

A Digital Health Education Intervention to Improve Breast Self-Examination Knowledge among Adolescent Girls

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ABSTRACT

Breast cancer remains a major health concern among women, as delayed detection contributes to high morbidity and mortality. Breast Self-Examination (BSE) is a simple and accessible method for early detection, yet limited knowledge of BSE among adolescents remains a concern. **This study aimed to** assess changes in adolescent girls' knowledge of breast cancer early detection following BSE health education at SMA Santo Thomas 1 Medan. **A quantitative study using a pre-experimental one-group pre-test–post-test design was conducted.** The participants consisted of 54 Grade XI female students who were selected through simple random sampling. Data were collected using a 13-item knowledge questionnaire administered before and after the intervention. The data were analyzed using the Wilcoxon signed-rank test at a significance level of $p < 0.05$. **Prior to the intervention, most respondents demonstrated** adequate knowledge (70.4%), while 20.4% had poor knowledge and 9.3% had good knowledge. After the intervention, the proportion of respondents with good knowledge increased to 87%, while 13% demonstrated adequate knowledge. The Wilcoxon analysis demonstrated a statistically significant difference in knowledge scores between the pre-test and post-test ($p < 0.001$). **These findings indicate that** BSE health education was associated with an improvement in adolescent girls' knowledge and may inform school-based breast cancer health education programs.

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1. INTRODUCTION

Breast cancer contributes substantially to morbidity and mortality while continuing to affect women as one of the most prevalent health problems [1]. Delayed diagnosis is a major factor contributing to breast cancer mortality and may occur because of inadequate awareness and limited knowledge of early detection practices. Breast Self-Examination (BSE) provides a simple and accessible approach that allows women to recognize abnormal breast changes and increase awareness of breast health [2]. The Ministry of Health of the Republic of Indonesia promotes BSE as a simple method that can be performed independently to identify lumps and other abnormal signs in the breast at an early stage [3]. However, BSE should be distinguished from formal breast cancer screening methods, as it is primarily intended to promote breast awareness and recognition of abnormal changes rather than replace established screening procedures. Many women still have limited knowledge and awareness regarding the correct implementation of BSE due to inadequate information about its definition,

objectives, benefits, and examination procedures. Therefore, strengthening knowledge of BSE may contribute to greater breast health awareness and support early detection education.

Adolescence is an important period for establishing health awareness and preventive behaviors, including knowledge related to breast health [4]. However, knowledge of BSE among adolescent girls remains limited. The initial assessment of 10 female students at SMA Santo Thomas 1 Medan indicated that 60% of the respondents (6 students) had adequate knowledge of BSE, while the remaining 40% (4 students) showed good knowledge. Several components of BSE, including its procedures and benefits, were still poorly understood by the respondents. These findings highlight the need for well-structured health education to strengthen adolescents' understanding and awareness of breast health and early detection practices. Health education is a promotive strategy that provides accurate health information and may support the development of appropriate health-related behaviors [5].

The implementation of breast cancer health education is aligned with broader global and national priorities for non-communicable disease prevention and health promotion [6]. The study supports the achievement of Sustainable Development Goal (SDG) 3, Good Health and Well-being, with particular relevance to Target 3.4. This target focuses on reducing premature deaths caused by non-communicable diseases through prevention and health promotion initiatives. In Indonesia, breast cancer prevention and early detection are supported by national health policies [7]. The Ministry of Health of the Republic of Indonesia promotes BSE as an accessible approach to increasing awareness of abnormal breast changes and encouraging women to perform breast self-examinations [3]. Although previous studies have examined BSE education among adolescents, the interventions have varied in educational methods, settings, intervention intensity, and measured outcomes [8]. Earlier studies have used approaches such as leaflets, audiovisual media, class-based education, and peer education. However, evidence remains limited regarding the implementation of a structured, repeated BSE education intervention within a senior high school setting and its effect on adolescent girls' knowledge [9].

