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건강신념모델 기반 스마트폰 유방자가검진 교육 애플리케이션 개발 및 사용성 평가

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Development and Usability Evaluation of a Health Belief Model-Based Smartphone Breast Self-Examination Education Application

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Abstract

Purpose: This study aimed to develop a health belief model-based smartphone breast self-examination (BSE) education application and to evaluate its usability through expert assessment. **Methods:** A methodological design was used, and the application was developed in three stages: content development, application design, and implementation. The application included educational materials, step-by-step BSE instructions, video-based guidance, Q&A, and chatbot-based communication. Usability was evaluated by seven experts, including two nurses working at a breast cancer center, three nursing professors with application development experience, and two information technology experts. Data were analyzed using descriptive statistics. **Results:** The final application had six main components: main screen, survey, educational materials, educational video, Q&A, and chatbot-based communication function. The total usability score was 77.00±2.00 out of 80, and the mean item score was 4.81±0.13 out of 5. The mean scores for content accuracy, accessibility and convenience, speed and connection, and overall impression were 19.29±0.76, 28.71±0.49, 14.71±0.49, and 14.29±0.76, respectively. **Conclusion:** The health belief model-based smartphone BSE education application showed high expert-rated usability. The results provide preliminary evidence for applying smartphone-based BSE education in community settings.

Keywords: Breast self-examination; Mobile applications; Health belief model; Breast cancer; Usability testing

Introduction

Digital health has become an important strategy for delivering preventive health education and supporting self-management behaviors in daily life [1]. Mobile health applications can provide repeated education, reminders, self-monitoring, tailored information, and communication support through smartphones [2,3]. These functions are useful for health behaviors that need to be practiced repeatedly outside clinical settings [2,4]. Recent reviews have shown that mobile applications can support health behavior change when they include behavior change techniques such as prompts, feedback, goal setting, and self-monitoring [2,4,5]. Therefore, smartphone-based health education should not be designed only as information delivery. It should be developed as a structured tool that helps users understand, remember, and apply health information in everyday life [1,3].

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Breast self-examination (BSE) is a self-care behavior that requires procedural knowledge, repeated practice, and confidence. Women need to know when to perform BSE, how to visually inspect and palpate their breasts, and when to seek professional evaluation after noticing unusual changes [6,7]. Recent global cancer statistics indicate that breast cancer remains one of the most frequently diagnosed cancers among women, which supports the continuing need for accessible breast health education [8]. However, BSE education is different from simple knowledge education. It requires step-by-step guidance, visual demonstration, confidence building, and cues for regular practice. Mobile applications may be useful for this purpose because they can provide educational content repeatedly and at the point of need [2,5].

Previous studies have reported positive effects of smartphone-based BSE interventions [9-11]. Shakery et al. found that a smartphone application improved women's BSE performance [9]. Kang et al. reported that smartphone application education combined with hands-on practice improved BSE-related outcomes among nursing students in South Korea [10]. Yusuf et al. showed that a breast awareness mobile application increased knowledge of breast cancer risk factors, awareness of warning signs, and confidence in performing BSE [11]. In addition, personalized mobile education has been proposed as a useful strategy for BSE learning because it can provide information in a user-accessible and adaptable format [12]. Also, smartphone breast applications have been shown to enhance BSE-related knowledge and practice while promoting health motivation and self-efficacy associated with early detection behaviors [13].

As such, smartphone-based BSE studies have mainly focused on educational interventions designed to improve women's knowledge, perception, and BSE performance [9-13]. However, relatively limited attention has been focused on the development of theory-driven applications and the systematic usability evaluation of BSE applications [13]. Although smartphone-based BSE interventions have shown promise, many health applications are developed with limited explicit use of behavioral theory. This may make it difficult to explain how app functions influence users' cognitive and motivational processes. The Health Belief Model (HBM) has been widely used in nursing and public health research to understand breast cancer screening and BSE-related behaviors [14-16]. According to the HBM, health behavior is influenced by perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy [14-16]. Applying the HBM to a BSE education application can help translate theoretical constructs into functional app components. For example, educational content can increase perceived susceptibility and severity. Video-based guidance can reduce perceived barriers and increase perceived benefits. Reminders as customized hate menstrual cycle-based notification, Q&A, and interactive support can serve as cues to action and strengthen self-efficacy. Therefore, an HBM-informed application may provide a more systematic approach than a simple information-based application. In contrast to previous studies that primarily evaluated educational outcomes, the present study focused on the theory-based development of a smartphone BSE education application and its systematic usability evaluation by experts from nursing and information technology fields.

