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ORIGINAL ARTICLE

Vital signs and other observations used to detect deterioration in pregnant women: an analysis of vital sign charts in consultant-led UK maternity units

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Short title: Obstetric vital signs charts

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ABSTRACT

Background: Obstetric early warning systems are recommended for monitoring hospitalised pregnant and postnatal women. We decided to compare: (i) vital sign values used to define physiological normality; (ii) symptoms and signs used to escalate care; (iii) type of chart used; and (iv) presence of explicit instructions for escalating care.

Methods: One hundred and twenty obstetric early warning charts and escalation protocols were obtained from consultant-led maternity units in the UK and Channel Islands. These data were extracted: values used to determine normality for each maternal vital sign; chart colour-coding; instructions following early warning system triggering; other criteria used as triggers.

Results: There was considerable variation in the charts, warning systems and escalation protocols. Of 120 charts, 89.2% used colour; 69.2% used colour-coded escalation systems. Forty-one (34.2%) systems required the calculation of weighted scores. Seventy-five discrete combinations of 'normal' vital sign ranges were found, the most common being: heart rate = 50–99 beats/min; respiratory rate = 11–20 breaths/min; blood pressure, systolic = 100–149 mmHg, diastolic = $\leq$89 mmHg; S_pO_2 = 95–100%; temperature = 36.0–37.9°C; and AVPU assessment = Alert. Most charts (90.8%) provided instructions about who to contact following triggering, but only 41.7% gave instructions about subsequent observation frequency.

Conclusion: The wide range of 'normal' vital sign values in different systems suggests a lack of equity in the processes for detecting deterioration and escalating care in hospitalised pregnant and postnatal women. Agreement regarding 'normal' vital sign ranges is urgently required and would assist the development of a standardised obstetric early warning system and chart.

Keywords: Obstetric Emergency Team; Patient Safety; Standards of Care; Trigger Tools; Maternity; Women's health.

Introduction

Early warning systems are recommended for monitoring the condition of hospitalised pregnant and postnatal women, to facilitate early detection and management of clinical deterioration.[1-6] Some maternity units use systems designed primarily for the non-pregnant population.[7] Others employ obstetric-specific systems comprising 'calling criteria' based on maternal vital sign measurements, symptoms and clinical signs, and conditions that

commonly cause maternal morbidity and mortality.[8-10] The regular measurement of a woman's vital signs is a universal feature of obstetric early warning systems (ObsEWS) and choosing the correct normal ranges for measured variables is fundamental to their appropriate, safe and efficient use.[11] However, publications suggest that ObsEWS vary with respect to the included vital signs and physiological values used to reflect normality.[1-10]

Several types of ObsEWS exist. Some trigger a clinical response by a midwife, obstetrician or rapid-response team,[12] when one or more abnormal observations are identified.[3] Others trigger the same response when one or more markedly abnormal, or two or more mildly abnormal, observations are present.[13,14] These systems are frequently used alongside charts featuring colour-coded shading to highlight markedly and mildly abnormal vital signs ranges, often shaded in red and yellow, respectively (Fig. 1).[1,15] A third type of ObsEWS allocates points in a weighted manner, based on the derangement of a woman's measured vital signs from pre-defined 'normal' ranges (Table 1).[16,17] The sum of these points, known as the early warning score (EWS), is used to direct subsequent care. Some hospitals use combinations of the three systems.

We decided to analyse early warning charts in routine use in consultant-led maternity units in the UK and Channel Islands to establish vital sign values used to determine normality in ObsEWS. We also identified other items used as triggers for escalating care (e.g. maternal symptoms, clinical signs and conditions), the type of vital signs chart used and the presence of explicit instructions for escalating care.

Methods

We wrote to all lead consultant anaesthetists registered with the Obstetric Anaesthetists' Association (OAA) to request participation in an analysis of obstetric early warning charts, ObsEWS and associated escalation protocols used in consultant-led maternity units in the UK and Channel Islands. Contact details were provided by the OAA**.** We requested a copy of the vital signs/ObsEWS chart and associated escalation protocol used in each unit. Invitees were asked to send these by email or mail (a stamped-addressed envelope was provided). Invitees were assured that all data would remain confidential, and no hospital identifiers would be revealed during presentations or publications arising from the study. The study extended two earlier OAA-approved surveys (Nos. 76 & 135) into UK ObsEWS and escalation policies, undertaken by members of our group.[8,9]

Non-responding leads/units were contacted again via telephone, follow-up letter and email. All were contacted a minimum of seven times (one telephone call, three letters and

three emails). All documentation received by the study group was scanned, given a unique hospital identifier (No. 1–194) and uploaded to a secure database for analysis.

