Noman *et al. BMC Cancer* (2024) 24:1506
https://doi.org/10.1186/s12885-024-13214-5

BMC Cancer

RESEARCH

Open Access

Investigating the effect of the educational intervention based on the Health Belief Model on the knowledge and beliefs of Yemeni teachers in the use of breast cancer screening: a randomized controlled trial study

Sarah Noman[1*], Nadya Mohamed Elfeturi Elarusy[2*], Hejar Abdul Rahman[3], Suriani Ismail[3], Meram Azzani[4], Sahar Mohammed Taresh[5,6] and Musheer A. Aljaberi[7]

Abstract

Background Breast cancer (BC) is the most prevalent cancer among women. Teachers play a crucial role in promoting healthy behaviors, including breast cancer screening (BCS). This study aimed to assess the impact of an Health Belief Model (HBM)-based educational intervention on BCS uptake, knowledge, and beliefs among female Yemeni teachers in Klang Valley, Malaysia.

Methods A cluster-randomized controlled trial was conducted with 180 participants from 12 schools, randomly assigned to intervention or control groups. The intervention group participated in a 90-minute educational session, with follow-up assessments at baseline, and at 1, 3, and 6 months' post-intervention, using validated Arabic questionnaires. Data analysis was performed using SPSS version 22.0, with Generalized Estimating Equations (GEE) applied to assess differences within and between groups over time. Statistical significance was set at $P < 0.05$.

Results At baseline, there were no significant differences between groups. Post-intervention, the intervention group showed significantly higher rates of breast self-examination (BSE) and clinical breast examination (CBE) compared to the control group, with adjusted odds ratios (AOR) of 17.51 (CI: 8.22–37.29) for BSE and 2.75 (CI: 1.42–5.32) for CBE. Over six months, BSE performance in the intervention group increased, with AORs improving from 11.01 (CI: 5.05–24.04) to 18.55 (CI: 8.83–38.99). Similarly, CBE uptake rose from 1.60 (CI: 1.02–2.52) to 2.27 (CI: 1.44–3.58). Secondary outcomes revealed significant gains in knowledge and beliefs in the intervention group, including increased confidence in performing BSE and reduced perceived barriers.

*Correspondence:
Sarah Noman
saranoman12@gmail.com
Nadya Mohamed Elfeturi Elarusy
n.elarusy@zu.edu.ly
Full list of author information is available at the end of the article

Conclusions The HBM-based educational intervention effectively enhanced BCS uptake, improved knowledge, and decreased barriers to BCS among Yemeni teachers in Malaysia, highlighting the potential of targeted educational programs to promote cancer screening behaviors in underserved populations.

Clinical trial registration Retrospectively registered, ANZCTR (ACTRN12618000173291). Registered on February 02, 2018.

Keywords Early detection of breast cancer, Health knowledge, Beliefs, Health education, Teachers

Introduction

Breast cancer (BC) is a major global health issue, responsible for about 685,000 deaths worldwide in 2020. Almost half of all BC cases appear in females with no certain risk factors beyond age and gender [1]. Though the occurrence of BC is lower in developing nations compared to developed countries [2], the death rate is particularly higher in these less wealthy regions [3]. This disparity is mainly due to lower proportions of breast cancer screening (BCS) in developing nations [4], which delays early detection and successful treatment [5]. In Yemen, a developing country, BC accounts for the highest proportion of new cancer cases, with 2,872 cases (25.4%) and 1,528 deaths (14.0%) [6]. As in many other developing nations, cases in Yemen are often diagnosed at more progressive stages or after metastasis has occurred [7]. Hence, improving early detection and screening programs efforts is critical for rising survival proportions and treatment outcomes in these counties.

Recent security issues and instability in Yemen have forced many Yemenis to pursue refuge in Malaysia. Nevertheless, Yemeni females living in Malaysia face many challenges in accessing BCS services that are available to Malaysian women. These barriers contribute to a lower uptake of BCS underscore the broader difficulties surrounding the health needs of refugees in Malaysia [8]. Addressing these barriers is essential for refining health outcomes and confirming equitable access to crucial screening facilities for Yemeni refugees.

Early detection of BC throughout screening examinations is known to reduce death rates [9]. Various approaches have been assessed for BCS, including breast self-examination (BSE), clinical breast examination (CBE), and mammography (MMG) [10]. Although BSE and CBE are significant practices for early detection at the population level, there is inadequate scientific evidence to support their efficacy in reducing BC death [11]. However, women are encouraged to observe any changes in their breasts, as both BSE and CBE contribute to awareness, probably leading to earlier diagnosis. In contrast, MMG has been proven to significantly reduce BC mortality. Therefore, it is recommended that BSE and CBE be complemented with MMG for effective screening. However, in many developing countries, MMG is not widely available due to healthcare system limitations [11].

Several epidemiological studies have examined BCS practices among diverse community samples of women, consistently showing low rates of BCS utilization across various countries [12, 13]. In Yemen, similar research indicates that the rate of females practicing BSE ranges from 11 to 17.4%, with only 30.3% engaging in regular BSE [14, 15]. Alarmingly, just 1.6% of women in Yemen have undergone MMG [16]. Studies on MMG screening rates in Yemen are limited, however, available research highlights low participation, mainly due to limited accessibility and high costs. According to a systematic review, only 24.7% of physicians referred their patients for MMG screening annually, regardless of the patients' medical history or symptoms [17]. This low referral rate is probable influenced by the limited availability of MMG services and high costs, which can prevent both physicians and patients from following regular screening. In contrast, MMG screening uptake among Malaysian women is considerably higher, with a prevalence of 51.9% [18]. This contrast underscores a significant gap in screening practices between local Malaysian women and Yemeni women residing in Malaysia, who may face unique cultural, informational, or logistical barriers to accessing BCS services. These findings emphasize the need for targeted efforts to improve awareness, accessibility, and promotion of BCS within the Yemeni community in Malaysia.

BCS behaviors are influenced by a variety of factors. The Panel on Racial and Ethnic Disparities in Medical Care identified a causal relationship between institutional factors, patient characteristics, and provider interactions as contributors to disparities in healthcare treatment across racial and ethnic groups [19]. Furthermore, differences in medical care are significantly associated with cultural beliefs about healthcare [20]. In addition to cultural factors, health beliefs specifically impact women's BCS behaviors [21, 22]. A significant body of research has examined the influence of knowledge and beliefs on BCS practices. Studies frequently identify a lack of knowledge and the existence of misconceptions about BC and BCS as the main barriers to screening among women in several countries [23–25]. Likewise, low knowledge and insufficient health beliefs about BC among Yemeni women have been identified as significant barriers to BCS. This result is constant with the work of Al-Sakkaf and Basaleem, who identified these concerns as key obstacles to successful screening in Yemen [14]. Addressing these gaps in knowledge and beliefs is essential for improving BCS uptake and overall health outcomes.

Numerous models and theories have been used to understand early detection of BC, with the Health Belief Model (HBM) being one of the most distinguished. The HBM has worked as the theoretical framework for various educational interventions aimed at improving factors that influence BCS behaviors [12, 26]. According to its concept, health-related risks can significantly influence women's health behaviors. For example, women who observe themselves as at threat for BC are more possible to engage in BSE. Moreover, women motivated by health concerns, who perceive more benefits and encounter fewer barriers, are more prone to practice BSE. The HBM also proposes that higher knowledge about BCS behaviour is associated with increased rates of screening practices [27].

While numerous intervention studies have examined BCS practices among various groups of women worldwide [23, 24, 28], there is a notable gap in research focusing specifically on female teachers and their BCS practices. Although some studies in Malaysia have explored BCS practices among Malaysian teachers, similar research concerning Yemeni teachers residing in Malaysia is lacking. Addressing this gap could provide valued insights into the unique challenges and needs of this group regarding BCS. Teachers hold a unique and influential role in society, not only as educators but also as respected role models who can promote healthy behaviors. By targeting female teachers, this study recognizes their potential to drive health awareness and encourage BCS practices within their communities. Teachers have a direct impact on shaping the attitudes and behaviors of younger generations, creating a culture of health consciousness that may persist throughout their students' lives. This influence is especially important for Yemeni teachers residing in Malaysia, who, upon returning to Yemen, could play a crucial role in spreading the knowledge and practices they have acquired to their native communities. Furthermore, female teachers from minority groups may face unique cultural and logistical barriers to BCS that differ from those experienced by other populations, underscoring the importance of studying this specific group. Addressing these unique challenges can lead to tailored interventions that enhance BCS awareness and participation, both locally and potentially in their communities abroad.

Considering the previously discussed barriers and the influential role teachers play in promoting healthy behaviors, educational intervention has been identified as cost-efficient and the most effective method to increase awareness of BCS. Currently, no studies have been published on BCS among Yemeni women in Malaysia. This research intends to fill this gap by providing valuable information that can inform future initiatives to expand BC awareness programs and develop preventive strategies within this group. To the best of the researchers' knowledge, this is the first research to evaluate the effect of an educational intervention based on the HBM among female Yemeni teachers in Malaysia. The overall objective is to develop and evaluate a BCS program for Yemeni female teachers in the Klang Valley, Malaysia using the HBM.

Methods

Design and settings

This study is a parallel cluster-randomized controlled trial (cRCT), with schools serving as the unit of randomization. The target population consists of Yemeni female school teachers. The study follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines for cluster-randomized trials. The trial aims to evaluate the effect of an educational intervention on BCS uptake among Yemeni female school teachers at Arabic schools in Klang Valley, Malaysia.

There are 19 Arabic schools in Klang Valley, with teachers from various Arab countries; however, the majority are Yemeni, as six of these schools are specifically Yemeni schools. The intervention group received an educational program on BCS, while the control group was provided with the educational materials once the study was completed. Evaluations were conducted at baseline and at one, three, and six months post-intervention.

