Appendix A Supplementary Tables

Table A-1: Summary of Open Science indicators for all studies

Study	Article open access	Data sharing agreement	Data open source	Methods reproducible	Protocol referenced	Registration number listed	Reporting guidelines mentioned
Development studies including development and validation studies							
Irish MEWS, 2014	Yes	NA	NA	Yes partially	No	No	No
Scottish MEWS, 2021	Yes	NA	NA	No	No	No	No
Escobar, 2020	No	No	No	Yes partially	No	No	No
Gorthi, 2009	No	No	No	No	No	No	No
Hannola, 2021	Yes	No	No	Yes partially	No	No	No
Ibanez Lorente, 2021	No	Yes	Yes	Yes completely	No	No	Yes
Mhyre, 2014	No	NA	NA	Yes partially	No	No	No
Raza, 2022	Yes	Yes	Yes	No	No	No	No
Ryan, 2017	Yes	No	No	Yes partially	No	No	Yes
Shields, 2016	No	No	No	Yes partially	No	No	No
External validation only studies							
Arnolds, 2022	Yes	Yes	No	Yes partially	No	No	No
Arnolds, 2019	No	No	No	Yes partially	No	No	No
Blumenthal, 2019	No	No	No	Yes partially	No	No	No
Blumenthal, 2021	No	No	No	Yes partially	No	No	No
Hedriana, 2016	No	No	No	Yes partially	No	No	No
Kern-Goldberger, 2022	No	No	No	Yes completely	No	No	No
Rathore, 2018	No	No	No	Yes partially	No	No	No
Singh, 2016	No	No	No	Yes partially	No	No	No
Singh, 2012	Yes	No	No	No	No	No	No
Valent, 2017	No	No	No	Yes completely	No	No	No

Table A-2: Summary of predictors and which studies included them in their developed scores or models

Predictor	n	Irish MEWS	Scottish MEWS	MEWC, Mhyre	Modified MEWC, Ibanez-Lorente	MEWT, Shields, 2016	Modified CEMACH MOEWS Hannola, 2021	Escobar, 2020	Gorthi, 2009	Raza, 2022	Ryan, 2017
SBP	10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DBP	8	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Heart Rate	8	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Temperature	7	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes
Respiratory Rate	7	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Oxygen saturation	6	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Urine Output	4	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Maternal Age	3	No	No	No	No	No	No	Yes	Yes	Yes	No
Neuro Response	2	Yes	Yes	No	No	No	No	No	No	No	No
Pain	2	Yes	No	No	No	No	Yes	No	No	No	No
Amniotic Fluid	2	No	No	No	No	No	No	No	Yes	No	No
Gestational Age	2	No	No	No	No	No	No	Yes	Yes	No	No
Looks Unwell	1	No	Yes	No	No	No	No	No	No	No	No
Accelerations	1	No	No	No	No	No	No	No	Yes	No	No
Admission Severity Score	1	No	No	No	No	No	No	Yes	No	No	No
Albuminuria	1	No	No	No	No	No	No	No	Yes	No	No
Basal Fetal Rate	1	No	No	No	No	No	No	No	Yes	No	No
Blood Glucose Level	1	No	No	No	No	No	No	No	No	Yes	No
Bmi Within 30 Days Of Admission	1	No	No	No	No	No	No	Yes	No	No	No
Cervical Dilation (Cm)	1	No	No	No	No	No	No	Yes	No	No	No

Comorbidity Score At Admission	1	No	No	No	No	No	No	Yes	No	No	No
Decelerations	1	No	No	No	No	No	No	No	Yes	No	No
Delivered (Y/N)	1	No	No	No	No	No	No	Yes	No	No	No
Diabetes Mellitus Indicator	1	No	No	No	No	No	No	Yes	No	No	No
Fever (Time With Temp >= 100.4 Farrenheightin H)	1	No	No	No	No	No	No	Yes	No	No	No
Fetal Movement	1	No	No	No	No	No	No	No	Yes	No	No
Gestational Diabetes	1	No	No	No	No	No	No	Yes	No	No	No
Gravidity	1	No	No	No	No	No	No	No	Yes	No	No
Growth Of Fetus	1	No	No	No	No	No	No	No	Yes	No	No
Heart Rate	1	No	No	No	No	Yes	No	No	No	No	No
Height	1	No	No	No	No	No	No	No	Yes	No	No
Hourly Severity Score In Previous 24 Hours	1	No	No	No	No	No	No	Yes	No	No	No
Hyperglycemia	1	No	No	No	No	No	No	No	Yes	No	No
Indicator For Dilation Missingness	1	No	No	No	No	No	No	Yes	No	No	No
Indicator For Station Missingness	1	No	No	No	No	No	No	Yes	No	No	No
Lochia	1	No	No	No	No	No	No	No	No	No	No
Maximum Temperature	1	No	No	No	No	No	No	No	No	No	Yes
Metorragia	1	No	No	No	No	No	No	No	Yes	No	No
Number Of Children Including Current Pregnancy	1	No	No	No	No	No	No	Yes	No	No	No

Placental Localization	1	No	No	No	No	No	No	No	Yes	No	No
Rupture Of Membranes (Elapsed Time Since)	1	No	No	No	No	No	No	Yes	No	No	No
Seizures	1	No	No	No	No	No	No	No	Yes	No	No
Severity Score Of >= 75 (time since)	1	No	No	No	No	No	No	Yes	No	No	No
Severity Score Of >= 75 (time with)	1	No	No	No	No	No	No	Yes	No	No	No
Umbilical Doppler	1	No	No	No	No	No	No	No	Yes	No	No
Uterine Contractions	1	No	No	No	No	No	No	No	Yes	No	No
Variability	1	No	No	No	No	No	No	No	Yes	No	No
Weight	1	No	No	No	No	No	No	No	Yes	No	No
Weight Gain	1	No	No	No	No	No	No	No	Yes	No	No

Table A-3: Details of the methods used by the four studies that developed a maternal early warning score using a statistical approach.