Two members of the research team (GS and RI) analysed each chart individually, and created a spreadsheet containing amalgamated data. Where opinions differed, charts were re-checked to establish a single result for each data item.

We documented whether each obstetric early warning chart was colour-coded, and if the chart identified: (i) who to call on ObsEWS triggering; and (ii) the frequency of vital signs monitoring expected after activation. We identified items used as triggers for escalation (i.e. vital signs, maternal symptoms, clinical signs, and conditions) from the chart alone, or, where necessary, from the chart and the associated EWS. For each maternal vital sign parameter studied (i.e. respiratory rate (RR), heart rate (HR), systolic blood pressure (sBP), diastolic blood pressure (dBP), mean blood pressure (mBP), temperature (T), AVPU (Alert-Voice-Pain-Unresponsive) and oxygen saturation (S_pO_2)), we noted (a) whether it was used as a component of the ObsEWS, and (b) the values used to determine physiological normality on the vital signs chart or, if used, in the EWS. Similarly, we did the same for Glasgow Coma Score (GCS), maternal urine output and maternal oxygen administration. In addition, we noted whether other observations, criteria or abnormalities (e.g. presence of maternal proteinuria; uterine tone; maternal pain) were used as triggers in the early warning system.

In line with guidance from the NHS Health Research Authority, this service evaluation did not require ethical review by an NHS or Social Care Research Ethics Committee or management permission through the NHS R&D office. Approval for the study was obtained from the OAA Surveys Subcommittee.

Results

A total of 194 lead obstetric anaesthetists were invited to contribute obstetric early warning charts and escalation protocols from their unit(s). Charts were returned by 127 (65.5%) but seven (3.6%) were unusable (e.g. poor quality photocopy, black and white photocopy where colour-coding was used). Of the 120 charts available for analysis, 88 were from England; 15 from Scotland; 11 from Wales; 5 from Northern Ireland and 1 from the Channel Islands.

There was considerable variation in the design of obstetric early warning charts. Of the 120 usable charts, 107/120 (89.2%) used colour in some way, but only 83/120 (69.2%) used a colour-coded escalation system. Two different systems were used to escalate care to more experienced staff, or to advise subsequent clinical actions. A colour-coded triggering system similar to that developed in Scotland and described in the 2007 Confidential Enquiry

into Maternal and Child Health (CEMACH) report,[1] was used in 79/120 (65.8%) (Fig. 1). A system that required staff to calculate an EWS from an aggregate weighted system was used in 41/120 (34.2%). Where a colour-coded system based on the presence of one or more abnormal observations (red/yellow) was used (n=79), all except one (triggering score not stated) escalated care in the presence of either two yellow vital signs values or one red value. Where an aggregate weighted EWS was used to escalate care (n=41), the lowest aggregate score that triggered a bedside assessment by a doctor was 2 (4/41), 3 (15/41) 4 (15/41), 5 (4/41) and 6 (3/41).

Table 2 shows aggregated data for vital signs and related measurements used as a component of the trigger system: specifically, number of discrete 'normal' ranges in use across the units surveyed for each individual vital sign; lowest and highest value in any 'normal' range; most commonly used 'normal' range; number of charts using the most commonly used 'normal' range; and whether the parameter was (i) used as a component of the triggering system, (ii) recorded but not used in the triggering system, or (iii) not recorded nor used.