Sample size calculation

The total sample size required to detect statistically significant differences for the primary outcome (proportion of BCS uptake) was calculated using the formula for the difference between two population proportions [29]. The parameters used were a power of 0.80, an alpha level of 0.05 for a two-sided test, P1 = 0.71, and P2 = 0.43 [30].

$$\mathrm{n} = \frac{\left\{ \mathrm{Z}_{1-\alpha/2}\sqrt{2\bar{\mathrm{P}}\left(1-\bar{\mathrm{P}}\right)} + \mathrm{Z}_{1-\beta}\sqrt{\mathrm{P}_1\left(1-\mathrm{P}_1\right) + \mathrm{P}_2\left(1-\mathrm{P}_2\right)} \right\}^2}{\left(\mathrm{P}_1-\mathrm{P}_2\right)^2}$$

$$n = (16)\,2/(0.71 - 0.43)2 = 47$$

The power calculations indicated a minimum sample size of 47 teachers per group (47*2 = 94). Accounting for a 20% attrition rate (94/0.80 = 118) and a 10% expected proportion of eligibility (118/0.90 = 131), the required sample size was further adjusted by the design effect (design effect = 1.4), resulting in a total sample size of 183 teachers (131*1.4 = 183). The number of clusters (schools) needed was calculated to be 10 (183/19 = 10). However, to achieve the required sample size, a total of twelve schools that met the eligibility criteria were included in the study.

Sampling method

Cluster sampling was utilized to select the schools for this study. Out of the 19 Arabic schools in Klang Valley, 12 schools that met the eligibility criteria were chosen for participation. Each of these 12 schools (clusters) was assigned a serially numbered unique code. Block randomization was then used to assign the clusters to either the intervention or control group, resulting in six clusters in each group. All teachers who agreed to participate from each selected school were involved in the study.

Eligibility criteria

Schools were qualified for inclusion if they met the subsequent criteria: (1) Arabic schools situated in Klang Valley, and (2) schools that agreed to contribute to the study. Schools were excluded if they did not have Yemeni female teachers. For teachers, the inclusion criteria were: (1) Yemeni female teachers currently teaching at the selected schools, (2) aged 20 years and above, and (3) those who signed a consent form to participate. Teachers were excluded if they (1) were scheduled to retire during the study period, (2) had been detected with BC, or (3) were lactating or pregnant.

Recruitment of participants

After obtaining consent from the responsible authorities of all selected schools, small group meetings were arranged at each school with the assistance of school coordinators. During these meetings, the researcher explained the study's objectives, benefits, and eligibility criteria to the participants. Written consent forms were then collected from the participants, who were asked to complete the baseline data questionnaire. Following this, the educational intervention was delivered to the intervention group. Post-intervention assessments were conducted at three intervals: one month, three months, and six months after the intervention. To ensure truthful responses, participants were encouraged to respond honestly, and all questionnaires were kept anonymous. The flow diagram of the study design is outlined in Fig. 1.

Type of randomization

Sequence generation

In this study, schools were used as the unit of randomization, and block randomization was applied. To assign the 6 clusters (schools) to the study groups, a randomization sequence was generated with the Sealed Envelope Tool Software, with a 1:1 allocation ratio, employing random block sizes of 2 and 4. As a result, 6 clusters were randomly assigned to the intervention group, and 6 clusters to the control group. To confirm allocation concealment, both clusters received a unique treatment allocation code inside a serially numbered, sealed opaque envelope. These envelopes were distributed to the schools, and the envelopes were opened to allocate the clusters to either the intervention or control group according to the unique codes created by the software. Ultimately, 90 teachers were assigned to the intervention group and 90 teachers to the control group.

Intervention

Development of the intervention

An educational intervention on BCS, grounded in the HBM, was developed for the intervention group. This program was designed based on guidelines from the American Cancer Society (ACS) [31], the American College of Obstetricians and Gynecologists (ACOG) [32], and the International Agency for Research on Cancer (IARC) [33]. The aim was to address gaps in BC knowledge and to amend beliefs associated with BC. The educational program incorporated the six concepts of the HBM: perceived seriousness, perceived susceptibility, perceived barriers, perceived benefits, confidence, and health motivation. The control group received the educational materials after the completion of the study, and they completed the same set of questionnaires at baseline, and at one, three, and six months post-intervention. A detailed description of the educational program has been provided elsewhere [34]. The intervention was delivered to the intervention group through a variety of mediums, including PowerPoint presentations, training sessions, a booklet, a five-minute short video on BSE techniques, another five-minute video testimony by a BC survivor, a CD, a BC awareness logo sticker, and short reminder text messages.

Implementation of the educational intervention

After baseline data collection, a 90-minute, one-day educational session on BCS was provided to schools in the intervention group. The sessions were conducted by the study investigator with the assistance of a qualified research assistant. Three sessions were conducted per week, with groups of five to fifteen participants. The technique for the educational program was as follows:

a) A sixty-minute PowerPoint presentation was provided, with a modified 5-minute film on BSE, and another five-minute testimony short video by a BC survivor sharing her experience. These resources covered common information about the physiology and anatomy of the breast, BC knowledge, BCS methods, and the significance of breast health awareness.
b) A thirty-minute training session followed, which comprised hands-on training of BSE using a

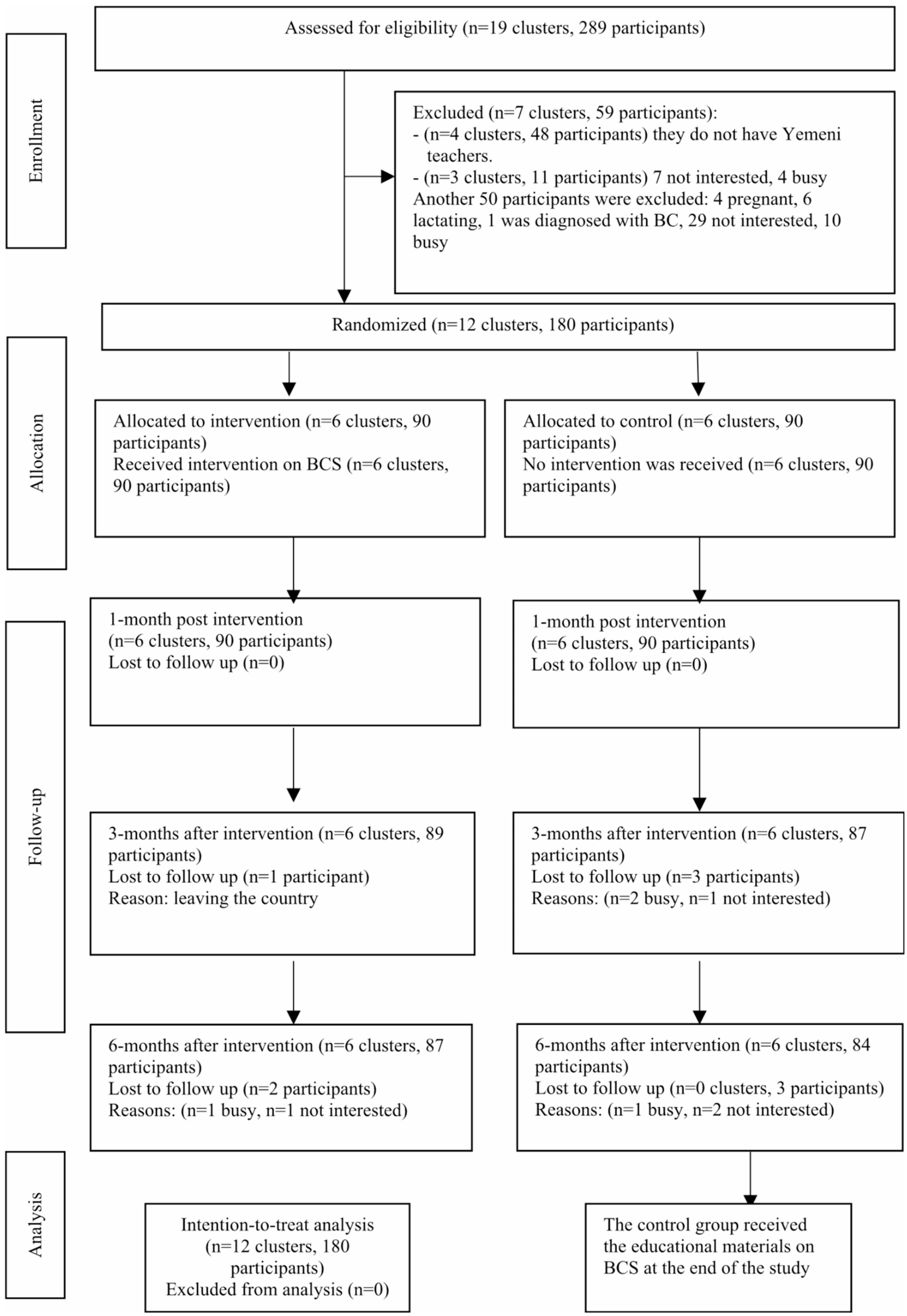

Fig. 1 Flow diagram on study design and outcome evaluation

silicone breast with implanted lumps. Throughout this session, teachers learned about the palpation techniques, search strategy, and signs of BC. Teachers then practiced BSE on the model.

c) Each teacher received a booklet, a BC logo sticker, and a CD on the BSE film. These materials were proposed to emphasize the key messages delivered during the program, and to serve as reminders of the significance of BCS.
d) All teachers in the intervention group continued to receive text messages for the subsequent six months. These messages delivered key recommendations about BCS, aimed at motivating, reminding, and encouraging participants to practice BCS.