Therefore, the contribution of the present study lies in evaluating a structured BSE health education intervention specifically implemented among Grade XI female students in a senior high school setting. The intervention consisted of three structured educational sessions of approximately 30-40 minutes, delivered through a lecture method supported by a Health Education Session Plan (SAP) and BSE module. Knowledge was assessed before and after the intervention, providing context-specific evidence regarding changes in adolescent girls' knowledge following structured BSE education. The findings may support healthcare providers and educational institutions in developing school-based breast health education strategies [10]. Beyond conventional classroom education, BSE health education can be adapted to different educational environments through small-group learning, peer education, school health programs, and community-based adolescent activities. Its implementation may also be supported by educational media such as modules, leaflets, slides, and videos to improve accessibility and engagement among adolescents [11, 12]. These flexible approaches may facilitate wider implementation of BSE education across schools and other adolescent health promotion settings. Therefore, the study was designed to analyze changes in adolescent girls' knowledge regarding breast cancer early detection following BSE health education at SMA Santo Thomas 1 Medan.

2. LITERATURE REVIEW

2.1. Health Education as a Health Promotion Intervention

Health education is an essential component of health promotion that aims to improve individuals' knowledge, attitudes, and ability to make appropriate health-related decisions. Within breast cancer prevention efforts, health education can strengthen awareness of risk factors, early signs, and preventive measures, including BSE [13]. Beyond providing health-related information, it encourages individuals to develop a better understanding of health issues and make informed choices that support healthier behaviors [14].

Recent research has indicated that the delivery of structured health education is effective in strengthening adolescent girls' knowledge of breast cancer prevention and BSE [15]. Studies have reported significant improvements in knowledge following health education interventions using different approaches, including direct teaching, audiovisual media, and demonstration-based education. These findings indicate that the use of structured and appropriate educational methods can facilitate adolescents' understanding of BSE and strengthen their awareness of breast cancer early detection. Since adolescence represents a critical stage for developing long-term health behaviors, providing health education during this period may serve as an important preventive strategy [16].

Previous studies have generally focused on improving adolescents' knowledge and awareness through BSE education, while some have additionally examined attitudes or preventive practices [17]. The present study differs by specifically evaluating changes in BSE-related knowledge before and after a structured health education intervention among Grade XI female students. The use of a one-group pre-test–post-test design allows the study to identify measurable changes in respondents' knowledge following the intervention. This focus complements previous research by providing evidence regarding changes in knowledge following BSE health education in a school-based adolescent population [18].

Several theoretical frameworks explain how health education can improve health-related knowledge. In this study, the theoretical framework is informed by the Health Belief Model (HBM) and Notoatmodjo's cognitive domain of knowledge [19]. The HBM provides a conceptual behavioral context for understanding preventive health actions. It proposes that individuals' engagement in preventive behaviors may be influenced by their perceptions of health risks, perceived severity, perceived benefits, perceived barriers, and cues to action. In the context of BSE, health education may provide information that increases adolescents' awareness of breast cancer and the importance of recognizing abnormal breast changes [20].

Notoatmodjo's cognitive framework further explains how health education can improve knowledge through progressive learning, including knowing, comprehension, application, analysis, synthesis, and evaluation [21]. Through structured BSE education, adolescents receive information about the definition, benefits, purpose, and procedures of BSE, which can improve their understanding and ability to apply the information [22]. Therefore, health education is expected to strengthen knowledge by providing relevant information and facilitating the cognitive learning process [23].

Accordingly, the theoretical relationship in this study can be described as follows. Structured BSE health education is expected to increase adolescents' understanding of BSE and breast cancer early detection, which may subsequently be reflected in improved knowledge scores. The HBM is used only as a conceptual behavioral context for understanding the preventive relevance of BSE education, whereas Notoatmodjo's cognitive framework supports the explanation of knowledge improvement measured through the pre-test and post-test. The present study did not empirically measure HBM constructs or actual BSE behavior. Therefore, the theoretical framework is used to explain the rationale for the intervention and the expected change in knowledge rather than to test the HBM empirically [24, 25, 26].

