Validation and modification of a cardiotocograph interpretation training programme for midwives in South Africa to address existing interpretation inconsistencies, using the virtual nominal group technique

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Background. Conventional models of cardiotocograph (CTG) interpretation training have focused on adherence to interpretation guidelines. There is a need for training in interpreting CTGs that emphasises integrating the complete clinical picture to inform clinical decision-making and improve patient safety.
Objectives. To develop and validate a CTG interpretation training programme for midwives in South Africa to address the existing inconsistencies in interpretation.
Methods. This study was underpinned by the Analysis, Development, Design, Implementation and Evaluation (ADDIE) theoretical framework. The study followed an explanatory sequential mixed-methods design with the aim of exploring and describing midwives' level of knowledge of CTG interpretation and their learning needs. The learning needs identified informed the development of a training programme. A panel of nine experts participated in a virtual nominal group technique to validate the training programme and prioritise the learning units through anonymous ranking.
Results. CTG interpretation training made up of the following learning units was developed and validated with the assistance of maternal and child health experts: Introduction to CTG interpretation; Technical aspects of CTG monitoring; Factors that affect the fetal heart rate during labour; Diagnosis; Clinician-woman relationship; Effective and timely communication of accurate information; Formulation of a comprehensive management plan after CTG interpretation; Using appropriate guidelines to inform decision-making; and Medicolegal hazards.
Conclusion. This CTG interpretation programme differs from other conventional training programmes in that it focuses on the multifaceted nature of CTG interpretation and does not confine the training to CTG interpretation guidelines.

Keywords. cardiotocograph; cardiotocograph interpretation; training programme; low- and middle-income countries; fetal heart monitoring.

S Afr J Child Health 2025;20(1):eS13. https://doi.org/10.7196/SAJCH.2025.v20i1.S13

There is ongoing debate in the scientific community pertaining to the relevance of the cardiotocograph (CTG) as a fetal wellbeing assessment tool during the intrapartum period. The intra-observer and inter-observer variability of CTG interpretation remains a key concern. In high-income countries it has been suggested that artificial intelligence could be a useful tool in assisting midwives and obstetricians to overcome the subjectivity of CTG interpretation, which leads to increased inter- and intra-observer variability. This approach will unfortunately leave low- and middle-income countries (LMICs) behind, as they are often subject to resource constraints. Training has been suggested as an intervention to overcome the current limitations of CTG monitoring and interpretation.

The shortfall of current CTG interpretation programmes is the lack of standardisation in interpretation guidelines. This deficiency leads to varying nomenclature among professionals, which affects training of midwives in CTG interpretation. Conventional CTG interpretation training programmes are limited to classifying CTG traces based on predetermined criteria rather than including the clinical context and the adaptation of CTG features to intrapartum events. Furthermore, in LMICs CTG interpretation training programmes are few and far between. Ugwumadu *et al.*[1] recommend that the aforementioned gaps should be addressed through intensification of CTG interpretation training that will emphasise recognition and management of both normal and abnormal traces with consideration of intrapartum factors.

South Africa (SA) currently does not have a standardised CTG interpretation training programme. Each nursing education institution that offers a midwifery programme teaches CTG interpretation according to the midwifery educators' discretion. There is no prescribed minimum duration that a CTG interpretation training programme should meet. Adding to the inconsistencies of CTG interpretation training is that there is no nationally adopted CTG interpretation guideline. The National Integrated Maternal and Perinatal Care Guidelines for South Africa make use of the International Federation of Gynecology and Obstetrics (FIGO)[2] and National Institute

for Health and Care Excellence (NICE)[3] guidelines for CTG interpretation. The SA Maternity Case Record,[4] which is a type of home-based record,[5] also utilises the FIGO guideline to guide intrapartum CTG interpretation during labour. In contrast, some districts in Gauteng Province are known to use the American College of Obstetricians and Gynecologists guideline[6] for CTG interpretation. These inconsistencies in policy cause confusion among interpreters.