Intervention fidelity

To ensure constant delivery of the educational module, the investigator followed a standardized educational protocol. To further improve the participants' engagement, the investigator conducted BSE practice sessions utilizing role-play methods and provided feedback. Additional technique to support fidelity included the BC logo stickers and the monthly reminder messages. These approaches intended to stress the significance of BCS practices, motivate participants, and emphasize the key messages of the program.

Study instrument

The study utilized four sets of self-administered questionnaires, initially designed in English and subsequently translated into Arabic. Each questionnaire is divided into the following sections:

Part I: Socio-demographic factors

This section includes five questions designed to capture the socio-demographic characteristics of the participants, such as age, education level, marital status, income, and family history of BC. Additionally, it contains one question regarding the participants' prior exposure to information about BCS.

Part II: breast cancer screening uptake

This section measures BSE practices and frequency through self-report questions. Participants are asked: (a) "Have you ever performed BSE?" (yes/no) and (b) "How often do you perform BSE?" (Options include once a month, once every 2–3 months, other, never). Participants who perform BSE once a month or more are classified as practicing regular BSE, while those who report less frequent or no BSE are classified as practicing irregular BSE. Additionally, CBE and MMG uptake is assessed through self-report questions, categorizing participants as either "practicing" or "not practicing."

Part III: knowledge of breast cancer

Knowledge of BC and BCS methods was assessed using a modified questionnaire adapted from Parsa [35], Akhtari-Zavare et al. [24], and McCance et al. [36]. The self-administered questionnaire comprised 35 items, categorized into: symptoms of BC (6 items), risk factors of BC (14 items), breast health awareness (5 items), and BCS approaches (10 items). A full knowledge questionnaire is included in Additional File 1. Responses were recorded on a nominal scale of "True," "False," and "I do not know." Participants received one score for each correct answer and zero scores for incorrect or uncertain responses. The maximum possible score was 35, and the minimum was 0. Higher scores implied greater knowledge.

Part IV: Health belief model scales

The Champion's Health Belief Model Scale (CHBMS) was used to evaluate beliefs related to BC in this study. The original CHBMS comprises eight self-reported scales: perceived susceptibility (5 items), perceived seriousness (7 items), perceived benefits of BSE (6 items), perceived barriers to BSE (6 items), confidence in the ability to perform BSE (11 items), health motivation (7 items), benefits of MMG (6 items), and barriers to MMG (5 items) [37, 38]. Since the original scale did not include beliefs regarding CBE, permission was obtained from Parsa to incorporate her validated sections for CBE, which include two subscales: benefits of CBE (4 items) and barriers to CBE (6 items) [39]. The final CHBMS consisted of 63 questions across ten subscales. All items were measured using a 5-point Likert scale: Strongly disagree (1 score), Disagree (2 scores), Neutral (3 scores), Agree (4 scores), and strongly agree (5 scores). Scores were summed for analysis, with higher scores representing stronger beliefs [37]. All scales are positively associated with screening behaviors, except for barriers, which are negatively related.

Quality control of study instruments

The translation of the questionnaire and educational module followed forward-backward translation. Subsequently, the questionnaire and module were reviewed by a panel of seven experts to assess validity. This panel included three medical doctors, a psychology professor, a consultant radiologist, and two nurses. The panel's feedback focused on ensuring the content was clear and understandable. Based on their suggestions, revisions were made to enhance clarity and relevance. After the adjustments, the revised tools were deemed culturally appropriate, with a content validity index (CVI) of 0.95%. The translated questionnaire and educational module were then pre-tested with 30 Yemeni female schoolteachers not involved in the main study. Participants were asked to identify any difficult or inappropriate words or expressions. Based on their feedback, some terms and phrases were revised, and the final versions of the questionnaire and educational module were developed.

The internal consistency reliability of each factor was calculated using Cronbach's alpha, with values of $\alpha \geq 0.70$ considered desirable. The reliability of the knowledge questionnaire was confirmed, with alpha coefficients ranging from 0.81 to 0.95. Exploratory factor analysis (EFA) of the translated items identified four factors, explaining a total variance of 55.89%. The items demonstrated adequate factor loadings, ranging from 0.51 to 0.89. For the CHBMS, alpha coefficients ranged from 0.76 to 0.87. EFA identified six factors related to BSE, five factors for CBE, and five factors for MMG, with total variances explained at 47.69%, 51.19%, and 52.63%, respectively. The factor loadings for these items ranged from 0.47 to 0.88, indicating satisfactory associations across factors. A more comprehensive discussion of the study's validity is available elsewhere [40].

Data analysis

Data were analysed using IBM SPSS Statistics software, version 22.0. The significance level was set at $p < 0.05$. Generalized Estimating Equations (GEE) were employed as a robust method for cluster data analysis. This approach assessed differences in group effects (schools and teachers), within-group effects (time), and interactions between group and time effects over time. Simple mean effects for continuous variables were analyzed to evaluate differences in outcome variables between and within groups across time. Generalized Estimating Equations (GEE) were chosen over repeated measures ANOVA or other non-parametric tests (e.g., McNemar or Mann-Whitney) due to the structure and requirements of the study. Unlike repeated measures ANOVA, which assumes normally distributed continuous outcomes, GEE is suitable for analyzing correlated data in longitudinal or cluster-randomized studies and can accommodate various outcome types (e.g., binary, count, continuous). GEE accounts for the clustering within groups (schools and teachers) and manages intracluster correlations, allowing for robust parameter estimates even when data are non-normally distributed. Additionally, GEE is advantageous for interpreting marginal (population-level) effects, which aligns with the study's aim to assess overall intervention effectiveness on BCS behavior among Yemeni teachers over time. This flexibility and robustness make GEE an optimal choice for this clustered data structure. Missing values for continuous variables were handled using the Expectation Maximization (EM) algorithm, while missing data for categorical variables were addressed through regression imputation. The analysis adhered to the intention-to-treat principle, including all participants who were randomized.

Table 1 Comparisons of participants' socio-demographic characteristics in the two groups at baseline

Characteristics	Intervention group ($n = 90$) n(%)	Control group ($n = 90$) n(%)	Test Statistic	*P* value
Age (years)				
Mean (SD)	33.38(6.19)	33.57(5.68)	t = -0.213	0.831
Income (RM)				
Median (IQR)	1550(50)	2000(50)	Mann-U=4.66	0.067
Marital status				
Married	74(82.2)	64(71.1)	F=4.671	0.149
Divorced/Separated	2(2.2)	3(3.3)		
Widowed	1(1.1)	0(0.0)		
Single	13(14.5)	23(25.6)		
Education level				
Undergraduate & Diploma	80(88.9)	81(90.0)	$\chi^2 = 0.059$	0.808
Postgraduate	10(11.1)	9(10.0)		
Family History of BC				
Yes	17(18.9)	16(17.8)	$\chi^2 = 0.037$	0.847
No	73(81.1)	74(82.2)		
Read/heard about BCS				
Yes	61(67.8)	71(78.9)	$\chi^2 = 2.841$	0.092
No	29(32.2)	19(21.1)		

SD standard deviation. t=independent t-test, Mann-U=Mann-Whitney U, F=Fisher's exact test, $\chi^{2=}$Chi-square test, *Significant result ($P < 0.05$)

Results

A total of 180 teachers were recruited for the research. The response rate was 100% at both the baseline and the one-month data collection points. However, four participants withdrew at the 3-month follow-up, and an additional five participants withdrew at the 6-month follow-up. Ultimately, 171 participants completed the study, resulting in a 95% response rate.

Comparisons of socio-demographic characteristics between the two groups

To evaluate the homogeneity of socio-demographic and other characteristics between the two groups, a comparison was conducted. As presented in Table 1, no significant differences were found between the two groups across all variables.

Generalized estimating equations (GEE) analysis of changes in the primary outcome variable (BCS uptake) between and within intervention and control groups over time

Table 2 displays the results of the GEE analysis, which adjusted for confounding factors. The analysis revealed a significant overall effect on BSE performance, BSE frequency, and CBE, with significant findings for group

Table 2 GEE analysis of group, time, and interaction effect for BCS uptake

	Group		Time		Group & time/ predictors	
	χ^2(df)	*P* value	χ^2(df)	*P* value	χ^2(df)	*P* value
BSE Performance	105.765(1)	< 0.001*	52.554(3)	< 0.001*	36.062(3)	< 0.001*
BSE Frequency	42.774(1)	< 0.001*	13.985(3)	0.003*	14.491(3)	0.002*
CBE	5.516(1)	0.019*	14.590(3)	0.002*	10.311(3)	0.016*
					Age = 5.266(1)	0.022*
MMG	0.647(1)	0.421	4.126(2)	0.127	0.678(2)	0.713

*Significant result (*P* < 0.05)

Table 3 GEE analysis of BCS uptake between and within the two groups

	BSE		BSE frequency		CBE		MMG	
	χ^2 (df)	AOR (95% CI), *p* value	χ^2 (df)	AOR (95% CI), *p* value	χ^2 (df)	AOR (95% CI), *p* value	χ^2 (df)	AOR (95% CI), *p* value
Between groups								
IG vs. CG	55.059(1)	17.51(8.22, 37.29), < 0.001*	31.901(1)	17.36(6.45, 46.74), < 0.001*	9.041(1)	2.75(1.42, 5.32), 0.003*	0.264(1)	1.41(0.38, 5.27), 0.607
Within groups								
IG(Time 2)	36.302(1)	11.01(5.05, 24.04), < 0.001*	11.803(1)	5.51(2.08, 14.59), < 0.001*	4.109(1)	1.60(1.02, 2.52), 0.043*		
IG (Time 3)	42.051(1)	13.56(6.17, 29.81), < 0.001*	27.497(1)	8.99(3.95, 20.42), < 0.001*	13.932(1)	2.06(1.41, 2.99),< 0.001*		
IG (Time 4)	59.398(1)	18.55(8.83, 38.99), < 0.001*	27.310(1)	11.79(4.68, 29.78), < 0.001*	12.386(1)	2.27(1.44, 3.58), 0.001*		
CG(Time 2)	0.052(1)	1.07(0.61, 1.87), 0.819	1.568(1)	2.12(0.66, 6.84), 0.211	0.200(1)	1.000(0.99-1.00), 0.66		
CG (Time 3)	0.733(1)	1.29(0.724, 2.281), 0.392	0.0001(1)	1.000(0.28, 3.54), 1.000	0.338(1)	1.08(0.84, 1.37), 0.56		
CG (Time 4)	0.866(1)	1.36(0.71, 2.61), 0.352	0.142(1)	1.27(0.37, 4.33), 0.706	0.202(1)	1.08(0.78, 1.48), 0.65		

IG intervention group, CG control group, *Significant result (*P* < 0.05)

effects, within-group effects, and interaction effects between group and time ($p<0.05$). In contrast, no significant differences were observed in the group effect ($p=0.421$), within-group effect ($p=0.127$), or interaction effect ($p=0.713$) for MMG uptake.