Variations in vital signs ranges used to define 'normality' for each of: HR, RR, sBP, dBP, SpO_2 and T are shown in Appendix A. For HR, RR, sBP and S_pO_2, the most commonly chosen 'normal' range was used in only approximately 50% of units. The most commonly used combination of 'normal' ranges was that described in the CEMACH report,[1] [HR, 50-99 beats/min; RR, 11-20 breaths/min; sBP, 100-149 mmHg; dBP, $\leq$89 mmHg; S_pO_2, 95-100%; T, 36.0-37.9^oC; and AVPU, A] however, this was used in only 16/120 (13.3%) units. Of the 120 charts assessed, 102 (85%) included all seven vital signs that appear on the CEMACH chart (i.e. HR; RR; sBP; dBP; S_pO_2; T; AVPU). However, there were 75 discrete combinations of 'normal' ranges in use for these seven vital sign sets. We could find no evidence that any unit used a different ObsEWS for different stages of pregnancy or in the postpartum period.

Table 3 shows the range of maternal symptoms and signs, and other clinical observations or measurements used as components of the ObsEWS reviewed. Whilst many of these supplementary observations formed part of a colour-coded chart and triggering system, some of these items contributed weightings to an aggregate EWS value.

The baseline frequency for recording vital signs was not always recorded on the ObsEWS charts. Where recorded, it varied between units and was usually every 12 h or more frequent. Only 50/120 (41.7%) units provided instructions about changes in the vital sign measurement frequency once vital sign abnormalities were identified. In these circumstances,

the subsequent vital signs measurement frequency was increased to a variable extent, usually to every 15-30 min. Usually, the frequency was determined by the degree of physiological derangement observed. Most charts (109/120; 90.8%) provided instructions about who to contact once the ObsEWS had triggered.

Discussion

We found a lack of agreement amongst the ObsEWS employed in consultant-led maternity units in the UK and Channel Islands regarding the most appropriate vital sign parameters to measure and vital sign values regarded as 'normal' values for each parameter. These disparities probably exist because there is a paucity of knowledge regarding which vital signs, or combination of vital signs, are predictive of maternal deterioration during and after pregnancy, and this makes it difficult to obtain agreement on the necessary appropriate vital signs to measure routinely or to include in an ObsEWS. Similarly, although it is known that pregnancy alters maternal physiology,[18] data are lacking regarding the normal maternal vital sign ranges for each stage of pregnancy, labour and the postpartum period.[11]

Uncertainties arising from these knowledge gaps result in potential conflicts in maternal care. The vital sign normal ranges in several ObsEWS studied lie outside the recently published reference ranges in healthy term pregnant women undergoing caesarean section.[19] More than 20% of units which include S_pO_2 in their ObsEWS use an S_pO_2 'normal' range with a lower limit below 94%, i.e. below the British Thoracic Society recommended lower limit for target S_pO_2 during pregnancy.[20] The normal ranges used for some parameters overlap with those used to highlight possible sepsis,[21-23] which is especially concerning as sepsis is a significant direct cause of maternal mortality and morbidity.[24] There are also examples of blood pressure 'normal' ranges overlapping with those used by the National Institute for Health and Care Excellence to define mild diastolic and severe systolic hypertension in pregnancy.[25] In addition, parameters and normal values used in units in the UK and Channel Islands are also different to those being used in iMEWS in Ireland[2] and in the Maternal Early Warning Criteria recommended in the USA.[3] Data collection to establish a set of 'normal' vital signs ranges for pregnancy is currently underway[11] and may lead to resolution of some of these uncertainties and disparities.

Determination of a set of 'normal' vital signs ranges for pregnancy would facilitate development of a single validated ObsEWS for the UK and Channel Islands, although a particular challenge will be identification of suitable clinical outcomes against which ObsEWS can be validated. It would also be important to identify whether it is necessary or

feasible to introduce a different ObsEWS for each phase of pregnancy. Introducing a different ObsEWS for each phase might be impractical since introducing just a single standardised ObsEWS can be challenging.[26,27]

There was also variation in ObsEWS and vital signs charts used in the 120 units. Most units use a chart similar to that in the 2007 CEMACH report, employing a two-colour triggering system, but in many units the chart had been modified. The remainder used an aggregate weighted triggering system requiring calculation of an EWS. There was also variation concerning when and how to escalate care. Currently two-thirds of units use an ObsEWS that triggers when one or more markedly abnormal (red), or two or more mildly abnormal (yellow), observations occur. Superficially, these systems appear different to those based on aggregate weighted scoring systems. However, they can be considered aggregate weighted scoring systems with a triggering value of 2 (if red observations score 2 points and yellow score 1). Therefore, issues that require resolution are (i) agreement on the range of weightings (i.e., 0-2 or 0-3), and (ii) the aggregate EWS at which care escalation occurs. These questions can only be answered following collection and analysis of one or more large databases of maternal observations and outcomes. The design of a suitable ObsEWS chart is beyond the scope of our article.