Article	**Modelling approach**	**Variable selection approach**	**Multiple observation sets per patient and methods for handling**	**Handling of continuous predictors described**	**Full model described**	**Were risk groups created**	**Simplified model created**
Escobar, 2020	Logistic	LASSO, gradient boosting, estimation of relative contribution, and clinical judgment	Yes: analysed at individual hospital stay, static and hourly. Number of observation sets not provided.	Yes	Partially: -2.39Delivered -0.12GA + 0.04ComorbidityScore +0.02HourlySeverityScore +0.03SBP +0.02AdmissionSeverityScore +0.05SeverityScoreMoreThan75(time with) -0.005ROM + 0.03MaternalAge -0.30StationCharted +0.20DilationCharted +0.17Temperature +0.24GestationalDiabetes -0.07Dilation + 1.74ShockIndex +0.14DiabetesMellitus -0.10Parity -0.005SeverityScoreMoreThan75(time since) +0.08Fever(time with) +0.009BMI	No	No

Article	Modelling approach	Variable selection approach	Multiple observation sets per patient and methods for handling	Handling of continuous predictors described	Full model described	Were risk groups created	Simplified model created
Gorthi, 2009	Decision trees	Other - Literature survey of relevant parameters used in routine care	Unclear	No	No	No	No
Raza, 2022	Deep learning-based model	Other - All predictors available in dataset	Unclear	No	No (not applicable)	No	No
Ryan, 2017	Logistic	Stepwise	Yes: Included both highest and lowest value of vital signs. Number of observation sets not provided.	No	Partially – 1.14maximum temperature + 0.06HeartRate + 0.05SBP + 0.22RespiratoryRate	No	No
SBP Systolic Blood Pressure; BMI Body Mass Index; ROM Rupture of Membranes							

Table A-4: Sample size reported for the four papers reporting the development of a maternal early warning score using statistical methhods.

Article	**Sample size**	**Outcome**	**Number of events (Units = % or n)** [1]
Model developed using statistical methods (based on data)			
Escobar, 2020	176,731	Composite of maternal death, ICU admission, maternal morbidities (eclampsia, severe preeclampsia with elevated severity of illness, haemorrhage, emboli, major deterioration without ICU transfer, uterine rupture) and neonatal outcomes (fetal death, neonatal hypoxic ischemic encephalopathy, neonatal acidosis)	Maternal death (0.01%), Composite (1.33%), more than 2 (0.25%) Morbidites: AP haemorrhage (0.04%), AP pulmonary embolus (0.004%), AP severe preeclampsia (0.42%), AP eclampsia (0.003%), AP transfer to ICU for cause (0.01%), AP LAPS2 of more than 110 (0.01%), Intrauterine fetal demise (0.02%), neonatal acidosis (0.32%), Hypoxic ischemic encephalopathy (0.12%), Uterine Rupture (0.09%), PP haemorrhage (0.31%), PP pulmonary embolus (0.009%), PP severe preeclampsia (0.03%), PP eclampsia (0.002%), PP transfer to ICU for cause (0.20%), PP LAPS2 of more than 120 (0.10%), PP death (0.01%), Aggregated severe preeclampsia (0.46%), fetal or neonatal (0.38%),

Article	Sample size	Outcome	Number of events (Units = % or n) [1]
Gorthi, 2009	Not reported	Categories of risk complication	Not reported
Raza, 2022	1,218	Categories of risk complication	Not reported
Ryan, 2017	184	Admission to ICU for >24 hours during in-hospital stay	ICU admission (N=46)
Developed using clinical consensus			
Hannola, 2021	NA	Composite of maternal morbidity (preeclampsia, infection including sepsis or PP haemorrhage)	NA
Shields, 2016	NA	Composite of maternal morbidity (infection/sepsis, pulmonary, severe pre-eclampsia-hypertension and severe haemorrhage)	NA
Mhyre, 2014	NA	Maternal deterioration	
Ibáñez -Lorente , 2021	NA	Composite of ICU admission, surgery within two hours of delivery and length of stay more than seven days	NA

[1]Number of events at observation level were not presented by any study

AP Antepartum, PP Postpartum

Table A-5: Predictor variables considered as candidates and included in the final model, reported for the papers reporting the development of a maternal early warning score

Article	Number of candidate predictors	Number of predictors in final model	Predictors in final model
Model developed using statistical methods (based on data)			
Escobar, 2020	NA	35	Delivered (y/n), Gestational age (week), Comorbidity score at admission, Hourly severity score in previous 24 hours, SBP (lowest within the hour), Admission severity score, Severity score of >= 75, Rupture of Membranes (elapsed time since), Maternal age (years at admission), indicator for station missingness, indicator for dilation missingness, Temperature (highest within the hour), Gestational Diabetes, Cervical dilation (cm), Shock Index (highest heart rate/lowest SBP), Diabetes mellitus indicator, Number of children including current pregnancy, Severity score of >=75, Fever (time with temp >= 100.4 Fahrenheit), BMI within 30 days of admission
Gorthi, 2009	31	22	Maternal Age, Gravidity, Gestational Age, Height, Weight, Weight gain, Blood Pressure, Metorragia, Uterine Contractions, Amniotic Fluid Loss, Seizures, Albuminuria, Hyperglycemia, Basal fetal heart rate, Variability, Accelerations, Decelerations, Fetal Movement, Placental Localization, Growth of Fetus, Umbilical Doppler
Raza, 2022	6	6	Maternal age, SBP, DBP, Blood glucose level, Temperature, Heart Rate
Ryan, 2017	8	4	Maximum temperature, heart rate, SBP, respiratory rate

