

Effect of a Culturally Adapted Birth Preparedness and Complication Readiness Training Intervention on Knowledge Attitudes and Practices among Hehe Pregnant Women in Rural Iringa Tanzania a Controlled Pretest Posttest Quasi Experimental Study

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Abstract

Background

Birth preparedness and complication readiness (BPCR) is a key strategy for improving maternal and neonatal outcomes; however, educational materials developed through direct translation may not adequately reflect local cultural and linguistic contexts. This study evaluated the effectiveness of a culturally adapted BPCR education programme developed using the Cultural Equivalence Model of Translation among pregnant women attending antenatal care clinics in rural Tanzania.

Methods

A controlled pretest–posttest quasi-experimental study was conducted among 176 pregnant women (88 intervention; 88 control) attending ANC clinics in two rural districts of Iringa Region, Tanzania. Participants in the intervention group received culturally adapted BPCR education, whereas the control group received the standard translated BPCR manual. BPCR knowledge, attitudes, and practices were assessed before and after the intervention using structured questionnaires. Independent-samples and paired t-tests compared between- and within-group differences. Difference-in-Differences regression and multiple linear regression analyses were performed to estimate intervention effects while adjusting for baseline characteristics and potential confounders.

Results

Baseline knowledge and practice scores were comparable between groups, although the intervention group had significantly lower attitude scores ($p < 0.001$). Following the intervention, the intervention group achieved significantly higher knowledge (38.49 ± 7.54 vs. 32.70 ± 5.61 ; mean difference = 5.79, $p < 0.001$) and practice scores (9.60 ± 1.40 vs. 9.03 ± 1.58 ; mean difference = 0.57, $p = 0.012$) than the control group, while post-intervention attitude scores did not differ significantly ($p = 0.482$). Within-group analyses demonstrated significant improvements in knowledge, attitudes, and practices in the intervention group (all $p < 0.001$). DID analysis confirm significantly greater improvements attributable to the intervention for knowledge ($\beta = 7.18$, $p < 0.001$), attitudes ($\beta = 2.55$, $p = 0.006$), and practices ($\beta = 0.99$, $p = 0.010$). After adjustment for baseline measures and sociodemographic characteristics, intervention exposure remained the only independent predictor of higher post-intervention knowledge ($\beta = 5.88$, 95% CI: 3.84–7.92; $p < 0.001$) and, together with baseline practice, significantly predicted post-intervention practice scores ($\beta = 0.66$, 95% CI: 0.20–1.11; $p = 0.005$).

Conclusions

Culturally adapted BPCR education was more effective than the standard translated educational manual in improving pregnant women's BPCR knowledge, attitudes, and practices. Integrating culturally and linguistically adapted educational materials into routine ANC services may enhance maternal health communication and strengthen birth preparedness in rural settings. Further research should evaluate the long-term effectiveness, scalability, and cost-effectiveness of culturally adapted maternal health education interventions.

Trial registration

Pan African Clinical Trials Registry: Current Controlled Trials PACTR202607626025411, registered retrospectively on 09 July 2026 <https://pactr.samrc.ac.za> Retrospectively registered.

Background

Maternal and neonatal mortality remain major global public health challenges, particularly in low- and middle-income countries. Globally, an estimated 260,000 women die annually from preventable maternal causes, corresponding to a maternal mortality ratio of 197 per 100,000 live births (1, 2, 3). Likewise, for neonates, about 2.3 million neonatal deaths are caused by factors that were preventable (3, 4). In Sub-Saharan Africa maternal deaths was 442 per 100,000 which accounted for 70% of global fatalities, a substantial proportion of deaths, reflecting inequalities in access to timely and quality maternal health services (1, 2, 3).

Tanzania is among of the countries that experience a high maternal mortality burden, with maternal mortality remaining above global targets despite improvements in maternal health services (5). A large number of these deaths are associated with three critical delays: the delay in recognizing danger signs, the delay in deciding to seek care, and the delay in reaching appropriate healthcare facilities (6, 7, 8).

Most maternal and neonatal deaths result from preventable obstetric complications, including postpartum hemorrhage, hypertensive disorders, sepsis, and obstructed labor, which can rapidly become fatal without timely and appropriate care (9). These outcomes are closely linked to delays in seeking, reaching, and receiving care, which are described in the Three Delays Model (10). The first delay pertains to decision-making within households and is significantly affected by a lack of awareness regarding danger signs, socio-cultural beliefs, and insufficient birth preparedness (11).

Birth Preparedness and Complication Readiness (BPCR) is widely recognized as a crucial strategy to reduce these delays by encouraging pregnant women and their families to plan for childbirth while anticipating emergencies (12). The major components of the strategy are recognizing danger signs (during pregnancy, delivery, the postnatal period, and in the newborn) and birth preparedness and complications readiness (arranging transport, saving money, identifying blood donors, and skilled birth attendants) (13, 14, 15). The evidence indicates that BPCR interventions can improve knowledge, foster positive attitudes, and enhance timely utilization of health services (16).

Despite the BPCR intervention being integrated into antenatal care (ANC) in all health facilities globally and nationally, women's BPCR knowledge and practice remain suboptimal in many rural settings, including Tanzania, particularly in Iringa region where it is 11% (17, 18). In many countries, a significant portion of

the population resides in rural areas, where they maintain their cultural practices and speak their own languages, as seen in the Hehe community in the Iringa region (19, 20). The existing BPCR education materials rely on standardized health education, which often literally translates medical concepts into widely spoken languages, such as Swahili, without considering local cultural and linguistic contexts (21, 22). Literal translations may not convey the intended meaning of medical concepts, particularly in communities where indigenous languages and cultural interpretation strongly influence health behavior, as they are shaped by local dialects and cultural frameworks, including the Hehe community (23). This gap hinders comprehension, reduces engagement, and ultimately limits behavior change.

The Cultural Equivalent Theory by Nida, emphasizes the importance of adapting health interventions to ensure semantic, conceptual, and contextual relevance to the target population (24). Applying this approach to BPCR training may enhance understanding, improve attitudes, and promote appropriate practices by aligning health messages with community-specific meanings and expressions (16). Evidence suggests that culturally tailored approaches incorporating adapted health education interventions may effectively address these gaps. Such approaches involve the integration of locally meaningful terminologies and contextualized communication strategies, which may enhance comprehension, acceptability, and cultural relevance of health messages (25). These approaches enhance comprehension, acceptability, and cultural relevance. However, evidence on the effectiveness of culturally adapted BPCR interventions developed through participatory cultural adaptation processes in Tanzania remains limited.

Therefore, this study aimed to evaluate the effect of a Culturally Adapted Birth Preparedness and Complication Readiness (CABPCR) education programme, delivered using the Culturally Equivalent Modified Training Manual (CEMTM), compared with a Standard Translated BPCR (STBPCR) education programme delivered using the Standard Translated Manual (STM), on knowledge, attitudes, and practices among indigenous Hehe pregnant women in the Iringa Region of Tanzania.

Methods and materials

Study design, and setting

A controlled pretest–posttest quasi-experimental design with multistage cluster-based allocation was employed to evaluate the effect of the CABPCR education programme delivered using the CEMTM, compared with the STBPCR education programme delivered using the STM, on pregnant women's BPCR knowledge, attitudes, and practices. Two districts in the Iringa Region were purposively selected based on their predominantly rural characteristics, similarity in maternal healthcare services, and suitability for implementing a culturally adapted BPCR intervention. One district was assigned to the intervention group and the other to the control group. Within each district, divisions, wards, and villages were selected using random sampling procedures. The intervention and control groups were implemented within their respective districts, with selected health facilities participating according to the assigned study arm. The control group received routine ANC services together with a standard translated BPCR manual that had not undergone cultural adaptation, while the intervention group received the culturally adapted BPCR training. Participants from selected health facilities were recruited using systematic sampling procedures.

