detected cases of deterioration (low, medium, high)	SIRS Pre-eclampsia	Total cases managed in the ward
2023	992	48	1001
2024	890	56	881

Impact on Clinical Response Times and Maternal Outcomes

The median time from detection to intervention remained at 4 minutes, while 90% of cases were detected and escalated immediately (within 0 minutes), enabling prompt response and early intervention. Although ICU admissions increased slightly from 1 to 2 cases, maternal mortality improved, decreasing from 0.06% in 2023 to 0% in 2024 (Table 3).

Table 3. Impact of the System on Clinical Response Times and Maternal Outcomes

Outcome measure / Year	Collected chart	Median time to response (in minutes)	ICU admission	Mortality
2023	14017	4	1	3 (0.65%)
2024	12956	0	2	0 (0%)

Impact of the Khoula Saving Mother Score (K-SMS) on the Length of Stay (LOS) for maternity patients

A major reduction in the total length of stay in the Obstetric Ward highlights the strong positive impact of the Khoula Saving Mother Score (K-SMS) on early detection, timely intervention, and faster maternal recovery. Conversely, a significant increase in the Gynecology Ward's length of stay was observed, which may be attributed to more complex or referred gynecological cases after 2023. This trend is likely unrelated to K-SMS, as the system primarily targets obstetric patients rather than gynecological admissions.

Table 4. Impact of the Khoula Saving Mother Score (K-SMS) on the Length of Stay (LOS).

Ward	LOS 2023	LOS 2024	Change	% Change
Obstetric Ward	10,120	4,435	−5,685	−56.2%
Gynecology Ward	3,951	9,431	+5,480	+138.7%

Effectiveness of KSMS on promoting early detection & management

K-SMS data across both wards shows an overall improvement in maternal risk detection and management in 2024. In the Obstetric Ward, medium-risk activations increased while high-risk cases declined by 37.5%, indicating earlier recognition and timely response to maternal deterioration. Conversely, the Gynecology Ward recorded fewer medium-risk alerts and a minor increase in high-risk cases, likely reflecting changes in patient complexity rather than K-SMS performance. Overall, the findings demonstrate the tool's effectiveness in enhancing early warning and reducing severe maternal outcomes within obstetric care.

Table 5. Effectiveness of KSMS on promoting early detection & management

Year	Wards	%Medium Risk	%High Risk
2023	Obstetric	87.7%	12.3%
	Gynecology	100%	0%
2024	Obstetric	93.5%	6.5%
	Gynecology	85.7%	14.3%

Discussion

The study demonstrates a notable improvement in healthcare providers' adherence to the maternal early warning system protocol and highlights the system's effectiveness in early detection and response to maternal deterioration. The comparison between 2023 and 2024 reveals positive trends in staff behavior, detection accuracy, and clinical outcomes.

Improvement in Adherence to Protocol

The reduction in cases not reported to the Maternal Emergency Response Team (MERT) from 43 in 2023 to 18 in 2024 reflects a significant enhancement in staff compliance. The total number of cases attended by MERT also increased from 39 to 55, with no cases reported as "informed but not seen" in 2024. These improvements suggest that nursing staff are more vigilant and responsive in activating the MERT, indicating growing trust and familiarity with the protocol. This aligns with literature emphasizing the importance of rapid response systems in reducing maternal morbidity when staff adherence is high.

Effectiveness of Early Detection

The Early Warning System (EWS) continued to be effective in detecting maternal deterioration. While the total number of detected cases slightly decreased from 992 to 890, the number of specific critical conditions such

as SIRS and preeclampsia increased from 48 to 56. This could indicate a more accurate and confident use of the tool, rather than over-alerting for less critical parameters. Importantly, the vast majority of these cases 99% in 2023 and 98% in 2024 were managed at the ward level, reducing the burden on intensive care units and reflecting timely and appropriate interventions.