2.2. BSE for Early Breast Cancer Detection

BSE is a simple and accessible approach that can help individuals recognize abnormal changes in the breast and increase awareness of breast health. It does not require expensive equipment and can be performed independently after individuals receive appropriate instruction. However, BSE should be distinguished from formal breast cancer screening. BSE and breast awareness are primarily intended to help individuals recognize abnormal breast changes and seek appropriate medical evaluation, whereas formal screening involves established screening modalities recommended for specific populations according to applicable clinical guidelines. Therefore, BSE should not be presented as a substitute for formal breast cancer screening.

Despite its simplicity, the practice of BSE may be influenced by individuals' knowledge, awareness, and confidence in performing the examination correctly [27]. Previous studies have reported that limited knowledge of BSE procedures, breast cancer risk factors, and warning signs may be associated with lower engagement in breast health and early detection practices [28]. Therefore, educational interventions aimed at improving knowledge may help strengthen awareness of breast health and early detection, particularly among adolescent populations.

2.3. Knowledge of Breast Cancer Early Detection Among Adolescent Girls

Knowledge is a fundamental factor influencing health behavior because individuals with adequate knowledge may be better able to recognize health risks and participate in preventive actions. Among adolescent girls, knowledge regarding breast health and early detection awareness is important because it can establish awareness and preventive health attitudes during an important stage of development [29].

The current study identified that adolescent girls still experienced limitations in understanding BSE, particularly regarding its definition, objectives, benefits, and examination procedures [30]. The preliminary assessment conducted at SMA Santo Thomas 1 Medan showed that most respondents had only moderate knowledge, indicating the need for targeted educational interventions to improve understanding of breast health and early detection practices [31].

Recent studies have highlighted that adolescents who receive breast cancer-related health education demonstrate improved knowledge and awareness following educational interventions [32]. However, evidence regarding the effectiveness of structured BSE health education among school-based adolescent populations remains limited, particularly in evaluating changes in knowledge before and after a structured intervention [33].

2.4. Effectiveness of Health Education in Improving BSE Knowledge

Previous research has indicated that health education interventions can increase knowledge related to disease prevention and early detection practices. Through systematic delivery of information, individuals can develop a better understanding of the importance, procedures, and benefits of preventive health practices [34]. In breast cancer health education, BSE-focused education may serve as a strategy to strengthen awareness of breast health and recognition of abnormal changes [35].

This study builds on previous research by examining changes in adolescent girls' knowledge following BSE-focused health education through a pre-test and post-test design. Rather than merely describing existing levels of knowledge, the study assesses changes in knowledge following the educational intervention. The findings may support the development of school-based health education programs that enhance adolescents' awareness of breast health and breast cancer early detection [31].

3. RESEARCH METHODS

A pre-experimental one-group pre-test–post-test design was used in this quantitative study [36]. The design was used to assess changes in adolescent girls' knowledge of breast cancer early detection following BSE health education [37]. The study compared respondents' knowledge before and after the intervention to assess changes following the educational program.

Because the study sought to assess changes in adolescent girls' knowledge of breast cancer early detection following BSE health education, a one-group pre-test–post-test design was selected. No control or comparison group was included in the study. Figure 1 illustrates the overall research process.



Figure 1. Operational Framework for the Research

3.1. Sample and Population

The sample consisted of 54 adolescent girls who were selected using simple random sampling. This sampling method was applied to provide eligible students with equal opportunities to participate in the study. All selected participants participated in the health education intervention and completed the knowledge assessment before and after the intervention.

The study population comprised female students enrolled in Grade XI at SMA Santo Thomas 1 Medan, Indonesia. Adolescent girls were selected as the target population because adolescence represents an important stage for developing preventive health awareness and establishing healthy behaviors related to breast health.