The present study was conducted to develop and validate a CTG interpretation training programme for midwives in SA to address the existing inconsistencies in interpretation, using the virtual nominal group technique (NGT). According to the researchers' knowledge, there has not been any validated CTG interpretation training programme for midwives in SA. This study used an explanatory sequential mixed-methods design to develop the exit-learning outcomes, intended learning outcomes, and teaching and evaluation methods for an intrapartum CTG interpretation programme for midwives in SA. The Analysis, Development, Design, Implementation and Evaluation (ADDIE) model for instructional design was used as a theoretical underpinning to the study.[7] The developed CTG training programme may be used or amended as appropriate in midwifery or medical education for undergraduate and postgraduate education in other LMICs. Furthermore, this training programme may be used as part of continuing professional development training in LMICs.

Methods

This study took place in three phases: phase 1 was the empirical phase, which was the explanatory sequential mixed-methods phase; phase 2 was training programme development; and phase 3 was validation of the developed CTG training programme.

Description of the quantitative strand

The quantitative strand of the study aimed to assess midwives' level of knowledge of CTG interpretation and to identify the factors that affect this. The quantitative strand followed a quantitative, descriptive cross-sectional design. The setting of this part of the study was four public hospitals in Gauteng, of which two are district hospitals and two central hospitals. To ensure that the midwives who participated in the study were accustomed to interpreting the CTG during the intrapartum period, the study population comprised midwives working in labour wards and those in antenatal wards who conducted inductions of labour. The total number of midwives directly involved in intrapartum care across the four hospitals was 152. A biostatistician was consulted to calculate the sample size, and census sampling was recommended. All 152 midwives who were involved in intrapartum care during the time of data collection were therefore approached to take part in the study.

Data were collected through a questionnaire with three sections. The first elicited the demographic profile of the participants, while the second and third each comprised a questionnaire. The second section consisted of the Electronic Fetal Monitoring Knowledge Scale developed by Gourounti *et al.*[8] The third section consisted of the Cardiotocograph Interpretation Skills Test, which assessed midwives' visual interpretation of the intrapartum CTG through three different brief scenarios and was developed by Devane and Lalor.[9] Permission to use these tools was obtained from the copyright holders.

The reliability of the questionnaire was assessed through a pilot study conducted at an institution of higher education in Gauteng. The reliability of an instrument signifies the consistency of the measures of an attribute, concept or situation that are obtained in a study.[10] Postgraduate diploma in midwifery students made up the population for the pilot study, and a total of 16 completed questionnaires were submitted. The Cronbach alpha coefficients of the total instrument were 0.79. Alpha values >0.70 are sufficient evidence to support the internal consistency of the instrument.[11]

Data were collected from December 2022 to January 2023. The researcher and a research assistant invited all midwives working in the labour ward, as well as those from the antenatal ward who were involved in induction of labour, to participate in the study. A total of 122 self-administered questionnaires were completed and returned to the researcher. Data were analysed in consultation with a biostatistician using Stata version 18 (StataCorp, USA).

Description of the qualitative strand

The qualitative strand of the study aimed to explore midwives' perspectives of and learning needs for CTG interpretation. During the qualitative strand of the study, face-to-face semi-structured interviews were conducted using an interview guide. The interview guide was developed by the researcher in consultation with the supervisory team, based on the findings of the quantitative strand. The researcher conducted focus group and individual interviews. The decision regarding the type of interview to conduct was based on how busy the ward was at the time, which influenced the number of midwives available to sit down with the researcher for an interview. A total of 30 midwives participated in six focus group discussions with two to eight midwives each, and five individual interviews. Interviews lasted 20 - 60 minutes. Of the 30 participants who participated in the qualitative strand of the study, 24 had also participated in the quantitative strand. Data were analysed using Braun and Clarke's[12] six steps of qualitative data analysis.