The 2007 CEMACH report indicated that there was *"…an urgent need for the routine use of a national obstetric early warning chart, similar to those in use in other areas of clinical practice…"* and suggested an auditable standard for such a chart to be developed and piloting started by the end of 2008.[1] The 2011 publication by the Maternal Critical Care Working Group[4] also recommended the introduction of a standard early warning system and chart for obstetrics. These guidelines are currently being updated and are expected to recommend the use of a standard ObsEWS incorporating six physiological parameters: RR, S_pO_2, T, sBP, dBP, and HR.[28] These parameters would seem to have face validity because they are almost identical to those previously recommended by anaesthetists[9] and midwives.[10]

There is evidence that the majority of UK obstetric anaesthetists support the need for a standardised, validated tool to prompt midwives and medical staff to summon help.[8,9] The benefits of standardising aspects of healthcare include reduced staff confusion and misunderstanding, consistency in clinical decision-making, reduced error rate, improved reliability, transferability across organisations and the opportunity for uniform staff training.[29] Despite this and the validation of the CEMACH chart in 2012,[13] there has been little progress in getting universal agreement on systems for detecting maternal deterioration in UK obstetric population. This may be because standardised systems are often perceived as

a challenge to professional autonomy and jurisdiction.[26] Midwives may be reluctant to adopt ObsEWS, because they can see no inherent value.[10,27] Midwives also felt that clinical judgement was superior to the ObsEWS and that informing a doctor when the ObsEWS recommended escalation was unnecessary, if the midwife believed that the woman was well.[27] We found no evidence that maternal concern about their perceptions of being at risk was included as a formal component of any ObsEWS triggering system.[30]

The study has several strengths and weaknesses. It is the largest and most detailed study of ObsEWS to date. Two researchers used a common, objective, systematic approach to interrogate the early warning system charts independently, and analysis was not subject to influence by participating centres. The assistance of the contributing units contacted was essential. However, despite trying to contact leads/units multiple times, only 65.5% of units provided charts and a few were unusable. In addition, not all maternity units in the UK and Channel Islands are represented in the OAA database. Consequently, our data may be subject to non-response and volunteer bias, implying that the results may not necessarily reflect the actual use of ObsEWS in other centres. Nevertheless, the findings of variation in the design, type and structure of vital signs charts, ObsEWS and escalation systems in the units studied would be unchanged (other than in magnitude) by data from additional units.

There is a lack of consensus regarding the vital sign values used to reflect physiological normality in ObsEWS used in consultant-led UK and Channel Island maternity units. Improving agreement would facilitate the introduction of a standardised national obstetric early warning chart, ObsEWS and escalation system, but this requires further research. Standardisation would improve the equality of maternal care across units.

Disclosure

GBS was a co-developer of the VitalPAC clinical software system, a collaborative development of The Learning Clinic Ltd (TLC) and Portsmouth Hospitals NHS Trust (PHT). GBS was an employee of PHT until 31/03/2011. The VitalPAC software charts patient vital sign measurements and provides decision support to bedside clinical staff regarding the need for the escalation of care. GBS was a member of the following groups: Royal College of Physicians of London's National Early Warning Score Development and Implementation Group; National Institute for Health and Care Excellence Guideline Development Group on 'Acutely ill patients in hospital. Recognition of and response to acute illness in adults in hospital'; National Patient Safety Agency Observatory group considering' Deterioration not recognised or not acted on'; Department of Health Emergency Care Strategy Team's