3.2. Data Collection Method

Data were collected using a structured questionnaire designed to assess respondents' knowledge of BSE. The questionnaire comprised 13 statements addressing the definition, objectives, benefits, and procedures of BSE and was adopted from a previously developed questionnaire [38]. Previous testing demonstrated that all items had validity coefficients exceeding the *r*-table value of 0.361, while the reliability test yielded a Cronbach's alpha coefficient of 0.88, indicating good internal consistency. Based on these results, no further validity or reliability testing was performed in the present study.

A dichotomous scoring system was applied to the questionnaire. For favorable statements, a "True" response received a score of 1, while a "False" response received a score of 0. For unfavorable statements,

specifically items 5 and 6, reverse scoring was applied, with “True” scored as 0 and “False” as 1. The total scores were categorized into three levels of knowledge: poor (1–4), adequate (5–8), and good (9–13). The same 13-item questionnaire and scoring procedure were applied during both the pre-test and post-test to allow direct comparison of respondents’ knowledge before and after the intervention.

3.3. Health Education Intervention and Data Collection Procedure

The intervention provided in this study was a structured health education program regarding BSE. The intervention aimed to improve adolescent girls’ understanding of breast cancer early detection, including the importance of BSE, its benefits, and the correct procedures for performing breast self-examination [39].

Three sessions were conducted as part of the health education intervention. A pre-test was administered first to assess respondents’ baseline knowledge. This was followed by the delivery of health education on BSE. The same questionnaire was administered as a post-test following the intervention to assess changes in respondents’ knowledge.

3.4. Data Analysis

Data analysis involved both descriptive and inferential statistical procedures. Descriptive analysis was used to present the distribution of respondents’ knowledge levels before and after the intervention. Data were analyzed using IBM SPSS Statistics version 27 for Windows. The normality of the pre-test and post-test knowledge scores was assessed using the Kolmogorov-Smirnov test. The results indicated that the data were not normally distributed ($p = 0.001$, $p < 0.05$). Therefore, the Wilcoxon signed-rank test was used to compare knowledge scores between the pre-test and post-test measurements. A p-value of less than 0.05 was considered statistically significant.

A statistically significant difference between the pre-test and post-test measurements was interpreted as an improvement in knowledge following the BSE health education intervention. Because the study used a one-group pre-test–post-test design without a control or comparison group, the observed change cannot be interpreted as definitive evidence of a causal effect of the intervention.

4. RESULTS AND DISCUSSION

This section reports the study findings and interprets them in relation to the impact of health education on adolescent girls’ knowledge of BSE. The findings are organized according to the respondents’ knowledge levels measured before and after the educational intervention, followed by a discussion of the changes observed after the health education intervention.

4.1. Results

4.1.1. Respondents’ Knowledge Level Before Health Education Intervention

Table 1 and Figure 2 illustrate the respondents’ knowledge levels prior to the BSE health education intervention. The findings indicated that a majority of the 54 adolescent girls had an adequate level of knowledge, with 38 respondents (70.4%) falling into this category. Meanwhile, 11 respondents (20.4%) had poor knowledge, whereas only 5 respondents (9.3%) were classified as having good knowledge.

The findings suggest that, prior to the educational intervention, most adolescent girls had limited understanding of BSE, including its definition, purpose, benefits, and proper procedures. This lack of comprehensive knowledge emphasizes the need for structured health education to enhance adolescents’ awareness and understanding of breast cancer early detection.

