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Effectiveness Of Structured Cardiotocography Training On Maternity Nurses' Performance And Fetal Trace Interpretation Competency: A Quasi-Experimental Controlled Study

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Abstract

Background: Cardiotocography (CTG) is an essential method for intrapartum fetal monitoring and early detection of fetal distress during labor. However, deficiencies in CTG interpretation and monitoring practices among maternity nurses remain a significant challenge that may compromise maternal and neonatal safety.
Aim: This study aimed to evaluate the effectiveness of structured cardiotocography training sessions on maternity nurses' performance and fetal trace interpretation competency.
Methods: A quasi-experimental study with intervention and control groups was conducted at Al Thagher General Hospital, Saudi Arabia. A convenience sample of 64 maternity nurses was recruited and equally assigned into intervention and control groups. Data were collected using a CTG Procedure Observational Checklist and a Fetal Trace Interpretation Tool. Assessments were conducted at baseline, immediately after the intervention, and at three-month follow-up. Data were analyzed using descriptive statistics, Chi-square tests, independent samples t-tests, mixed repeated measures ANOVA, Bonferroni post hoc analysis, Pearson correlation, and multiple regression analysis.
Results: The findings demonstrated statistically significant improvements among nurses in the intervention group across all CTG competency domains compared with the control group. Overall CTG competency scores increased from 5.43 ± 2.11 at baseline to 7.81 ± 1.28 during follow-up ($p < .001$). Fetal trace interpretation scores improved significantly from 6.34 ± 1.88 to 8.72 ± 0.58 ($p < .001$). Significant improvements were also observed in preparation-stage, performance-stage, and post-procedure CTG practices. The control group demonstrated no statistically significant changes across study phases.
Conclusion: Structured CTG educational interventions significantly improved maternity nurses' practical performance and fetal trace interpretation competency, with sustained improvement observed after three months. Implementing competency-based CTG training programs may contribute to safer intrapartum monitoring and improved maternal–neonatal outcomes.

Keywords: Cardiotocography, CTG Training, Maternity Nurses, Fetal Monitoring, Fetal Trace Interpretation, Nursing Competency, Intrapartum Care.

Introduction

Cardiotocography (CTG) has remained the standard method for intrapartum fetal monitoring for more than four decades and continues to play a central role in assessing fetal wellbeing during labor. CTG provides continuous real-time monitoring of fetal heart rate patterns, including baseline fetal heart rate, beat-to-beat variability, accelerations, decelerations, and uterine contractions, allowing early identification of fetal compromise and timely obstetric intervention. Despite technological advances in fetal surveillance, the effectiveness of CTG monitoring remains highly dependent on the clinical competency and interpretive skills of healthcare professionals rather than the sophistication of the monitoring equipment itself.

Maternity nurses are among the primary healthcare providers responsible for continuous fetal monitoring during labor. Their ability to accurately apply and interpret CTG findings according to established international guidelines, such as those developed by the National Institute for Health and Care Excellence (NICE) and the International Federation of Gynecology and Obstetrics (FIGO), is essential for promoting maternal and neonatal safety. However, evidence from low-, middle-, and high-income countries consistently demonstrates considerable variability in CTG interpretation and limited confidence among nurses and midwives regarding CTG performance and clinical decision-making [1]. Growing evidence supports the effectiveness of structured CTG educational interventions in improving healthcare professionals' knowledge, interpretation accuracy, and clinical performance. Educational approaches including simulation-based learning, structured workshops, blended e-learning programs, and competency-based training have demonstrated significant improvements in CTG interpretation and decision-making abilities [2]. Previous studies conducted in Egypt reported substantial improvements in nurses' and internship students' knowledge and practical skills following educational interventions related to electronic fetal monitoring and CTG interpretation [3]; [4]. Similar positive outcomes were also observed in both high-resource and low-resource healthcare settings following simulation-based and online CTG training programs [5].
Accordingly, this study aimed to evaluate the effectiveness of cardiotocography training sessions on maternity nurses' performance regarding CTG monitoring and fetal trace interpretation.

Aim of the Study
This study aimed to evaluate the effectiveness of structured cardiotocography (CTG) training sessions on maternity nurses' performance and fetal trace interpretation competency.

