# Effectiveness of an Artificial Intelligence-Based Mobile Application on Perception and Practices regarding Early Breast Cancer Detection among Postmenopausal Women

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**Abstract**

**Background:** The artificial intelligence Know Your Lemons mobile application offers an innovative approach to enhance women's knowledge, beliefs, and engagement in early breast cancer detection. Aim: Evaluate the effectiveness of an artificial intelligence-based mobile application on perception and practices regarding early breast cancer detection among postmenopausal women**. Design and Setting:** A quasi-experimental design was conducted at the outpatient clinic of the Obstetrics and Gynecology department at Kafr El-Sheik University Hospital, Egypt. **Sample:** A purposive sample of 139 postmenopausal women participated in the study. **Tools:** Data were collected using four instruments: **a structured interview comprising three parts —**demographic characteristics, clinical and reproductive history, and knowledge about early breast cancer detection; **women's practices for promoting early detection and prevention of breast cancer; the App Usability and Engagement Scale; and the Health Belief Model Scale. Results:** Following the intervention, participants demonstrated significant improvements in knowledge and early detection practices, including breast self-examination, clinical breast examination, and mammography. Usability and engagement with the app increased markedly, and health beliefs improved across all Health Belief Model constructs, with a reduction in perceived barriers. **Conclusion:** The artificial intelligence-based mobile application "Know Your Lemons" proved to be effective, user-friendly, and motivational in improving postmenopausal women's perception and practices regarding early breast cancer detection. **Recommendation:** Integrating artificial intelligence-based educational tools into national health programs may strengthen early detection and enhance women's health outcomes.

**Keywords:** Artificial Intelligence-Based Mobile Application, Breast cancer, Postmenopausal women.

## Introduction:

Breast cancer is the most prevalent cancer among women globally and continues to be a major cause of cancer-related death **(Sung et al. 2021)**. Early detection is essential for lowering morbidity and mortality since, despite advancements in treatment, the prognosis of breast cancer is primarily determined by the stage at diagnosis **(Bray et al., 2018)**. Hormonal, genetic, and lifestyle variables increase the risk, especially for postmenopausal women **(Dietz et al.,2020)**.

Breast self-examination (BSE), clinical breast examination (CBE), and mammography are examples of traditional screening methods that have shown differing levels of efficacy in early detection of breast cancer. Nonetheless, obstacles such as a lack of knowledge, cultural misunderstandings,

and insufficient availability of health information hinder women's involvement in screening procedures, particularly in low- and middle-income nations **(Gupta et al., 2020 or 2013; WHO, 2023)**. Women's perceptions, knowledge, attitudes, and beliefs about cancer and screening proved to have a significant impact on the preventive behaviors of the women **(Yeshitila et al., 2021)**.

One possible tactic to address the gaps in cancer awareness and screening adoption is the incorporation of digital health tools. Artificial intelligence (AI)-powered mobile health (mHealth) apps can provide engaging, individualized, and easily accessible health education, enabling women to take preventative measures **(Salmani, Ahmadi and Shahrokhi 2020)**. The "Know Your Lemons" (KYL) mobile application is one of these technologies that has received international attention for educating women about breast cancer risk factors, symptoms, and the significance of early detection through the use of straightforward visual metaphors **(Know Your Lemons Foundation, 2023)**.

Research indicates that AI-based applications improve adherence to screening recommendations, change health perceptions, and improve knowledge retention as well as practices **(Roosan et al., 2020); Zhao et al., 2022)**. A digital health invention called the AI-Based Know Your Lemons Mobile Application aims to improve women's awareness and behavior around early breast cancer screening. In order to lower barriers for breast cancer awareness and screening, the Know Your Lemons Foundation launched a global campaign that included a mobile app that uses artificial intelligence (AI) to offer personalized education, symptom recognition, and risk assessment tools **(Know Your Lemons Foundation, 2023)**.

Through AI integration, the app may modify instructional materials according to user attributes like age, risk factors, and symptoms reported. Women are more equipped to make educated decisions regarding clinical breast examination (CBE), breast self-examination (BSE), and mammography use thanks to this individualized approach, which also increases health literacy **(Nasution et al., 2021).**The program fills gaps in traditional health education, particularly for people with limited access to healthcare resources, by fusing AI-driven reminders, customized information, and visual learning through the "12 lemons" metaphor **(Khakpaki, 2025)**.

Global measures for early identification and prevention of breast cancer, which continues to be the most frequent among women worldwide, are in line with digital health interventions such as the Know Your Lemons app **(Yen et al., 2023)**.Research indicates that applications for mobile health (mHealth), especially those that use artificial intelligence (AI), might greatly increase awareness, screening uptake, and adherence to preventive practices, which will lower mortality and late-stage diagnosis **(Jacobs et al., 2024; Fajriani & Anggraeni 2023)**.

