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Development and evaluation of an online cardiotocography course tailored to LMIC settings: a feasibility study conducted in a tertiary care hospital in Sri Lanka

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Abstract

Objective Effective cardiotocography (CTG) training is crucial for accurate interpretation and timely interventions in low-resource settings. This mixed-method study in Sri Lanka developed and assessed an online CTG course to address training gaps and improve neonatal outcomes. The study involved a clinical audit, course development, implementation, and evaluation via the Kirkpatrick model.

Results The audit revealed lapses in CTG documentation, interpretation, and interventions. The posttest scores improved by 40.6% (152.8%), but some participants did not complete the course because of a lack of motivation, time constraints, and inadequate facilities. Postimplementation audits revealed improvements in practices, although uterine contraction documentation and overall impression recording declined. The findings suggest the feasibility and effectiveness of online self-learning courses in improving CTG knowledge and practices in Sri Lanka. However, motivation, incentives, and reinforcement measures are needed for better outcomes.

Keywords Cardiotocography, Feasibility studies, Health personnel education, Internet-based intervention, Program evaluation

Introduction

Cardiotocography (CTG) is an integral component of intrapartum fetal monitoring. It is an early recognition system and an intervention to prevent obstetric and neonatal complications [1]. Inaccurate CTG interpretation may lead to considerable obstetric complications [2], litigation [3] and unnecessary interventions [4].

Many countries provide CTG training to their obstetric teams, which mostly leads to improved knowledge, interpretational skills and overall outcomes [5]. However, many of these existing training courses are conducted in resource-rich countries and do not adequately address the shortcomings that exist in LMICs, such as costly adjuncts for fetal assessment [6]. Furthermore, caregivers in LMICs do not have easy access to many CTG courses available [7–9].

Sri Lanka has favorable key maternal and newborn care indicators, especially compared with other

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LMICs; however, previous studies suggest gaps in fetal monitoring and CTG interpretation [10, 11]. Within the framework of a comprehensive quality improvement study, we developed and pilot-tested a freely accessible web-based course on CTG interpretation to increase the knowledge and skills of healthcare professionals in maternity services. This paper delineates the process of development, initial pilot testing and feasibility assessment of this web-based CTG training course in Sri Lanka prior to its full-scale implementation.

Methods

The study was conducted in four distinct phases from May 2019 to June 2022. It was implemented at the Professorial Unit, De Soysa Hospital for Women (DSHW), Colombo, Sri Lanka. The methodology of this cycle is delineated below in Fig. 1. We used the Kirkpatricks model [12] for the evaluation of the course.

Phase 1- Audit of cases of fetal distress

A retrospective audit of all the clinical records of women diagnosed with fetal distress over a 6 month period (May 2019—October 2019) was conducted. Cases were identified from the birth registry and reviewed by two experts, and findings were recorded in an audit proforma and subsequently analyzed. The audit proforma (supplementary file 1) was developed on the basis of the standards for case management established by the National Institute of Clinical Excellence (NICE) [13], the International Federation of Gynecology and Obstetrics [14] and the Sri Lanka College of Obstetricians and Gynecologists (SLCOG) [15]. During the review process, practices of the reference standards in applicable cases were recorded under three categories: documentation, interpretation, and interventions. The findings of the audit were presented at an audit meeting where major gaps in management were identified, and the decision to develop an online course on CTG was made.

Phase 2—Course development

A literature review on CTG interpretation was conducted utilizing the Google Scholar and PubMed databases for articles published between 31st January 2012 and 31st January 2020. Additionally, the websites of key organizations involved in the training of intrapartum caregivers (Federation of Obstetrics and Gynecology, Royal College of Obstetrics and Gynecology, Society of Obstetricians and Gynecologists of Canada, World Health Organization, National Institute of Clinical Excellence, Sri Lanka College of Obstetrics and Gynecology) were examined. All relevant articles were reviewed for citations not