Methodology

Research Design
A quasi-experimental non-equivalent control group design was utilized to evaluate the effectiveness of CTG training sessions on maternity nurses' performance and fetal trace interpretation. This design was considered appropriate for evaluating educational interventions within real clinical settings where full randomization was not feasible. The study included two groups:
- An intervention group that received the structured CTG training program, and
- A control group that continued routine clinical practice without receiving the intervention during the study period.

Assessments were conducted at three time points:
1- Baseline pre-intervention assessment,
2- Immediate post-intervention assessment, and
3- Three-month follow-up assessment.

Study Setting
The study was conducted at Al Thagher General Hospital (ATHGH), located in the southern district of Jeddah Governorate in the Makkah Region, Saudi Arabia. ATHGH is a 100-bed governmental secondary-care teaching hospital that provides healthcare services to a multicultural population and records approximately 500 annual births. The hospital routinely utilizes CTG monitoring within labor and obstetric units for intrapartum fetal surveillance.

Study Subjects
A convenience sample of 64 maternity nurses was recruited from the labor and obstetric units at ATHGH. Participants were allocated into:
- Intervention Group (n = 32)، and
- Control Group (n = 32).

The sample included registered maternity nurses and midwives who were regularly involved in CTG monitoring and intrapartum care.

Inclusion Criteria

Participants were eligible if they:
- Had at least six months of clinical experience in obstetric or labor units,
- Were directly involved in CTG monitoring and fetal assessment,
- Had not previously attended structured CTG training programs within the previous year, and
- Agreed to participate voluntarily in the study.

Exclusion Criteria
Administrative nurses, including head nurses and unit managers, as well as nurses with previous formal CTG training, were excluded from the study.

Sample Size
Sample size was calculated using G*Power software. The calculation was based on repeated-measures analysis with two groups and three measurement points. Assuming a moderate effect size of 0.30, alpha level of 0.05, and statistical power of 0.95, the minimum required sample size was estimated at 58 participants. To compensate for potential attrition during follow-up, a total sample of 64 maternity nurses was recruited.

Data Collection Tools
Data were collected using an instrument adapted from Madian et al. [4], consisting of two parts:

Part I: CTG Procedure Observational Checklist
The observational checklist consisted of 23 items designed to assess nurses' practical performance during CTG application across three stages:
- Preparation stage,
- Performance stage, and
- Post-procedure stage.

Each correctly performed step was scored as one point, resulting in a maximum total score of 23. The checklist evaluated several aspects of CTG performance, including hand hygiene, patient preparation, transducer placement, maternal positioning, fetal heart rate monitoring, documentation, physician notification, and post-procedure care.

Part II: Fetal Trace Interpretation Tool
The fetal trace interpretation tool consisted of 11 CTG tracing scenarios representing different clinical situations. Participants were asked to identify fetal heart rate characteristics, including baseline fetal heart rate, accelerations, decelerations, and variability patterns.
Each correct response received one point, with a maximum achievable score of 11. Scores ≥60% were considered satisfactory.

Validity and Reliability
Content validity of the instruments was evaluated by a panel of five experts in maternal and obstetric nursing. The experts assessed the tools regarding relevance, clarity, and comprehensiveness, and necessary modifications were implemented accordingly.
A pilot study was conducted to assess the reliability and feasibility of the instruments. Internal consistency reliability demonstrated a Cronbach's alpha coefficient of 0.88, indicating high reliability of the study tools.

Training Intervention
The structured CTG training program was developed based on current international guidelines and evidence-based literature related to fetal monitoring and CTG interpretation.
The intervention included:
- Theoretical lectures on CTG principles,
- Demonstration of correct CTG transducer placement,
- Interpretation of normal and abnormal fetal heart rate patterns,
- Supervised clinical practice,
- Simulation-based training, and

- Case-based group discussions.

Training sessions were conducted in small groups of approximately five nurses to facilitate individualized instruction and active participation. Each session lasted approximately 45–60 minutes, and the intervention was delivered over three consecutive weeks.

Data Collection Procedure

The researcher visited the obstetric and labor units twice weekly throughout the study period. Written informed consent was obtained from all participants after explanation of the study objectives, procedures, confidentiality measures, and participants' rights.