'Competencies for Recognising and Responding to Acutely Ill Patients in Hospital'; National Cardiac Arrest Audit Steering Committee; Executive Committee of the Resuscitation Council (UK); and the RC (UK) Immediate Life Support (ILS) course working group. GBS was also a paid expert adviser to South Eastern HSC Trust concerning the Report of the Northern Ireland Audit of Physiological Early Warning Scoring Systems (2010). GBS is a co-recipient of an NIHR Health Service and Delivery Research grant into 'Nurse staffing levels, missed vital signs observations and mortality in hospital wards'. GBS is the current President of the International Society for Rapid Response Systems.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online versionnat http://dx.doi.org/10.1016/j.ijoa.2017.xx.xxx

376 **Table 1 Typical obstetric early warning score**

	3	2	1	0	1	2	3
Breathing rate (breaths/min)	<10			10-14	15–20	21–30	>30
SpO2 (%)	<94			>94			
Temperature (°C)		<35.0	35.0–35.9	36.0–38.0		>38.0	
Systolic blood pressure (mmHg)	<80	80–90	91–100	101–140	141–150	151–159	>160
Diastolic blood pressure (mmHg)				<90	91–100	101–110	>110
Heart rate (beats/min)	<40	41–50	51–60	61–100	101–110	111–130	>130
Level of consciousness				Alert	Responds to Voice	Responds to Pain	Unconscious

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Table 2 Vital signs and other related measurements used to trigger early warning system escalation

	HR (beats/ min)	RR (breaths/ min)	sBP (mm Hg)	dBP (mm Hg)	mBP (mm Hg)	SpO 2 (%)	T (°C)	AVP U	Use of O_2	Urin e (mL/ h)	GCS
Numbe r of discret e 'norma l' ranges in use for each vital sign	16	14	21	15	2	12	7	2	-	-	-
Lowest value used in 'norma l' range	40	8	80	40	0	90	35.0	A or V	-	-	-
Highes t value used in 'norma l' range	109	20	199	100	≤124	100	38.0	A	-	-	-
Most comm only used 'norma l' range	50–99	11–20	100–149	≤89	≤124	95–100	36.0–37.9	A	-	>30	-
Numbe r using most comm on range	62/120	64/120	59/120	88/117	6/7	59/112	74/119	109/112 (97.3 %)	-	13/48 (27.1 %)	1/1 (100 %)
	(51.7%)	(53.3%)	(49.2 %)	(75.2 %)	(85.7 %)	(52.7 %)	(62.2 %)				
Used as compo nent of escalat ion system	120/120	120/120	120/120	117/120	7/120	112/ 120	119/120	112/ 120	8/120 (6.6 %)	48/120 (40.0 %)	1/120 (0.8 %)
	(100%)	(100%)	(100	(97.5	(5.8 %)	(93.3 %)	(99.2 %)	(93.3 %)			

			%)	%)							
Recorded but not used	0/120	0/120	0/120	0/120	14/120	7/120	1/120	0/120	101/120 (84.2%)	55/120 (45.8%)	0/120 (0%)
	(0%)	(0%)	(0%)	(0%)	(11.7%)	(5.8%)	(0.8%)	(0%)			
Not recorded or used	0/120	0/120	0/120	3/120	99/120	1/120	0/120	8/120	11/120 (9.2%)	17/120 (14.2%)	119/120 (99.2%)
	(0%)	(0%)	(0%)	(2.5%)	(82.5%)	(0.8%)	(0%)	(6.7%)			

Data are number (%)

HR, heart rate; RR, respiratory rate; sBP, systolic blood pressure; dBP, diastolic blood pressure; mBP, mean blood pressure; T, temperature; AVPU, (Alert-Voice-Pain-Unresponsive); GCS, Glasgow Coma Scale.

385 **Table 3 Maternal symptoms and signs, and other clinical observations or measurements used as**
386 **a component of obstetric early warning systems**