Table 3 displays the overall results of the GEE analysis for BCS uptake between and within the study groups over time. The analysis exposed significant differences between the two groups for BSE performance, BSE frequency, and CBE ($p<0.05$). However, no significant differences were found in MMG uptake between the groups ($p=0.607$). The GEE analysis further assessed changes in BCS uptake within the two groups over time. For the intervention group, the adjusted odds ratio (AOR) for performing BSE was 11.01 ($p<0.001$) at one month, increasing to 13.56 ($p<0.001$) at three months, and reaching 18.55 ($p<0.001$) at six months. Nevertheless, no significant changes in BSE performance were detected within the control group over time. Regarding BSE frequency, the AOR within the intervention group was 5.51 ($p<0.001$) at one month, rising to 8.99 ($p<0.001$) at three months, and 11.79 ($p<0.001$) at six months. No significant changes were noted in BSE frequency within the control group over time. For CBE uptake, the AOR within the intervention group was 1.60 ($p=0.043$) at one month, increasing to 2.06 ($p<0.001$) at three months, and 2.27 ($p<0.001$) at six months. Conversely, no significant changes in CBE uptake were observed within the control group over time.

Generalized estimating equations (GEE) analysis of changes in secondary outcome variables (knowledge and beliefs) between and within the two groups over time

As displayed in Table 4, the GEE analysis shown a significant overall effect on mean knowledge scores, with significant findings for group effects, within-group effects, and interaction effects between group and time ($p<0.001$). Similarly, the GEE analysis indicated a significant overall effect on mean belief scores for most HBM subscales, with the exception of perceived seriousness, perceived susceptibility, barriers to CBE, and barriers to MMG for group effects ($p<0.05$). For within-group effects, significant differences were detected in mean belief scores for HBM subscales except for perceived seriousness and barriers to MMG ($p<0.05$). Additionally, a significant interaction effect was found between group and time ($p<0.05$) on mean belief scores for HBM subscales, excluding

Table 4 GEE analysis of group, time, and interaction effect for knowledge and beliefs

	Group		Time		Group & time/ predictors	
	χ^2(df)	*P* value	χ^2(df)	*P* value	χ^2(df)	*P* value
knowledge	178.514(1)	< 0.001*	149.276(3)	< 0.001*	146.294(3)	< 0.001*
					Read/heard on BC = 7.005(1)	0.008*
SUS	0.555(1)	0.456	24.321(3)	< 0.001*	7.038(3)	0.071
					Read/heard on BC = 8.810(1)	0.003*
SER	2.159(1)	0.142	2.607(3)	0.456	0.548(3)	0.908
					Age = 6.347(1)	0.012*
BEN (BSE)	29.207(1)	< 0.001*	33.217(3)	< 0.001*	39.030(3)	< 0.001*
					FH of BC = 4.688(1)	0.030*
					Read/heard on BCS = 6.261(1)	0.012*
BAR (BSE)	15.745(1)	< 0.001*	28.536(3)	< 0.001*	35.292(3)	< 0.001*
CON	7.028(1)	0.008*	29.579(3)	< 0.001*	28.869(3)	< 0.001*
					Read/heard on BCS = 8.565(1)	0.003*
HM	23.206(1)	< 0.001*	9.126(3)	0.028*	8.979(3)	0.030*
BEN (MMG)	20.833(1)	< 0.001*	22.107(3)	< 0.001*	10.310(3)	0.016*
BAR (MMG)	2.587(1)	0.108	4.424(3)	0.219	1.642(3)	0.650
					Read/heard on BCS = 4.225(1)	0.040*
BEN (CBE)	17.833(1)	< 0.001*	14.879(3)	0.002*	31.210(3)	< 0.001*
BAR (CBE)	2.485(1)	0.115	15.982(3)	0.001*	7.712(3)	0.052

SUS susceptibility of BC, SER seriousness of BC, BEN benefits, BAR barriers, HM health motivation, CON confidence, FH family history, *Significant result ($P<0.05$)

Table 5 Pairwise comparison of overall mean scores of knowledge and beliefs between the two groups

	Mean (S.E)		Mean difference (I-J) S.E	(95% CI), *P* value[b]
	IG	CG		
Knowledge	24.85(0.377)	17.77(0.528)	7.08(0.530)	(6.04, 8.12), < 0.001*
SUS	20.09(5.04)	19.87(5.03)	0.22(0.30)	(-0.37, 0.82), 0.456
BEN (BSE)	25.38(0.291)	23.46(0.356)	1.92(0.36)	(1.22, 2.62), < 0.001*
BAR (BSE)	11.61(0.22)	13.20(0.34)	-1.59(0.401)	(-2.37, -0.80), < 0.001*
CON	33.85(0.53)	31.97(0.72)	1.88(0.71)	(0.49, 3.27), 0.008*
HM	28.90(0.31)	27.24(0.30)	1.65(0.34)	(0.98, 2.33), < 0.001*
BEN (MMG)	23.46(0.38)	21.69(0.51)	1.77(0.39)	(1.01, 2.53), < 0.001*
BEN (CBE)	16.62(0.140)	15.44(0.26)	1.18(0.28)	(0.63, 1.72), < 0.001*
BAR (CBE)	17.37(0.27)	18.03(0.33)	-0.66(0.42)	(-1.48, 0.16), 0.115

SUS susceptibility of BC, SER seriousness of BC, BEN benefits, BAR barriers, HM Health motivation, CON Confidence, *Significant result ($P<0.05$). [b] Adjustment for multiple comparisons Bonferroni

perceived seriousness, perceived susceptibility, barriers to MMG, and barriers to CBE.

Pairwise comparisons of knowledge and HBM scales mean scores

Table 5 presents the pairwise comparison of overall knowledge mean scores between the two groups. The analysis revealed a significant mean difference in knowledge mean scores between the two groups over time, with a mean difference of 7.08 ($p<0.001$) after adjusting for covariates. The pairwise comparison of mean scores for HBM scales showed significant increases in the intervention group compared to the control group over six months. Notable differences were found in the following subscales: benefits of BSE (mean difference = 1.92, $p<0.001$), barriers to BSE (mean difference = -1.59, $p<0.001$), confidence to perform BSE (mean difference = 1.88, $p=0.008$), health motivation (mean difference = 1.65, $p<0.001$), benefits of MMG (mean difference = 1.77, $p<0.001$), and benefits of CBE (mean difference = 1.18, $p<0.001$). In contrast, no significant differences were detected for the subscales of perceived susceptibility, perceived seriousness, barriers to CBE, and barriers to MMG.

Within-group analysis

The within-group analysis demonstrated a significantly greater increase in knowledge mean scores in the intervention group compared to the control group over six months. Specifically, the knowledge mean scores in the intervention group improved from 18.05 to 27.14