Response Time and Escalation

A key outcome of this system is the reduction in the time between detection and intervention. The median time to intervention remained at 4 minutes, with 90% of cases escalated within 0 minutes in 2024. This demonstrates the efficiency of the response workflow and supports evidence that rapid escalation leads to better outcomes. The increased readiness of staff and improved communication channels likely contributed to this swift action.

Clinical Outcomes
ICU Admissions and Mortality

Although ICU admissions increased slightly (from 1 to 2), maternal mortality dropped from 0.06% to 0%. This finding is particularly encouraging, as it suggests that the system not only supports early detection but also enables life-saving interventions before deterioration becomes irreversible. The increase in ICU admission might be attributed to better identification of high-risk patients needing intensive care, reflecting more accurate triage decisions rather than failure of ward management.

Conclusion
Interpretation and Implications

Collectively, the data indicate that the implementation and maturation of the maternal early warning system have had a tangible impact on clinical practice. The improvements in MERT activation, confidence in detecting critical conditions, and decreased mortality underscore the value of continuous staff training, auditing, and feedback loops. Furthermore, the findings support scaling up this approach and integrating it into maternal safety bundles and national guidelines. 3 The Potential Impact of K- SMS implementation.

K- SMS ensured using a standardized vital sign thresholds and clinical triggers to identify women at risk of conditions like sepsis, preeclampsia, or postpartum hemorrhage. This early detection can lead to timely interventions, reducing morbidity and mortality. Moreover, by flagging abnormalities early, K- SMS can decrease the progression to severe outcomes, like organ failure and ICU admission. This aligns with global efforts to meet maternal health targets, such as those in the Sustainable Development Goals. K- SMS provides a structured framework that standardizes communication among healthcare teams. It often includes escalation protocols, ensuring that nurses, midwives, and physicians respond promptly and consistently. Finally, while initial implementation requires investment (e.g., staff training, system integration), preventing severe complications can reduce hospital costs associated with prolonged stays, ICU admissions, or litigation.

Strength of the study

The Khoula Saving Mother Score (KSMS) study has several key strengths that underscore its potential impact on maternal health care:

a) K-SMS introduces a novel and structured tool specifically tailored to the early detection of maternal complications, filling a critical gap in maternal health care.

b) The study prioritizes maternal care and safety by providing an evidence-based framework for escalation of care, potentially reducing preventable maternal morbidity and mortality.

c) The development and validation of the K-SMS involved a multidisciplinary team of obstetricians, midwives, and other healthcare professionals, ensuring that the score is both clinically relevant and practical for diverse healthcare setting.

d) The K-SMS is designed to be simple, user-friendly, and practical, making it accessible for use by healthcare providers across different levels of expertise, especially in resource-limited setting.

e) By emphasizing early warning signs and timely intervention, the K-SMS shifts maternal healthcare from a reactive to a proactive model, improving outcomes through early detection and management.

f) The score was developed based on rigorous clinical data and validated against established benchmarks, ensuring its reliability and relevance to clinical practice.

g) The framework has the potential to be scaled and adapted to suit different healthcare systems and regions, making it a valuable tool for global maternal health improvement.

h) The implementation of K-SMS not only benefits maternal outcomes but also enhances the training and awareness of healthcare providers regarding the importance of timely recognition and escalation of maternal complications.

These strengths demonstrate the potential of the KSMS to improve maternal care and outcomes while providing a strong foundation for future research and broader implementation.