Baseline comparability between the intervention and control groups was assessed before implementation of the intervention. To minimize contamination between study arms, the intervention and control groups were implemented in geographically separate districts, reducing the likelihood of interaction and exchange of intervention-related information among participants. This design enabled assessment of changes in BPCR knowledge, attitudes, and practices over time and allowed comparisons of outcomes both within and between study groups.

The study was guided by four complementary theoretical frameworks. Cultural Equivalence Theory (24) informed the development and cultural adaptation of the CABPCR education programme and the CEMTM, ensuring linguistic, conceptual, and contextual equivalence of educational messages. The Theory of Planned Behavior (26) provided the behavioral framework by proposing that improvements in knowledge and attitudes enhance behavioral intentions, which subsequently influence BPCR practices. The Health Belief Model (27) supported the educational emphasis on increasing awareness of obstetric danger signs, perceived susceptibility and severity of pregnancy complications, perceived benefits of birth preparedness, and motivation to adopt recommended BPCR behaviors. The Three Delays Model provided the maternal health context by highlighting how improved birth preparedness and complication readiness can reduce delays in deciding to seek care and reaching appropriate health facilities, thereby contributing to improved maternal and neonatal outcomes (28).

The study was conducted in Kilolo and Mufindi districts of the Iringa Region, located in the southern highlands of Tanzania. Baseline data were collected from 18 to 21 November 2025, while post-intervention data were collected from 16 to 19 December 2025. The study area is predominantly rural and mainly inhabited by the indigenous Hehe ethnic group, whose cultural beliefs, traditional practices, and language (Kihehe) may influence maternal health behaviors, including BPCR (29). Maternal healthcare services in the study area are provided through dispensaries, health centers, and hospitals, with ANC serving as the primary entry point for maternal healthcare. ANC coverage in the Iringa Region is approximately 81% (5, 30). Despite relatively high ANC utilization, challenges remain regarding birth preparedness, recognition of maternal and newborn danger signs, and timely utilization of skilled birth attendance, particularly in rural communities. Therefore, the study was conducted among pregnant women attending routine ANC services at selected health facilities to evaluate the effect of a culturally adapted BPCR intervention and to explore culturally relevant factors influencing BPCR among indigenous Hehe pregnant women.

Characteristics of participants

Inclusion criteria

The study included pregnant women in their first and second trimesters attending antenatal care services in the selected health facilities. Women in the third trimester were excluded to allow sufficient time for participation in the intervention and follow-up assessments. Eligible participants were indigenous women of the Hehe ethnic group who had resided in the Iringa Region for at least six months. Additionally, participants were required to be physically and psychologically stable and willing to provide informed consent to participate in the study.

Exclusion criteria

Pregnant women working within the health system were excluded due to their prior exposure to maternal health education, including BPCR content. Women who were already enrolled in other research studies or health programs were also excluded to avoid potential interference with the intervention. Furthermore, pregnant women who developed complications during the study period, such as pregnancy-induced hypertension or intrauterine fetal death, as well as those with pre-existing medical conditions such as heart disease or stroke, were excluded due to the likelihood of limited participation in study activities. Women who declined to provide informed consent were also excluded.

Sample size and sampling techniques

Sample size

The sample size was determined using WinPepi software (version 11.65) based on detecting a difference in mean knowledge scores between intervention and control groups, with a 95% confidence level and 80% statistical power (31). The expected variability of the outcome was obtained from a previous quasi-experimental study conducted in a comparable low-resource setting (32), where standard deviations for the intervention and control groups were 5.2 and 3.4, respectively, and used to inform variability estimates. The minimum required sample size was 149 participants. After adjusting for a 10% non-response rate, the final sample size was 164 participants (82 per group). However, for practical reasons related to the standard class size of 14–15 learners, the current study included 10.25 learners, which is estimated to be 11 learners from 8 selected villages, resulting in a total of 88 participants per group and 176 participants across the two groups. A total of 176 participants completed both baseline and post-intervention assessments and were included in the final analysis. There was no participant missed during post intervention data collection.

Sampling technique and group allocation

A multistage sampling technique was used. Two districts were purposively selected based on rural characteristics and cultural homogeneity, followed by random selection of divisions, wards, and villages within each district. At the health facility level, eligible pregnant women were selected using systematic sampling from antenatal care registers, whereby every kth eligible attendee during the recruitment period was enrolled. Due to the quasi-experimental design, districts were assigned to study arms, with one district allocated to the intervention group receiving culturally adapted Swahili BPCR training and the other serving as the control group receiving direct, Swahili-translated BPCR education materials, which was the standard education. The allocation was non-random at the cluster level. Individual random allocation was not performed. Instead, cluster-based allocation was used. The study sites were allocated at the district level, with selected districts assigned to either the CABPCR intervention condition or the STBPCR control condition. The allocation process was determined before participant recruitment by the research team based on the study design and feasibility considerations.

Development of the CABPCR intervention and preparation of the STBPCR control programme

The CABPCR education programme was developed through a systematic cultural adaptation process guided by the Cultural Equivalence Theory (24), which emphasizes achieving semantic, conceptual, experiential, and cultural equivalence when adapting health communication materials across languages and cultural contexts. The development process followed Beaton's recommendations by the principles of translation and cross-cultural adaptation recommended by Beaton et al. (33).

The intervention development began with the translation and cross-cultural adaptation of the original English BPCR education content into Swahili. A committee of experts from various disciplines, including linguistic experts, maternal health professionals, research methodologists, health administrators, and the principal investigator, reviewed the translated materials to assess linguistic accuracy, cultural appropriateness, conceptual equivalence, and technical consistency with the original BPCR content.

The development of the CABPCR intervention and the STBPCR control programme was based on the standard translated Swahili BPCR education content. After completion of the initial translation and harmonization process, the standard translated BPCR manual was duplicated into two copies. One copy was subjected to further cultural adaptation through a participatory process guided by the Cultural Equivalence Theory. This process involved community exploration among Hehe pregnant women to identify culturally meaningful terminologies, locally understood expressions, and contextually relevant explanations related to BPCR concepts. The identified cultural elements were integrated into the translated BPCR content, followed by expert review and pretesting, resulting in the CEMTM, which was used to deliver the CABPCR intervention.

The second copy of the standard translated BPCR manual was retained without cultural modification and used as the control educational material. This manual represented the STBPCR education programme and contained the translated BPCR messages without the incorporation of community-derived culturally equivalent terminologies, contextual explanations, or culturally specific examples. Therefore, both programs were based on the same original BPCR educational content, while the primary difference between the intervention and control conditions was the cultural adaptation component incorporated into the CABPCR programme.

Following expert review, a qualitative exploration was conducted through FGD among Hehe pregnant women attending ANC services different from the study area in the Iringa region to identify culturally meaningful terminologies, expressions, concepts, and explanations related to BPCR messages. The findings from the community consultations were analyzed thematically and used to modify the translated BPCR content. Specifically, culturally equivalent words, locally understood expressions, and contextually appropriate explanations were integrated into the educational messages to improve comprehension, acceptability, and relevance for the Hehe community.

The modified BPCR education content was then reviewed by the expert committee to ensure that the incorporated cultural elements maintained the intended meaning and evidence-based BPCR recommendations. The preliminary CEMTM was subsequently pretested among 10 pregnant women from the target population different from the study area who were not included in the main study to assess clarity, acceptability, usability, and contextual appropriateness. Feedback obtained during pretesting was incorporated into the final version of the CEMTM.