Article	Number of candidate predictors	Number of predictors in final model	Predictors in final model
Developed using clinical consensus			
Hannola, 2021	Not reported	NA	SBP, DBP, heart rate, respiratory rate, oxygen saturation, temperature, pain score
Shields, 2016	Not reported	NA	SBP, DBP, heart rate, respiratory rate, oxygen saturation, temperature, altered mental status, mean arterial pressure, disproportionate pain, fetal heart rate
Mhyre, 2014	Not reported	NA	SBP, DBP, heart rate, respiratory rate, oxygen saturation, urine output, maternal agitation, confusion or unresponsiveness and patient with preeclampsia reporting a non-remitting headache or shortness of breath
Ibáñez - Lorente , 2021	Not reported	NA	SBP, DBP, heart rate, respiratory rate, oxygen saturation, urine output, uterine involution measurement, bleeding greater than 500ml
SBP Systolic blood pressure, DBP diastolic blood pressure, BMI Body Mass Index			

Table A-6: Summary of the approach to missing data for the four studies that developed a MOEWS using data

Article	**Missing data during development discussed**	**Amount of missing data presented**	**Missing data assumption**	**Handling of missing data**	**Effect of missing data at implementation discussed**
Escobar, 2020	Reported	Missing data reported by outcome status for predictors	Unclear	LOCF, imputed to normal, missing indicators, and trajectories	Not discussed
Gorthi, 2009	Not reported	Not reported	Not reported	Not reported	Not discussed
Raza, 2022	Not reported	Not reported	Not reported	Not reported	Not discussed
Ryan, 2017	Reported	Missing data reported by outcome status for predictors.	MAR	Complete cases	Not discussed
MAR Missing at Random, LOCF Last observation carried forward					

Table A-7: Assessment of apparent performance in the four studies developing a maternal early warning score using a data-driven approach

Study	**Apparent performance assessed**	**Discrimination**	**Calibration**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Escobar, 2020	No	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Gorthi, 2009	No	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Raza, 2022	No	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Ryan, 2017	Yes	Not reported	Not reported	Reported	Reported	Not reported	Reported
PPV Positive Performance Value NPV Negative Performance Value							

Table A-8: Reporting of the internal validation by the studies that developed a MOEWS on data

Study	IV assessed	IV method	Discrimination	Calibration	Sensitivity	Specificity	PPV	NPV
Escobar, 2020	Yes	Split sample	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Gorthi, 2009	Yes	Cross-validation	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Raza, 2022	Yes	Split sample	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Ryan, 2017	No	None	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported

IV Internal validation

PPV Positive Performance Value

NPV Negative Performance Value

Table A-9: Summary of included validation studies with population and primary outcome

Study	Score(s) validated	Data source	Population	Primary outcome
Arnolds, 2019	MEWC	Retrospective cohort/dataset,	In-hospital admission for delivery after 23 weeks gestation and all observations recorded until the second stage of labour excluding the anaesthetic record. Intrapartum.	Composite of ICU admission, maternal mortality and maternal morbidity (haemorrhage, pre-eclampsia with severe features, suspected infection, pulmonary embolus, cerebral venous sinus thrombosis, intracranial bleed, acute asthma, status epilepticus, diabetic ketoacidosis, myocardial infarction, pulmonary oedema, anaesthetic complication)
Arnolds, 2022	CEMACH MOEWS, MEWC, MEWT	Retrospective cohort/dataset,	Women ≥18 years admitted to a hospital ward after transfer from labour and delivery. The cohort includes both postpartum patients as well as patients who were initially admitted to labour and delivery prior to transfer to the antepartum ward.	Composite of ICU admission and maternal mortality within 24 hours of a ward observation

Blumenthal, 2019	CEMACH MOEWS, MEWC, MEWT	Retrospective cohort/dataset, USA	In-hospital admission for delivery. Intrapartum to early post-partum	Composite of ICU admission, maternal mortality or morbidity (acute myocardial infarction, acute renal failure, adult respiratory distress syndrome, amniotic fluid embolism, aneurysm, cardiac arrest/ventricular fibrillation, disseminated intravascular coagulation, eclampsia, heart failure during procedure or surgery, internal injuries of thorax or abdomen or pelvis, intracranial injuries, puerperal cerebrovascular disorder, pulmonary oedema, severe anaesthesia complications, sepsis, shock, sickle cell anaemia with crisis, blood transfusion, cardiac monitoring, conversion of cardiac rhythm, hysterectomy, operations on heart or pericardium, temporary tracheostomy, ventilation)
Blumenthal, 2021	MEWT	Retrospective cohort/dataset, USA	In-hospital admission for delivery. Intrapartum to early post-partum.	Composite of ICU admission, prolonged postpartum length of stay, maternal morbidity (sepsis/severe sepsis, cardiopulmonary, hypertension, haemorrhage)