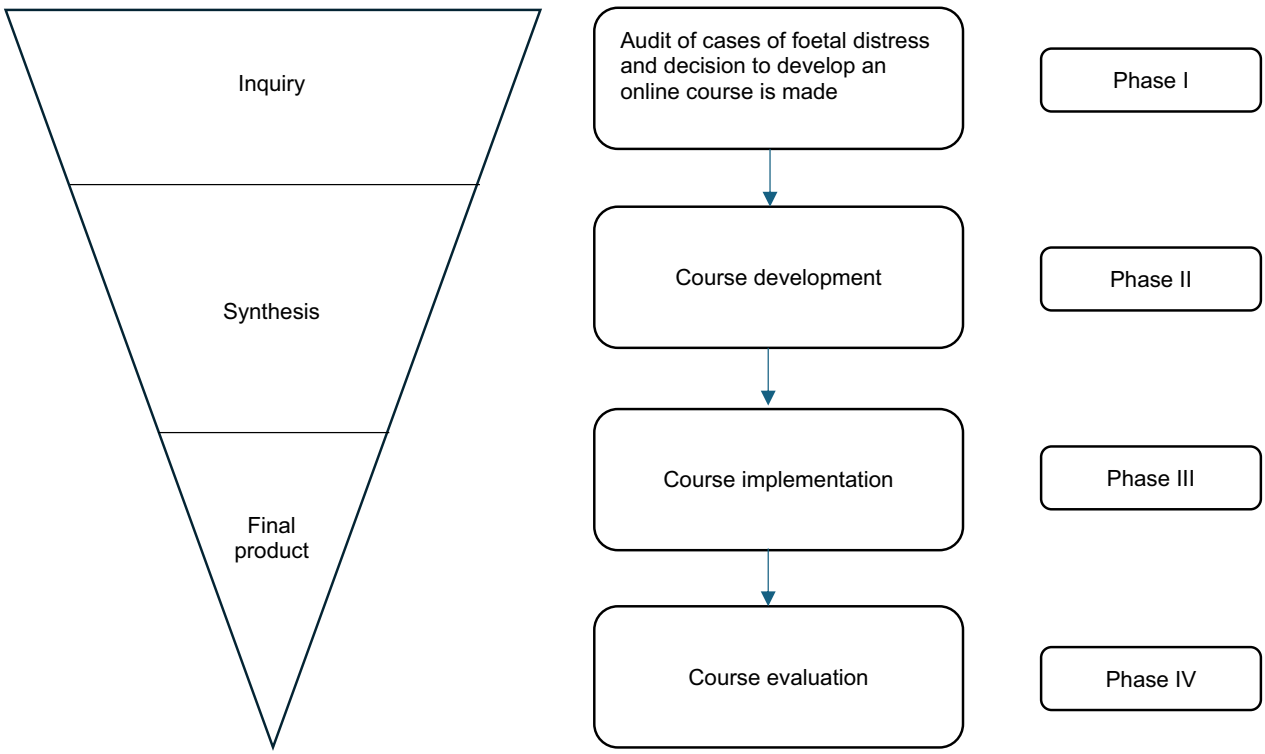

Fig. 1 Course synthesis and evaluation process

included in the initial search. The search was executed by a three-member team, including a consultant obstetrician, and was restricted to articles published in the English language. The relevant articles were identified by the search team through examination of titles and abstracts for course development.

Phase 3—Course implementation

This phase included peer review of the course content and structure, optimization, piloting and implementation among the caregivers. This phase commenced in May 2021 and continued for a duration of six months.

The online course for CTG interpretation was developed and hosted in the domain www.obssl.edu.lk. The ADDIE model (Analysis, Design, Development, Implementation and Evaluation) [16] of instructional material design, a standard framework utilized in the design and development of training courses, was applied. Feedback was utilized to optimize the course content, CTG graphics and pre/posttests prior to course launch. Doctors and midwives/nurses employed in the unit were invited to enroll and participate in the course. Additionally, final-year medical students and caregivers from other units of the same hospital were invited to enrol. During this period, no alternative CTG courses were conducted to educate the caregivers. A helpline was established to support participants during the course, reminder e-mails were dispatched to participants demonstrating a lack of progress and those who did not complete the course within the allocated timeframe.

Phase 4—Course evaluation

This phase comprised obtaining pretest and posttest scores of participants who completed the course, providing formal online feedback from all participants, and conducting mini telephone interviews with participants who failed to complete the course to explore the reasons. This phase commenced in November 2021 to June 2022. Anonymized and aggregated data, including pretest and posttest scores along with participant feedback, were gathered and analyzed, and statistical significance was assessed via a paired sample t test.