The finalized CEMTM served as the educational material for delivering the CABPCR intervention. The manual incorporated culturally relevant terminology, locally meaningful explanations, and context-specific terms while maintaining alignment with recommended BPCR components, including birth planning, recognition of maternal and obstetric danger signs, preparation for skilled birth attendance, emergency preparedness, antenatal care attendance, and decision-making for seeking maternal healthcare.

Patient and public involvement

Patients and members of the public were not involved as research partners in the design, conduct, analysis, interpretation, or reporting of this study. Pregnant women participated as study participants and provided information used to evaluate the intervention. Their perspectives contributed to understanding the cultural and contextual relevance of BPCR education; however, they were not involved in decision-making regarding the research process.

Description of the implementation of CABPCR) (intervention) and STBPCR (control)

The CABPCR was based on the previously developed CEMTM. The CABPCR programme aimed to improve BPCR knowledge, attitudes, and practices among indigenous Hehe pregnant women attending antenatal care services.

The CABPCR programme consisted of one structured face-to-face group education session delivered once during pregnancy. The session lasted approximately two hours and was conducted in a group setting. The teaching dose consisted of a single educational contact covering essential BPCR components, including birth planning, recognition of maternal and obstetric danger signs, preparation for skilled birth attendance, emergency preparedness, antenatal care attendance, and decision-making related to seeking maternal healthcare.

The CABPCR programme was delivered using participatory teaching approaches, including interactive discussions, question-and-answer sessions, clarification of participants' concerns, and culturally responsive communication strategies. The educational content was adapted to reflect participants' cultural beliefs, perceptions, experiences, and locally meaningful expressions while maintaining consistency with evidence-based BPCR recommendations.

The intervention was delivered by trained midwives from health facilities outside the study sites. Facilitators received orientation on the CABPCR content, use of the CEMTM, intervention delivery procedures, and culturally sensitive communication approaches to ensure standardized implementation. The CEMTM served as the primary educational material and incorporated culturally relevant concepts, messages, and terminologies identified through a participatory cultural adaptation process. The adaptation aimed to ensure linguistic accuracy, conceptual equivalence, and contextual relevance of BPCR messages for the Hehe community.

The effectiveness of the CABPCR programme was assessed by measuring BPCR knowledge, attitudes, and practices using a structured questionnaire administered before the intervention at baseline and four weeks after completion of the training.

Standard Translated BPCR education programme (STBPCR) (control group)

Participants in the control group received the STBPCR using the Standard Translated Manual (STM). Similar to the intervention group, participants received one face-to-face group education session lasting approximately two hours, delivered by trained maternal health professionals.

The STBPCR programme covered the same core BPCR topics, including birth planning, recognition of maternal and obstetric danger signs, preparation for skilled birth attendance, emergency preparedness, antenatal care attendance, and maternal healthcare decision-making. The same teaching approaches, including interactive discussions and question-and-answer sessions, were applied.

However, unlike the CABPCR programme, the STM had not undergone cultural adaptation. Although the content was translated into Swahili, it did not incorporate community-derived culturally equivalent terminologies, locally contextualized explanations, or culturally specific examples. Therefore, the primary difference between the CABPCR and STBPCR programme was the cultural and linguistic adaptation of BPCR educational content in the intervention group.

BPCR knowledge, attitudes, and practices in the control group were assessed using the same structured questionnaire and assessment schedule as the intervention group, including baseline assessment and follow-up assessment four weeks after the educational session.

The CABPCR intervention manual (CEMTM) and the Standard Translated BPCR manual (STM) used in this study are available from the corresponding author upon reasonable request. Due to the nature of the educational intervention, participants and intervention facilitators were not blinded to group assignment. However, research assistants involved in outcome assessment and data collection were not involved in intervention delivery to minimize measurement bias. Data analysts were blinded to group identity during initial data cleaning and analysis by using coded group identifiers. Complete blinding was not feasible because the intervention involved delivery of culturally adapted educational content. Both groups received a structured BPCR education session with similar

duration, teaching approaches, and core BPCR components. The main difference between groups was the educational material used: the CABPCR intervention group received education using the CEMTM, while the control group received education using the STBPCR manual without cultural adaptation.

All participants who completed baseline assessment and received the assigned educational programme were included in the analysis according to their allocated study group. Participants were analyzed according to the intervention condition assigned to their cluster (CABPCR intervention group or STBPCR control group). No missing outcome data were observed; therefore, no missing data handling procedures were required.

Both groups continued to receive routine antenatal care services provided by the health facilities according to national maternal healthcare guidelines. No additional BPCR educational intervention was provided outside the assigned study programmes.

Data collection methods

Data were collected using a structured, researcher-administered questionnaire. Trained research assistants (midwives) conducted face-to-face interviews with participants in a private and quiet setting within ANC clinics. The questionnaire was administered verbally, and participants provided responses accordingly. Clarifications were offered where necessary to ensure accurate understanding of the questions.

Data collection instruments and procedures

Data collection instruments

The study used a structured questionnaire adapted from standardized BPCR monitoring tools developed by Jhpiego (34). The structured questionnaires were used to assess pregnant women's knowledge and practices of pregnant women regarding BPCR, while attitudes data was collected using Likert-scale. The instrument consisted of sections covering sociodemographic characteristics, knowledge of danger signs during pregnancy, childbirth, postpartum, and newborn periods, attitudes toward BPCR, and practices related to birth preparedness and complication readiness (13). The tool was adapted to the local context of the study population to ensure clarity and relevance while maintaining the original constructs.

Knowledge was assessed across key domains, including danger signs during pregnancy, childbirth, and the postpartum period; newborn danger signs; and birth preparedness. Attitudes were assessed perceptions and beliefs toward BPCR and maternal health service utilization. Practices were assessed based on participants' preparedness actions such as saving money for birth, identifying transport, and selecting skilled birth attendants. Composite scores were generated for each outcome by summing relevant questionnaire items, with higher scores indicating better knowledge, more positive attitudes, and improved BPCR practices.

Validity and reliability of the tool

The validity and reliability of the study instrument was supported by its prior development and validation by Jhpiego for assessing knowledge, attitudes, and practices related to BPCR among pregnant women in low-resource settings, including Tanzania (33, 34). The tool has been widely used in similar studies across different countries, where acceptable internal consistency has been reported, including Malaysia (36) (Cronbach's alpha = 0.72), Kenya (37) (Cronbach's alpha = 0.756), and Ethiopia (38) (Cronbach's alpha = 0.85). These findings indicate that the instrument demonstrates acceptable to good internal consistency across different contexts, confirming its reliability for measuring BPCR-related knowledge, attitudes, and practices. The total knowledge score was used as the outcome variable in the analysis. Additionally, the adapted questionnaire underwent translation, expert review, and pretesting among pregnant women in an area different from the study area before use.

Study variable

Independent Variables

The primary independent variable was study group assignment, representing exposure to either the CABPCR or the STBPCR. The study group variable was coded as 0 = control group (STBPCR delivered using the STM) and 1 = intervention group (CABPCR delivered using the CEMTM).

Additional independent variables included baseline outcome scores and sociodemographic and obstetric characteristics, including maternal age, gestational age, gravidity, religion, marital status, living with a partner, educational level, reading ability, and occupation. These variables were included as covariates in adjusted regression analyses to control for baseline differences and participant characteristics.