Integration of mixed-methods findings

The development of the CTG interpretation training programme outline for midwives was based on the quantitative and qualitative results that emerged from phases 1 and 2 of the study, respectively. Data from the qualitative and quantitative strands of the study were integrated using the Pillar Integration Process,[13] which resulted in the identification of pillar-building themes.[14] A total of six pillars were identified: (*i*) substandard CTG interpretation training leads to a lack of understanding of key concepts; (*ii*) absence of norms and standards pertaining to CTG interpretation training; (*iii*) Essential Steps in Managing Obstetric Emergencies (ESMOE) training does not result in improved CTG interpretation scores; (*iv*) lack of standardisation of CTG interpretation guidelines causes confusion among interpreters; (*v*) level of knowledge of foundational concepts of CTG interpretation affects clinical judgement; and (*vi*) CTG interpretation skill is a combination of understanding of CTG characteristics, fetal heart rate pattern, fetal physiology and clinical context.[14]

Development of the CTG interpretation programme outline

The researchers converted the pillar-building themes from the integrated data into exit-level outcomes. An exit-level outcome is defined as a performance level at which a candidate who is completing a qualification is expected to be found competent when assessed.

Thereafter, learning objectives, which were identified from the results of phases 1 and 2, were formulated. A learning objective is defined as a statement that organises the interaction, gives a clear focus for teaching discussions, and provides criteria for evaluation.[15] The formulated learning objectives were then aligned to relevant

taxonomies. The learning objectives that fell under the cognitive domain were aligned with *Handbook I: Cognitive Domain* of *Taxonomy of Educational Objectives: The Classification of Educational Goals*.[16] The learning objectives that could be categorised under the affective domain were aligned with *Handbook II: Affective Domain* of *Taxonomy of Educational Objectives: The Classification of Educational Goals*.[17] The learning objectives that were identified as psychomotor statements were aligned with 'The classification of educational objectives, psychomotor domain' by Simpson.[18]

Appropriate teaching and learning strategies were then identified for each unit. The following assessment methods were identified for this training programme: multiple-choice questions, structured short-answer questions, structured long-answer questions, and observation of performance through role-play. Associated assessment criteria were based on the criteria for evaluation as provided by the specific learning objective.

The nominal group technique

The NGT is a structured face-to-face interaction, usually involving 5 - 12 participants.[19,20] The aim of consensus methods is to determine the degree to which experts agree about a given issue.[20,21] In this study, the NGT was used to gain consensus from experts in midwifery education and practice on a training programme for midwives that addresses the inconsistencies that exist in CTG interpretation. Owing to the various geographical locations of identified experts, a virtual discussion was deemed more fit for purpose.

A panel of nine maternal and neonatal experts was recruited to participate in a virtual NGT discussion to validate the developed CTG interpretation training programme. The researchers preferred the virtual NGT consensus method over the Delphi technique, because the NGT allows for immediate generation of ideas and prioritisation of those ideas.[22] The aim of this consensus exercise was for experts to review the generated learning objectives, assessment criteria and teaching and learning strategies of the CTG training programme for SA midwives developed by the researchers. The consensus exercise also aimed to validate the developed CTG programme, and to prioritise the learning units through ranking.[23,24]

Data collection

The NGT discussion was video recorded for transcription purposes with the consent of the participants. The NGT discussion took place in November 2024. Data collection using the NGT followed five steps, namely silent generation, round robin, clarification, ranking and discussion.[24]

As part of silent generation of ideas, a draft CTG training programme that had been developed by the researchers was labelled 'document 1', an additional document for reviewers to comment on the learning objectives, associated assessment criteria and teaching and learning strategies was labelled 'document 2', and a third document provided an overview of the phases of the study using a diagram. Participants were asked to review the draft CTG training programme content by ranking the generated learning units in document 1 under the headings Include, Modify, and Exclude. Responses for documents 1 and 2 were sent to the first author prior to the virtual NGT discussion. Participants were requested not to discuss the documents with each other.

A virtual NGT discussion was then held to gain consensus on the learning objectives of the draft CTG training programme. The NGT was facilitated by an experienced professor of nursing who is also a research methodology expert and has conducted multiple NGT discussions. The role of the facilitator was to support the consensus discussion by making sure that the steps of the NGT were followed. As the facilitator was not a maternal and child health expert, she was able to remain neutral in the decision-making process. The facilitator's expert guidance enabled the panellists to remain focused on the task of validating the developed CTG training programme.[25] The first author moderated the session.