Escobar, 2020	Escobar, 2020	Retrospective cohort	Admitted for delivery, GA more than 22 weeks; fetal heart rate active on admission; delivery (live birth or fetal loss) occurred after admission. Antepartum and Postpartum	Composite of ICU admission, maternal mortality, maternal morbidity (eclampsia, severe preeclampsia with elevated severity of illness, haemorrhage, emboli, major deterioration without ICU transfer, uterine rupture) and neonatal outcomes (fetal death, neonatal hypoxic ischemic encephalopathy, neonatal acidosis)
Hannola, 2021	Obstetric EWS (An adapted version of CEMACH MOEWS) and the CEMACH MOEWS	Prospective cohort/dataset	Women considered to have an increased risk for morbidity after birth (BMI > 35 kg/m^2, PPH > 1500 g, pre-eclampsia, clinical judgement, chorioamnionitis during birth or type 1 diabetes). Early postpartum after transfer from labour room or caesarean section recovery room	Composite of maternal morbidity (preeclampsia, infection/sepsis, post-partum haemorrhage)
Hedriana, 2016	MEWT	Retrospective case-control study, USA.	Cases were women at term or preterm requiring obstetric triage (hypertension, vaginal	ICU admission at any point during hospital admission after transfer from a maternal ward

			bleeding, abdominal pain, ruptured membranes, fever, gastrointestinal symptoms, etc.) who were transferred to ICU from a maternal ward (antepartum, intrapartum and postpartum) Exclusion criteria was direct admission to ICU from the emergency department. Control group were women admitted to the maternity units after triage with normal delivery outcome over a 24-hour period.	
Ibáñez - Lorente , 2021	Modified MEWC	Prospective cohort/dataset	Pregnant women admitted to hospital for delivery. Early post-partum.	Composite of ICU admission, surgery within two hours of delivery and length of stay more than seven days
Kern-Goldberger, 2022	MOEWS, MEWC, MEWT	Retrospective cohort/dataset	Pregnant women at any gestational age, 18+ who were admitted for delivery.	Composite of maternal morbidity (haemorrhage, infection, acute cardiovascular disease, acute pulmonary disease)

			Intrapartum and immediate postpartum	
Rathore, 2018	ONEWS	Prospective cohort/dataset	Pregnant women or within 42 days of end of pregnancy who had any one or more of: high-risk pregnant woman admitted from obstetrics and gynaecology emergency, had undergone surgery within the last 24h, and was already admitted in obstetrics ward and became sick. Women admitted directly to the ICU were excluded.	Composite of ICU admission, maternal mortality and maternal morbidity (haemorrhage, pre-eclampsia/eclampsia, renal dysfunction, liver dysfunction, cardiac arrest, pulmonary oedema, acute respiratory dysfunction, cerebrovascular event, septicaemic shock, massive pulmonary embolism)
Ryan, 2017	CEMACH MEOWS	Retrospective case-control study, Canada,	Pregnant or recently pregnant (<6 weeks after the end of the pregnancy, irrespective of gestational age at the end of the pregnancy) admitted women who subsequently	Admission to ICU for >24 hours during in-hospital stay

			required admission to the ICU for >24 hours. Antepartum and immediate post-partum.	
Shields, 2016	Shields, MEWT, 2016	Prospective, USA	Pregnant women admitted to hospital maternity centre. Any stage of pregnancy.	Composite of maternal morbidity (infection/sepsis, pulmonary, severe pre-eclampsia-hypertension and severe haemorrhage)
Singh, 2012	CEMACH MOEWS	Retrospective cohort/dataset, England	Women between 20 weeks gestation and 6 weeks postpartum who were admitted as an inpatient to the maternity unit. Any stage of pregnancy	Composite of ICU admission maternal mortality and maternal morbidity (haemorrhage, pre-eclampsia, suspected infection, anaesthetic complication, acute asthma) occurring within 30 days of in-hospital admission
Singh, 2016	CEMACH MOEWS	Prospective cohort	Pregnant women in labour beyond 28 weeks gestation and up to 6 weeks postpartum	Composite of maternal morbidity (hypertensive disorder of pregnancy, eclampsia, obstetric haemorrhage, suspected infection, pulmonary oedema, shock, gestational diabetes, diabetic ketoacidosis, intracranial bleed, acute asthma, status epilepticus, neonatal outcomes)

Valent, 2017	CEMACH MOEWS	Retrospective cohort/dataset,	Pregnant women admitted to hospital and diagnosed with acute pyelonephritis during antepartum period	Composite of ICU admission or maternal morbidity (pulmonary injury, blood transfusion, sepsis)

Table A-10: Summary of sample size of validation studies

Article	Sample size	Outcome (events, Units = % or n)	Number of events presented at observation level
Escobar, 2020	41657	Total (N= 638, 1.53%), Antepartum hemorrhage (0.04), AP pulmonary embolus (0.01), Antepartum severe preeclampsia (0.29), Antepartum eclampsia (0.005), Antepartum transfer to ICU for cause (0.01), Antepartums LAPS2 of more than 110 (0.04), Intrauterine fetal demise (0.06), neonatal acidosis (0.43), Hypoxic ischemic encephalopathy (0.16), Uterine Rupture (0.12), PP haemorrhage (0.35), PP pulmonary embolus (0.005), PP severe preeclampsia (0.02), PP eclampsia <0.001, PP transfer to ICU for cause (0.30), PP LAPS2 of more than 120 (0.16), PP death (0.01), Aggregated severe preeclampsia (0.31), fetal or neonatal (0.53), maternal (1.04), Composite (1.53), more than 2 (0.35)	No
Hannola, 2021	828	Pre-eclampsia (n=65), PPH (n=112), Infection (n=33)	No
Ryan, 2017	184	46 ICU admissions	No
Shields, 2016	12611	ICU admission (n=47) and/or composite of maternal morbidity (n=1); sepsis (n=1.3/1000); cardiovascular dysfunction (not reported), severe preeclampsia-hypertension (not reported), and severe haemorrhage (n=0.03))	No
Arnolds, 2022	19611	43 ICU admissions or deaths, 3 deaths	No