Limitation of the study

While the Khoula Saving Mother Score (K-SMS) demonstrates significant potential in improving maternal care through early detection and timely intervention, the study can include some limitations like:

- The sample size and diversity of participants included in the study may not fully represent all possible maternal conditions or complications. This could limit the robustness of the score in detecting rare or less common maternal health issues.
- The study assumes consistent adherence to the K-SMS protocol by healthcare providers. However, real-world challenges such as resource limitations, staffing issues, or varying levels of training and awareness may impact its practical effectiveness.
- While the K-SMS is designed to be objective, some components may still rely on subjective clinical judgment, which could lead to variability in scoring between different practitioners.
- As with any early warning system, there is a possibility of false positives leading to unnecessary interventions, which could increase the burden on healthcare resources and cause undue stress for patients.
- Implementing the early warning system using handwritten paper charts has several barriers and disadvantages, including:

- Human errors & documentation issue
- Incomplete or missing data: nurses or midwives might forget to document vital signs or symptoms.
- Calculation errors: manual calculation of scores can lead to mistakes in risk assessment.
- Delayed detection & response
- Time-consuming: filling out paper charts takes time, delaying recognition of deterioration.
- Lack of automated alerts: unlike electronic systems, paper charts do not trigger alarms for abnormal values.
- Storage & accessibility issues
- Prone to loss or damage: paper records can be misplaced, lost, or damaged by spills, fire, or wear.
- Compliance & adherence challenges
- Inconsistent use: staff may forget or skip steps in documentation, leading to variability in adherence.
- Resistance to change: some healthcare providers may prefer old documentation methods and resist using the new system.
- Data analysis & quality improvement limitations
- Difficult to analyze trends: unlike digital records, paper charts make it hard to track patient deterioration over time.
- No real-time data sharing: data cannot be instantly shared with senior staff or specialists for decision-making.

- Paper consumption: continuous use of paper is not environmentally sustainable.
- Storage costs: large volumes of paper records require physical storage space and maintenance.

Implications of the study

The findings of the Khoula Saving Mother Score (K-SMS) study have several important implications for maternal healthcare, both in clinical practice and broader healthcare policy

- The K-SMS provides a structured and evidence-based tool to identify early warning signs of maternal complications, enabling timely intervention and reducing preventable maternal morbidity and mortality.
- The adoption of the K-SMS promotes a standardized approach to monitoring maternal health, reducing variability in clinical practice and improving consistency in patient care.
- By offering a clear and easy-to-use scoring system, the K-SMS empowers healthcare providers at all levels, particularly in resource-limited settings, to make informed decisions about escalation of care.
- The implementation of the K-SMS has the potential to enhance the skills and awareness of healthcare providers through training on early recognition of maternal complications, contributing to a more competent and prepared workforce.
- The K-SMS supports a proactive approach to maternal care, which can improve resource allocation and reduce the burden on tertiary care facilities by addressing complications earlier at primary and secondary care levels.
- The K-SMS fosters a culture of safety by prioritizing early recognition and escalation of care, which can improve patient outcomes and enhance trust in healthcare systems.
- The study lays the groundwork for future investigations into maternal health by identifying gaps in existing care pathways and providing a model for testing other early warning systems or interventions.
- The K-SMS can inform healthcare policies by demonstrating the effectiveness of structured monitoring tools in improving maternal health outcomes, encouraging the integration of such tools into national and regional maternal care guidelines.
- By reducing severe maternal complications through early detection, the K-SMS may contribute to more efficient use of healthcare resources, potentially lowering costs associated with emergency interventions and prolonged hospital stays.

These implications highlight the broad potential of the K-SMS to transform maternal care practices, enhance provider capabilities, and contribute to global efforts to improve maternal health outcomes.