Table 1. Pre-Health Education Knowledge Level of BSE among Grade XI Female Students at SMA Santo Thomas 1 Medan

Knowledge Level	Frequency (n)	Percentage (%)
Poor	11	20.4
Adequate	38	70.4
Good	5	9.3
Total	54	100.0

Table 1 shows that the majority of respondents demonstrated an adequate level of knowledge about Breast Self-Examination (BSE) prior to the health education intervention. In contrast, 20.4% of respondents

demonstrated a poor level of knowledge, while only 9.3% demonstrated a good level of knowledge. These results indicate that most respondents had an adequate level of knowledge about BSE prior to the intervention. Therefore, health education may be used to further enhance their knowledge and awareness of breast cancer early detection.

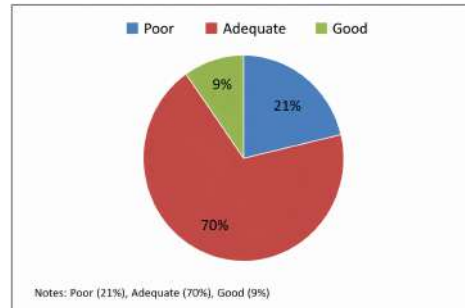


Figure 2. Distribution Based on Pre-Test Knowledge Level Before Health Education about BSE

4.1.2. Respondents' Knowledge Level After Health Education Intervention

Respondents' knowledge levels increased after the BSE health education intervention, as shown in Table 2 and Figure 3. Of the 54 respondents, 47 (87.0%) demonstrated a good level of knowledge, while 7 (13.0%) demonstrated an adequate level of knowledge. No respondents were categorized as having a poor level of knowledge after the intervention.

This increase in knowledge suggests an improvement in adolescent girls' understanding of BSE following the health education intervention. During the instructional sessions, respondents received information on breast cancer prevention, the importance of early detection, and the correct procedures for performing BSE.

Table 2. Post-Intervention BSE Knowledge Levels among Female Eleventh-Grade Students at SMA Santo Thomas 1 Medan in 2025

Knowledge Level	Frequency (n)	Percentage (%)
Poor	0	0.0
Adequate	7	13.0
Good	47	87.0
Total	54	100.0

As shown in Table 2, 47 respondents (87.0%) demonstrated a good level of knowledge, while 7 respondents (13.0%) demonstrated an adequate level of knowledge after the BSE health education intervention. No respondents were categorized as having a poor level of knowledge. These findings indicate that following the intervention, the majority of respondents demonstrated a good level of knowledge.

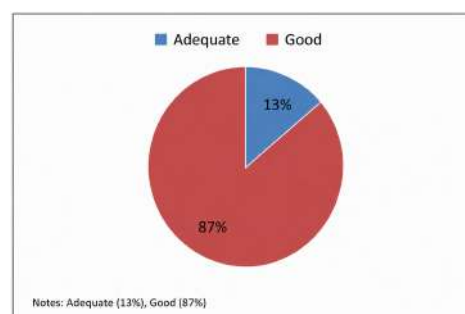


Figure 3. Distribution Based on Post-Test Knowledge Level After Health Education about BSE

Following the health education intervention, 87% of respondents were classified as having good knowledge, while the remaining 13% demonstrated an adequate level of knowledge. No respondents were categorized as having poor knowledge, indicating an overall improvement in BSE knowledge after the intervention, as illustrated in Figure 3.

4.2. Changes in BSE Knowledge Following Health Education

Changes in adolescent girls' knowledge of BSE following the health education intervention were assessed using the Wilcoxon signed-rank test, with descriptive results presented in Table 3. The mean coded knowledge value increased from 1.89 ± 0.538 at the pre-test to 2.87 ± 0.339 at the post-test, representing an increase of 0.98 in the coded mean value. A substantial shift was also observed in the proportion of respondents categorized as having good knowledge, which increased from 9.3% before the intervention to 87.0% afterward, representing a 77.7 percentage-point increase. The statistical analysis showed a significant difference between the pre-test and post-test knowledge measurements ($p < 0.001$).