The design quality of a BSE application is also important for its educational usefulness. A BSE application should provide accurate information, clear procedural demonstration, reminders, and interactive support. App-based behavior change interventions are more likely to be useful when they include active engagement features, such as prompts, feedback, self-monitoring, and tailored information [4,5]. In addition, sustained use and adoption of mHealth technologies depend on how well applications adapt to user needs and real-world contexts [17]. At the same time, health applications need systematic quality and usability evaluation [18,19]. Poor navigation, unclear content, low accessibility, or technical instability can reduce user engagement and limit real-world use [18,19]. This study focused on the development of a theory-driven application grounded in the HBM and the systematic evaluation of its usability by experts from nursing and information technology fields. Therefore, this study aimed to develop an HBM-based smartphone BSE education application and to provide preliminary evidence for applying smartphone-based BSE education in community settings.

Methods

1. Study design

This study was a methodological study conducted to develop a HBM-based smartphone BSE education application and to evaluate its usability through expert assessment.

2. Theoretical Framework

The smartphone BSE education application was developed based on the HBM. The HBM was used to organize the educational contents and application functions according to perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. Educational materials on breast cancer and BSE were designed to enhance users' perceived susceptibility and perceived severity. Video-based BSE guidance was included to increase perceived benefits and reduce perceived barriers related to not knowing how to perform BSE. Survey, Q&A, and interactive support functions were designed to provide cues to action and strengthen users' self-efficacy in performing BSE.

3. Development of the Smartphone BSE Education Application

The application was developed through three stages: content development, application design, and implementation.

In the first stage, educational contents were developed based on breast cancer and BSE-related information, BSE procedures, and previous literature on BSE-related knowledge, health beliefs, and practice. The contents included breast cancer-related information, the appropriate timing of BSE, step-by-step BSE procedures, and guidance on when to seek professional evaluation after noticing unusual breast changes. An educational video was also produced to provide visual demonstration of the BSE procedure. The educational contents were developed based on the breast cancer screening guidelines [6,7] and prior literature on self-examination of the breast, and were reviewed by two oncology advanced practice nurse with more 20 years of clinical experience and one nursing professor with clinical experience at the breast cancer center to ensure the validity of the contents. Based on the feedback on the accuracy, clarity, and educational appropriateness of the contents, the application contents were confirmed.

In the second stage, the structure and interface of the application were designed. The application was organized to allow users to access a pre-survey, educational materials, an educational video, and reminders as customized hate menstrual cycle-based notification, Q&A, and interactive communication functions. The interface was designed to help users move through the contents in a simple and sequential manner.

In the third stage, the application was implemented as a hybrid-type smartphone application compatible with both iOS and Android. The final application consisted of a main screen, survey, educational materials, educational video, Q&A, and a chatbot-based communication function.

4. Expert Usability Evaluation

The usability of the developed application was evaluated by seven experts. The expert panel consisted of two oncology advanced practice nurse with more 20 years of clinical experience, three nursing professors with experience in application development with more 5 years of oncology clinical experience, and two mobile health technologies. The experts reviewed the application using an application evaluation scale. The original scale for evaluating nursing websites was developed by Tsai and Chai [20] and later adapted by Kang and Suh for smartphone application evaluation [21]. The instrument consists of 16 items across four domains: content accuracy, accessibility and convenience, speed and connection, and overall impression. The modified instrument demonstrated satisfactory internal consistency reliability, with a Cronbach's α of .90 reported by Kang and Suh [21]. Each item was

rated on a 5-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Higher scores indicated better usability. The content accuracy domain included four items, accessibility and convenience included six items, speed and connection included three items, and overall impression included three items. The total possible score ranged from 16 to 80. The experts evaluated whether the application provided accurate and useful BSE-related information, whether the menus and contents were easy to access, whether the application operated smoothly, and whether the overall design was appropriate for BSE education.

5. Data Analysis

Data from the expert usability evaluation were analyzed using descriptive statistics. Minimum, maximum, means, and standard deviations were calculated for each evaluation domain. The results were presented by domain.

6. Ethical Considerations

This study focused on the development of a smartphone BSE education application and expert usability evaluation. The experts were informed that participation was voluntary and that they could withdraw from the evaluation at any time. The collected evaluation data were used only for research purposes and were analyzed anonymously. The application was developed for educational purposes and collected only minimal personal information from users. No sensitive health information was stored within the application. Survey responses were anonymized and stored on a password-protected server accessible only to the research team. Access to the application was restricted to authorized users during the evaluation period.