Measurement of BPCR Knowledge

The outcome variable was BPCR knowledge, attitudes and practice of pregnant women on BPCR. BPCR knowledge assessed using a 64-item questionnaire covering six BPCR-related domains: danger signs during pregnancy (14 items), labor and childbirth (8 items), postnatal care (11 items), newborn care (14 items), birth preparedness (8 items), and antenatal care (11 items). Each item had a dichotomous response (yes/no) and was scored as 1 for a correct response indicating knowledge and 0 for an incorrect response. The overall BPCR knowledge score was calculated by summing responses across all 64 items, resulting in a total score ranging from 0 to 64. Higher scores indicated greater BPCR knowledge, while lower scores indicated limited knowledge. The total knowledge score was used as the outcome variable in the analysis.

Sociodemographic and obstetric characteristics were collected through face-to-face interviews using a structured questionnaire. Maternal age was recorded in completed years, gestational age in weeks of pregnancy, and gravidity as prim gravida or multigravida. Marital status was categorized as single, married. Educational level was classified as, primary education, ordinary-level education and above. Reading ability was categorized as read easily or read with difficulty. Occupation was categorized as peasant or businesswoman/employee. Continuous variables were recorded numerically, whereas categorical variables were coded according to their respective response categories for statistical analysis.

Attitudes towards BPCR were assessed using 15 statements measured on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Responses were summed to generate an overall attitude score, with higher scores indicating more favorable attitudes towards BPCR.

BPCR practices were measured using 12 dichotomous (Yes/No) items assessing recommended birth preparedness behaviors. Each appropriate practice was scored as one (1), while inappropriate or absent practices were scored as zero (0). Total practice scores ranged from 0 to 12, with higher scores indicating better BPCR practices.

Data collection procedure

Data were collected using a structured, researcher-administered questionnaire adapted from standardized BPCR monitoring tools developed by Jhpiego (34). Baseline (pre-intervention) data were collected through face-to-face interviews conducted in a private setting (16 dispensaries from 16 villages) within ANC clinics by trained research assistants (midwives) fluent in Swahili and Hehe. Each interview lasted approximately 25–30 minutes.

Following baseline data collection, participants in both the intervention and control groups received a single two-hour structured educational session delivered through interactive group discussions. After completion of the session, participants were scheduled for a follow-up assessment four weeks later using the same questionnaire and there was no loss of participants in all study groups. All participants recruited during baseline were available during evaluation.

To ensure data quality and minimize potential bias, research assistants were recruited from health facilities outside the study area and received standardized training before data collection (39). Training covered questionnaire administration, ethical considerations, interview techniques, and maintaining neutrality during interviews. Separate teams were assigned to intervention delivery and outcome assessment to minimize contamination and interviewer bias (40). Trainers who delivered the intervention were not involved in data collection, and baseline and post-intervention assessments were conducted by independent research assistants. Information bias was reduced through the use of a standardized questionnaire administered uniformly at baseline and follow-up in both study groups, with the same instrument used for both assessments (41). To reduce social desirability bias and protect confidentiality, participants were assigned unique identification numbers instead of names, and interviews were conducted in private settings (42). Recall bias was minimized by conducting the post-intervention assessment four weeks after completion of the intervention.

This was an open-label (non-blinded) controlled study. To minimize contamination between study arms, the intervention and control groups were implemented in different districts. Participants, trainers, and implementers had no interaction across districts, and participants were unaware of activities taking place in other villages or health facilities, thereby reducing the likelihood of information exchange between study arms.

Post-intervention assessment

Post-intervention assessment was conducted four weeks after completion of the intervention. Data were collected by trained research assistants (experienced midwives) who had not participated in baseline data collection to minimize measurement bias. The same questionnaire, data collection procedures, and interview approach used during the baseline assessment were applied to both the CABPCR and STBPCR programme group. Each participant interview lasted approximately 25–30 minutes.

A total of eight data collectors participated in the post-intervention assessment. They were midwives recruited from health facilities outside the study area using the same eligibility criteria during baseline data collection. Data collectors received standardized training from the same training team on questionnaire administration, ethical considerations, and maintaining neutrality during interviews. To minimize contamination and prevent information exchange between study arms, training and deployment arrangements for data collectors were conducted separately for the intervention and control groups. Four data collectors were assigned to the CABPCR education programme - intervention group and four to the STBPCR education programme group - control group according to the evaluation timetable. Data collectors were blinded to study allocation during outcome assessment.

Data Analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (IBM SPSS) Statistics version 27. Prior to inferential analyses, assumptions of normality were assessed using the Shapiro-Wilk test. Since outcome variables were normally distributed ($p > 0.05$), parametric statistical methods were employed. Baseline differences between the intervention and control groups were examined using independent-samples t-tests for continuous variables and chi-square tests for categorical variables. The dataset was checked for completeness, and no missing data were identified; therefore, all eligible participants were included in the analyses.

Descriptive statistics were used to summarize participants' sociodemographic characteristics and study variables. Continuous variables were presented as means and standard deviations, while categorical variables were summarized using frequencies and percentages.

To evaluate the effect of the culturally adapted BPCR training intervention on knowledge, attitudes, and practices, a difference-in-differences (DID) analysis was conducted. The study group variable was coded as 0 = control group and 1 = intervention group, while the time variable was coded as 0 = pre-intervention and 1 = post-intervention. The DID estimator was represented by the interaction term between study group and time (Group $\times$ Time), which assessed whether changes in outcome scores over time differed between the intervention and control groups.

The DID regression models were specified as follows: **Knowledge score:** Knowledge post = $\beta_0 + \beta_1(\text{Group}) + \beta_2(\text{Time}) + \beta_3(\text{Group} \times \text{Time}) + \epsilon_i$. **Attitude score:** Attitude post = $\beta_0 + \beta_1(\text{Group}) + \beta_2(\text{Time}) + \beta_3(\text{Group} \times \text{Time}) + \epsilon_i$. **Practice score:** Practice post = $\beta_0 + \beta_1(\text{Group}) + \beta_2(\text{Time}) + \beta_3(\text{Group} \times \text{Time}) + \epsilon_i$ where β_0 represents the intercept, β_1 – β_3 represent regression coefficients, and ϵ_i represents the error term. Estimated marginal means were calculated to illustrate changes in outcome scores between the intervention and control groups over time.

Additionally, analysis of covariance (ANCOVA) models was performed to identify factors associated with post-intervention knowledge, attitudes, and practices while controlling for baseline outcome scores and sociodemographic characteristics. The adjusted models included study group, baseline outcome score, education level, gravidity, marital status, occupation, and living arrangement as covariates.

Covariates were coded as follows: age (< 20 years = 0, 20–34 years = 1, ≥ 35 years = 2); gravidity (primigravida = 0, multigravida = 1); gestational age (< 12 weeks = 1, 13–24 weeks = 2); marital status (single = 0, married = 1); living with a partner (no = 0, yes = 1); education level (primary education = 0, secondary education and above = 1); occupation (housewife = 0, self-employed or formally employed = 1); and reading ability (reads with difficulty = 0, reads easily = 1).

The general ANCOVA model was specified as: Outcome post = $\beta_0 + \beta_1(\text{Group}) + \beta_2(\text{Outcome pre}) + \beta_3(\text{Education}) + \beta_4(\text{Gravidity}) + \beta_5(\text{Marital status}) + \beta_6(\text{Occupation}) + \beta_7(\text{Living with partner}) + \epsilon_i$ where Outcome post represents the post-intervention knowledge, attitude, or practice score; Outcome pre represents the corresponding baseline score; β_0 represents the intercept; β coefficients represent regression coefficients; and ϵ_i represents the error term. Regression results were reported as coefficients (β), 95% confidence intervals and statistical significance was set at $p < 0.05$.

No comparative analysis of harms was performed because no intervention-related adverse events were reported.