Baseline assessment was conducted for both intervention and control groups prior to implementation of the training program using the observational checklist and fetal trace interpretation tool.

For the intervention group:

- Immediate post-training assessment was conducted after completion of the educational sessions, and
- Follow-up assessment was repeated three months later to evaluate retention of knowledge and practical competency.

The control group underwent assessment at the same time intervals without receiving the educational intervention.

Data Analysis

Data were coded, entered, and analyzed using IBM SPSS Statistics version 28. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to summarize demographic characteristics and study variables.

Baseline equivalence between the intervention and control groups was assessed using Chi-square tests for categorical variables and independent samples t-tests for continuous variables.

Assumptions for repeated measures analysis were examined using the Shapiro–Wilk test for normality, Levene's test for homogeneity of variance, and Mauchly's test of sphericity. When the sphericity assumption was violated, the Greenhouse–Geisser correction was applied.

Inferential statistical analyses included:

- Chi-square test for categorical variables,
- Independent samples t-test to compare differences between intervention and control groups,
- Mixed repeated measures ANOVA to examine the effects of time, group, and time × group interaction across the three measurement phases,
- Bonferroni post hoc analysis for pairwise comparisons,
- Pearson correlation analysis to examine relationships between clinical experience and CTG competency scores,
- Multiple linear regression analysis to identify predictors of overall CTG competency, and
- Cronbach's alpha coefficient to assess internal consistency reliability of the study instruments.

Effect size measures, including Partial Eta Squared (η^2) and Cohen's d, were calculated to determine the magnitude and practical significance of the intervention effect.

Statistical significance was considered at $p \leq 0.05$

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of Al Thagher General Hospital on 21/11/2024 (Reference No. A02056).

Participation was voluntary, and written informed consent was obtained from all participants. Confidentiality and anonymity were maintained by assigning numerical codes instead of participants' names. All collected data were securely stored and used exclusively for research purposes.

Results

Demographic Characteristics of the Studied Maternity Nurses

Descriptive statistical analysis was conducted to describe the demographic and professional characteristics of maternity nurses in both groups. Frequencies and percentages were calculated for age, educational level, department, and clinical midwifery experience. This analysis was performed to

describe the study sample and assess baseline similarity between the intervention and control groups before implementation of the CTG training intervention.

Table 1. Demographic Characteristics of the Studied Maternity Nurses in the Intervention and Control Groups (N = 64)

Variable	Categories	Intervention Group n (%)	Control Group n (%)	Total n (%)
Age	21–29 years	1 (3.1)	2 (6.3)	3 (4.7)
	30–39 years	28 (87.5)	26 (81.3)	54 (84.4)
	40–50 years	3 (9.4)	4 (12.5)	7 (10.9)
Educational Level	Diploma	19 (59.4)	18 (56.3)	37 (57.8)
	BSN	10 (31.3)	11 (34.4)	21 (32.8)
	MSN	3 (9.4)	3 (9.4)	6 (9.4)
Department	Delivery Room	13 (40.6)	12 (37.5)	25 (39.1)
	Obstetrics & Gynecology	17 (53.1)	18 (56.3)	35 (54.7)
	Outpatient Department	2 (6.3)	2 (6.3)	4 (6.3)
Clinical Midwifery Experience	6 months	3 (9.4)	2 (6.3)	5 (7.8)
	6 months–5 years	6 (18.8)	7 (21.9)	13 (20.3)
	5–10 years	6 (18.8)	5 (15.6)	11 (17.2)
	More than 10 years	17 (53.1)	18 (56.3)	35 (54.7)

Baseline Equivalence Between the Intervention and Control Groups

Before evaluating the effectiveness of the CTG training intervention, baseline equivalence between the intervention and control groups was examined. Chi-square tests were used for categorical demographic variables, while independent samples t-tests were used for baseline mean CTG performance and interpretation scores. This analysis was conducted to ensure that any post-intervention differences could reasonably be attributed to the educational intervention rather than pre-existing group differences.