Article	Sample size	Outcome (events, Units = % or n)	Number of events presented at observation level
Arnolds, 2019	400	99/400 (25%) total. Obstetric hemorrhage (48, 12%), preeclampsia with severe features (23, 6%), suspected infection (37, 9%), pulmonary embolus (5, 1%), cerebral venous sinus thrombosis (0), intracranial bleed (0), acute asthma (0), status epilepticus (0), diabetic ketoacidosis (1 <1%), myocardial infarction (0), pulmonary edema (5, 1%), anesthetic complication (1, <1%), any ICU admission (2 ,<1%), maternal mortality (1 <1%)	No
Blumenthal, 2021	204	Composite of ICU admission, maternal morbidity in-hospital (2.06/100 deliveries)	No
Blumenthal, 2019	202	Blood transfusion (62, 78.5), Pulmonary edema (12, 15.2), Hysterectomy (11, 3.9), Adult respiratory distress syndroms (8, 10.1), Disseminated intravascular coagulation (7, 8.9%), Acute renal failure (7, 8.9%), Eclampsia (5, 6.3%), Sepsis (4, 5.1%), Internal injuries of the thorax, abdomen, pelvis (4, 5.1), Cardiac monitoring (3, 3.8%), Shock (1, 1.3%), Myocardial infarction (1, 1.3%), Cardiac arrest (1, 1.3%), Obstetric haemorrhage (21, 26.6%), Prolonged postpartum length of stay (12, 15.2%), preeclampsia (10, 12.7%), ICU admission (9, 11.4%), Maternal mortality (1, 1.3%)	No
Hedriana, 2016	54429*	ICU admission (n=262)	No

Article	Sample size	Outcome (events, Units = % or n)	Number of events presented at observation level
Ibanez Lorente, 2021	1166	ICU Admission (n=18, 1.5%), surgery (n=15, 1.3%), Length of stay >7 days (n=13, 1.1%)	No
Kern-Goldberger, 2022	14597	2451 at least one morbidity event (16.8%), 980 haemorrhage (6.7%), 1337 infection (9.2%), 362 Acute Cardiovascular Disease (2.5%), 275 Acute Pulmonary Disease (1.9%)	No
Rathore, 2018	500	CAMO (n=159), haemorrhage (n=29), pre-eclampsia/eclampsia (n=96), renal dysfunction (n=13), liver dysfunction (n=14), cardiac arrest (n=7), pulmonary oedema (n=6), acute respiratory dysfunction (n=5), cerebrovascular event (n=1), septicaemic shock (n=2), massive pulmonary embolism (n=3), ICU admission and maternal death in-hospital	No
Singh, 2016	1065	Hypertensive disorder of pregnancy (69%), eclampsia, obstetric haemorrhage, suspected infection, pulmonary oedema, shock, gestational diabetes, diabetic ketoacidosis, intracranial bleed, acute asthma, status epilepticus, neonatal outcomes	No
Singh, 2012	676	Obstetric haemorrhage (43%), Pre-eclampsia (31%), Suspected Infection (20%), Anaesthetic complication (4%), Acute asthma (2%)	No
Valent, 2017	123*	Pulmonary injury (2), ICU admission, blood transfusion (7), or sepsis (8)	No

Table A-11: Summary of missing data in validation studies

Study	Missing data referred to	Proportion missing	Assumption	Approach
Arnolds, 2019	No	Not reported	Not reported	Not reported
Arnolds, 2022	No	Not reported	Not reported	Not reported
Blumenthal, 2019	No	Not reported	Not reported	Not reported
Blumenthal, 2021	No	Not reported	Not reported	Not reported
Escobar, 2020	Yes	Not reported	Unclear	LOCF, imputed to normal, missing indicators, and trajectories
Hannola, 2021	No	Not reported	Not reported	Not reported
Hedriana, 2016	No	Not reported	Not reported	Not reported
Ibanez Lorente, 2021	No	Not reported	Not reported	Not reported
Kern-Goldberger, 2022	No	Not reported	Not reported	Not reported
Rathore, 2018	No	Not reported	Not reported	Not reported
Ryan, 2017	Yes	Missing data reported by outcome status for predictors.	Other: When MEOWS variables were missing, it was assumed that these observations were not recorded because they were	Use of complete cases

Study	Missing data referred to	Proportion missing	Assumption	Approach
			not perceived to be abnormal and they would not have fallen into the 'red' or 'amber' trigger categories.	
Shields, 2016	No	Not reported	Not reported	Not reported
Singh, 2012	Yes	Number of completed charts reported	Unclear	Filled in missing by reviewing all notes available
Singh, 2016	No	Not reported	Not reported	Not reported
Valent, 2017	No	Not reported	Not reported	Not reported

Table A-12: Reporting of the performance metrics of the validation studies

Study	Discrimination	Calibration	Sensitivity	Specificity	NPV	PPV
Arnolds, 2019	No	No	Assessed	Assessed	Assessed	Assessed
Arnolds, 2022	Yes	No	Assessed	Assessed	Assessed	Assessed
Blumenthal, 2019	No	No	Assessed	Assessed	Not assessed	Not assessed
Blumenthal, 2021	No	No	Assessed	Assessed	Not assessed	Not assessed
Escobar, 2020	Yes	Yes	Assessed	Assessed	Not assessed	Assessed
Hannola, 2021	No	No	Assessed	Assessed	Assessed	Assessed
Hedriana, 2016	No	No	Assessed	Assessed	Assessed	Assessed
Ibanez Lorente, 2021	No	No	Assessed	Assessed	Assessed	Assessed
Kern-Goldberger, 2022	No	No	Not assessed	Assessed	Assessed	Assessed
Rathore, 2018	Yes	No	Assessed	Assessed	Assessed	Assessed
Ryan, 2017	No	No	Assessed	Assessed	Assessed	Assessed
Shields, 2016	No	No	Assessed	Assessed	Assessed	Assessed
Singh, 2012	No	No	Assessed	Assessed	Assessed	Assessed
Singh, 2016	No	No	Assessed	Assessed	Not assessed	Not assessed
Valent, 2017	Yes	No	Assessed	Assessed	Assessed	Assessed