Overall, the findings indicate a statistically significant and descriptively substantial increase in adolescent girls' knowledge of breast cancer early detection following BSE health education. Based on these findings, the null hypothesis was rejected, indicating that the pre-test and post-test knowledge measurements differed significantly. However, because the study used a one-group pre-test–post-test design without a control group, the observed increase should not be interpreted as definitive evidence of a causal effect of the intervention. Furthermore, the findings are limited to changes in knowledge and should not be interpreted as evidence of improvements in BSE practices or other health-related behaviors.

Table 3. Descriptive Knowledge Values Before and After BSE Health Education

	N	Mean	Std. Deviation
Pre-test	54	1.89	0.538
Post-test	54	2.87	0.339

4.3. Discussion

4.3.1. Knowledge Level of Adolescent Girls Before Health Education Intervention

The findings of this study showed that before receiving health education about BSE, most respondents had an adequate level of knowledge (70.4%), while 20.4% had poor knowledge and only 9.3% demonstrated good knowledge. This finding indicates that adolescent girls' understanding of breast cancer prevention and early detection methods was still limited before receiving structured health education.

Limited knowledge of BSE among adolescents may be related to inadequate exposure to breast health information, particularly regarding the purpose, benefits, and correct procedures of breast self-examination. Knowledge is an important component of preventive health behavior, as a better understanding of health risks may help individuals recognize the importance of early detection and engage in appropriate preventive practices. In the context of breast cancer prevention, gaps in knowledge may hinder the development of awareness and confidence in performing BSE correctly.

Previous studies conducted among adolescent populations have shown that inadequate knowledge regarding breast cancer and BSE remains a common issue. Many adolescents are aware of breast cancer as a health problem but have limited understanding regarding early detection methods and the correct practice of BSE. This condition highlights the importance of introducing breast health education during adolescence as an early preventive strategy before individuals enter higher-risk age groups.

4.3.2. Improvement of Knowledge After Health Education Intervention

The study's findings showed that after obtaining health education regarding BSE, respondents' knowledge significantly improved. Only 5 respondents (9.3%) had good knowledge before the intervention, increasing to 47 respondents (87.0%) after the intervention. Furthermore, no respondents were classified as having poor knowledge after receiving the health education intervention. These findings indicate that structured health education improved adolescents' knowledge of breast cancer early detection.

The importance of health education as a learning process that gives people correct and pertinent health information can account for the increase in knowledge. The significance of BSE, its advantages, and the proper procedures for performing breast self-examination were explained to the respondents through educational workshops. Participants can clear up prior misconceptions and increase their awareness of preventative health practices when information is presented in an organized way.

The results of this study are in line with earlier research demonstrating that health education can increase teenage girls' understanding of breast self-examination. BSE-related health education raised young women's knowledge and awareness of breast cancer prevention, according to [40]. Similarly, previous research found that health education using educational media improved adolescents' knowledge regarding BSE. Other

studies using different approaches, such as lecture-based education, audiovisual media, and peer education, have also reported improvements in knowledge and preventive behavior. Although these studies differed in educational methods and measured outcomes, their findings are consistent with the present study, which showed a substantial increase in respondents with good knowledge after three structured health education sessions. This comparison suggests that repeated and structured exposure to BSE information is an important component in strengthening adolescents' understanding of breast cancer early detection.

4.3.3. Effectiveness of Health Education on Breast Self-Examination Knowledge

The Wilcoxon Signed-Rank Test revealed a statistically significant difference in knowledge scores between the pre-test and post-test measurements ($p < 0.001$). This finding indicates that the BSE health education intervention was associated with a significant improvement in adolescent girls' knowledge of breast cancer early detection.

The positive outcome of the intervention suggests that focused health education can help reduce knowledge gaps among adolescents. The increase in knowledge after intervention suggests that school-based health education can serve as an effective approach for introducing preventive health behaviors. Schools provide a strategic environment for delivering health promotion programs because adolescents can be reached collectively and continuously through structured educational activities.