Results

1. Development Process of the Smartphone BSE Education Application

The smartphone BSE education application was developed through three stages: content development, application design, and implementation. In the content development stage, educational materials and video-based contents were produced to provide breast cancer-related information, the appropriate timing of BSE, step-by-step BSE procedures, and guidance on when to seek professional evaluation after noticing unusual breast changes. In the application design stage, the structure and interface were organized to allow users to access the program contents in a simple and sequential manner. The application included a main screen, survey, educational materials, educational video, Q&A, and a chatbot-based communication function. In the implementation stage, the application was developed as a hybrid-type smartphone application compatible with both iOS and Android.

2. Components of the Smartphone BSE Education Application

The final smartphone BSE education application consisted of six main components: a main screen, survey, educational materials, educational video, Q&A, and chatbot-based communication function. The survey component was included to assess users’ BSE-related characteristics and awareness before education. The educational materials provided written information on breast cancer, the timing of BSE, and step-by-step BSE procedures. The educational video provided visual guidance for BSE procedures to support procedural learning. The Q&A component was developed to reinforce users’ understanding of BSE-related contents. The chatbot-based communication function was included to provide interactive support and help users ask questions related to BSE and breast health. In terms of the HBM, the educational materials and video contents were linked to perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. The survey, Q&A, and chatbot functions were linked to cues to action and self-efficacy by encouraging users to reflect on their own breast health and supporting confidence in performing BSE (Figure 1).

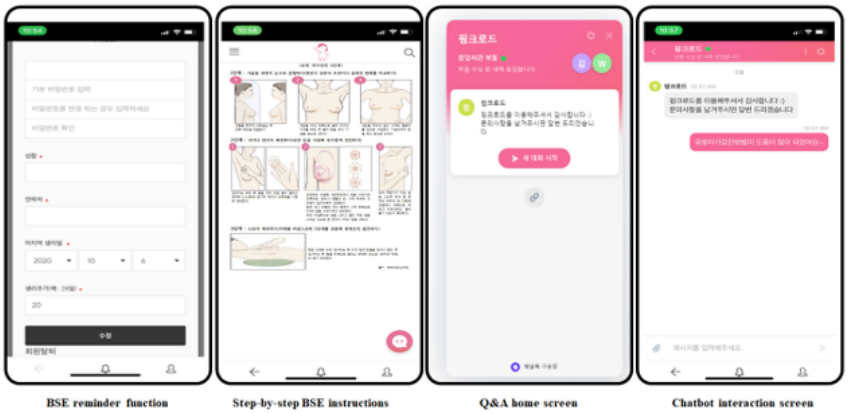

Figure. 1. Main components of the smartphone BSE education application. BSE=breast self-examination.

3. Expert Usability Evaluation of the Application

The results of the expert usability evaluation are presented in Table 1. The usability of the smartphone BSE education application was evaluated by seven experts, including two nurses working in a breast cancer center, three nursing professors with experience in application development, and two information technology experts with experience in application development. The mean score for content accuracy was 19.29±0.76 out of 20. The mean score for accessibility and convenience was 28.71±0.49 out of 30. The mean score for speed and connection was 14.71±0.49 out of 15. The mean score for overall impression was 14.29±0.76 out of 15. The total usability score was 77.00±2.00 out of 80, with scores ranging from 74 to 79. The mean item score was 4.81±0.13 out of 5. These findings indicate that the smartphone BSE education application received high usability ratings across all domains. In particular, the high scores for content accuracy, accessibility and convenience, and speed and connection suggest that the application was evaluated as educationally appropriate, easy to use, and technically stable.

Table 1. Expert Usability Evaluation of the Smartphone BSE Education Application (N=7)

Domain	No. of items	Possible range	Min	Max	Mean ± SD
Content accuracy	4	4–20	18	20	19.29 ± 0.76
Accessibility and convenience	6	6–30	28	29	28.71 ± 0.49
Speed and connection	3	3–15	14	15	14.71 ± 0.49
Overall impression	3	3–15	13	15	14.29 ± 0.76
Total usability score	16	16–80	74	79	77.00 ± 2.00
Mean item score	16	1–5	4.63	4.94	4.81 ± 0.13

BSE, breast self-examination; SD, standard deviation.

Discussion

This study developed an HBM-based smartphone BSE education application and evaluated its usability through expert assessment. The application was designed to support regular BSE practice by integrating educational materials, step-by-step instructions, video-based guidance, Q&A, and chatbot-based communication. The expert usability evaluation showed high scores across all domains. Previous studies have shown that smartphone-based BSE interventions can improve BSE performance, health beliefs, knowledge, awareness, and confidence [9-13]. The present study extends this body of evidence by focusing on the development and expert usability evaluation of an HBM-informed BSE education application.