Finally, a reaudit of clinical practices in the professorial unit was conducted at a point when all ward staff had participated and completed the online course. Clinical records of mothers with fetal distress from January 2022 to June 2022 were retrieved and analyzed by the same clinical experts using the identical audit proforma. This component was used to evaluate changes in the clinical practices of the caregivers.

Results

Phase 1

A retrospective audit was conducted on 69 clinical records of women diagnosed with fetal distress between May 2019 and October 2019. The age range of the subjects was 18–44 years, with a mean age of 26.8 years. The majority of the women were primiparous, and most infants were delivered between 37 + 0 weeks and 40 + 6 weeks of gestation. The predominant risk factors observed in the majority of women included gestational diabetes, gestational age > 40 weeks, and small for gestational age.

The documentation and interpretation of key parameters and interventions were reviewed by the clinical experts, with reference to standard practice guidelines. There were notable deviations from guidelines, with key parameters such as uterine contractions (2.9%), maternal temperature (4.3%) and maternal risk factors (7.2%) poorly documented. Conversely, a separate group of parameters were well documented, including the name of the mother (81.2%), CTG paper speed at 1 cm/hour (79.7%), and date and time (76.8%).

Although in most cases (91.3%), there was evidence that the CTG was seen by the relevant doctor, slightly more than half of the cases (54.5% and 54.8%, respectively) had their overall impressions recorded and their clinical context appropriately documented. In most cases (94.2%), there was no record of previous CTG traces being appropriately considered or compared with the CTGs that led to interventions. Similarly, acceleration (81.2%) and the baseline heart rate (79.7%) were not accurately documented or interpreted.

Analysis of the documented interventions revealed that senior team members, such as the Consultant or Senior Registrar, were informed regarding the CTG in 98.4% of the cases and that oxytocin infusion was discontinued immediately in response to abnormalities in the CTG in 96.4% of the cases. However, in the majority of patients, continuous CTG was not recommended despite indications (83.3%). In addition, in many patients with an indication, there was no documentation of positioning in the left lateral position (72.1%).

Overall, major lapses in case management identified by the audit included poor documentation (94.2%), unnecessary interventions for nonpathological CTGs (68.1%), incorrect interpretation of CTGs (65.2%), and not positioning in the left lateral position (72.1%).

Phase 2

The literature search carried out on Google Scholar and PubMed identified 493 results, and 16 records

were identified through a website search. A total of 76 duplicates and 402 nonrelevant articles were excluded. A total of 31 records were included for review. These included eight academic publications [17–24], eleven international guidelines [13–15, 25–32], five hospital guidelines [33–37], two web-based learning courses [38, 39] and two web-based CME web resources [40, 41], along with three standard textbooks [42–44], to ensure the inclusion of essential content.

Phases 3 and 4

During the study period, 113 participants registered for the course, and 53 (46.9%) successfully completed it during the given three-month period. Medical officers and intern medical officers constituted more than half the participants (52.8%), whereas only nine medical students participated.

All 133 participants provided feedback, which was mostly positive. The feedback provided to the participants is shown in Table 1.

Analysis of the pretest and posttest scores of the 53 participants revealed pretest scores ranging from 0 to 91% (average 26.53%) and posttest scores ranging from 0 to 100% (average 67.08%). Almost all (96.2%) achieved a comparatively higher posttest score. A submission error was found to cause two posttest marks to be 0. The average improvement was 40.55 points (a 152.84% increase) out of 100 points. A paired sample t test revealed a statistically significant difference ($p < 0.001$).

Among the 60 participants who did not complete the course, the majority (70.0%) cited a lack of motivation as the primary reason for discontinuation. Time constraints were reported by 20.0% of the participants, whereas 6.7% attributed their inability to continue to lack a proper device or adequate internet access. The remaining 3.3% did not specify a reason.

A reaudit of clinical practices was conducted 6 months post-intervention (January—June 2022) using the same audit proforma and categories as Phase 1. Clinical records of 101 mothers with fetal distress were reviewed by the same clinical experts.

The majority of fetal assessment parameters improved following the implementation of the online course (Table 2).