Additional analyses included multivariable linear regression models to adjust for potential confounding factors, including baseline outcome scores and selected sociodemographic and obstetric characteristics. These analyses were planned as part of the analytical strategy. No post-hoc subgroup or sensitivity analyses were conducted.

Results

A total of 176 pregnant women were enrolled, with 88 participants allocated to the CABPCR intervention group and 88 participants allocated to the STBPCR control group. All enrolled participants received the assigned educational programme and were included in the primary outcome analysis. There were no losses to follow-up or exclusions after allocation. All enrolled participants completed baseline and post-intervention assessments and were included in the final analysis. All harms or unintended events in each group. No adverse events or unintended consequences related to the educational interventions were reported in either group.

Sociodemographic characteristics of study participants

Table 1 presents the baseline sociodemographic and obstetric characteristics of the 176 study participants by study group. Most participants were aged 20–34 years, were between 13 and 24 weeks of gestation, were multigravida, married, and living with a partner. The majority had primary education, reported reading easily, and were engaged in farming as their main occupation (Table 1).

Table 1
Baseline sociodemographic characteristics of pregnant women by study group (N = 176).

Variables	Category	Intervention group n (%)	Control group n (%)
Age (years) Mean ± SD (Min-Max)		26.50 ± 6.35 (18–44)	26.38 ± 5.89 (18–42)
	< 20	15 (17.0)	13 (14.8)
	20–34	60 (68.2)	65 (73.9)
	≥ 35	13 (14.8)	10 (11.4)
Gestational age (months) Mean ± SD (Min-Max)		4.80 ± 1.13 (2–6)	4.53 ± 1.29 (2–6)
	≤12 weeks	11 (12.5)	20 (22.7)
	13–24 weeks	77 (87.5)	68 (77.3)
Gravidity			
	Primigravida	21 (23.9)	10 (11.4)
	Multigravida	67 (76.1)	78 (88.6)
Marital status			
	Single	15 (17.0)	8 (9.1)
	Married	73 (83.0)	80 (90.9)
Living with a partner			
	No	18 (20.5)	10 (11.4)
	Yes	70 (79.5)	78 (88.6)
Educational level			
	Primary education	57 (64.8)	64 (72.7)
	Secondary education and above	31 (35.2)	24 (27.3)
Reading ability			
	Easily	82 (93.2)	86 (97.7)
	With difficulty	6 (6.8)	2 (2.3)
Occupation			
	Peasant	78 (88.6)	80 (90.9)
	Business woman/employed	10 (11.4)	8 (9.1)

Intervention group = CABPCR education programme delivered using CEMTM; Control group = STBPCR education programme delivered using STM.

Baseline comparison of knowledge, attitudes, and practices between intervention and control groups

Table 1 presents the baseline comparison of knowledge, attitudes, and practices between the intervention and control groups. At baseline, the mean knowledge score was slightly lower in the intervention group (21.01 ± 7.42) than in the control group (22.51 ± 5.80); however, the difference was not statistically significant (mean difference = - 1.50, $p = 0.137$). Similarly, the mean practice score was lower in the intervention group (7.41 ± 2.25) than in the control group (7.85 ± 1.78), but the difference was not statistically significant (mean difference = - 0.44, $p = 0.150$). In contrast, the intervention group had a significantly lower mean attitude score (21.58 ± 3.47) compared with the control group (24.69 ± 5.11), with a mean difference of - 3.11 ($p < 0.001$). These findings indicate that the intervention and control groups were comparable with respect to baseline knowledge and practices but differed significantly in baseline attitudes (Table 2).

Table 2
Baseline comparison of knowledge, attitudes, and practices between intervention and control groups (pre-test)

	Intervention (n = 88)	Control (n = 88)		
	Mean ± SD	Mean ± SD	Mean difference	P-Value
Knowledge	21.01 ± 7.42	22.51 ± 5.80	-1.50	0.137
Attitudes	21.58 ± 3.47	24.69 ± 5.11	-3.11	0.000
Practice	7.41 ± 2.25	7.85 ± 1.78	-0.44	0.150

Mean difference = Intervention group mean – Control group mean, SD = standard deviation

An independent-samples *t*-test was used to compare mean scores between the intervention and control groups at pretest.

Intervention group = CABPCR education programme delivered using CEMTM; Control group = STBPCR education programme delivered using STM.

Post-intervention comparison of BPCR knowledge, attitudes, and practices between intervention and control groups

Table 3 presents the comparison of knowledge, attitudes, and practices between the intervention and control groups at post-intervention assessment. The mean knowledge score was significantly higher among participants in the intervention group compared with the control group (38.49 ± 7.54 vs. 32.70 ± 5.61), with a mean difference of 5.79 points ($p < 0.001$). Similarly, participants in the intervention group had significantly higher practice scores than those in the control group (9.60 ± 1.40 vs. 9.03 ± 1.58), with a mean difference of 0.57 points ($p = 0.012$). However, there was no statistically significant difference in attitude scores between the intervention and control groups at post-intervention assessment (24.41 ± 4.31 vs. 24.86 ± 4.31 ; mean difference = -0.45 , $p = 0.482$). These findings indicate that the intervention was associated with improvements in knowledge and practices, while no significant difference in attitudes was observed between the groups after the intervention (Table 3).

Table 3
Post-intervention comparison of BPCR knowledge, attitudes, and practices between intervention and control groups

	Intervention (n = 88)	Control (n = 88)		
	Mean $\pm$ SD	Mean $\pm$ SD	Mean difference	P-Value
Knowledge	38.49 ± 7.54	32.70 ± 5.61	5.79	0.000
Attitudes	24.41 ± 4.31	24.86 ± 4.31	-0.46	0.482
Practices	9.60 ± 1.40	9.03 ± 1.58	0.57	0.012

Mean difference = Intervention group mean – Control group mean, SD = standard deviation

An independent-samples *t*-test was used to compare mean scores between the intervention and control groups at posttest.

Intervention group = CABPCR education programme delivered using CEMTM; Control group = STBPCR education programme delivered using STM.

Within-group comparison of birth BPCR knowledge, attitudes, and practices before and after the intervention

Table X presents the within-group changes in BPCR knowledge, attitudes, and practices from pre-test to post-test among participants in the intervention and control groups. In the intervention group, the mean knowledge score increased from 21.01 ± 7.42 at pre-test to 38.49 ± 7.54 at post-test, representing a significant improvement of 17.48 points ($p < 0.001$). The control group also showed a significant increase in knowledge scores, from 22.51 ± 5.80 to 32.81 ± 5.55 , with a mean improvement of 10.29 points ($p < 0.001$).

Attitude scores in the intervention group improved significantly, increasing from 21.58 ± 3.47 at pre-test to 24.41 ± 4.31 at post-test, corresponding to a mean increase of 2.82 points ($p < 0.001$). In contrast, the control group showed only a slight increase in attitude scores, from 24.69 ± 5.11 to 24.98 ± 4.19 , and this change was not statistically significant ($p = 0.660$).

Similarly, practice scores increased significantly in the intervention group, from 7.41 ± 2.25 at pre-test to 9.60 ± 1.40 at post-test, representing a mean increase of 2.19 points ($p < 0.001$). The control group also demonstrated a significant improvement in practice scores, increasing from 7.85 ± 1.78 to 9.06 ± 1.58 , with a mean increase of 1.20 points ($p < 0.001$) (Table 4).