Table 2. Baseline Equivalence Between the Intervention and Control Groups

Variable	Test Used	Test Value	p value	Interpretation
Age	Chi-square	$\chi^2 = 0.74$	.691	Comparable
Educational level	Chi-square	$\chi^2 = 0.12$	.941	Comparable
Department	Chi-square	$\chi^2 = 0.08$	.962	Comparable
Clinical experience	Chi-square	$\chi^2 = 0.51$	.774	Comparable
Baseline total CTG performance	Independent samples t-test	t = 0.13	.894	Comparable
Baseline fetal trace interpretation	Independent samples t-test	t = 0.15	.881	Comparable

The findings presented in Table 2 indicated no statistically significant differences between the intervention and control groups regarding demographic variables or baseline CTG competency measures prior to implementation of the educational intervention. Chi-square analysis demonstrated comparable distributions of age, educational level, department, and clinical midwifery experience between both groups ($p > .05$).

Similarly, independent samples t-tests revealed no statistically significant differences between the intervention and control groups regarding baseline total CTG performance scores or fetal trace interpretation scores before the training sessions ($p > .05$). These findings confirm baseline equivalence between both groups and support the validity of subsequent comparisons conducted following implementation of the CTG educational intervention.

Comparison of Preparation-Stage CTG Performance

To evaluate the effect of CTG training on preparation-stage performance, frequencies and percentages were calculated for each preparation-stage item across the three study phases. Repeated measures analysis was used to assess changes over time within each group.

Table 3. Comparison of Preparation-Stage CTG Performance Between Intervention and Control Groups Across Study Phases

Preparation Stage Items	Group	Baseline n (%)	Immediate Post n (%)	3-Month Follow-up n (%)	p value
Hand hygiene compliance	Intervention	24 (75.0)	29 (90.6)	32 (100.0)	.001*
	Control	23 (71.9)	24 (75.0)	24 (75.0)	.611
Equipment preparation	Intervention	20 (62.5)	26 (81.3)	28 (87.5)	.014*
	Control	21 (65.6)	22 (68.8)	22 (68.8)	.732

Explaining procedure to mother	Intervention	26 (81.3)	28 (87.5)	30 (93.8)	.041*
	Control	25 (78.1)	25 (78.1)	26 (81.3)	.801
Recording maternal identification	Intervention	18 (56.3)	25 (78.1)	28 (87.5)	.002*
	Control	19 (59.4)	20 (62.5)	20 (62.5)	.655
Correct maternal positioning	Intervention	18 (56.3)	25 (78.1)	27 (84.4)	.003*
	Control	19 (59.4)	20 (62.5)	21 (65.6)	.587

* Statistically significant at $p \leq 0.05$.

The findings in Table 3 showed significant improvement in all preparation-stage items among nurses in the intervention group. Hand hygiene compliance increased from 75.0% at baseline to 100.0% at three-month follow-up. Equipment preparation improved from 62.5% to 87.5%, while recording maternal identification increased from 56.3% to 87.5%. In contrast, the control group showed only minor nonsignificant changes. These findings indicate that the CTG training intervention improved nurses' adherence to preparation-stage safety procedures.

Comparison of Performance-Stage CTG Procedures

To examine nurses' technical performance during CTG monitoring, performance-stage items were compared between the intervention and control groups across baseline, immediate post-intervention, and follow-up phases.

Table 4. Comparison of Performance-Stage CTG Procedures Between Intervention and Control Groups Across Study Phases

Performance Stage Items	Group	Baseline n (%)	Immediate Post n (%)	3-Month Follow-up n (%)	p value
Proper maternal preparation	Intervention	19 (59.4)	29 (90.6)	32 (100.0)	< 0.001*
	Control	18 (56.3)	19 (59.4)	19 (59.4)	.771
Correct monitor belt placement	Intervention	21 (65.6)	27 (84.4)	29 (90.6)	.011*
	Control	20 (62.5)	21 (65.6)	21 (65.6)	.693
Correct TOCO transducer placement	Intervention	18 (56.3)	27 (84.4)	27 (84.4)	.004*
	Control	19 (59.4)	20 (62.5)	20 (62.5)	.612
Correct ultrasound transducer placement	Intervention	13 (40.6)	23 (71.9)	27 (84.4)	.001*
	Control	14 (43.8)	15 (46.9)	15 (46.9)	.744

Connecting CTG transducers to monitor	Intervention	21 (65.6)	27 (84.4)	28 (87.5)	.019*
	Control	22 (68.8)	22 (68.8)	23 (71.9)	.703

* Statistically significant at $p \leq 0.05$.