Recommendations

- Incorporate the K SMS into Al Shifa health record systems to enable automated scoring, alerts, and seamless documentation.
- Provide comprehensive training for healthcare professionals on the use of the K SMS Observation Chart, emphasizing scoring criteria, interpretation, and escalation protocols.
- Develop and disseminate clear guidelines on actions to be taken at various score thresholds to ensure uniform responses across healthcare settings.
- Regularly validate the scoring system using updated clinical data to ensure it remains sensitive and specific in detecting maternal risks.
- Establish a framework to monitor key maternal health indicators (e.g., morbidity, mortality, and time to intervention) post-implementation.
- Collect feedback from end-users (nurses, midwives, obstetricians) to refine the chart and scoring methodology.
- Conduct studies comparing K SMS with other maternal risk assessment tools to highlight its unique advantages.
- Evaluate the economic impact of implementing K SMS, including cost savings from reduced complications.
- Advocate for the inclusion of K SMS in national maternal healthcare protocols.
- Collaborate with healthcare policymakers, professional associations, and patient advocacy groups to promote awareness and adoption.
- Raise awareness among pregnant women and their families about the importance of early warning systems in maternal care.
- Enable patients and families to report experiences with K SMS, contributing to quality improvement efforts.
- Conduct periodic audits to assess compliance, accuracy, and effectiveness of K SMS implementation
- Invest in ongoing training and infrastructure to support the long-term sustainability of K SMS.
- Roll out K SMS in select healthcare settings to evaluate feasibility before nationwide implementation.
- Explore opportunities to adapt and implement K SMS in low- and middle-income countries facing high maternal mortality rates.

By following these recommendations, the K SMS Observation Chart can be optimized and scaled to improve maternal health outcomes effectively, contributing to reduced morbidity and mortality in mother [41,67].