Discussion

This study represents an inaugural online Sri Lankan course designed to enhance the knowledge and interpretation of CTGs among healthcare professionals. We aimed to evaluate the effectiveness of the course on the basis of the Kirkpatrick four-level model of training [12]: a model that classifies the outcomes of a course as related to learners' reactions, learning as a result of training, behaviors following training, and clinical outcomes. The initial response from the participants was highly favorable, indicating that the course achieved Kirkpatrick Level 1. Numerous similar courses have documented positive learner experiences postcourse [45, 46], and observing this response toward a novel course is not unexpected.

The course encountered significant challenges during implementation; the primary challenge was participants' deceleration or cessation of progress due to diminished motivation. These findings are not atypical in online

Table 1 Feedback of the participants (n = 113)

Question	Strongly disagree, n (%)	Disagree, n (%)	Neither agree nor disagree, n (%)	Agree, n (%)	Strongly agree, n (%)
Learning objectives were clearly mentioned	3 (2.7)	0 (0.0)	0 (0.0)	35 (31.0)	75 (66.4)
Learning objectives were appropriate to the course (missing = 1)	2 (1.8)	0 (0.0)	0 (0.0)	35 (31.3)	75 (67.0)
Presentation slides were clear and easy to understand	2 (1.8)	0 (0.0)	4 (3.5)	29 (25.7)	78 (69.0)
Content covered in this course was relevant to my work setting	2 (1.8)	0 (0.0)	3 (2.7)	27 (23.9)	81 (71.7)
Audio narration was clear and consistent throughout the course (missing = 3)	1 (0.9)	1 (0.9)	2 (1.8)	35 (31.8)	71 (64.5)
Visual aids used were appropriate (missing = 1)	2 (1.8)	1 (0.9)	1 (0.9)	34 (30.4)	74 (66.1)
Pre course assessment and post course assessment were consistent with the learning objectives (missing = 2)	2 (1.8)	1 (0.9)	1 (0.9)	42 (37.8)	65 (58.6)
Pre course assessment and post course assessment were appropriately challenging (missing = 2)	4 (3.6)	0 (0.0)	1 (0.9)	37 (33.3)	69 (62.2)
Supplementary reading materials were clearly stated to support student success (missing = 3)	2 (1.8)	0 (0.0)	2 (1.8)	45 (40.9)	61 (55.5)
The overall delivery of the course will improve my patient care (missing = 1)	2 (1.8)	0 (0.0)	2 (1.8)	31 (27.7)	77 (68.8)

Table 2 Comparison of audit and reaudit findings between 2019 and 2022

Documentation	Applicable and appropriate* (2019 %)	Applicable and appropriate* (2022)
CTG Paper speed set at 1 cm/hour (SLCOG)	55 (79.7)	101 (100)
The date and time settings validated on the machine and noted on the CTG (SLCOG)	53 (76.8)	100 (99.0)
Name of the mother documented on the relevant CTG (SLCOG)	56 (81.2)	100 (99.0)
Age of the mother documented on the relevant CTG (SLCOG)	6 (8.8)	0 (0.0)
BHT number documented on the relevant CTG (SLCOG)	36 (52.2)	94 (93.1)
Maternal risk factors appropriately documented (SLCOG)	5 (7.2)	101 (100)
Maternal pulse rate documented (NICE/SLCOG)	9 (13.0)	101 (100)
Maternal temperature documented (NICE)	3 (4.3)	95 (94.1)
Uterine contractions documented (NICE)	2 (2.9)	58 (57.4)
Fetal heart rate documented (NICE)	7 (10.1)	101 (100)
Interpretation		
The CTG was interpreted and attended to immediately (GPP)	63 (91.30)	93 (98.9)
Baseline heart rate documented (FIGO, NICE, SLCOG)	14 (20.29)	101 (100)
Accelerations accurately documented (FIGO, NICE, SLCOG)	13 (18.84)	5 (17.9)
Deceleration interpreted accurately and documented (FIGO, NICE, SLCOG)	19 (27.54)	57 (81.4)
Maternal uterine contractions noted and documented (FIGO, NICE, SLCOG)	13 (18.84)	27 (29.7)
Overall impression of the CTG has been recorded (SLCOG)	34 (54.84)	48 (51.1)
Interventions		
Oxytocin infusion stopped immediately in response to the CTG (FIGO, NICE, SLCOG)	27 (96.4)	28 (90.3)
Continuous CTG was advised (FIGO, NICE, SLCOG)	10 (16.7)	37 (40.7)
A repeat CTG was performed (FIGO, NICE)	46 (73.0)	45 (46.9)
Patient placed in the left lateral position (FIGO, NICE, SLCOG)	17 (27.9)	19 (95.0)
IV fluids were administered (FIGO, NICE)	14 (58.3)	18 (94.7)
Seniors were informed regarding the CTG (NICE, SLCOG)	62 (98.4)	96 (99.0)
A vaginal examination was performed (SLCOG)	41 (64.0)	76 (76.8)
Cervical dilation noted (GPP)	43 (65.2)	74 (74.7)