A major strength of this study is that the application was developed using the HBM as a theoretical framework [15]. Many digital health applications provide health information, but their behavioral mechanisms are often unclear when they are not explicitly

linked to theory [4,5,22]. In this study, educational materials were designed to address perceived susceptibility and severity, while video-based BSE guidance was used to enhance perceived benefits and reduce perceived barriers. Reminders as customized hate menstrual cycle-based notification, Q&A, and chatbot-based communication functions were linked to cues to action and self-efficacy. This structure is consistent with previous research suggesting that theory-based mobile applications may better support breast awareness and health behavior change than applications that provide information alone [14,16,22]. In particular, Nasution et al. emphasized the need to develop breast examination awareness applications based on HBM components, and Yusuf et al. reported that breast awareness mobile applications can improve knowledge, awareness, and confidence among women [11,22]. Therefore, the HBM-based design of the present application may help users move from simple awareness to practical readiness for BSE.

The high usability scores in this study indicate that the application was evaluated positively in terms of content accuracy, accessibility and convenience, speed and connection, and overall impression. Content accuracy is a critical component of health application quality [18,19,23], as inaccurate or unclear information may undermine user trust, reduce engagement, and limit the educational value of the application [24]. The high score for accessibility and convenience suggests that the application structure and menu flow were considered easy to use by experts. The high score for speed and connection also indicates that the application was technically stable during expert review. These findings are meaningful because recent reviews have emphasized that usability, information quality, technical stability, and accessibility are core elements in the evaluation of mHealth applications [18,19,24-28]. Giebel et al. identified broad quality dimensions for mHealth apps, including information quality, usability and design, technology, and data security [24]. Galavi et al. also reported that usability problems in mHealth applications can reduce effective use and should be systematically addressed during development [25,26]. Thus, the high usability results of this study provide preliminary support for the quality and feasibility of the developed BSE education application.

The developed application can be utilized as a useful tool for the spread and practice of breast self-examination awareness. Face-to-face BSE education can improve knowledge and practice; however, when education is delivered as a single or time-limited session, repeated exposure and sustained practice may be difficult to maintain [10,13]. In contrast, a smartphone app-based program can provide repeated access to educational materials, visual guidance, and interactive support [13,24]. This is important because BSE requires not only knowledge but also procedural learning, confidence, and regular cues to action. Prior reviews of mobile health and breast cancer-related applications suggest that digital tools can support self-management, education, symptom monitoring, and confidence when they provide evidence-based information and user-oriented functions [23,29,30]. In this study, the inclusion of educational materials, step-by-step BSE instructions, and chatbot-based Q&A may help users review BSE procedures repeatedly and seek clarification when needed. However, the present findings should be interpreted as evidence of usability, not as evidence of effectiveness. Future studies should examine whether use of the application improves BSE knowledge, health beliefs, self-efficacy, and actual BSE practice among women in community settings.

This study has several limitations. First, the application was evaluated by seven experts, but end-user usability testing with women in the target population was not conducted in this phase. Expert evaluation is useful in the early stage of application development, but user-centered evaluation is needed to identify practical barriers in real-world use. Second, this study assessed usability only and did not test the effectiveness of the application on BSE-related outcomes. Further studies are needed to evaluate its effectiveness in improving breast health knowledge, health beliefs, and BSE practice among women. Third, the evaluation focused on content and usability domains, while additional issues such as data privacy, long-term engagement, notification fatigue, and integration into community health education were not fully examined. Previous studies have emphasized that sustainable mHealth development requires human-centered design, iterative evaluation, adaptation to user needs, and consideration of real-world implementation contexts [17,27]. Therefore, future research should conduct user testing with women of diverse ages, refine the application based on user feedback, and evaluate its effects using quasi-experimental or randomized controlled designs.

Conclusion

This study developed an HBM-based smartphone BSE education application and evaluated its usability through expert assessment. The developed application integrated educational materials, step-by-step BSE instructions, video-based guidance, Q&A, and chatbot-based communication to support women's breast awareness and regular BSE practice. The expert usability evaluation showed high scores across all domains, indicating that the program was evaluated as educationally appropriate, easy to use, and technically stable. The findings provide preliminary evidence that an HBM-informed smartphone app-based BSE education program may be a useful digital tool for community-based breast health education. Future studies should conduct user-centered usability testing with women in the target population and evaluate the effects of the program on BSE knowledge, health beliefs, self-efficacy, and actual BSE practice. Further refinement based on user feedback will be important before broader dissemination in community health settings.

Conflict of interest

The author declared no conflict of interest.

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Authors contribution

All work was done by Kim SH. The author declare that no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

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