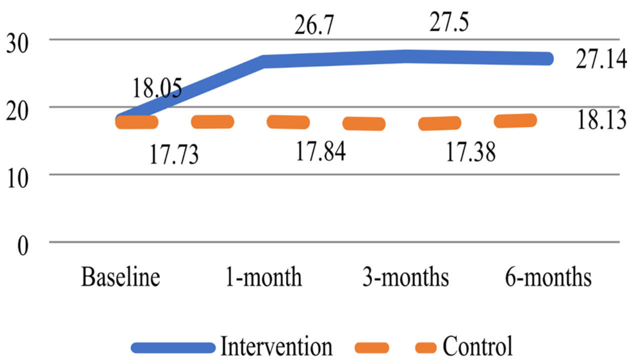

Fig. 2 Knowledge scores within groups over time

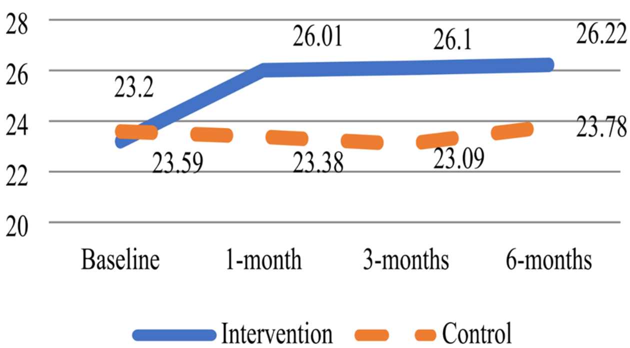

Fig. 3 Benefit of BSE within groups over time

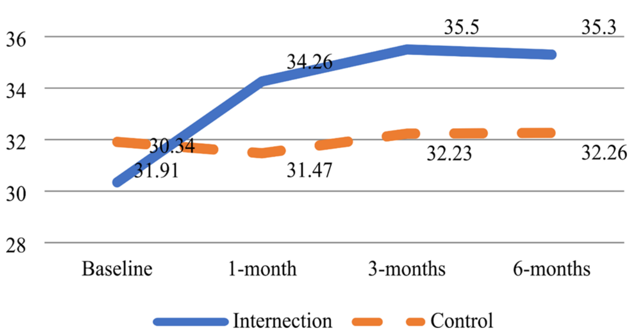

Fig. 4 Confidence on BSE within groups over time

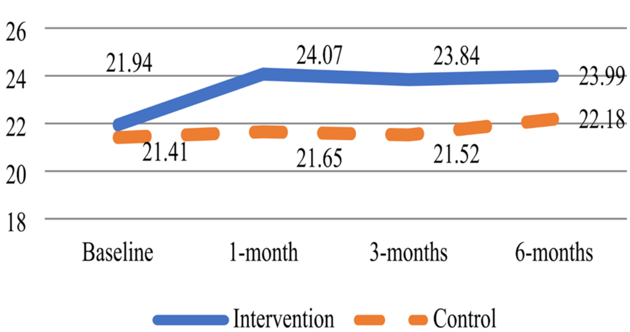

Fig. 5 Benefit of mammography within groups over time

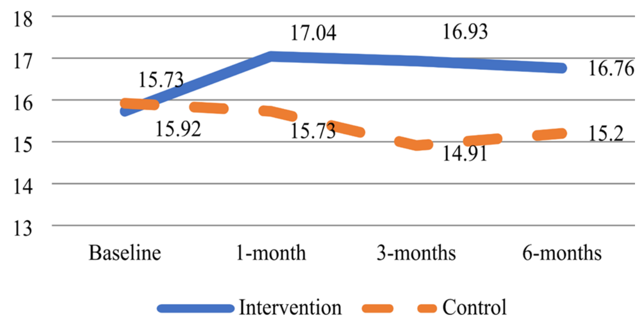

Fig. 6 Benefits of CBE within groups over time

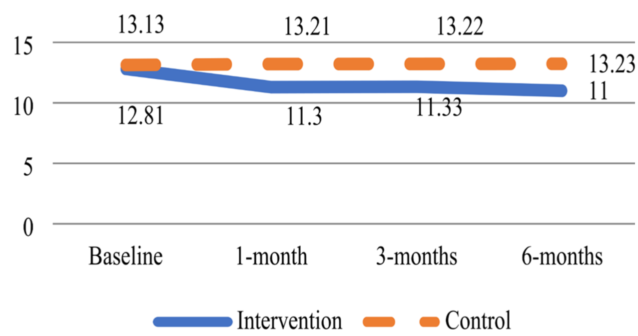

Fig. 7 Barriers of BSE within groups over time

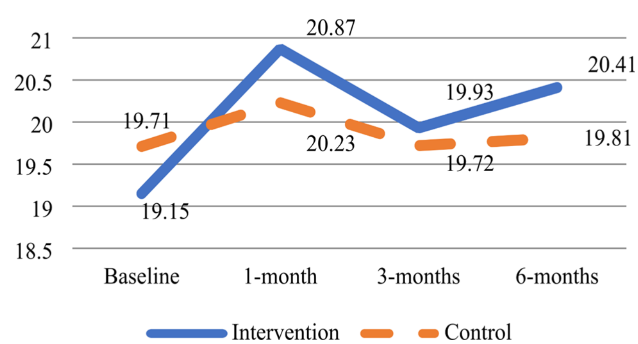

Fig. 8 Perceived susceptibility within groups over time

($p < 0.001$). In contrast, no statistically significant differences were detected in knowledge mean scores at the four time points for the control group, as illustrated in Fig. 2.

Changes in health beliefs over six months

Over six months, the intervention group revealed a significant increase in mean health beliefs scores compared to the control group for several subscales: benefits of BSE (23.20 to 26.22, $p < 0.001$; Fig. 3), confidence to implement BSE (30.34 to 35.30, $p < 0.001$; Fig. 4), benefits of MMG (21.94 to 23.99, $p = 0.017$; Fig. 5), and benefits of CBE (15.73 to 16.76, $p = 0.031$; Fig. 6). Additionally, barriers to BSE decreased significantly (12.81 to 11.00, $p = 0.002$; Fig. 7). Nevertheless, no significant differences were detected within the two groups for the subscales

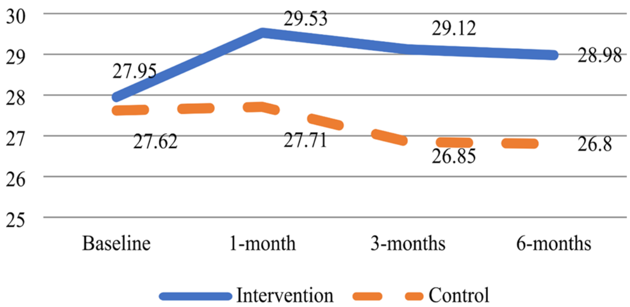

Fig. 9 Motivation within groups over time

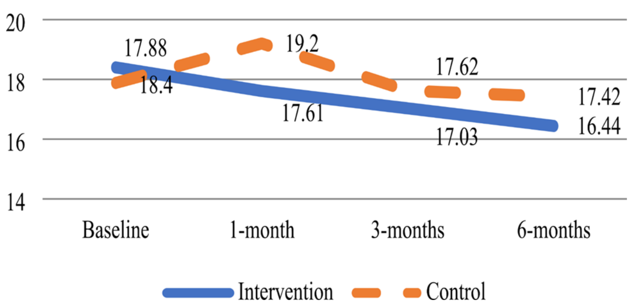

Fig. 10 Barriers of CBE within groups over time

of perceived susceptibility (Fig. 8), health motivation (Fig. 9), and barriers to CBE (Fig. 10).

Discussion

This randomized controlled trial (RCT) proposed to assess whether the practice, knowledge, and beliefs of teachers regarding BCS would improve following the implementation of an educational intervention. The study results suggest that the health educational intervention had a positive impact, as evidenced by significant improvements in the teachers' BCS practices, knowledge, and beliefs after the intervention.

Breast self-examination

The results of this study display a significant improvement in BSE uptake among the intervention group compared to the control group over time. This improvement may be attributed to the simplicity of performing BSE and the effectiveness of the practical training session with the breast model, combined with the educational program. These findings suggest that practical, skill-based education can successfully increase both the implementation and frequency of BSE. These findings align with similar intervention studies that have shown improved BSE performance among those who received educational interventions compared to participants who did not [12, 23, 24, 41, 42]. The results are constant with studies by Akhtari-Zavare et al. [24], Masoudiyekta et al. [23], and Tuzcu et al. [12], which found that participants who practiced BSE on breast models with lumps demonstrated higher performance and frequency of BSE than those who learned through lectures, leaflets, videos, or other educational methods. Therefore, the educational intervention incorporating practical BSE training, along with the other components developed in this study, may be effective in increasing BSE practice and frequency in similar demographic groups.

Health belief model and BSE

Several intervention studies have supported the present findings, emphasizing the effectiveness of using the HBM as a theory-based approach to improving BSE behaviors [12, 23, 24, 28, 41]. A systematic review had supported the effectiveness of educational interventions on BSE globally, finding theory-based, hands-on approaches particularly effective for increasing screening behaviours [21]. Similarly, in a recent study conducted on female teachers in Iran, found significantly higher frequencies of BSE in the intervention group than in the control group six months post-HBM-based intervention, reinforcing the efficacy of educational initiatives grounded in HBM [43].

Recommendations and limitations for BSE

While BSE is no longer recommended as a primary screening method due to limited evidence of its effectiveness, it has been shown to empower women to notice any changes in their breasts. As a result, women are encouraged to become familiar with their breasts and promptly report any changes to physician. Experts suggest that self-awareness can be as efficient as regular BSE [44]. Additionally, the Malaysian Clinical Practice Guidelines recommend BSE not as a screening method, but as a tool for raising awareness [45].

Clinical breast examination

The findings of this study reveal a positive impact of the intervention on CBE performance. The results showed that CBE practice was significantly higher in the intervention group compared to the control group. These results are consistent with those from a RCT conducted by Elder et al. [46], which found a significant increase in CBE performance in the cancer screening condition from 47 to 63% compared to the control group. Similar findings were observed in studies conducted in Iran by Mirmoammadi et al. and Fathollahi-Dehkordi and Farajzadegan [28, 47], which also demonstrated the efficacy of educational interventions in promoting CBE practice.

There are notable similarities between the findings of this study and those reported by Tuzcu et al. [12], which found that after a 6-month follow-up, the rate of CBE practice was better in the intervention group compared to the control group (34.1% vs. 10.1%). The significant increase in CBE performance among participants in the intervention group of our study may be attributed to the distribution of printed materials on BCS methods and the motivational follow-up through telephone messages post-intervention. Likewise, studies by Akhtari-Zavare et al., Masoudiyekta et al., and Mirmoammadi et al. [23, 24, 28] identified motivational telephone messages and printed materials as effective strategies for rapidly improving BCS uptake.

A randomized controlled study supports these findings, reporting that the intervention group exhibited a notably higher frequency of CBE six months post-training [43]. Likewise, a systematic review emphasized that educational interventions are generally effective in promoting CBE and enhancing women's knowledge and participation in screening practices worldwide [21]. The interesting finding of the current study is the relationship between age and CBE uptake. These findings are consistent with the study of Tuzcu et al. [12], who stated that CBE increased by 1.1 (CI: 1.03–1.16) with each additional year of age. This association is supported by other studies, indicating that older women are more likely to perform CBE [48], perhaps due to increased perception of risk. Nevertheless, a study by Andegiorgish et al. [49] reported no significant association between CBE practice and age (P=0.961), suggesting that further study may be needed to investigate the impact of age on CBE uptake.