During the NGT session, the first author conducted a brief presentation of the overview of the study and the developed training programme to ensure that all participants understood the rationale for the NGT discussion. Thereafter the moderator guided the experts through the steps of the NGT. During the item generation phase of the NGT discussion, experts silently generated items of support in response to the following question: 'Considering the developed CTG training programme, what can be done to improve the quality of the learning outcomes?'

The steps described below were then followed during the NGT. Generated items were presented on a Word document (Microsoft 365, USA), which was shared on the screen to enable all participants to see it in real time for round-robin purposes. When all the ideas generated by the panellists had been exhausted, a discussion phase followed during which they were able to explain their individual responses. Fellow panellists were also allowed to add on to or propose new items for the generated list. Similar items were grouped together and duplicate items were removed. Items that were outside the scope of this NGT discussion were also removed.

Lastly, anonymous electronic ranking of priority items was conducted through the Microsoft Teams polling option (Microsoft 365, USA).[26] All the experts participated in the ranking. None of the authors participated in the item generation or the voting. The meeting lasted for 3 hours.

The day after the virtual NGT discussion, an updated CTG training programme with all the inputs of the experts was circulated through Google Docs (Google, USA) for final inputs and validation. All the experts had access to everyone's inputs on the shared Google Doc. This was a live document and was kept open for inputs for a period of 2 weeks.

Data analysis

Data analysis of the content validation through ranking of the learning units that were included in the draft CTG training programme was conducted through calculation of total scores per item and total scores per ranker. During the virtual NGT discussion, data analysis was performed simultaneously with data collection using thematic analysis.[12] The Microsoft Teams polling option allowed for anonymous automated prioritisation of learning outcomes per theme through ranking according to the highest score.

Ethical considerations

This study protocol was not registered on any database or journal. The study received ethical approval from the University of Pretoria Faculty of Health Sciences Ethics Committee (ref. no. 580/2021).

Results

The NGT recruitment and virtual NGT discussion took place in November 2024. After the consensus meeting, the authors drafted the updated CTG interpretation training programme and then shared it with the panellists. All comments and revisions were taken into consideration, and the CTG training programme was revised accordingly. Deviations from the original protocol included holding the NGT discussion virtually instead of face to face to accommodate the multiple locations of experts and researchers.

A total of nine experts participated in the study. The response rate for the pre-NGT discussion questionnaires was seven (77.8%). All nine experts participated in the virtual NGT discussion and the validation of the final CTG training programme. Table 1 indicates the characteristics of the NGT expert panel.

Ranking

The experts were requested to rank each learning unit of the draft CTG training programme in document 1 under the following headings: Include (3 points); Modify (2 points); and Exclude (1 point). A total of seven experts participated in this exercise, and the results are shown in Table 2.

Results of the virtual NGT consensus meeting

During the virtual NGT discussions, experts identified study units and learning objectives that needed to be added to the CTG interpretation training programme that had been circulated. The learning objectives that had been generated during the round robin and those that had emerged during discussions were grouped by themes to form learning units. Colour coding was used to identify learning objectives that could be grouped under one theme.

Consolidation of NGT discussion findings

Following the virtual NGT, the authors consolidated the initial CTG interpretation programme with the proposed additions that had been suggested by the experts. The final post-NGT discussion CTG interpretation training programme is shown in Table 3. The final exit learning outcomes of the developed CTG training programme, as validated by the experts, are: Fundamentals of CTG monitoring; Integration of CTG findings; Clinical judgement; Woman-centred care; Communication; Planning; Evidence-based care; and Ethical, legal and professional practice.

Table 1. Characteristics of the nominal group technique expert panel (*N*=9)

Characteristic	*n* (%)*
Age (years), mean	56
Experience (years), mean	33.6
Type of specialist	
Advanced midwife and neonatal specialist	6 (66.7)
Direct-entry midwife who trained outside SA	1 (11.1)
Neonatal nursing specialist	1 (11.1)
Consultant obstetrician and maternal and fetal medicine subspecialist	1 (11.1)
Position	
Professor	2 (22.2)
Associate/adjunct professor	3 (33.3)
Lecturer	2 (22.2)
Research fellow	1 (11.1)
Midwife advisor	1 (11.1)
Highest qualification	
PhD	6 (66.7)
Master's	1 (11.1)
Bachelor of nursing science and advanced midwife specialist	2 (22.2)
Society of Midwives of South Africa leadership	2 (22.2)
SA provinces represented	
Free State	1 (11.1)
Gauteng	5 (55.6)
Western Cape	3 (33.3)
SA public universities represented	7/26 (26.9)

SA = South Africa.
*Except where otherwise indicated.