The practical significance of this knowledge improvement is that better understanding of the purpose, benefits, and procedures of BSE may provide an important foundation for future preventive awareness and informed breast-health decisions. However, the present study did not assess whether increased knowledge was translated into actual BSE behavior. Future studies should therefore evaluate BSE practice, procedural accuracy, attitudes, self-efficacy, and longer-term knowledge retention to determine whether knowledge improvement is maintained and translated into preventive behavior.

The originality of this study is reflected in its emphasis on adolescent girls as a target group for early preventive efforts, rather than primarily addressing adult women or individuals at high risk. By introducing BSE education during adolescence, this study emphasizes the importance of developing breast cancer awareness before individuals enter periods with greater health risks. Accordingly, incorporating BSE education into school-based health promotion initiatives could contribute to strengthening awareness of early breast cancer detection and helping reduce delays in diagnosis.

Several limitations should be considered when interpreting the findings. The use of a pre-experimental one-group pre-test–post-test design without a control group limits the ability to establish that the observed increase in knowledge was exclusively attributable to the health education intervention. In addition, the intervention schedule had to be adjusted to school activities, and data collection was conducted in two groups because of space limitations. Future studies should use a control group, larger samples, and longer follow-up to assess knowledge retention and actual BSE practice.

5. CONCLUSION

This study shows that adolescent girls' understanding of breast cancer early detection can be greatly improved by health education on breast self-examination (BSE). Although most respondents had adequate knowledge of BSE concepts, benefits, and procedures before the intervention, some aspects were still not fully understood. A significant increase in knowledge was seen after the educational intervention, indicating that organized health education can successfully raise adolescents' awareness of breast cancer prevention and early detection.

The statistical results further support the effectiveness of school-based health education as a preventive strategy for improving adolescents' knowledge of breast cancer early detection techniques. A substantial difference in knowledge before and after the intervention was confirmed by the Wilcoxon Signed Rank Test, which yielded a statistically significant result ($p < 0.001$). Therefore, incorporating BSE education into adolescent health programs may help increase preventive knowledge and encourage healthy behaviors from an early age.

The long-term impacts of BSE education should be investigated in more detail, especially with regard to the attitudes, confidence, and actual BSE practices of adolescents. To evaluate the sustainability of knowledge gains and their potential conversion into consistent preventive behaviors, studies with larger and more diverse populations, various educational settings, and longer follow-up periods are also advised.

6. MANAGERIAL IMPLICATION

The findings of this study provide practical implications for healthcare providers, educational institutions, and public health stakeholders involved in adolescent health promotion and breast cancer prevention. The substantial improvement in BSE-related knowledge suggests that structured health education may be incorporated into routine school health-promotion activities rather than delivered only as a one-time intervention. Program sustainability could be supported through collaboration among school administrators, teachers, nurses, health educators, and community health stakeholders, with the structured Health Education Session Plan (SAP) and BSE module used as practical educational resources. The intervention approach may also be adapted for implementation in other senior high schools and adolescent health-promotion settings, while considering differences in student characteristics and available resources. Future studies should involve larger and more diverse populations across multiple schools, preferably using controlled designs and longer follow-up periods, to evaluate knowledge retention and determine whether improved knowledge is subsequently associated with attitudes, self-efficacy, procedural accuracy, and actual BSE practice.

7. DECLARATIONS

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7.2. Author Contributions

Conceptualization: MK and JZ; Methodology: MK, JZ, and LT; Software: JZ; Validation: MK and LT; Formal Analysis: MK and JZ; Investigation: MK and JZ; Resources: LT; Data Curation: JZ and LT; Writing Original Draft Preparation: LT and MK; Writing Review and Editing: MK, JZ, and LT; Visualization: MK, LT; Visualization: MK; All authors (MK, JZ, LT) have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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7.5. Declaration of Conflicting Interest

The authors declare that there are no financial or personal conflicts of interest that could have influenced the findings or conclusions presented in this study.

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