Mammography

The results of this study suggest that there were no significant differences in MMG uptake between or within the two groups. The low MMG practice rate in this study could be attributed to numerous factors: the small number of respondents over 40 years old (17%), lack of insurance coverage, short follow-up period, and absence of screening programs. These findings align with Wu & Lin [50], who stated similar challenges in improving screening level. In contrast to our findings, a study by Gondek et al. [51] assessing the efficacy of a health education program for immigrant women in the USA stated a significant increase in MMG screening post-intervention. However, the study reported that women from Middle Eastern backgrounds were less likely to contribute in screening compared to Thai and Burmese women. This lower rate was attributed to cultural factors, such as the family structure in Middle Eastern, where women often rely on male relatives for medical care decisions. This may also justify the low MMG rates in our study, as it similarly involved women from Middle Eastern nations.

In another contrast to the findings of this study, Lee-Lin et al. [30] reported significantly different findings among Chinese American immigrant females. The study reported six months' post-intervention, the intervention group was 9 times more probable to practice MMG compared to the control group (OR=9.10, 95% CI: 3.50-23.62). One possible explanation for the high education program effect is that research grant funding covered MMG costs for participants, reducing financial barriers. This financial support, unavailable to population in our study, could account for the lower MMG screening rates. Similarly, studies implemented in the USA [46, 52] and Turkey [11] found significantly higher MMG level in the intervention group compared to the control group. One possible explanation for these contradictory findings is that the HBM used in our intervention focuses primarily on intra-personal factors related to health behavior, such as disease perceptions and self-efficacy. However, the HBM provides limited insight into social, interpersonal, and economic barriers to health behaviour change [53].

In contrast, studies like those by Lee-Lin et al. and Taymoori et al. [30, 54] utilized a combination of health behavior models that address more multifaceted needs, leading to better screening level. The findings of our study suggest that Yemeni women in Malaysia encounter many challenges in accessing MMG screening facilities, involving limited healthcare services, language barriers, transportation difficulties, cultural norms, and high costs. Addressing these issues may require a long-term culturally tailored educational method that involves local culture sensitivities, includes family members, and explore ways to reduce screening costs. Such method may be essential to shift health practices and overcome traditional barriers.

Breast cancer screening knowledge

The results of the present research indicate that teachers in the intervention group showed a significant increase in BC knowledge following the intervention, compared to participants in the control group. This important improvement may be attributed to the information offered through the program. Moreover, the high level of education between the women in the study sample may have contributed to the success of the education program. The findings align with studies by Rabbani et al., Akhtari-Zavare et al., and Yılmaz et al. [13, 24, 55], as well as study by Khiyali et al. [41]. The current findings also consistent with the results of a quasi-experimental study in Iran [23].

Furthermore, a recent descriptive study on women in urban Lucknow, India, found a substantial increase in BC awareness post-intervention. This improvement suggests that targeted educational programs can significantly raise BC awareness, potentially aiding early detection among urban populations, especially where awareness levels may initially be low [56]. Moreover, a study among women in Egypt found a significant increase in BCS knowledge after the implementation of an educational intervention, highlighting the potential for parallel programs to increase knowledge in diverse populations [57].

However, some previous studies have stated that educational programs were not effective in improving BC knowledge across different groups. For example, Elder et al. [46] found no significant difference in BC knowledge scores between intervention group and control groups, proposing that intervention effectiveness may vary based on some factors such as delivery approach, content, and participant engagement. In this study, previous exposure to information about BCS was positively associated with improved BC knowledge. Women who had previously read or heard about BCS were more knowledgeable about BC. These results are consistent with previous study by Hussen et al. [58], who found that participants with prior information about BC were more possible to have greater knowledge than those without such information.

Beliefs about breast cancer screening

The findings of the current research indicate that, following the educational intervention, there was a significant progress in most health beliefs subscales in the intervention group. The notable improvement in knowledge and beliefs among participants underscores their readiness to acquire more health information and develop skills to promote healthy behaviors. However, the lack of significant differences in some belief subscales may be attributed to the homogeneity of the study sample concerning socio-demographic factors, which could explain the limited variation in respondents' beliefs about BC.

These findings support Yılmaz et al. [13], who reported a significant improvement in post-test mean scores for benefits, barriers, health motivation, and self-efficacy. The findings of the current study also align with a RCT conducted in Iran, which found important differences between the study groups in perceived benefits of CBE, MMG, self-confidence, and health motivation. Nevertheless, no significant differences were detected for perceived susceptibility and severity [28]. Additionally, a similar study conducted in Egypt found a significant improvement in beliefs related to BSE after implementing an educational program based on the HBM [57]. Similarly, the present study's findings are consistent with Khiyali et al. [41], which demonstrated significant improvements in the benefits of BSE, barriers to BSE, and self-efficacy in the intervention group. In line with these results, Akhtari-Zavare et al. [24] indicated significant differences between the study groups for the benefits of BSE, barriers to BSE, and confidence, though not in perceive seriousness or susceptibility.

In contrast to these findings, Kocaöz et al. [42] found no evidence of the efficacy of the intervention in the benefits of BSE. Similarly, Lee-Lin et al. and Tuzcu et al. [12, 59] found no significant difference in the benefits of MMG. Elder et al. [46] found that scores for barriers to MMG and CBE were significantly lower in the intervention group compared to the control group, which is inconsistent with the current study. The non-significant changes in MMG barriers detected here may be related to improvements in participants' knowledge about the cost of MMG, fear of radiation, and the fact that a majority of the respondents were below the recommended age for MMG.

While the current study did not show significant improvement in perceived susceptibility, studies by Fathollahi-Dehkordi & Farajzadegan, Tuzcu et al., Yılmaz et al., and Htay et al. [12, 13, 47, 60] reported a significant increase in susceptibility scores post-interventions. This discrepancy may be justified by participants' younger age, with younger women probably perceiving BC risk as mostly relevant to older women. Another factor could be that studies employing multiple health behavior models have been more effective in addressing women's multidimensional needs by considering cultural, economic, and social impacts on health beliefs [47, 59]. In contrast, this study used only the HBM, which primarily focuses on individual health-related perceptions. Factors significantly associated with health beliefs in this study included age, prior exposure to BCS information, and family history of BC. These findings align with Yılmaz et al. [13], who reported a significant association between prior knowledge of BCS and susceptibility, benefits of BCS, and confidence. Similarly, Kissal et al. [61] reported an association between self-efficacy and family history of BC.

Cultural and logistical challenges in healthcare access

Although the education intervention positively influenced health beliefs in some areas, the effectiveness of BCS initiatives for Yemeni women in Malaysia is also shaped by substantial cultural and logistical challenges. Cultural beliefs and stigmas around BC can create fear or discomfort regarding BCS procedures, particularly among women who may lack familiarity with preventive healthcare practices. Additionally, younger women may view BC risk as more relevant to older women, limiting the effect of susceptibility-focused messages in the education intervention. Language barriers can also limit effective communication with healthcare providers, reducing women's ability to navigate healthcare services confidently and understand screening recommendations.

Logistical limitations further complicate access to health care services. Many women may experience financial limitations, making it difficult to afford transportation or healthcare costs, and limited availability of culturally sensitive healthcare providers may impact their comfort and trust in seeking services. Additionally, traditional family roles and responsibilities may restrict women's time and ability to prioritize personal healthcare, further hindering access.

Acknowledging these barriers provides a more comprehensive understanding of the context in which our intervention was implemented, highlighting potential limitations of the intervention's effectiveness. Addressing these factors in future interventions could improve Yemeni women's engagement with BCS initiative in Malaysia, strengthening the alignment of these interventions with the exclusive needs of this population.

Conclusion

This study aimed to assess the impact of a HBM-based educational intervention on BCS uptake, knowledge, and beliefs among Yemeni female teachers in Klang Valley, Malaysia. Our findings revealed low initial levels of BCS uptake, knowledge, and beliefs in this population, underscoring the need for targeted educational interventions. Following the intervention, there was a notable improvement in BSE and CBE uptake within the intervention group compared to the control group, aligning closely with the study's objective. However, MMG uptake did not show improvement between or within the two groups.

In addition, the intervention significantly increased knowledge scores in the intervention group over time compared to the control group. Health beliefs, particularly in the subscales of BSE benefits, BSE barriers, confidence, health motivation, MMG benefits, and CBE benefits, also demonstrated significant improvements in the intervention group. However, susceptibility, seriousness, and certain barriers (CBE and MMG) subscales showed no significant differences, indicating areas for further exploration.

Overall, the study effectively meets its aim by demonstrating that community-based educational programs, grounded in the HBM, are effective strategies for enhancing BCS behaviors, knowledge, and beliefs in this community. This research not only provides essential baseline data for future studies and health administrators but also emphasizes the critical role of educational programs in advancing public health outcomes within underserved populations.

The implications of these findings extend beyond the specific group of Yemeni female teachers in Malaysia. Similar HBM-based interventions could be adapted to reach other vulnerable populations who may face cultural, social, or logistical barriers to BCS. For instance, tailoring educational content to address the specific beliefs and challenges of different cultural or ethnic groups could increase its relevance and effectiveness. Furthermore, using community-based approaches and integrating mobile technology can broaden access and engagement, making these interventions applicable in various settings. Adapting this intervention model across diverse contexts may significantly enhance BCS uptake and awareness, contributing to global efforts in cancer prevention and early detection.