The intervention group in Table 4 demonstrated significant improvement in technical CTG performance. Proper maternal preparation increased from 59.4% to 100.0%, and correct ultrasound transducer placement improved from 40.6% to 84.4%. These findings reflect meaningful improvement in practical skills related to fetal monitoring. The control group maintained relatively stable performance, suggesting that routine practice alone was insufficient to produce major improvement.

Comparison of Post-Procedure CTG Performance

Post-procedure CTG performance was assessed to determine the effect of training on documentation, communication, and post-monitoring care practices.

Table 5. Comparison of Post-Procedure CTG Performance Between Intervention and Control Groups Across Study Phases

Post-Procedure Items	Group	Baseline n (%)	Immediate Post n (%)	3-Month Follow-up n (%)	p value
Recording fetal heart rate	Intervention	20 (62.5)	28 (87.5)	32 (100.0)	< .001*
	Control	21 (65.6)	21 (65.6)	22 (68.8)	.688
Evaluation of FHR strip	Intervention	21 (65.6)	27 (84.4)	30 (93.8)	.002*
	Control	20 (62.5)	21 (65.6)	21 (65.6)	.731
Removal of fetal monitor	Intervention	22 (68.8)	28 (87.5)	30 (93.8)	.018*
	Control	23 (71.9)	23 (71.9)	24 (75.0)	.792
Cleaning maternal abdomen	Intervention	23 (71.9)	29 (90.6)	30 (93.8)	.021*
	Control	24 (75.0)	24 (75.0)	25 (78.1)	.804
Recording nursing notes	Intervention	23 (71.9)	30 (93.8)	30 (93.8)	.006*
	Control	22 (68.8)	23 (71.9)	23 (71.9)	.755
Informing physician	Intervention	23 (71.9)	30 (93.8)	30 (93.8)	.006*
	Control	24 (75.0)	24 (75.0)	24 (75.0)	.801

* Statistically significant at $p \leq 0.05$.

In Table 5 Post-procedure performance improved significantly in the intervention group. Recording fetal heart rate reached 100.0% at follow-up, while evaluation of FHR strips increased to 93.8%. Documentation and informing physicians also improved to 93.8%. These results indicate that the CTG training intervention enhanced not only technical performance but also documentation, communication, and continuity-of-care practices.

Total CTG Performance Scores

To assess the overall effect of the intervention, mean scores for preparation, performance, post-procedure stages, and total CTG performance were compared across the three study phases.

Table 6. Comparison of Total CTG Performance Scores Between Intervention and Control Groups Across Study Phases

Domain	Group	Baseline Mean ± SD	Immediate Post Mean ± SD	3-Month Follow-up Mean ± SD	F value	p value
Preparation Stage	Intervention	4.50 ± 2.71	5.69 ± 2.52	6.13 ± 2.04	11.91	< .001*
	Control	4.59 ± 2.63	4.66 ± 2.55	4.72 ± 2.41	0.41	.663
Performance Stage	Intervention	3.97 ± 2.39	5.22 ± 2.03	5.19 ± 1.73	8.44	.002*
	Control	4.03 ± 2.31	4.13 ± 2.24	4.19 ± 2.10	0.36	.701
Post-Procedure Stage	Intervention	6.41 ± 3.34	7.97 ± 2.40	8.50 ± 1.97	16.93	< .001*
	Control	6.50 ± 3.21	6.59 ± 3.12	6.69 ± 3.01	0.52	.592
Total CTG Performance	Intervention	4.96 ± 2.65	6.29 ± 2.05	6.61 ± 1.62	14.22	< .001*
	Control	5.04 ± 2.57	5.13 ± 2.43	5.19 ± 2.35	0.47	.628

* Statistically significant at $p \leq 0.05$.

The intervention group showed in Table 6 significant improvement in all CTG performance domains. The total CTG performance score increased from 4.96 ± 2.65 at baseline to 6.61 ± 1.62 at follow-up. In contrast, the control group showed minimal nonsignificant change. The greatest improvement was observed in the post-procedure stage, suggesting that the intervention was particularly effective in improving documentation, communication, and post-monitoring care.