SLCOG Sri Lanka College of Obstetricians and Gynecologists, *FIGO* The International Federation of Gynecology and Obstetrics, *NICE* The National Institute of Health and Care Excellence, *GPP* Good practice point

* The denominator for these values is the cases where the particular standard is applicable

courses; in one massive open online course, substantial decreases in average certificate rates were observed [47], and student-specific demographic and social factors have been associated with reduced user engagement in such courses [48]. As Sri Lanka lacks a mandatory requirement or incentive for continuous medical education (CME), there is no compelling impetus for caregivers to complete the course and obtain certification. To increase caregiver motivation for CME activities, authorities should initiate CME and introduce compulsory training and revalidation courses. Until such measures are implemented, appropriate strategies for incentivizing such a course should be developed.

Current evidence demonstrates that comparable training programmes enhance participants' knowledge [49, 50]. Similarly, our study revealed a statistically significant improvement in posttest scores across all categories among those who completed the course (Kirkpatrick level 2). Changes in participant behavior following CTG training (Kirkpatrick level 3) were evaluated in the reaudit phase conducted subsequent to the implementation and utilization of the course by ward staff. This demonstrated an improvement in the majority of key clinical parameters, particularly in the documentation and intervention aspects, with less substantial improvement regarding CTG interpretation.

Notably, turning the mother to the left lateral position and administering IV fluids in appropriate cases resulted in marked improvement, which is a simple yet potentially life-saving intervention for the mother and fetus. Notably, certain previously adequate parameters were observed to have deteriorated, specifically, recording the overall impression of the CTG, repeating CTG where appropriate and discontinuing oxytocin infusion in response to the CTG. These represent areas for further emphasis and reinforcement, and subsequent audit

cycles should be conducted to enhance these practices. The introduction of a protocol and a CTG checklist may facilitate improvements in these practices in the future. It has also been reported that CTG knowledge was maintained for up to seven months following training courses [49, 51]. Studies indicate that frequent, repetitive testing with feedback may be more efficacious than review sessions [52, 53].

Conclusions

This study demonstrates the feasibility and efficacy of an online self-learning cardiotocography training course designed for healthcare professionals in LMIC settings, with a particular emphasis on Sri Lanka. The course addressed critical deficiencies in CTG interpretation and documentation, which were identified through a retrospective audit. Despite significant improvements in participants' knowledge and certain clinical practices, challenges such as low completion rates due to a lack of motivation and time constraints were notable impediments. These findings emphasize the necessity for healthcare educators and administrators to implement strategies that incentivize course completion and promote behavior change.

Limitations

A limitation of this study is the inability to correlate course success with Kirkpatrick level 4, as clinical outcomes such as intrapartum deaths, seizures, NICU admission rate and hypoxic ischemic encephalopathy were not assessed owing to feasibility issues. Nevertheless, numerous studies have demonstrated improvements in APGAR scores and reduced rates of hypoxic ischemic encephalopathy following the implementation of training courses in obstetric emergencies [54]. Additional limitations include the lack of a large number of participants and the absence of a control group. A multicenter study involving different similar settings and a control arm will be conducted in the future.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13104-025-07239-7.

Supplementary material 1.

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Author contributions
MR, RF and IW conceptualized and wrote the paper. AA, RF, MSDW, HS and ML revised the paper. All authors read and approved the final manuscript.

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Availability of data and materials
The dataset supporting the findings of this project is available from the authors upon request.

Declarations

Ethics approval and consent to participate
Ethics review Committee approval was obtained from the Ethics Review Committee of Faculty of Medicine, University of Colombo, Sri Lanka (EC/18/128). Patient data were anonymized prior to analysis. Informed consent was obtained from course participants via a Google consent form. All methods of this study were performed in accordance with the ethical principles of the Declaration of Helsinki for medical research involving human subjects.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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