Discussion

This study aimed to develop and validate a CTG interpretation training programme for midwives in SA to address the existing interpretation inconsistencies. The study was underpinned by the ADDIE theoretical framework. The CTG training programme was validated through a virtual NGT made up of a panel of nine experts. The learning units that are covered in the validated training programme are: Introduction to CTG interpretation; Technical aspects of CTG monitoring; Factors that affect the fetal heart rate during labour; Diagnosis; Clinician-woman relationship; Effective and timely communication of accurate information; Formulation of a comprehensive management plan after CTG interpretation; Using appropriate guidelines to inform decision-making; and Medicolegal hazards. These learning units are similar to those recommended by Ugwumadu *et al.*,[1] who advocate for CTG training to include correct use of the equipment, maternal and fetal pathophysiology, and understanding the role of infection and other fetal stressors and their interaction with asphyxia. The duration of this validated training programme is 40 hours, which translates to 5 days of training and four credits. This is supported by Ugwumadu *et al.*,[1] who recommend that CTG training programmes should have a minimum duration of 2 days.

The introductory unit of the training programme provides an overview of different methods of fetal heart monitoring and then describes the indications for fetal heart monitoring using the CTG. The authors of the present study would like to advocate for the use of the CTG in high-risk women. This is in line with the World Health Organization's intrapartum care recommendations for a positive birth experience and the International Confederation of Midwives (ICM) Essential Competencies for Midwifery Practice,[27] which advocates the use of tools and technologies for intermittent or continuous monitoring of fetal wellbeing. The ICM furthermore stipulates that unnecessary routine CTG monitoring should be prevented.

The developed training programme has a strong focus on fetal physiology as well as fetal responses to the progression of labour, the medications administered during labour, the effects of gestational age on observed fetal heart patterns, and maternal disease or conditions of pregnancy that negatively affect placental function. This is in line with the CTG interpretation chapter in the newly updated National Integrated Maternal and Perinatal Care Guidelines for South Africa.[28] A study by James *et al.*[29] in SA found that an in-service CTG training programme did not improve participants' CTG interpretation skills. The study found that midwives were unable to correctly differentiate between the maternal and fetal heart rate, to understand maternal and fetal physiology. The in-service training failed to improve midwives' CTG interpretation skills. In contrast, another study from SA[30] found that knowledge of healthcare professionals regarding CTG interpretation significantly improved when the training focused on fetal physiology. This substantiates that CTG interpretation training based on fetal physiology is the recommended method. Similarly, a study conducted in France by Zhu *et al.*[31] found that when CTG training was based on fetal physiology, participants were able to retain their level of knowledge over 6 months after training. These results were corroborated by another French study which found that training based on fetal physiology does not result in a reduction in knowledge levels

Table 2. Consolidated individual ranking of learning units included in the draft CTG interpretation training programme

Exit-level outcome	Study units	Ranking							Rankings total per item	Mean
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7		
Quality improvement	Unit 1 1.1 CTG interpretation terminology and guidelines	3	3	3	3	3	2	2	19	2.71
Understanding of key concepts of CTG interpretation	Unit 2 2.1 Technical aspects of CTG interpretation	2	2	3	3	3	2	2	17	2.43
	2.2 The characteristics of the CTG	3	3	3	3	3	2	2	19	2.71
Integration of CTG findings	Unit 3 3.1 Factors that affect the fetal heart pattern during labour	2	3	3	3	3	2	2	18	2.57
Clinical judgement	Unit 4 Interpreting the CTG	3	3	3	3	3	3	2	20	2.86
Effective communication	Unit 5 5.1 Communicating CTG findings with the labouring woman	3	2	3	3	3	3	2	19	2.71

CTG = cardiotocograph.

with increasing years of experience.[32] The study also found that participants' scores improved from a median of 1.5 before fetal physiology training to 4.0 after the training. The participants were able to recognise fetuses at risk of acidosis, and there was a 6.9% decrease in requests for fetal blood samples after the training.