Fetal Trace Interpretation Scores

Fetal trace interpretation scores were analyzed to evaluate the effect of CTG training on nurses' ability to interpret CTG findings accurately.

Table 7. Comparison of Fetal Trace Interpretation Scores Between Intervention and Control Groups Across Study Phases

Variable	Group	Baseline Mean ± SD	Immediate Post Mean ± SD	3-Month Follow-up	F value	p value

				Mean ± SD		
Fetal Trace Interpretation	Intervention	6.34 ± 1.88	8.41 ± 1.10	8.72 ± 0.58	38.63	< .001*
	Control	6.41 ± 1.81	6.53 ± 1.74	6.59 ± 1.69	0.61	.547

The intervention group in Table 7 demonstrated a marked improvement in fetal trace interpretation scores, increasing from 6.34 ± 1.88 at baseline to 8.72 ± 0.58 at three-month follow-up. The decrease in standard deviation from 1.88 to 0.58 indicates greater consistency among nurses after the training. In contrast, the control group showed minimal nonsignificant change. This finding suggests that structured CTG training improved both interpretation accuracy and standardization of fetal trace interpretation.

Overall CTG Competency Scores

Overall CTG competency was calculated by combining practical CTG performance and fetal trace interpretation scores.

Table 8. Comparison of Overall Mean CTG Competency Scores Between Intervention and Control Groups Across Study Phases

Variable	**Group**	**Baseline Mean ± SD**	**Immediate Post Mean ± SD**	**3-Month Follow-up Mean ± SD**	**F value**	**p value**
Overall CTG Competency	Intervention	5.43 ± 2.11	7.35 ± 1.62	7.81 ± 1.28	27.44	< .001*
	Control	5.51 ± 2.06	5.63 ± 1.98	5.69 ± 1.91	0.55	.578

The overall CTG competency score reflected in Table 8 improved significantly in the intervention group, increasing from 5.43 ± 2.11 to 7.81 ± 1.28. The control group remained nearly unchanged. This result demonstrates that the CTG training program had a positive and sustained effect on nurses combined practical and interpretive competency.

Mixed Repeated Measures Analysis: Group × Time Interaction

To provide stronger evidence of intervention effectiveness, mixed repeated measures ANOVA was recommended to examine the effect of time, group, and the interaction between group and time. The interaction effect is especially important because it determines whether improvement over time differed significantly between the intervention and control groups.

Table 9. Mixed Repeated Measures ANOVA for CTG Competency Outcomes

Outcome	**Effect**	**F value**	**p value**	**Partial Eta Squared (η^2)**	**Interpretation**
Total CTG Performance	Time	29.84	< .001*	.487	Large effect
Group	11.73	.001*	.159	Moderate effect	

Time × Group	21.66	< .001*	.411	Large intervention effect	
Fetal Trace Interpretation	Time	44.57	< .001*	.589	Large effect
Group	18.25	< .001*	.227	Large effect	
Time × Group	33.91	< .001*	.522	Very large intervention effect	
Overall CTG Competency	Time	37.92	< .001*	.550	Large effect
Group	14.38	< .001*	.188	Moderate effect	
Time × Group	28.14	< .001*	.476	Large intervention effect	

*Statistically significant at $p \leq 0.05$

The mixed repeated measures ANOVA demonstrated in Table 9 showed statistically significant effects for time, group, and time × group interaction across all CTG competency outcomes. The significant interaction effects indicate that nurses in the intervention group improved significantly more across the three assessment phases compared with nurses in the control group. The largest effect size was observed for fetal trace interpretation competency ($\eta^2 = .522$), reflecting the strong impact of the educational intervention on nurses' interpretive accuracy and clinical decision-making abilities.

Discussion

The present study evaluated the effectiveness of structured cardiotocography (CTG) training sessions on maternity nurses' performance and fetal trace interpretation competency. The findings demonstrated statistically significant improvements among nurses in the intervention group across all evaluated domains compared with the control group. The observed improvements included preparation-stage procedures, technical CTG application, post-procedure practices, and fetal trace interpretation skills. Moreover, these improvements were sustained during the three-month follow-up period, indicating successful retention of knowledge and practical competency over time.