Appendix B Search Strategies

The search strategy for each database (developed by an information specialist) comprised a combination of free-text terms and relevant controlled vocabulary headings (e.g. Mesh, EMTREE etc.) related to the intervention (early warning, trigger, prediction), outcomes of interest (maternal mortality, obstetric morbidity) and model design, development or validation (Appendix 1). Apart from the date limit mentioned above no other limits were applied to the search. MCJ screened the abstracts of all studies, with a second reviewer consulted as necessary (GSC or SG).

Database and platform: CINAHL (via EBSCOHost)

Search run on: 21 March 2023

1. TI ("Modified Early Obstetric Warning Score*" OR "Modified Early Obstetric Warning System*" OR "Maternal Early Recognition Criteria" OR "Modified Early Warning System*" OR "Maternal Early Warning Trigger*" OR "Maternal Early Obstetric Warning System*" OR "Irish Maternity Early Warning System*" OR "Obstetric Early Warning Score*" OR "Obstetric early warning system*" OR "Maternal Early Warning Criteria" OR "Modified Obstetric Early Warning Score*" OR "MOEWS" OR "MEWT" OR "MEWTs" OR "MEOWS" OR "MEWC" OR "MERC") OR AB ("Modified Early Obstetric Warning Score*" OR "Modified Early Obstetric Warning System*" OR "Maternal Early Recognition Criteria" OR "Modified Early Warning System*" OR "Maternal Early Warning Trigger*" OR "Maternal Early Obstetric Warning System*" OR "Irish Maternity Early Warning System*" OR "Obstetric Early Warning Score*" OR "Obstetric early warning system*" OR "Maternal Early Warning Criteria" OR "Modified Obstetric Early Warning Score*" OR "MOEWS" OR "MEWT" OR "MEWTs" OR "MEOWS" OR "MEWC" OR "MERC")

2. (MH "Early Warning Score") OR (MH "Early diagnosis") OR (MH "Severity of Illness Indices") OR (MH "Vital Signs") OR (MH "Decision Support Systems, Clinical")

3. TI (early N2 (warning or recognition or surveillance) N1 (trigger* or criteria or score* or system*)) OR AB (early N2 (warning or recognition or surveillance) N1 (trigger* or criteria or score* or system*))

4. S2 OR S3

5. TI (develop* OR design* OR creat* OR build* OR contruct* OR validat* OR evaluat*) OR AB (develop* OR design* OR creat* OR build* OR contruct* OR validat* OR evaluat*)

6. TI (prognos* N1 (modelling OR modeling OR model OR models OR predict* OR performance OR tools OR ability OR accuracy OR probability OR risk OR factor*)) OR AB (prognos* N1 (modelling OR modeling OR model OR models OR predict* OR performance OR tools OR ability OR accuracy OR probability OR risk OR factor*))

7. TI ("risk model*" OR "predict* the prognosis of" OR "predict* the risk of" OR "predict* the probability of" OR "candidate predictor*" OR "predictive clinical parameter*" OR "descriptive model*") OR AB ("risk model*" OR "predict* the prognosis of" OR "predict* the risk of" OR "predict* the probability of" OR "candidate predictor*" OR "predictive clinical parameter*" OR "descriptive model*")

8. TI (probability N1 (modelling or modeling or model or models)) OR AB (probability N1 (modelling or modeling or model or models))

9. TI (predict* N1 (modelling or modeling or model or models or tools or performance or ability or accuracy or probability or risk)) OR AB (predict* N1 (modelling or modeling or model or models or tools or performance or ability or accuracy or probability or risk))

10. TI ((prognos* or predict*) N1 (index or nomogram))

11. S6 OR S7 OR S8 OR S9 OR S10

12. (MH "Pregnancy") OR (MH "Maternal Mortality") OR (MH "Pregnancy Complications") OR (MH "Pregnancy outcomes") OR (MH "Labor Complications+") OR (MH "Pregnancy Complications, Infectious") OR (MH "Pregnancy-Induced Hypertension+") OR (MH "Uterine Rupture")

13. TI ((maternal OR maternity OR obstetric* OR perinatal OR pregnancy OR "antepartum" OR "ante-partum" OR "ante partum" OR delivery OR labour OR labor) N2 (morbidity OR death OR mortality OR "vital sign*" OR decompensation OR deteriorat* OR complication* OR infection* OR sepsis OR "ICU admission" OR "critical care" OR "intensive care" OR "high dependency unit*" OR "HDU" OR "HDUs" OR "critical level 2")) OR AB ((maternal OR maternity OR obstetric* OR perinatal OR pregnancy OR "antepartum" OR "ante-partum" OR "ante partum" OR delivery OR labour OR labor) N2 (morbidity OR death OR mortality OR "vital sign*" OR decompensation OR deteriorat* OR complication* OR infection* OR sepsis OR "ICU admission" OR "critical care" OR "intensive care" OR "high dependency unit*" OR "HDU" OR "HDUs" OR "critical level 2"))