It is essential to equip clinicians to systematically interpret CTG traces by analysing the five features of the CTG in the context of labour events and relevant history. It is therefore recommended that cardiotocographic interpretation be guided by the mnemonic DR C BRaVADO, which was developed by the Advanced Life Support in Obstetrics curriculum.[33] The mnemonic is applied as follows: DR (Define Risk as high, medium or low based on clinical situation), C (Contractions – frequency, duration, intensity, rhythm and resting tone); BRa (Baseline Rate); V (Variability – described as absent, minimal, moderate or marked); A (Accelerations – spontaneous, stimulated or none); D (Decelerations – absent, early, variable, late or prolonged); and O (Overall assessment and written plan).[33] This mnemonic will ensure that clinicians cover all the bases of CTG interpretation.

This CTG interpretation training programme also addresses effective communication strategies between members of the multidisciplinary team. Furthermore, it acknowledges the woman as part of the team. Studies have shown that patients who perceived communication between themselves and the healthcare team to be effective during labour reported greater satisfaction.[34,35] The programme encompasses learning objectives that equip clinicians to learn how to communicate effectively across disciplines. Studies have found that although clinicians are aware that effective information sharing between professionals is important, the reality on the ground is that communication across professions can be difficult.[36] This programme aims to equip maternity care staff with strategies to cultivate safe spaces for effective communication of CTG interpretation findings, with the aim of improving patient safety through improved maternal and neonatal outcomes.

This type of training programme is novel, as it is not limited to the boundaries of CTG interpretation guidelines; instead, it carefully takes the patient history and the unfolding events of labour to create a full clinical picture that gives meaning to the patterns noted on the CTG trace. For this reason, the expert panel ranked CTG interpretation guidelines sixth on the list of priority areas to be taught for effective CTG interpretation. This CTG interpretation training programme is tailored to equip midwives and obstetricians from LMICs, as these settings often do not have access to adjunct technologies that aid in CTG interpretation. The CTG interpretation classification terminology for the training programme will be aligned with both the National Integrated Maternal and Perinatal Care Guidelines for South Africa[28] and the SA Maternity Case Record.

The last unit to be covered by the CTG training programme is medicolegal hazards related to CTG monitoring and interpretation. Medicolegal cases involving cerebral palsy in SA courts are mainly judged on magnetic resonance imaging findings and cardiotocography to assess causation and liability. The CTG trace is seen as an important piece of evidence during litigation. It is considered to be proof of the events that transpired in the birthing room.[37] The outcomes of civil cases involving intrapartum mismanagement may lead to liability of the midwife in her personal capacity, and second-hand liability of the obstetrician involved as well as the hospital where the incident took place. For this reason, it is very important for clinicians to be equipped with skills on thorough record-keeping, storage of traces, and incident report writing.

Conclusion

A CTG interpretation training programme was developed using the ADDIE model for instructional design, and has been validated through a virtual NGT with a panel of nine experts. The training programme will be taught as a short course to supplement current undergraduate and postgraduate midwifery curricula, and may also be used for continuing professional development purposes. It is particularly useful for use in LMICs where resources may be limited. The programme is yet to be implemented – future research should therefore focus on the implementation and evaluation of the developed CTG interpretation training.