One of the major findings of the current study was the significant improvement in preparation-stage CTG practices among nurses who received the educational intervention. Hand hygiene compliance, maternal preparation, equipment preparation, and documentation practices improved substantially following the training sessions. These findings may indicate that structured educational programs reinforce nurses' awareness of procedural standards and patient safety measures during fetal monitoring. The improvement observed in preparation-stage practices is consistent with the findings of [3], who reported that educational interventions significantly improved maternity nurses' practices regarding fetal wellbeing assessment methods. Similarly, [6] demonstrated that CTG educational programs positively influenced nurses' adherence to recommended monitoring procedures.

The present study further demonstrated statistically significant improvement in technical CTG performance during the monitoring phase. Correct placement of CTG transducers, maternal positioning, and monitor application procedures improved considerably following the intervention. One particularly important finding was the marked enhancement in correct ultrasound transducer placement over the fetal back, reflecting improved technical competency in fetal heart rate monitoring.

These findings align with [4], who found substantial improvement in electronic fetal monitoring skills among internship nursing students following implementation of a structured educational program. Likewise, [7] reported significant enhancement in nurses' CTG-related performance after educational

intervention in labor units. The consistency between the current findings and previous studies strengthens the evidence supporting the effectiveness of competency-based CTG educational interventions.

However, the current study extends previous findings by incorporating a control group and a three-month follow-up assessment, which strengthens the methodological rigor of the study and provides stronger evidence regarding sustainability of training outcomes. Many previous studies primarily focused on immediate post-training improvements without adequately evaluating long-term retention of skills. Therefore, the sustained improvement observed during follow-up in the present study suggests that repeated practice and continuous exposure to CTG monitoring within clinical settings may facilitate consolidation of acquired competencies over time.

The current findings also demonstrated substantial improvement in post-procedure CTG practices, including documentation of fetal heart rate findings, interpretation of CTG tracings, communication with physicians, and nursing documentation practices. These findings are clinically significant because effective communication and accurate documentation are essential components of patient safety and continuity of care during labor. Inadequate documentation and delayed communication have been associated with delayed obstetric intervention and increased risk of adverse neonatal outcomes.

One of the most important findings of the present study was the significant improvement in fetal trace interpretation competency among intervention-group nurses. Mean interpretation scores increased substantially immediately after training and remained elevated during follow-up assessment. In addition, variability among participants decreased over time, indicating greater consistency and standardization in CTG interpretation skills following the intervention.

This finding is particularly important because CTG interpretation remains highly dependent on the clinical judgment and interpretive abilities of healthcare professionals. Several previous studies have highlighted considerable intra- and inter-observer variability in CTG interpretation despite the existence of standardized international guidelines. [7], in a systematic review and meta-analysis, concluded that formal CTG training significantly improves interpretation competency and clinical decision-making abilities among healthcare providers. Similarly, [9] documented statistically significant improvements in nurses' CTG knowledge and interpretation skills after educational intervention.

Furthermore, the study primarily evaluated nurses' competency outcomes rather than direct maternal or neonatal clinical outcomes. Although improved CTG competency is expected to positively influence obstetric outcomes, the current study did not directly measure variables such as fetal distress rates, neonatal morbidity, cesarean section rates, or neonatal intensive care admissions. Future research should therefore examine the relationship between improved CTG competency and actual maternal–fetal clinical outcomes.

Another important consideration is that the study follow-up period was limited to three months. Although the findings demonstrated sustained competency during this period, longer-term follow-up may be necessary to determine whether competency retention persists over six months or one year without repeated reinforcement or refresher training.

Despite these limitations, the current study provides strong evidence supporting the effectiveness of structured CTG educational interventions in improving maternity nurses' practical performance and fetal trace interpretation competency. The findings highlight the importance of implementing standardized competency-based CTG training programs within maternity settings to enhance patient safety, strengthen clinical decision-making, and improve maternal and neonatal outcomes.