Table 4
Within-group comparison of birth BPCR knowledge, attitudes, and practices before and after the intervention

Knowledge	Pretest	Posttest	Md	t	P-Value
Intervention	21.01 ± 7.42	38.49 ± 7.54	-17.48	-14.577	0.000
Control	22.51 ± 5.80	32.81 ± 5.55	-10.29	12.994	0.000
Attitudes					
Intervention	21.58 ± 3.47	24.41 ± 4.31	-2.82	-4.825	0.000
Control group	24.69 ± 5.11	24.98 ± 4.19	-0.28	-0.441	0.660
Practices					
Intervention	7.41 ± 2.25	9.60 ± 1.40	-2.19	-8.483	0.000
Control group	7.85 ± 1.78	9.06 ± 1.58	-1.20	-5.448	0.000

Values are presented as mean ± standard deviation. Md = mean difference (pretest minus posttest). A paired t-test was used to compare pretest and posttest scores within each study group. A negative mean difference indicates an increase in scores from pretest to posttest.

Intervention group = CABPCR education programme delivered using CEMTM; Control group = STBPCR education programme delivered using STM.

Multiple linear regression analysis of factors associated with post-test knowledge scores

After adjustment for baseline knowledge and sociodemographic factors, membership in the intervention group remained the only significant predictor of post-test knowledge scores ($\beta = 5.88$, 95% CI: 3.84–7.92, $p < 0.001$). No significant associations were observed for education, gravidity, marital status, living arrangement, reading ability, occupation, or age (Supplement Table 1).

Supplementary Table S1. Multiple linear regression analysis of factors associated with post-test BPCR attitudes scores.

β = unstandardized regression coefficient; CI = confidence interval. Reference categories: Group = control group (STBPCR education programme); Education = primary education or below; Gravidity = primigravida; Marital status = unmarried/separated/widowed; Living with partner = no; Reading ability = difficult/not able; Occupation = peasant; Age = < 20 years.

Multiple linear regression analysis of factors associated with post-test BPCR attitudes scores.

Multiple linear regression analysis showed that none of the examined variables were independently associated with post-test attitude scores after adjustment. The intervention group did not differ significantly from the control group ($\beta = -0.137$, 95% CI: -1.509 to 1.235; $p = 0.844$). Likewise, baseline attitude score and sociodemographic characteristics, including education, gravidity, marital status, living with a partner, reading ability, occupation, and age, were not significant predictors (all $p > 0.05$). Overall, the regression model was not statistically significant ($F(10,165) = 1.26$, $p = 0.256$) and explained 7.1% of the variance in post-test attitude scores ($R^2 = 0.071$) (Supplementary Table S2).

Supplementary Table S2. Multiple linear regression analysis of factors associated with post-test BPCR attitudes scores.

β = unstandardized regression coefficient; CI = confidence interval. Reference categories: Group = control group (STBPCR education programme); Education = primary education or below; Gravidity = primigravida; Marital status = unmarried/separated/widowed; Living with partner = no; Reading ability = difficult/not able; Occupation = peasant; Age = < 20 years.

Multiple linear regression analysis of factors associated with post-test BPCR practice scores.

In the adjusted ANCOVA model, assignment to the intervention group was independently associated with higher post-test BPCR practice scores ($\beta = 0.658$, 95% CI: 0.203–1.112, $p = 0.005$). Baseline practice score was also positively associated with post-test practice ($\beta = 0.119$, 95% CI: 0.003–0.234, $p = 0.044$). No significant associations were observed for education, gravidity, marital status, living with a partner, reading ability, occupation, or age ($p > 0.05$) (Supplement Table S3).

Supplementary Table S3. Multiple linear regression analysis of factors associated with post-test BPCR practice scores.

β = unstandardized regression coefficient; CI = confidence interval. Reference categories: Group = control group (STBPCR education programme); Education = primary education or below; Gravidity = primigravida; Marital status = unmarried/separated/widowed; Living with partner = no; Reading ability = difficult/not able; Occupation = peasant; Age = < 20 years.

Difference-in-Differences regression analysis of the effect of culturally adapted BPCR training on knowledge, attitudes, and practices.

The DID analysis showed that the culturally adapted BPCR training intervention significantly improved knowledge, attitudes, and practices (Table X). For knowledge, baseline scores did not differ significantly between groups ($\beta = -1.50$, $p = 0.135$), while the Group $\times$ Time interaction was significant ($\beta = 7.18$, $p < 0.001$), indicating a greater increase in knowledge scores in the intervention group compared with the control group.

For attitudes, the intervention group had lower baseline scores than the control group ($\beta = -3.11$, $p < 0.001$). Although the overall time effect was not significant ($\beta = 0.28$, $p = 0.662$), the Group $\times$ Time interaction was significant ($\beta = 2.55$, $p = 0.006$), demonstrating greater improvement in attitudes among participants receiving the intervention.

For practices, baseline scores were comparable between groups ($\beta = -0.44$, $p = 0.100$). The Group $\times$ Time interaction was significant ($\beta = 0.99$, $p = 0.010$), indicating that the intervention group achieved a greater improvement in BPCR practices compared with the control group (Table 5).

Table 5
Difference-in-Differences regression analysis of the effect of culturally adapted BPCR training on knowledge, attitudes, and practices

Knowledge					
Variable	Coefficient	Std. Error	t	P> t	95% CI
Group (Intervention vs Control)	-1.5	1.001328	-1.50	0.135	-3.469415 to .4694153
Time (Post vs Pre)	10.29545	1.001328	10.28	0.000	8.326039 to 12.26487
Group $\times$ Time	7.181818	1.416091	5.07	0.000	4.396644 to 9.966992
Constant	22.51136	.7080455	31.79	0.000	21.11878 to 23.90395
Attitudes					
Variable	Coefficient	Std. Error	t	P> t	95% CI
Group: Intervention	-3.113636	.6501038	-4.79	0.000	-4.392263 to -1.835009
Time: Post	.2840909	.6501038	0.44	0.662	0.994536 to 1.562718
Group $\times$ Time	2.545455	.9193856	2.77	0.006	.737203 to 4.353706
Constant	24.69318	.4596928	53.72	0.000	23.78906 to 25.59731
Practice					
Variable	Coefficient	Std. Error	t	P> t	95% CI
Group: Intervention	-.443	.268533	-1.65	0.100	-.9713336 to .08497
Time: Post	1.204545	.268533	4.49	0.000	.6763937 to 1.732697
Group $\times$ Time	.9886364	.379763	2.60	0.010	.2417169 to 1.735556
Constant	7.852273	.1898815	41.35	0.000	7.478813 to 8.225732

β = regression coefficient; CI = confidence interval. The reference categories were control group and pre-intervention period. The Group $\times$ Time interaction term represents the difference-in-differences estimate of the intervention effect. A positive interaction coefficient indicates a greater improvement in the intervention group compared with the control group over time.

Estimated marginal means of Knowledge, attitudes and practice for the groups

The estimated marginal means showed improvements in BPCR knowledge, attitudes, and practices over time in both groups, with greater improvements observed in the intervention group. For knowledge, the control group's estimated mean score increased from 7.85 (95% CI: 7.48–8.23) at baseline to 9.06 (95% CI: 8.68–9.43) at post-intervention, whereas the intervention group's estimated mean increased from 7.41 (95% CI: 7.04–7.78) to 9.60 (95% CI: 9.23–9.98).

For attitudes, the control group's estimated mean increased slightly from 24.69 (95% CI: 23.79–25.60) to 24.98 (95% CI: 24.07–25.88), while the intervention group's estimated mean increased from 21.58 (95% CI: 20.68–22.48) to 24.41 (95% CI: 23.50–25.31).