Table 3. Validated CTG interpretation training programme outline

Exit-level outcome	Unit	Specific learning outcome	Teaching and learning strategy	Duration	Associated assessment criteria
Fundamentals of CTG monitoring	Unit 1: Introduction to CTG interpretation	At the end of this lesson, the student midwife/midwife/clinician will demonstrate knowledge and understanding of the fundamentals of CTG monitoring and interpretation, which are: • Methods of fetal heart monitoring during labour • The purpose of CTG interpretation • The CTG as an assessment tool for fetal wellbeing • Physiological adaptations of the fetal heart during labour • Indications for intermittent auscultation • Indications for continuous CTG monitoring • Apply ethical considerations for prioritisation of patients who would benefit from CTG monitoring in resource-constrained areas • The limitations of CTG monitoring	Didactic lecture	3 hours	The student midwife/midwife/clinician will demonstrate knowledge and understanding of the fundamentals of CTG monitoring and interpretation through a multiple-choice question test
		At the end of this lesson, the student midwife/midwife/clinician is expected to use appropriate CTG terminology to identify the features of the fetal heart pattern, which are: • Descriptions of wave forms – amplitude, duration, strength, acme, nadir • Fetal heart baseline • Fetal heart baseline variability • Decelerations • Contractions • Different fetal heart patterns • Introduction to CTG interpretation guidelines	Workshop: Studying different types of CTGs	4 hours	The student midwife/midwife/clinician will use his/her knowledge of the definitions of the basic features of the CTG to correctly label the basic CTG features on a CTG strip

continued

Data availability. The datasets generated and analysed during the present study are available from the corresponding author (SL) on reasonable request. Additionally, the data can be accessed via None at None, under the accession number None. Any restrictions or additional information regarding data access can be discussed with the corresponding author.

Declaration. The research for this study was done in partial fulfilment of the requirements for SL's PhD (Nursing Science) degree at the University of Pretoria.

Acknowledgements. The researchers would like to acknowledge and thank the facilitator of the NGT, Prof. Rugira Modeste, and all the experts who participated in the NGT during the validation process.

Author contributions. SL was responsible for the conception and design of the study, acquisition, analysis and interpretation of data, and drafting of the article. FMM and RG assisted in the conception and design of the study, analysis and interpretation of data, and revising the article.

Funding. This study was funded by the Department of Higher Education and Training New Generation of Academics Programme and the National Research Foundation, grant no. N00696. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of interest. None.

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Table 3. (continued) Validated CTG interpretation training programme outline

Exit-level outcome	Unit	Specific learning outcome	Teaching and learning strategy	Duration	Associated assessment criteria
	Unit 2: Technical aspects of CTG monitoring	At the end of this lesson, the student midwife/midwife/clinician will be expected to demonstrate the technical aspects of CTG monitoring, which are: • The care of CTG equipment • The names of different parts of the CTG machine • The functions of different parts of the CTG machine • Correct insertion of the CTG tracing paper • Setting the correct time and date on the machine • Setting the CTG machine at the correct paper speed for monitoring and interpretation • Differentiation between the ultrasound and toco transducers • Correct placement of the transducers • Differentiation between maternal and fetal heart • Maternal positioning during CTG monitoring • Repositioning of CTG transducers in the case of readings that are not clear	Demonstration through simulation	3 hours	The student will demonstrate behavioural skills which indicate that he/she is competent at the technical aspects of CTG monitoring through the following actions: • Correct care of CTG equipment • Correct identification of different parts of the CTG machine • Correct description of functions of different parts of the CTG machine • Correct insertion of the CTG tracing paper • Setting the correct time and date on the machine • Setting the CTG machine at the correct paper speed for monitoring and interpretation • Differentiation between the ultrasound and toco transducers • Correct placement of the transducers • Differentiation between maternal and fetal heart • Maternal positioning during CTG monitoring. • Repositioning of CTG transducers in the case of readings that are not clear
Integration of CTG findings	Unit 3: Factors that affect the fetal heart rate during labour	At the end of this lesson, the student midwife/midwife/clinician will be able to describe how the following clinical contexts impact on CTG interpretation: • Fetal sleep/wake cycle • Fetal response to the progression of labour • Medications that affect the fetal heart pattern • Effect of gestational age on fetal heart rate • Maternal disease or pregnancy-induced medical disorders that negatively affect placental function • Effects of maternal positioning on the fetal heart rate	Workshop: Problem-based learning	7 hours	The student midwife/midwife/clinician will integrate information from the intrapartum notes and the partograph to justify the patterns that are noted on the CTG trace

continued

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Table 3. (continued) Validated CTG interpretation training programme outline