	Recorded on chart - used as component of triggering system	Recorded on chart - not used as component of triggering system	Not recorded on chart nor used as component of triggering system	Used as a component of aggregate EWS
Maternal pain score	76 (63.3%)	24 (20.0%)	20 (16.7%)	3 (2.5%)
Characteristics of lochia	68 (56.7%)	9 (7.5%)	43 (35.8%)	0
Proteinuria	65 (54.2%)	12 (10.0%)	43 (35.8%)	7 (5.8%)
Mother looks unwell	63 (52.5%)	0	57 (47.5%)	2 (1.7%)
Characteristics of amniotic fluid	47 (39.2%)	5 (4.2%)	68 (56.7%)	1 (0.8%)
Presence of nausea	13 (10.8%)	25 (20.8%)	82 (68.3%)	0
Drains/blood loss	12 (10.0%)	7 (5.8%)	101 (84.2%)	1 (0.8%)
Uterine tone	11 (9.2%)	6 (5.0%)	103 (85.8%)	0
Sedation level	3 (2.5%)	12 (10.0%)	105 (87.5%)	1 (0.8%)
Briskness of neuroreflexes	3 (2.5%)	7 (5.8%)	110 (91.7%)	0
Level of epidural-related motor block	3 (2.5%)	5 (4.2%)	112 (93.3%)	0
Level of epidural-related sensory block	2 (1.7%)	6 (5.0%)	112 (93.3%)	0
Maternal blood glucose level	2 (1.7%)	18 (15.0%)	100 (83.3%)	0

387 Data are number (%)
388

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Legends for figure

Fig. 1 Obstetric early warning chart described in the CEMACH report of 2007 (Reproduced with permission of Dr.F Mcilveney, Forth Valley Royal Hospital)

AN EXAMPLE OF AN OBSTETRIC EARLY WARNING CHART. REPRODUCED WITH THE KIND PERMISSION OF DR. FIONA MCILVENEY (1)

OBSTETRIC EARLY WARNING CHART (FOR MATERNITY USE ONLY)

Name: _____ **DOB:** _____

_____ **Ward:** _____

NHS Grampian

CONTACT DOCTOR FOR EARLY INTERVENTION IF PATIENT TRIGGERS ONE RED OR TWO YELLOW SCORES AT ANY ONE TIME

	Date :																		
	Time :																		
RESP (write rate in corresp. box)	>30																		>30
	21-30																		21-30
	11-20																		11-20
	0-10																		0-10
Saturations	95-100%																		11-20
	<95%																		95-100%
Administered O_2 (L/min.)																			%
Temp	39																		39
	38																		38
	37																		37
	36																		36
	35																		35
HEART RATE	170																		170
	160																		160
	150																		150
	140																		140
	130																		130
	120																		120
	110																		110
	100																		100
	90																		90
	80																		80
	70																		70
	60																		60
	50																		50
	40																		40
Systolic blood pressure	200																		200
	190																		190
	180																		180
	170																		170
	160																		160
	150																		150
	140																		140
	130																		130
	120																		120
	110																		110
	100																		100
	90																		90
	80																		80
	70																		70
	60																		60
	50																		50
Diastolic blood pressure	130																		130
	120																		120
	110																		110
	100																		100
	90																		90
	80																		80
	70																		70
	60																		60
	50																		50
	40																		40
URINE	passed (Y/N)																		passed (Y/N)
Proteinuria	protein ++																		protein ++
	protein >++																		protein >++
Amniotic fluid	Clear/Pink																		Clear/Pink
	Green																		Green
NEURO RESPONSE (√)	Alert																		Alert
	Voice																		Voice
	Pain																		Pain
	Unresponsive																		Unresponsive
Pain Score (no.)	0-1																		0-1
	2-3																		2-3
Lochia	Normal																		Normal
	Heavy / Fresh Offensive																		Heavy / Fresh Offensive
Looks unwell	NO (√)																		YES (√)
	YES (√)																		NO (√)
Total Yellow Scores																			
Total Red Scores																			

Requests for copies of the original chart in MS Excel format may be made to Dr Fiona McIlveney at: Fiona.McIlveney@fvah.scot.nhs.uk

Reference

1. International Journal of Obstetric Anesthesia (2006) 15, S1-S43 Abstracts of free papers presented at the annual meeting of the Obstetric Anaesthetists? Association, Glasgow 11-12 May, 2006.

"Early-warning scoring in obstetrics". P Harrison, C Hawe, F McIlveney. Department of Anaesthesia, Stirling Royal Infirmary, Stirling, UK.

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Highlights

- Early warning systems used in UK consultant-led maternity units vary considerably
- Many different vital sign ranges are used to define normal maternal physiology
- Research is required to inform the normal vital sign ranges expected during pregnancy
- Obstetric early warning systems and charts should be standardised