Similarly, for BPCR practices, the control group's estimated mean increased from 7.85 (95% CI: 7.48–8.23) to 9.06 (95% CI: 8.68–9.43), whereas the intervention group's estimated mean increased from 7.41 (95% CI: 7.04–7.78) to 9.60 (95% CI: 9.23–9.98). These estimated marginal means indicate greater improvements over time in the intervention group, consistent with the significant Group $\times$ Time interaction observed in the Difference-in-Differences analyses (Table 6).

Table 6
Estimated marginal means of Knowledge, attitudes and practice for the groups

Knowledge:							
Group	Time	Margin	Std. Error	t-value	P-value	95% CI Lower	95% CI Upper
Control	Pre	22.51136	.7080455	31.79	0.000	21.11878	23.90395
Control	Post	32.80682	.7080455	46.33	0.000	31.41423	34.19941
Intervention	Pre	21.01136	.7080455	29.68	0.000	19.61878	22.40395
Intervention	Post	38.48864	.7080455	54.36	0.000	37.09605	39.88122
Attitudes:							
Group	Time	Margin	Std. Error	t-value	P-value	95% CI Lower	95% CI Upper
Control	Pre	24.69318	0.4596928	53.72	0.000	23.78906	25.59731
Control	Post	24.97727	0.4596928	54.33	0.000	24.07315	25.8814
Intervention	Pre	21.57955	0.4596928	46.94	0.000	20.67542	22.48367
Intervention	Post	24.40909	0.4596928	53.10	0.000	23.50497	25.31322
Practice:							
Group	Time	Margin	Std. Error	t-value	P-value	95% CI Lower	95% CI Upper
Control	Pre	7.852273	.1898815	41.35	0.000	7.478813	8.225732
Control	Post	9.056818	.1898815	47.70	0.000	8.683358	9.430278
Intervention	Pre	7.409091	.1898815	39.02	0.000	7.035631	7.782551
Intervention	Post	9.602273	.1898815	50.57	0.000	9.228813	9.975732

Values are adjusted estimated marginal means derived from the Difference-in-Differences model. CI = confidence interval. Pre = pre-intervention assessment; Post = post-intervention assessment. The estimates represent adjusted BPCR knowledge, attitude, and practice scores for the control and intervention groups at each assessment time point.

Discussion

This study evaluated the effectiveness of a culturally adapted BPCR education programme developed using the Cultural Equivalence Model of Translation among pregnant women attending ANC clinics in rural Tanzania. Overall, the findings demonstrate that the culturally adapted intervention significantly improved BPCR knowledge and practices compared with the standard translated educational manual. Although no significant between-group difference in post-intervention attitude scores was observed using independent-samples t-tests, the DID analysis demonstrated significantly greater improvements in attitudes among women who received the culturally adapted intervention. Furthermore, multivariable analyses showed that intervention exposure was the strongest independent predictor of post-intervention knowledge and practice scores after adjustment for baseline characteristics and potential confounders. These findings suggest that cultural adaptation of maternal health education materials can substantially enhance the effectiveness of ANC health education in rural settings.

The baseline characteristics indicated that the intervention and control groups were generally comparable with respect to sociodemographic and obstetric characteristics, with no statistically significant differences in baseline knowledge or practice scores. However, participants in the intervention group had significantly lower baseline attitude scores than those in the control group. Such baseline differences are not uncommon in quasi-experimental studies where random allocation of individuals is not feasible and underscore the importance of using analytical approaches that account for pre-existing group differences (43) (44). The application of ANCOVA and DID analyses therefore strengthened the validity of the study by adjusting for baseline imbalance and isolating the intervention effect.

The most notable finding was the substantial improvement in BPCR knowledge among participants who received the culturally adapted educational intervention. Although knowledge improved in both study groups, reflecting the contribution of routine ANC education and repeated exposure to BPCR messages, the increase was significantly greater among women receiving the culturally adapted manual. The DID analysis further confirmed that the intervention produced an additional improvement in knowledge beyond changes attributable to time alone. These findings are consistent with previous intervention studies demonstrating that culturally tailored maternal health education enhances comprehension, knowledge retention, and understanding of obstetric danger signs compared with conventional health education approaches (16) (45)(46)(47).

The superior improvement in knowledge observed in the intervention group is likely attributable to the incorporation of culturally equivalent words, phrases, and locally meaningful expressions identified through qualitative exploration among the Hehe community. Language represents more than a communication tool; it conveys cultural meanings, experiences, and shared interpretations of health and illness. Educational messages delivered using culturally familiar terminology may therefore reduce cognitive barriers, improve message comprehension, and facilitate recall of health information (48). This interpretation is

consistent with the Cultural Equivalence Model of Translation, which proposes that culturally meaningful adaptation enhances conceptual equivalence and improves communication effectiveness across populations with different linguistic and cultural backgrounds (24).

These findings also align with the Health Belief Model, which suggests that improved knowledge increases individuals' awareness of susceptibility to pregnancy complications, perceived severity of obstetric emergencies, and perceived benefits of adopting recommended preventive behaviors (49). By improving understanding of danger signs and birth preparedness components, culturally adapted education may have strengthened women's perceptions of risk and increased motivation to engage in BPCR-related behaviors.

The intervention also resulted in significantly greater improvements in BPCR practices. Participants receiving the culturally adapted education demonstrated higher post-intervention practice scores than those receiving the standard translated manual, and intervention assignment remained an independent predictor of practice after adjustment for baseline practice and sociodemographic characteristics. These findings suggest that improved comprehension of BPCR information translated into behavioural changes, including adoption of recommended birth preparedness measures. Similar findings have been reported in community- and facility-based maternal health interventions conducted in sub-Saharan Africa and other low- and middle-income countries, where enhanced maternal education has been associated with improved birth preparedness, skilled birth attendance, and timely care-seeking (50)(51). The observed relationship between improved knowledge and better practices supports behavioral theories proposing that knowledge serves as an important precursor to behavior change. According to the Theory of Planned Behavior, improved understanding may positively influence behavioural beliefs, strengthen intentions, and increase the likelihood of adopting recommended maternal health practices (52). Nevertheless, knowledge alone may not always result in behavioural change, as social support, household decision-making power, financial resources, accessibility of health services, and cultural norms also influence BPCR practices (53)(54)(55). The greater improvement observed in the intervention group therefore suggests that culturally appropriate communication may have reduced barriers to translating knowledge into action.,

The findings can also be interpreted within the framework of the Three Delays Model, which proposes that maternal morbidity and mortality are influenced by delays in deciding to seek care, reaching an appropriate health facility, and receiving adequate care after arrival (28). Birth preparedness and complication readiness interventions primarily address the first and second delays by improving women's recognition of obstetric danger signs, encouraging advance planning for skilled birth attendance, identifying transport and financial resources, and promoting timely care-seeking. By enhancing BPCR knowledge and preparedness practices through culturally adapted education, the CABPCR programme may strengthen women's readiness to respond promptly to obstetric emergencies and thereby contribute to reducing avoidable delays in accessing lifesaving maternal healthcare. Although this study did not directly measure maternal or neonatal outcomes, the observed improvements in BPCR knowledge and practices are consistent with the mechanisms proposed by the Three Delays Model.

Although post-intervention attitude scores did not differ significantly between groups in the independent-samples comparison, within-group analysis demonstrated significant improvement among women receiving the culturally adapted intervention but not among women in the control group. More importantly, the DID analysis showed a significant Group $\times$ Time interaction, indicating that attitudes improved significantly more among intervention participants than among controls after accounting for baseline differences. This apparent discrepancy reflects the fact that participants in the intervention group began the study with significantly lower attitude scores than those in the control group. Although the intervention substantially reduced this baseline gap, the adjusted post-intervention attitude scores remained only slightly lower than those of the control group, resulting in a non-significant cross-sectional comparison despite significant longitudinal improvement.