Exit-level outcome	Unit	Specific learning outcome	Teaching and learning strategy	Duration	Associated assessment criteria
Clinical judgement	Unit 4: Diagnosis	At the end of this lesson, the student will combine the elements of the acronym DR C BRaVADO[33] to interpret and classify the CTG: • DR (Define Risk as high, medium or low based on clinical situation) • C (Contractions – frequency, duration, intensity, rhythm and resting tone) • BRa (Baseline Rate) • V (Variability – described as absent, minimal, moderate or marked) • A (Accelerations – spontaneous, stimulated or none) • D (Decelerations – absent, early, variable, late or prolonged) • O (Overall assessment and written plan)	Workshop: Problem-based learning	8 hours	The student will demonstrate the ability to integrate clinical findings pertaining to CTG interpretation to classify the CTG trace as normal, suspicious or pathological
Woman-centred care	Unit 5: Clinician-woman relationship	At the end of this lesson, the student midwife/midwife/ clinician will cultivate a therapeutic clinician-patient relationship with women in labour by: • Using simple and culturally acceptable language to explain CTG interpretation findings • Recognising anxiety and addressing fears of labouring women	Workshop: Problem-based learning	1 hour	The student midwife/ midwife/ clinician will use role-play to demonstrate the soft skill of cultivating a therapeutic clinician-patient relationship with women in labour by: • Using simple and culturally acceptable language to explain CTG interpretation findings • Recognising anxiety and addressing fears of labouring women
Communication	Unit 6: Effective and timely communication	At the end of this lesson, the student midwife/midwife/ clinician will demonstrate the ability to use the principles of teamwork to listen to other members of the multidisciplinary team, and respectfully explain and defend their clinical opinion of CTG interpretation	Workshop: Problem-based learning	2 hours	The student midwife/ midwife/ clinician will demonstrate the soft skill of being able to work in a team by using role-play through listening to other members of the multidisciplinary team, respectfully explaining and defending their clinical opinion of CTG interpretation
		At the end of this lesson, the student midwife/ midwife/clinician will demonstrate the ability to listen to other members of the multidisciplinary team's clinical opinion of the CTG interpretation with respect	Workshop: Problem-based learning	1 hour	The student midwife/ midwife/ clinician will use role-play to display their ability to listen to other members of the multidisciplinary team respectfully, regarding their clinical opinion pertaining to the CTG

continued

Table 3. (continued) Validated CTG interpretation training programme outline

Exit-level outcome	Unit	Specific learning outcome	Teaching and learning strategy	Duration	Associated assessment criteria
Planning	Unit 7: Formulation of a comprehensive management plan after CTG interpretation	At the end of this lesson, the student midwife/midwife/ clinician will be competent in responding to normal-adaptive and abnormal CTG interpretation findings by formulating an individualised care plan that promotes maternal and fetal wellbeing	Workshop: Problem-based learning	4 hours	The student midwife/ midwife/ clinician will demonstrate competence in responding to normal-adaptive and abnormal CTG interpretation findings by formulating an individualised care plan that promotes maternal and fetal wellbeing
		At the end of this lesson, the student midwife/midwife/ clinician will demonstrate knowledge and understanding of the Situation, Background, Assessment, Recommendation (SBAR) instrument[38] in the SA Maternity Case Record during transfer of a high-risk woman and/or neonate to the next level of care	Workshop: Problem-based learning	2 hours	The student midwife/ midwife/clinician will be graded on their ability to comprehensively and factually complete the SBAR form prior to transferring a high-risk woman and/ or neonate to the next level of care
Evidence-based care	Unit 8: Using appropriate guidelines to inform decision-making	At the end of this lesson, the student midwife/midwife/ clinician will apply their knowledge of established guidelines to guide clinical decision-making	Didactic lecture	3 hours	The student midwife/ midwife/ clinician will be graded on their ability to integrate relevant CTG interpretation guidelines during CTG interpretation
Ethical, legal and professional practice	Unit 9: Medicolegal hazards	At the end of this lesson, the student midwife/midwife/ clinician will apply best practice standards and legal principles by ensuring accurate recording of CTG interpretation and the associated care actions	Didactic lecture	2 hours	The student midwife/ midwife/ clinician will audit completed labour records to evaluate best practice standards and legal principles by auditing the CTG interpretation records and the associated care actions

CTG = cardiotocograph; SA = South African.

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Received 15 August 2025. Accepted 27 November 2025.