Strengths of the study

The current study possesses numerous strengths. Firstly, it employed a rigorous randomization design, considered the gold standard in intervention studies. The use of a cluster-randomized design effectively prevented contamination between individuals assigned to different treatment groups. Additionally, the study applied the HBM and utilized the validated CHBMS to evaluate women's beliefs about BC and BCS. Notably, this study is the first to develop and evaluate a BCS intervention specifically for Yemeni teachers in Malaysia.

Another strength is the high response rate and low dropout rate, which helped maintain the distribution of the population across study groups and ensured the comparability and validity of the findings. Furthermore, the study employed an intention-to-treat analysis approach, which facilitates unbiased comparisons between groups. Additionally, the use of GEE analysis is a critical strength, as it handles both normally and non-normally distributed data while adjusting for covariates and clustering effects.

Limitations of the study

Despite its strengths, this study has several key limitations that could affect the reliability and generalizability of its findings. One limitation is selection bias. Although efforts were made to reduce this by keeping cluster allocation confidential until after participants were selected, consented, and baseline data collected, selection bias remains a possibility and may influence the generalizability of findings beyond the study sample. The study's restriction to the Klang Valley area, along with the small sample size, limits generalizability to all Yemeni teachers in Malaysia. While GEE produced significant results for BSE uptake, the wide confidence intervals suggest potential variability, warranting cautious interpretation, which could impact the precision and stability of the estimates. This variability calls for larger sample sizes in future studies to confirm these findings and ensure more stable and generalizable estimates.

Another limitation is the reliance on self-reported data, which may introduce bias due to potential inaccuracies in participants' responses. To reduce this bias, we used clear, precise language, ensured confidentiality and anonymity, and maintained a brief data collection period; however, self-reporting could still affect reliability. Future research might consider incorporating objective measures, such as observational assessments or medical records, to improve data accuracy and validate self-reported data. Additionally, systemic barriers to BCS, such as the cost of MMG and the requirement for referrals, may have limited MMG access among participants.

This limitation underscores the importance of addressing accessibility challenges in future BCS interventions.

The educational intervention was conducted as a single 90-minute session due to the teachers' busy schedules, which may limit its effectiveness in driving lasting behavioral change. While additional materials, such as a BSE instructional CD, a booklet, and regular text message reminders over six months, were provided to reinforce key messages, a single session may still be insufficient to ensure the sustainability of knowledge and the conversion of awareness into long-term changes in attitudes and practices. Future studies could benefit from exploring multi-session interventions or sustained engagement approaches, as repeated exposure and ongoing support are likely to enhance the retention of knowledge and foster enduring behavioral change. This approach could be crucial for maximizing the long-term impact of health education programs on BCS practices.

Furthermore, the six-month follow-up for MMG and CBE evaluations, compared to the recommended annual screenings, limits our ability to assess longer-term uptake and adherence. Future studies could benefit from a follow-up period exceeding one year for a more comprehensive understanding of BCS behaviors over time. Finally, it is challenging to control for external information exposure in the control group, as participants may have encountered other sources of BCS information during the study period. This potential contamination could influence results and reduce the intervention's observed effect, highlighting a need for careful consideration of information exposure in future research. By addressing these limitations more fully, the study aims to present a transparent view of its findings and encourages further research to validate and expand upon these results.

Recommendations
Based on the findings of the current study and its limitations, numerous recommendations can be made. First, school teachers should actively participate in BC awareness programs, regularly practice BCS behaviors, and disseminate the knowledge they acquire to students and community members. Health organizations and policymakers are encouraged to develop and implement BC awareness programs that specifically include and support foreign women. Additionally, creating a mobile application for the educational module could facilitate broader distribution and accessibility among school teachers.

To improve MMG uptake, specific interventions addressing the financial and logistical barriers to screening are essential. These could include offering subsidized or free MMG, transportation assistance, or establishing mobile MMG units in underserved areas. Partnering with local health organizations or government agencies to provide these resources may also reduce the cost and accessibility challenges that often hinder screening, particularly in vulnerable populations. Additionally, developing culturally sensitive educational materials that address common misconceptions about MMG could encourage participation and reduce hesitancy. Future research may also benefit from examining the role of community leaders and family support in encouraging regular MMG, which could offer additional pathways to overcoming cultural and logistical barriers.

Further, future studies should focus on evaluating the effectiveness of this educational intervention across diverse groups of women with larger sample sizes, irrespective of their workplace, culture, nationality, or religion, to enhance generalizability. It is also recommended that future studies utilize more reliable data sources, such as medical reports, rather than relying solely on self-reported questionnaires. Furthermore, employing a variety of health behavioral models or theories could provide deeper perceptions of the psychosocial and cultural factors affecting BCS behaviors among women.

Abbreviations

BC	Breast Cancer
BCS	Breast Cancer Screening
BSE	Breast Self-Examination
CBE	Clinical Breast Exam
MMG	Mammography
HBM	Health Belief Model
CHBMS	Champion's Health Belief Model Scale
CVI	Content Validity Index
EFA	Explaratory Factor analysis
AOR	Adjusted odds Ratio

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12885-024-13214-5.

Supplementary Material 1: Title of data: Study questionnaire. Description of data: knowledge on BCS and practice related to BCS questionnaire

Acknowledgements
Not applicable.

Author contributions
SN conceived and led the design and development of the study. The development of the study proposal and data collection were overseen by SN, HAR, as well as SI. Data analysis was led by NMEE. SN, MA, MAA, as well as SMT were responsible for interpreting the data and writing the manuscript. The manuscript was read and approved in its final form by all authors.

Funding
No specific grant was obtained for this research from public, commercial, or nonprofit funding organisations.

Data availability
The corresponding author can provide the datasets utilised and/or analysed in the current study upon reasonable request.

Declarations

Ethics approval and consent to participate
The procedures were followed along with all applicable standards and regulations. The Universiti Putra Malaysia Ethics Committee granted ethical approval [Ref No. FPSK(EXP16) P151]. A copy of the consent form containing details about the study and the investigator was given to participants, who gave their full and informed consent to participate.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Community Health, Faculty of Medicine and Health Sciences, Taiz University, Taiz, Yemen
[2]Department of Community Medicine, Faculty of Medicine, University of Zawia, Zawia, Libya
[3]Department of Community Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang 43400, Malaysia
[4]Department of Public Health Medicine, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh, Selangor, Malaysia
[5]Taiz University, Taiz, Yemen
[6]Lincoln University College, Petaling Jaya, Selangor, Malaysia
[7]Department of Internal Medicine, Section Nursing Science, Erasmus University Medical Center (Erasmus MC), Rotterdam, The Netherlands

Received: 5 September 2024 / Accepted: 18 November 2024
Published online: 06 December 2024