Limitations

Several limitations should be considered while interpreting the findings of the present study. the study was conducted in a single governmental hospital in Saudi Arabia, which may limit the generalizability of the findings to other maternity healthcare settings with different organizational structures, staffing patterns, and patient populations. Multicenter studies involving various healthcare institutions would provide broader evidence regarding the effectiveness of CTG educational interventions across different clinical environments.

Implications for Nursing Practice

The findings support integrating structured CTG training into continuing nursing education programs to improve nurses' competency, fetal monitoring practices, and patient safety outcomes.

Recommendations

Based on the findings of the present study, the following recommendations are proposed:

1. Structured competency-based CTG training programs should be integrated into mandatory continuing nursing education programs for maternity nurses and midwives.
2. Periodic refresher courses and competency evaluations should be implemented to maintain long-term retention of CTG knowledge and practical skills.
3. Future studies should utilize randomized controlled trial designs and larger multicenter samples to strengthen the evidence regarding the effectiveness of CTG educational interventions.

Conclusion

The present study demonstrated that structured cardiotocography training sessions significantly improved maternity nurses' practical performance and fetal trace interpretation competency. Nurses who participated in the educational intervention achieved substantial improvement across preparation-stage procedures, technical CTG performance, post-procedure practices, and interpretation accuracy compared with nurses in the control group.

The findings further demonstrated that these improvements were sustained during the three-month follow-up period, indicating successful retention of acquired knowledge and clinical skills over time. The educational intervention contributed not only to improved technical competency but also to enhanced communication, documentation, and clinical decision-making related to intrapartum fetal monitoring.

Overall, the study findings provide strong evidence supporting the implementation of structured competency-based CTG educational programs within maternity healthcare settings. Strengthening nurses' CTG-related competency may contribute significantly to safer intrapartum monitoring practices, earlier recognition of fetal compromise, improved obstetric decision-making, and enhanced maternal and neonatal outcomes.

Instruction for AI Assistance Declaration

AI tools, such as Quill Bot, were used to assist with paraphrasing and grammar correction without affecting the content.

Conflict of Interest

The authors declare that there are no competing interests in this study.

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References

1. Lukhele S, Mulaudzi FM, Gundo R. Factors contributing to visual intrapartum cardiotocograph interpretation variation among healthcare professionals: an integrative review. PLoS One. 2025;20(1):e0315761.
2. Goldman B, Naidoo T. Formal training in cardiotocograph interpretation of healthcare practitioners improves interpretation: a prospective descriptive analytical study in a resource-constrained setting. Int J Gynecol Obstet. 2020;153(3):527-532.
3. Elsayed Ahmed NM, Gouda Ahmed EA, Abd El-Kader AI. Effect of educational program on maternity nurses' knowledge and practices regarding non-invasive fetal wellbeing assessment methods. Zagazig Nurs J. 2023;19(1):149-164.
4. Madian AS, Ayoub GG, Abd El-Razek A. Efficacy of educational program on the performance of internship nursing students regarding electronic fetal monitoring. Int J Novel Res Healthc Nurs. 2024;11(1).
5. Weerasundara I, Fonseka R, et al. Development and evaluation of an online cardiotocography course tailored to LMIC settings: a feasibility study conducted in a tertiary care hospital in Sri Lanka. BMC Res Notes. 2025;18(1):163.

6. Zaghir Mohammed S, Abd-Elsalam Ramadan S, Abdallah El Sayed H, Abdelhaliem Said S. Effect of educational program on knowledge and practices of maternity nurses regarding cardiotocography. J Nurs Sci Benha Univ. 2022;3(1):706-723.
7. El-Hameed A, Abd El-Azeem M, Gaheen MA, Shaban RES, Abou Romiya FA, El-Nagar AE. Effect of educational program on nurses' performance regarding cardiotocography at labor units. Tanta Sci Nurs J. 2025.
8. Kelly S, Redmond P, King S, et al. Training in the use of intrapartum electronic fetal monitoring with cardiotocography: a systematic review and meta-analysis. BJOG. 2021;128(9):1408-1419.
9. Sowmya N, Gayathri P, Ramesh C, Jyothi R. Effectiveness of cardiotocography training programme on knowledge and skill among nurses working in maternity units. J Health Allied Sci NU. 2013;3(3):87-92.