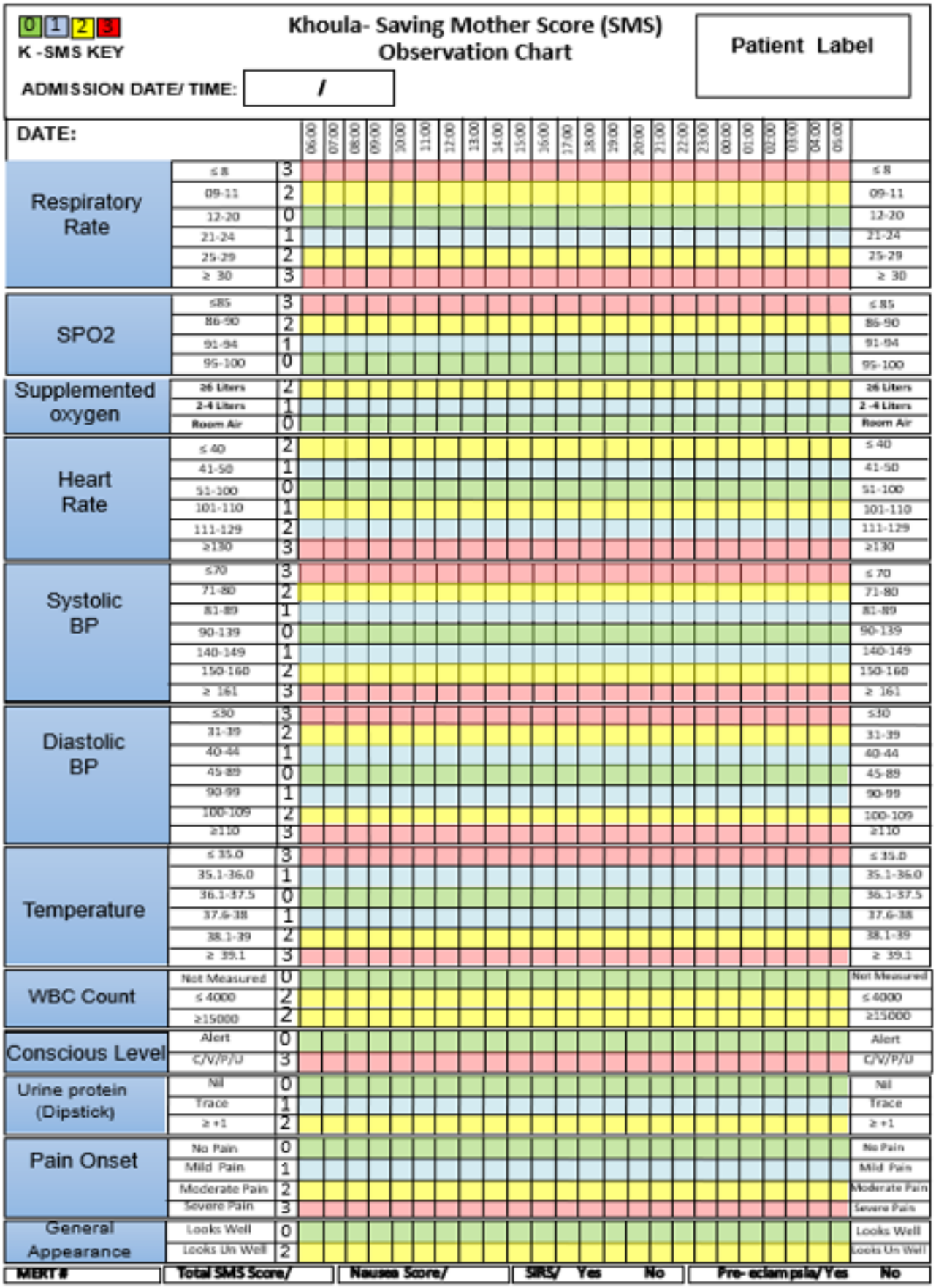
Conclusion

The introduction of the K-SMS at DGKH represents a proactive step toward enhancing maternal care by facilitating the early detection of clinical deterioration. By adopting a structured approach to monitoring and response, DGKH aims to improve maternal health outcomes and align with best practices in obstetric care.

The literature consistently underscores the importance of early detection tools like MEWS in improving maternal health outcomes. Studies indicate that tailored MEWS systems, especially those adapted to local settings, can lead to substantial reductions in maternal morbidity and mortality. The introduction of the K-SMS within DGKH has the potential to address specific challenges and improve the effectiveness of early warning systems in the context of this population. By contributing to timely interventions, the K-SMS could play a pivotal role in enhancing maternal care quality and reducing preventable maternal complications.

Appendices

Khoula Saving Mother Score Observation Chart



Khoula Saving Mother Score Key

Khoula Saving Mother Scores (Khoula SMS) Key								
Score	3	2	1	0	1	2	3	Normal K-SMS Score
Respiratory Rate (bpm)	≤ 8	9-11		12-20	21-24	25-29	≥ 30	
SPO2 (%)	≤ 85	86-90	91-94	95-100 (COPD) 88-92%				Low Risk K-SMS Score
Supplemented O2		≥ 6 liters	2-4 liters	Air				
Heart Rate (bpm)		≤ 40	41-50	51-100	101-110	111-129	≥ 130	Mild Risk K-SMS Score
Systolic BP (mmHg)	≤ 70	71-80	81-89	90-139	140-149	150-160	≥ 161	
Diastolic BP (mmHg)	≤ 30	31-39	40-44	45-89	90-99	100-109	≥110	High Risk K-SMS Score
Temperature (^{0}C)	≤ 35.0		35.1-36	36.1-37.5	37.6-38	38.1-39	≥39.1	Maternal SIRS
WBC		≤ 5000		Not measured		≥13000		
Conscious Level	C/V/P/U			Alert				Pre- Eclampsia
General appearance		Looks unwell		Looks well				
Urine Protein (dipstick)				Nil	Trace	≥+1		
Sudden Onset Pain				No Pain	Mild Pain	Moderate Pain	Severe Pain	

COPD = Chronic Obstructive Pulmonary Disease.
CVPU = C: Confusion/ agitation, V: response to verbal stimuli only, P: response to painful stimuli only & U: unconscious.
Single score trigger: Score of 3 in any single parameter is considered as high risk.

Consider the patient as maternal SIRS if a combination of alternations in the following variables is met: HR, RR, Temp, WBC count, hypotension, desaturation and looks unwell.

Consider the patient Pre- eclampsia, if a combination of alternations in the following variables is met: SBP ≥140, DBP ≥ 90 and urine dipstick of protein reading as ≥+1. In addition, the following features must be assessed to consider increase risk of impending eclampsia like headache, blurred vision, epigastric pain and edema.