14. TI (("post partum" OR "postpartum" OR "post-partum" OR "post natal" OR "postnatal" OR "post-natal" OR "post delivery" OR "postdelivery" OR "post-delivery") N2 (haemorrhage OR hemorrhage OR bleed* OR "blood loss")) OR AB (("post partum" OR "postpartum" OR "post-

partum" OR "post natal" OR "postnatal" OR "post-natal" OR "post delivery" OR "postdelivery" OR "post-delivery") N2 (haemorrhage OR hemorrhage OR bleed* OR "blood loss"))

15. TI ("pre-eclampsia" OR eclampsia OR preeclampsia OR HELLP OR "acute fatty liver of pregnancy" OR "rupture of the uterus") OR AB ("pre-eclampsia" OR eclampsia OR preeclampsia OR HELLP OR "acute fatty liver of pregnancy" OR "rupture of the uterus")

16. TI ((uterus OR uterine) N1 (ruptur* or perforat*)) OR AB ((uterus OR uterine) N1 (ruptur* or perforat*))

17. S12 OR S13 OR S14 OR S15 OR S16

18. S4 OR S11

19. S5 AND S17 AND S18

20. S1 OR S19

21. PY 2000 OR PY 2001 OR PY 2002 OR PY 2003 OR PY 2004 OR PY 2005 OR PY 2006 OR PY 2007 OR PY 2008 OR PY 2009 OR PY 2010 OR PY 2011 OR PY 2012 OR PY 2013 OR PY 2014 OR PY 2015 OR PY 2016 OR PY 2017 OR PY 2018 OR PY 2019 OR PY 2020 OR PY 2021 OR PY 2022 OR PY 2023

22. S20 AND S21

RESULTS = 3266 references

Database and platform: Embase 1974 to present (via OVID)

Search run on: 21 March 2023

1. ("Modified Early Obstetric Warning Score$" or "Modified Early Obstetric Warning System$" or "Maternal Early Recognition Criteria" or "Modified Early Warning System$" or "Maternal Early Warning Trigger$" or "Maternal Early Obstetric Warning System$" or "Irish Maternity Early Warning System$" or "Obstetric Early Warning Score$" or "Obstetric early warning system$" or "Maternal Early Warning Criteria" or "Modified Obstetric Early Warning Score$" or "MOEWS" or "MEWT" or "MEWTs" or "MEOWS" or "MEWC" or "MERC").mp.

2. exp Early warning score/ or Scoring system/ or Vital sign/ or Disease severity assessment/

3. (early adj2 (warning or recognition or surveillance) adj1 (trigger* or criteria or score$ or system$)).ti,ab,kw.

4. or/2-3

5. (develop$ or design$ or creat$ or build$ or contruct$ or validat$ or evaluat$).ti,ab.

6. (prognos$ adj1 (modelling or modeling or model or models or predict$ or performance or tools or ability or accuracy or probability or risk or factor$)).ti,ab,kw.

7. ("risk model$" or "predict$ the prognosis of" or "predict$ the risk of" or "predict$ the probability of" or "candidate predictor$" or "predictive clinical parameter$" or "descriptive model$").ti,ab,kw.

8. (probability adj1 (modelling or modeling or model or models)).ti,ab,kw.

9. (predict$ adj1 (modelling or modeling or model or models or tools or performance or ability or accuracy or probability or risk)).ti,ab,kw.

10. ((prognos$ or predict$) adj1 (index or nomogram)).ti.

11. or/6-10

12. Maternal Death/ or Maternal Mortality/ or exp Pregnancy complication/ or exp Labor complication/ or Obstetric emergency/ or exp "Eclampsia and preeclampsia"/ or Obstetric delivery/ or Maternal morbidity/

13. ((maternal or maternity or obstetric$ or perinatal or pregnancy or "antepartum" or "ante-partum" or "ante partum" or delivery or labour or labor) adj2 (morbidity or death or mortality or "vital sign$" or decompensation or deteriorat$ or complication$ or infection$ or sepsis or "ICU admission" or "critical care" or "intensive care" or "high dependency unit$" or "HDU" or "HDUs" or "critical level 2")).ti,ab,kw.

14. (("post partum" or "postpartum" or "post-partum" or "post natal" or "postnatal" or "post-natal" or "post delivery" or "postdelivery" or "post-delivery") adj2 (haemorrhage or hemorrhage or bleed$ or "blood loss")).ti,ab,kw.

15. ("pre-eclampsia" or eclampsia or preeclampsia or HELLP or "acute fatty liver of pregnancy" or "rupture of the uterus").ti,ab,kw.

16. ((uterus or uterine) adj1 (ruptur$ or perforat$)).ti,ab,kw.

17. or/12-16

18. 4 or 11

19. 5 and 17 and 18

20. 1 or 19

21. conference abstract.pt.

22. conference abstract.st.

23. 21 or 22

24. 20 not 23

25. limit 24 to yr="2000-2023"

RESULTS = 5751 references

Database and platform: Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present

Search run on: 21 March 2023

1. ("Modified Early Obstetric Warning Score$" or "Modified Early Obstetric Warning System$" or "Maternal Early Recognition Criteria" or "Modified Early Warning System$" or "Maternal Early Warning Trigger$" or "Maternal Early Obstetric Warning System$" or "Irish Maternity Early Warning System$" or "Obstetric Early Warning Score$" or "Obstetric early warning system$" or "Maternal Early Warning Criteria" or "Modified Obstetric Early Warning Score$" or "MOEWS" or "MEWT" or "MEWTs" or "MEOWS" or "MEWC" or "MERC").mp.

2. Early Warning Score/ or Early diagnosis/ or Severity of Illness Index/ or Vital Signs/ or "Decision Support Systems, Clinical"/

3. (early adj2 (warning or recognition or surveillance) adj1 (trigger$ or criteria or score$ or system$)).ti,ab,kw.