Independent post-test comparisons evaluate differences between groups at a single point in time, whereas DID analysis estimates the intervention effect by comparing changes over time between groups while controlling for baseline differences (56). Consequently, DID provides a more robust estimate of intervention effectiveness in quasi-experimental designs. The findings therefore suggest that the culturally adapted intervention positively influenced participants' attitudes toward BPCR despite the absence of statistically significant differences in absolute post-intervention scores.

The multivariable analyses demonstrated that intervention exposure was the only independent predictor of post-intervention knowledge, whereas both intervention exposure and baseline practice predicted post-intervention practice. None of the examined sociodemographic variables, including education level, gravidity, marital status, living arrangement, occupation, reading ability, or age, were significantly associated with post-intervention outcomes after adjustment. These findings suggest that the culturally adapted intervention was effective across different participant characteristics and that improvements were primarily attributable to the intervention rather than demographic differences.

Theoretical implications

This study contributes to maternal health intervention research by demonstrating that cultural adaptation is an important mechanism through which health education interventions achieve effectiveness. The findings extend the Cultural Equivalence Model of Translation by providing empirical evidence that adaptation based on culturally meaningful concepts, rather than direct translation alone, improves understanding and behavioural outcomes.

The findings also support the Health Belief Model and Theory of Planned Behavior by demonstrating that culturally appropriate communication can strengthen knowledge, perceptions of pregnancy risks, attitudes towards BPCR, and adoption of preventive behaviors. Importantly, this study suggests that the effectiveness of maternal health education depends not only on the availability of information but also on whether the information is culturally meaningful, understandable, and relevant to women's lived experiences.

Policy and practice implications

The findings have important implications for maternal health policy and ANC practice in Tanzania and similar low-resource settings. Although BPCR education is integrated into routine ANC services, educational materials are often developed through direct translation approaches that may not adequately capture local meanings and cultural interpretations. Incorporating culturally equivalent terminology into BPCR education may improve communication between healthcare providers and pregnant women, enhance understanding of maternal health messages, and strengthen preparation for childbirth and potential complications.

At the policy level, maternal health programme should consider cultural adaptation as an essential component of developing and revising health education materials. The integration of culturally adapted BPCR manuals into ANC services may represent a feasible and low-cost strategy for improving maternal health communication. Additionally, training healthcare providers in culturally responsive communication may further improve the quality of counselling provided during ANC visits.

Strengths of the study

This study has several strengths. First, the BPCR intervention was developed through a systematic cultural adaptation process informed by qualitative exploration among the target population. Therefore, the intervention was not simply translated linguistically but adapted to preserve cultural meaning and improve contextual relevance.

Second, the controlled pretest–posttest quasi-experimental design enabled assessment of changes over time between intervention and control groups. The use of DID analysis and ANCOVA strengthened the evaluation by accounting for baseline differences and adjusting for potential confounding factors.

Third, the study assessed multiple maternal health outcomes, including knowledge, attitudes, and practices, providing a comprehensive evaluation of intervention effectiveness. Finally, standardization of intervention delivery, including educational content, session frequency, duration, and assessment procedures, increased confidence that observed differences were related to cultural adaptation.

Limitations of the study

Several limitations should be considered. First, the quasi-experimental design without individual randomization limits the ability to establish causality, and residual confounding cannot be completely excluded. However, baseline assessment, ANCOVA adjustment, and Difference-in-Differences analyses strengthened the study's internal validity. Second, the study was conducted among pregnant women in selected rural districts of Iringa Region, where the population shares specific cultural and linguistic characteristics. Therefore, the findings may not be generalizable to urban populations or other ethnic groups with different cultural contexts. Third, BPCR practices were measured using self-reported responses, which may have been affected by recall bias or social desirability bias. Fourth, the relatively short follow-up period limited assessment of whether improvements in knowledge, attitudes, and practices were sustained throughout pregnancy or translated into improved maternal and neonatal outcomes. Finally, the study did not assess implementation costs, healthcare provider perspectives, or health-system requirements for large-scale adoption of the culturally adapted BPCR intervention.

Conclusion

This study demonstrates that a culturally adapted BPCR education programme is more effective than a standard translated educational manual in improving pregnant women's knowledge, attitudes, and practices related to birth preparedness and complication readiness. The findings highlight the importance of integrating cultural and linguistic adaptation into maternal health education interventions. Incorporating culturally appropriate BPCR materials into routine ANC services may strengthen maternal health promotion, improve communication between health providers and pregnant. Further research should evaluate the long-term effectiveness, feasibility, cost-effectiveness, sustainability, and scalability of culturally adapted BPCR interventions across diverse settings.

How harms were defined and assessed

No adverse events or harms related to the educational interventions were anticipated or observed during the study. Because the intervention involved a one-time maternal health education session and did not involve medical procedures, medications, or clinical treatment, systematic monitoring of adverse events was not performed. Participants were informed that participation was voluntary and that they could withdraw from the study at any time without affecting their access to antenatal care services

Explanation of interim analyses and stopping guidelines

No interim analyses were planned or conducted. Data were analyzed after completion of participant recruitment, intervention delivery, and follow-up assessment. Therefore, no stopping guidelines were established.

Declarations

Ethics approval, consent, and confidentiality

As the study involved human participants, ethical clearance and a permission letter were obtained from the Research Review Committee of the Research and Publication Office at the University of Dodoma prior to data collection (number MA.84/261/86/11). A written informed consent was obtained from all participants before their inclusion in the study. All procedures performed in this study involving human participants were conducted in accordance with institutional ethical standards and principles of the Declaration of Helsinki. Permission to conduct the study in the Iringa region was obtained from the

Permanent Secretary, President's Office, Regional Administration, and local government reference number AB.307/323/01"R"/70. Permission to use the ANC guidelines for the study was requested from the Ministry of Health, reference number PA.104/282/02. The permission to collect data in the Iringa region was obtained from the Iringa Regional Secretary, reference number Na.FA.225/265/01/J/281. The permission to collect data in the Mufindi and Kilolo districts was obtained from district directors; in the Mufindi district, the permission reference number was Na. HW/MUF/S.40/43/VOL.IV/39, and the Kilolo reference number was Na. KDC/S.10/4/VOLL.VIII/193. Prior to data collection, written informed consent was obtained from all participants. Throughout the study, participant confidentiality and privacy were strictly maintained by assigning unique identification numbers instead of using personal names. Cultural respect and sensitivity were carefully observed during all stages of the study to ensure that the training content, delivery, and implementation were culturally appropriate and did not conflict with participants' beliefs, values, or customary practices.

Specific objectives related to benefits and harms

The study objectives focused on evaluating the benefits of the culturally adapted BPCR education programme, specifically its effect on improving BPCR knowledge, attitudes, and practices among pregnant women. Potential harms related to the educational intervention, including participant burden, discomfort during discussions of maternal health issues, or inconvenience associated with study participation, were considered and monitored.

Trial Registration

Pan African Clinical Trials Registry PACTR202607626025411, registered retrospectively on 09 July 2026 <https://pactr.samrc.ac.za> Retrospectively registered.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available because they contain potential identifiable participant information. However, de-identified data are available from the corresponding author upon reasonable request for academic or research purposes, subject to approval by the relevant ethics committee and in accordance with institutional policies and participants consent.

Competing interests

The authors declared that they have no competing interest.

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Authors' contributions

RBM contributed to conceiving the study and conceptualization, writing the background information, study design, and study methodology. FVM, SAS, and RS contributed to the background, study design, approaches, and methodology, and the manuscript was refined with input from all authors.

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