References

1. World Health Organization. Breast Cancer. 2024 [https://www.who.int/news-room/fact-sheets/detail/breast-cancer
2. Zaidi Z, Cherif MH. The worldwide female breast cancer incidence and survival, 2018. Pan Arab J Oncol. 2019;12:2.
3. Allemani C, Weir HK, Carreira H, Harewood R, Spika D, Wang X-S, et al. Global surveillance of cancer survival 1995–2009: analysis of individual data for 25 676 887 patients from 279 population-based registries in 67 countries (CONCORD-2). Lancet. 2015;385:9972.
4. Torre LA, Islami F, Siegel RL, Ward EM, Jemal A. Global cancer in women: burden and trends. Cancer Epidemiol Biomarkers Prev. 2017;26:4444–57.
5. Oeffinger KC, Fontham ET, Etzioni R, Herzig A, Michaelson JS, Shih Y-CT, et al. Breast cancer screening for women at average risk: 2015 guideline update from the American Cancer Society. JAMA. 2015;314:151599–614.
6. International Agency for Research on Cancer. Global Cancer Observatory. 2023 [https://gco.iarc.who.int/media/globocan/factsheets/populations/887-yemen-fact-sheet.pdf
7. Harhra NA, Basaleem HO. Trends of breast cancer and its management in the last twenty years in Aden and adjacent governorates, Yemen. Asian Pac J Cancer Prev. 2012;13:9.
8. Chuah FLH, Tan ST, Yeo J, Legido-Quigley H. The health needs and access barriers among refugees and asylum-seekers in Malaysia: a qualitative study. Int J Equity Health. 2018;17:1–15.
9. Smith RA, Andrews KS, Brooks D, Fedewa SA, Manassaram-Baptiste D, Saslow D, et al. Cancer screening in the United States, 2017: a review of current American Cancer Society guidelines and current issues in cancer screening. Cancer J Clin. 2017;67:2100–21.
10. World Health Organization. Preventing cancer, [https://www.who.int/cancer/prevention/diagnosis-screening/breast-cancer/en/
11. da Costa Vieira RA, Biller G, Uemura G, Ruiz CA, Curado MP. Breast cancer screening in developing countries. Clinics. 2017;72:4244–53.
12. Tuzcu A, Bahar Z, Gözüm S. Effects of interventions based on health behavior models on breast cancer screening behaviors of migrant women in Turkey. Cancer Nurs. 2016;39(2):E40–50.
13. Yılmaz M, Sayın Y, Cengiz HÖ. The effects of training on knowledge and beliefs about breast cancer and early diagnosis methods among women. Eur J Breast Health. 2017;13:4.
14. Al-Sakkaf KA, Basaleem HO. Breast cancer knowledge, perception and breast self-examination practices among Yemeni women: an application of the health belief model. Asian Pac J Cancer Prev. 2016;17:3.
15. Ahmed BaA. Awareness and practice of breast cancer and breast-self examination among university students in Yemen. Asian Pac J cancer Prevention: APJCP. 2010;11:1.
16. Bawazir AA. Cancer incidence in Yemen from 1997 to 2011: a report from the Aden cancer registry. BMC Cancer. 2018;18:1–10.
17. Al-Naggar RA, Al-Maktari LA, Alshaikhli H, Trafford J, Saleh B, Mossfer SI. Crit Assess Three Decades Breast cancer Res Yemen: Syst Rev. 2021;2.
18. Azmi NAM, Muhammad J, Yusoff SSM, Hussin NRN. Mammogram Screening Uptake and its Associated factors among female staff in Health Campus, Universiti Sains Malaysia, Kelantan, Malaysia. Malaysian J Med Sciences: MJMS. 2023;30:5.
19. Kindig D, Thompson G. The right to equal treatment: an action plan to end racial and ethnic disparities in clinical diagnosis and treatment in the United States. J Ambul Care Manage. 2003;26.
20. Champion VL, Monahan PO, Springston JK, Russell K, Zollinger TW, Saywell RM Jr, et al. Measuring mammography and breast cancer beliefs in African American women. J Health Psychol. 2008;13(6):827–37.
21. Noman S, Shahar HK, Abdul Rahman H, Ismail S, Abdulwahid Al-Jaberi M, Azzani M. The effectiveness of educational interventions on breast cancer screening uptake, knowledge, and beliefs among women: a systematic review. Int J Environ Res Public Health. 2021;18:1.
22. Ersin F, Gözükara F, Polat P, Erçetin G, Bozkurt ME. Determining the health beliefs and breast cancer fear levels ofwomen regarding mammography. Turk J Med Sci. 2015;45(4):775–81.
23. Masoudiyekta L, Rezaei-Bayatiyani H, Dashtbozorgi B, Gheibizadeh M, Malehi AS, Moradi M. Effect of education based on health belief model on the behavior of breast cancer screening in women. Asia-Pacific J Oncol Nurs. 2018;5:1114–20.
24. Akhtari-Zavare M, Juni MH, Said SM, Ismail IZ, Latiff LA, Ataollahi Eshkoor S. Result of randomized control trial to increase breast health awareness among young females in Malaysia. BMC Public Health. 2016;16:1–11.
25. Alameer A, Mahfouz MS, Alamir Y, Ali N, Darraj A. Effect of health education on female teachers' knowledge and practices regarding early breast cancer detection and screening in the Jazan area: a quasi-experimental study. J Cancer Educ. 2019;34:865–70.
26. Taymoori P, Molina Y, Roshani D. Effects of a randomized controlled trial to increase repeat mammography screening in Iranian women. Cancer Nurs. 2015;38:4288–96.
27. Champion V, Menon U. Predicting mammography and breast self-examination in African American women. Cancer Nurs. 1997;20:5315–22.
28. Mirmoammadi A, Parsa P, Khodakarami B, Roshanaei G. Effect of consultation on adherence to clinical breast examination and mammography in Iranian women: a randomized control trial. Asian Pac J Cancer Prevention: APJCP. 2018;19:12.
29. Lemeshow S. Adequacy of sample size in health studies. Chichester: John Whiley & Sons Ltd; 1990.
30. Lee-Lin F, Nguyen T, Pedhiwala N, Dieckmann N, Menon U. A breast health educational program for Chinese-American women: 3-to 12-month postintervention effect. Am J Health Promotion. 2015;29:3173–81.
31. American Cancer Society. Breast cancer facts and figures: 2015–2016 Atlanta, GA [Available from: http://file:/C:/Users/USER/Downloads/breast-cancer-facts-and-figures-2015-2016%20(1).p
32. Oeffinger K, Fontham E, Etzioni R. New American Cancer Society breast cancer screening guidelines continue confusion, controversy for women and their providers. 2015.
33. International Agency for Research on Cancer. Screening Group: Breast cancer / breast self-examination (BSE). 2008 [https://screening.iarc.fr/breastselfexamination.php
34. Noman S, Shahar HK, Abdul Rahman H, Ismail S. Effectiveness of an educational intervention of breast cancer screening practices uptake, knowledge, and beliefs among Yemeni female school teachers in Klang Valley, Malaysia: a study protocol for a cluster-randomized controlled trial. Int J Environ Res Public Health. 2020;17:4.
35. Parsa P, Kandiah M, Zulkefli NM, Rahman HA. Knowledge and behavior regarding breast cancer screening among female teachers in Selangor, Malaysia. Asian Pac J Cancer Prev. 2008;9:2.
36. McCance KL, Mooney KH, Smith KR, Field R. Validity and reliability of a breast cancer knowledge test. Am J Prev Med. 1990;6:293–8.

37. Champion V. Development of a benefits and barriers scale for mammography utilization. Cancer Nurs. 1995;18:153–9.
38. Champion VL. Instrument refinement for breast cancer screening behaviors. Nurs Res. 1993;42:3139–43.
39. Parsa P, Kandiah M, Mohd Nasir M, Hejar A, Nor Afiah M. Reliability and validity of Champion's Health Belief Model Scale for breast cancer screening among Malaysian women. Singapore Med J. 2008;49:11.
40. Noman S, Shahar HK, Rahman HA, Ismail S, Aljaberi MA, Abdulrahman MN. Factor structure and internal reliability of breast cancer screening Champion's Health Belief Model Scale in Yemeni women in Malaysia: a cross-sectional study. BMC Womens Health. 2021;21:1–11.
41. Khiyali Z, Aliyan F, Kashfi SH, Mansourian M, Jeihooni AK. Educational intervention on breast self-examination behavior in women referred to health centers: application of Health Belief Model. Asian Pac J cancer Prevention: APJCP. 2017;18:10.
42. Kocaöz S, Özçelik H, Talas MS, Akkaya F, Özkul F, Kurtuluş A, et al. The effect of education on the early diagnosis of breast and cervix cancer on the women's attitudes and behaviors regarding participating in screening programs. J Cancer Educ. 2018;33:821–32.
43. Shoushtari-Moghaddam E, Shahnazi H, Hassanzadeh A. The effect of educational intervention based on the PEN-3 model on breast cancer screening behaviors. Front Public Health. 2023;11:1123888.
44. American Cancer Society. Cancer prevention & early detection facts & figures, 2017–2018. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/cancer-prevention-and-early-detection-facts-and-figures/cancer-prevention-and-early-detection-facts-and-figures-2017.pdf
45. Ministry of Health Malaysia. Management of breast cancer. 3rd ed. Putrajaya: Malaysia; 2019.
46. Elder J, Haughton J, Perez L, Martinez M, De la Torre C, Slymen D, et al. Promoting cancer screening among churchgoing latinas: fe en Accion/faith in action. Health Educ Res. 2017;32:2163–73.
47. Fathollahi-Dehkordi F, Farajzadegan Z. Health education models application by peer group for improving breast cancer screening among Iranian women with a family history of breast cancer: a randomized control trial. Med J Islamic Repub Iran. 2018;32:51.
48. Busakhala NW, Chite FA, Wachira J, Naanyu V, Kisuya JW, Keter A, et al. Screening by clinical breast examination in Western Kenya: who comes? J Global Oncol. 2016;2:3114–22.
49. Andegiorgish AK, Kidane EA, Gebrezgi MT. Knowledge, attitude, and practice of breast Cancer among nurses in hospitals in Asmara, Eritrea. BMC Nurs. 2018;17:1–7.
50. Wu T-Y, Lin C. Developing and evaluating an individually tailored intervention to increase mammography adherence among Chinese American women. Cancer Nurs. 2015;38:140–9.
51. Gondek M, Shogan M, Saad-Harfouche FG, Rodriguez EM, Erwin DO, Griswold K, et al. Engaging immigrant and refugee women in breast health education. J Cancer Educ. 2015;30:593–8.
52. Goel MS, O'Conor R. Increasing screening mammography among predominantly Spanish speakers at a federally qualified health center using a brief previsit video. Patient Educ Couns. 2016;99:3408–13.
53. Glanz K, Rimer BK, Viswanath K. Theory, research, and practice in health behavior and health education. 2008.
54. Taymoori P, Berry T. The validity and reliability of Champion's Health Belief Model Scale for breast cancer screening behaviors among Iranian women. Cancer Nurs. 2009;32:6465–72.
55. Rabbani SA, Al Marzooqi AMSK, Srouji AEM, Hamad EA, Mahtab A. Impact of community-based educational intervention on breast cancer and its screening awareness among arab women in the United Arab Emirates. Clin Epidemiol Global Health. 2019;7:4.
56. Sodhi N, Ahmad S, Hassan SB, Ahmad A. An Assessment of the impact of Educational interventions on breast Cancer awareness among women in Urban Lucknow. Int J Health Sci Res. 2024;14:9:1–8.
57. Elsawy MM, Mohamed HS, Mousa KM. Effect of utilizing Health Belief Model on Knowledge, Beliefs, and Behaviour of visually impaired women toward breast self-examination. Open Nurs J. 2023;17:1.
58. Hussen A, Kumbi M, Lette A, Nuriye S. Knowledge of breast cancer and associated factors among women reproductive age in Bale Zone, Southeast Ethiopia: a community based cross sectional study. Emerg Med. 2019;9:395.
59. Lee-Lin F, Pedhiwala N, Nguyen T, Menon U. Breast health intervention effects on knowledge and beliefs over time among Chinese American immigrants—a randomized controlled study. J Cancer Educ. 2015;30:3.
60. Htay MNN, Dahlui M, Schliemann D, Cardwell CR, Loh SY, Ibrahim Tamin NSB, et al. Changing health beliefs about breast cancer screening among women in multi-ethnic Malaysia. Int J Environ Res Public Health. 2022;19:31618.
61. Kissal A, Ersin F, Koç M, Vural B, Çetin Ö. Determination of women's health beliefs, breast cancer fears, and fatalism associated with behaviors regarding the early diagnosis of breast cancer. Int J Cancer Manage. 2018;11:12.

Publisher's note