Special considerations/ variables to be measured and recorded as per indicated/ advised:
Antenatal patients: blood loss and FHR (≥160).
Labor in progress patients: blood loss, FHR (≥160), perineum and uterine contractility.
Postnatal patients: Lochia.
Other considerations, like RBS, serum lactate and nausea scores:
No nausea= 0, slight nausea= 1, moderate nausea= 2, retching/ vomiting= 3.

Khoula SMS Escalation Protocol

Total score	Observation Frequency	Clinical Response
0	8th Hourly (06:00,14:00,22:00)Hrs	The nurse has to do continuous routine Khoula SMS monitoring with every set of observations.
1-3	4th Hourly	The Nurse has to: ✓ Re- assess "Khoula- SMS" score. ✓ Inform the **Shift in-charge nurse** for appropriate management. ✓ Continue re- assessment, if score remains under low risk, then inform MERT nurse and 1st on call if any medical concern needed.
4-6	Hourly until the score is < 3	The Nurse has to: ✓ Inform MERT nurse using the iSBAR communication tool. ✓ Inform the 1st On-Call of admitting specialty. ✓ Continue close monitoring. ✓ Consider monitoring of other special maternal parameters as per indicated, like RBS, Urinalysis, FHR, blood amount, Intake & Output, pain and nausea score, etc.
≥7 **Score 3 in one parameter**	Continuous monitoring	The Nurse has to: ✓ Inform MERT nurse using the iSBAR communication tool. ✓ Inform the 1st On-Call of admitting specialty. ✓ Emergency assessment by the 2nd On-Call of admitting specialty and Intensivist /anesthetist. ✓ Consider the transfer of the patient to a higher level of care (HD or ICU).
Maternal SIRS	Continue Same Khoula - SMS Score Observation Frequency	✓ Consider monitoring of Other SIRS variables (RR, HR, Temperature, WBC, hypotension and mental status). ✓ Consider presence of tubes/ catheters. ✓ Monitoring intake & output. ✓ If two criteria or more is met, patient triggers Sepsis, inform your in charge and immediately within hour discuss with your doctor about: 1. Measuring lactate level, LFT, Creatinine 2. Obtaining blood cultures before administering antibiotics, 3. Administer broad-spectrum antibiotics as per order, 4. Administration of IVF and crystalloids as per order. 5. Consider ICU transfer if sever sepsis/ septic shock.
Pre-Eclampsia	Continue Same Khoula - SMS Score Observation Frequency	✓ Consider monitoring and assessment of pre- Eclampsia variables (SBP, DBP, blurred vision, headache, epigastric pain, proteinuria and urine output). ✓ Assess fetal heart. ✓ Neurological assessment. ✓ Administration of antihypertensives, as per protocol. ✓ Magnesium as per protocol. ✓ Trandate as per protocol. ✓ Observe for seizure.

I.S.B.A.R

Verbal Communication Tool

Contact Medwives

Identify

►Identify yourself: name, position, location and who you are talking to.
►Identify your patient.

Situation

►State the reason your are calling for
►The reason I am calling is.....
If urgent, say so.

Background

►State the admission diagnosis and date of admission.
►Relevant medical history.
►A brief summary of treatment to date

Assessment

►State your assessment of patient e.g. vital signs (BP, resps, pulse, temp, sats), KEWS score, diagnosis mental state, pain, medications (epidural, PCA, anticoagulants).

Recommendation

►State request: what you want from them.
►Explain what you think needs to be done?
►Record name and number of contact

Don't Forget to Document the Call

Remember:

- ✓ Assess the patient
- ✓ Know the admitting diagnosis
- ✓ Read the most recent progress notes and assessment from the prior shifts
- ✓ Have appropriate documents available e.g. Nursing and Medical Records, KEWS score, allergies, IV fluids, resuscitation status.
- ✓ **Verify the recommendations and Document .**

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