4. or/2-3

5. (develop$ or design$ or creat$ or build$ or contruct$ or validat$ or evaluat$).ti,ab.

6. (prognos$ adj1 (modelling or modeling or model or models or predict$ or performance or tools or ability or accuracy or probability or risk or factor$)).ti,ab,kw.

7. ("risk model$" or "predict$ the prognosis of" or "predict$ the risk of" or "predict$ the probability of" or "candidate predictor$" or "predictive clinical parameter$" or "descriptive model$").ti,ab,kw.

8. (probability adj1 (modelling or modeling or model or models)).ti,ab,kw.

9. (predict$ adj1 (modelling or modeling or model or models or tools or performance or ability or accuracy or probability or risk)).ti,ab,kw.

10. ((prognos$ or predict$) adj1 (index or nomogram)).ti.

11. or/6-10

12. Pregnancy/ or Maternal Death/ or Maternal Mortality/ or Pregnancy Complications/ or Pregnancy outcome/ or exp Obstetric Labor Complications/ or exp Pregnancy Complications, Infectious/ or exp Hypertension, Pregnancy-Induced/

13. ((maternal or maternity or obstetric$ or perinatal or pregnancy or "antepartum" or "ante-partum" or "ante partum" or delivery or labour or labor) adj2 (morbidity or death or mortality or "vital sign$" or decompensation or deteriorat$ or complication$ or infection$ or sepsis or "ICU admission" or "critical care" or "intensive care" or "high dependency unit$" or "HDU" or "HDUs" or "critical level 2")).ti,ab,kw.

14. (("post partum" or "postpartum" or "post-partum" or "post natal" or "postnatal" or "post-natal" or "post delivery" or "postdelivery" or "post-delivery") adj2 (haemorrhage or hemorrhage or bleed$ or "blood loss")).ti,ab,kw.

15. ("pre-eclampsia" or eclampsia or preeclampsia or HELLP or "acute fatty liver of pregnancy" or "rupture of the uterus").ti,ab,kw.

16. ((uterus or uterine) adj1 (ruptur$ or perforat$)).ti,ab,kw.

17. or/12-16

18. 4 or 11

19. 5 and 17 and 18

20. 1 or 19

21. limit 20 to yr="2000-2023"

RESULTS = 7949 references

Database and platform: Web of Science Core Collection (via Clarivate at https://www.webofscience.com/wos/woscc/)

Edition: Science Citation Index Expanded (SCI-EXPANDED)-- 1900-present

Search run on: 21 March 2023

1. TS=("Modified Early Obstetric Warning Score*" OR "Modified Early Obstetric Warning System*" OR "Maternal Early Recognition Criteria" OR "Modified Early Warning System*" OR "Maternal Early Warning Trigger*" OR "Maternal Early Obstetric Warning System*" OR "Irish Maternity Early Warning System*" OR "Obstetric Early Warning Score*" OR "Obstetric early warning system*" OR "Maternal Early Warning Criteria" OR "Modified Obstetric Early Warning Score*" OR "MOEWS" OR "MEWT" OR "MEWTs" OR "MEOWS" OR "MEWC" OR "MERC")

2. TS=(early NEAR/2 (warning OR recognition OR surveillance) NEAR/1 (trigger* OR criteria OR score* OR system*))

3. TS=(develop* OR design* OR creat* OR build* OR contruct* OR validat* or evaluat*)

4. TS=(prognos* NEAR/1 (modelling OR modeling OR model OR models OR predict* OR performance OR tools OR ability OR accuracy OR probability OR risk OR factor*))

5. TS=("risk model*" OR "predict* the prognosis of" OR "predict* the risk of" OR "predict* the probability of" OR "candidate predictor*" OR "predictive clinical parameter*" or "descriptive model*")

6. TS=(probability NEAR/1 (modelling OR modeling OR model OR models))

7. TS=(predict* NEAR/1 (modelling OR modeling OR model OR models OR tools OR performance OR ability OR accuracy OR probability OR risk))

8. TI=((predict* OR prognos*) NEAR/1 (index OR nomogram))

9. #4 OR #5 OR #6 OR #7 OR #8

10. TS=((maternal OR maternity OR obstetric* OR perinatal OR pregnancy OR "antepartum" OR "ante-partum" OR "ante partum" OR delivery OR labour OR labor) NEAR/2 (morbidity OR death OR mortality OR "vital sign*" OR decompensation OR deteriorat$ OR complication* OR infection* OR sepsis OR "ICU admission" OR "critical care" OR "intensive care" OR "high dependency unit*" OR "HDU" OR "HDUs" OR "critical level 2"))

11. TS=(("post partum" OR "postpartum" OR "post-partum" OR "post natal" OR "postnatal" OR "post-natal" OR "post delivery" OR "postdelivery" OR "post-delivery") NEAR/2 (haemorrhage OR hemorrhage OR bleed* OR "blood loss"))

12. TS=("pre-eclampsia" OR eclampsia OR preeclampsia OR HELLP OR "acute fatty liver of pregnancy" OR "rupture of the uterus")

13. TS=((uterus OR uterine) NEAR/1 (ruptur* or perforat*))

14. #10 OR #11 OR #12 OR #13

15. #2 OR #9

16. #3 AND #14 AND #15

17. #1 OR #16

18. PY=(2000 OR 2001 OR 2002 OR 2003 OR 2004 OR 2005 OR 2006 OR 2007 OR 2008 OR 2009 OR 2010 OR 2011 OR 2012 OR 2013 OR 2014 OR 2015 OR 2016 OR 2017 OR 2018 OR 2019 OR 2020 OR 2021 OR 2022 OR 2023)

19. #17 AND #18

RESULTS = 1908 references