The **Health Belief Model (HBM)** explains how individuals' beliefs influence their health behaviors. It suggests that people are more likely to take preventive actions—like breast self-examination—if they believe they are at risk (susceptibility) that the disease is serious (severity) that the action has benefits, and that barriers can be overcome. The model also includes cues to action and self-efficacy, which motivate and support behavior change. It provides a useful framework for designing interventions to promote early breast cancer detection **(Azadi et al., 2025; Noman et al.,2024).**

All things considered, the Know Your Lemons mobile application, which is based on artificial intelligence, is a cost-effective, culturally flexible, and scalable tool for improving women's health literacy and proactive involvement in breast cancer prevention.It is a promising intervention to address the knowledge-practice gap in breast cancer screening because of its focus on visual teaching, AI customization, and

worldwide accessibility **(Altmannshofer et al., 2024)**.

To fill a significant gap in cancer preventive techniques, this study intends to assess the impact of the AI-based "Know Your Lemons "(KYL) mobile application on postmenopausal women's perception and practices of early breast cancer detection.

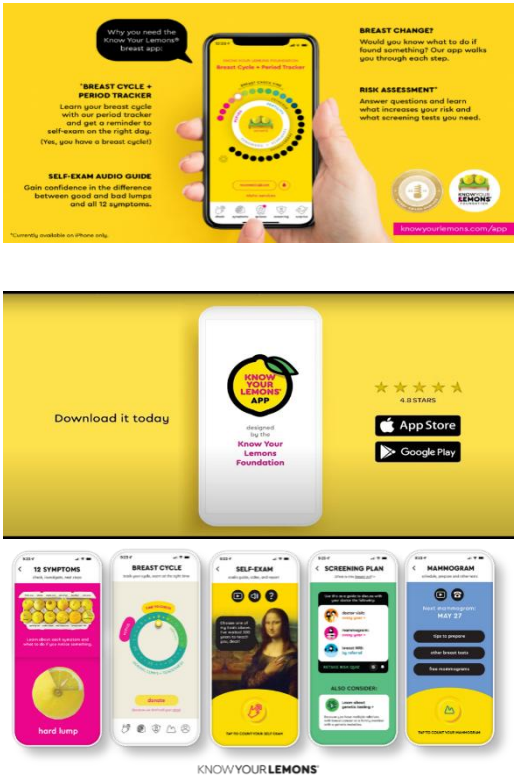


**Figure 1: Know Your Lemons App: A More Powerful Tool for Early Detection and Breast Health. knowyourlemons.org available at https://www. knowyourlemons.org › a...**

**Significance of the study:**

Breast cancer is still one of the most common causes of morbidity and death in women, and postmenopausal women are most at risk because of age-related and hormonal variables. Even though early detection techniques are effective, many populations still lack adequate knowledge and practices of breast self-examination, clinical breast examination, and screening mammography, especially in low- and middle-income environments. Effective prevention efforts are hindered by barriers such as inadequate knowledge, prevalent misconceptions, and restricted access to health information **(Chavda, Patel, and Ray 2022; Shama et al., 2024)**.

Despite the difference in the breast cancer incidence rates among developed and developing nations. The breast cancer remains the most common female cancer type in Egypt with an age-specific incidence rate of 48.8/105. Approximately 46,000 incident cases are forecasted in 2050. **(Azim et al., 2023).** Moreover, it is currently Egypt's second most common cause of cancer-related mortality, behind hepatocellular carcinoma, with an expected 11% death rate in 2020 **(International Cancer Control Partnership, 2020).**

Mobile applications and other digital health solutions are becoming more widely acknowledged as affordable means of promoting health. The Know Your Lemons (KYL) mobile application, which is powered by artificial intelligence, provides creative, visually appealing, and culturally sensitive instruction on breast cancer screening procedures and warning symptoms **Martín-Payo,2021)**. However, postmenopausal women, who are frequently underrepresented in digital health studies, have limited information regarding how well technology works to improve their understanding and practical habits related to early breast cancer detection. To improve prevention tactics and lower the number of late-stage breast cancer diagnoses, this gap must be filled **(Altmannshofer et al., 2024).**

**Aim of the Study:**

This study aimed to evaluate the effectiveness of an Artificial Intelligence-Based Mobile Application on perception and practices regarding early breast cancer detection among postmenopausal women, guided by the **Health Belief Model (HBM)** framework. Through the following specific objectives, the study seeks to:

1. **Assess** the baseline level of knowledge and practices regarding early breast cancer detection among postmenopausal women.
2. **Implement** an AI-based Know Your Lemons Mobile application designed to enhance perception, motivation, and correct techniques related to early detection (BSE, CBE, and mammography).
3. **Evaluate** the effectiveness of the AI-Based Know Your Lemons Mobile Application in improving postmenopausal women's **knowledge** and **practices** scores after intervention.
4. **Examine** changes in postmenopausal women's **health beliefs**—including perceived susceptibility, severity, benefits, barriers, cues to action, and self-efficacy—before and after using the AI-based mobile application.
5. **Determine** the relationship between knowledge, health beliefs, and early detection practices among postmenopausal women after the intervention.

**Research hypothesis**

Based on the study aim and objectives, the following hypotheses are proposed:

**$H_1$:** Postmenopausal women may exhibit a **significant improvement in the knowledge** of early breast cancer detection after using the AI-based mobile application compared to their pre-intervention.

**$H_2$:** Postmenopausal women may demonstrate a **significant improvement in the practices** of early breast cancer detection (BSE, CBE, and mammography) after using the AI-based mobile application.

**$H_3$:** There may be expected **significant positive changes in the health belief model constructs**—including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy—after the intervention.

**$H_4$:**A **positive correlation** between knowledge, practices, and health belief model scores among postmenopausal women after using the AI-based mobile application may be expected.

**Operational definitions:**

The **AI-Based *Know Your Lemons* Mobile Application** is a digital health tool developed by the *Know Your Lemons Foundation* to promote early detection and prevention of breast cancer through **artificial intelligence–driven personalization, visual education, and interactive learning**. The app uses the innovative *"12 lemons" metaphor* to illustrate common breast cancer symptoms in a simple, culturally adaptable manner, thereby overcoming literacy and language barriers (Know Your Lemons Foundation, 2023).

**Perception in this study means** knowledge of postmenopausal women regarding early breast cancer detection and changes in postmenopausal women's beliefs, attitudes, and motivational factors regarding early breast cancer detection, assessed by the Health Belief Model (HBM) scale following the use of the AI-based *Know Your Lemons* mobile application.

**Subject and Methods**

**Design:**

A quasi-experimental research design was employed to accomplish the aim of this study. The purpose of this research design was to determine the effect of a particular

intervention, programme, or event (a treatment).

**Setting:**

The study was conducted in the outpatient clinic of the Obstetrics and Gynecology department at Kafr El-Sheikh University Hospital, Egypt. This place is considered the most common setting for early breast cancer detection and clinical examination among postmenopausal women. Kafr El-Sheikh University Hospital consists of 6 floors with outpatient clinic of Obstetrics and Gynecology department at the first floor that compromised of one room contains two beds for examinations and two ultrasounds as well as cardiotocography CTG device.

**Subjects:**

A total flow rate of 1500 postmenopausal women were reported from statistical office of Kafr El-Sheikh University Hospital within 6 months period. A purposive sample of 139 postmenopausal women were selected according to the following inclusion criteria: aged 40 to <55 years, menopausal status, ownership of an Android smartphone, and the ability to operate mobile applications. Women previously diagnosed with breast cancer were excluded from participation. The sample size and power analysis were calculated using Epi-Info software statistical package created by World health organization and center for disease control prevention, Atlanta, Georgia, USA version 2002.The criteria used for the sample size calculation were as follows: 95% confidence limit, the sample size based on the previously mentioned criteria was N> 130 and the sample size calculation was increased to 139 to compensate for missed information and improved quality of the study data.

**Tools of data collection:**

**Four tools comprised the data collection instrument.**

**Tool I: Structured Interview:** The researchers developed it after an extensive literature review and examination of participants' medical records. It was designed to assess the demographic characteristics, clinical and reproductive history, and knowledge of postmenopausal women regarding early breast cancer detection using the AI-based *Know Your Lemons* mobile application. It comprised **three parts**:

**Part(1):Demographic Characteristics**

This section covered participants' personal data, including age, educational level, marital status, residence, occupation, and monthly income.

**Part (2): Clinical and Gynecological History**

This part gathered information on participants' age at menopause, family history of breast or ovarian cancer, Previous breast problems (lump, discharge, biopsy), previous breast screening practices (BSE, CBE, mammography), and experience with smartphones and health-related mobile applications.

**Part (3): Knowledge about Early Breast Cancer Detection and Prevention**

This section developed by the researchers based on literature reviews **(Akhtari-Zavare et al., 2015; Al-Mahmoud et al., 2020; Cheng et al., 2019)** that assessed participants' knowledge regarding the use of the AI-based *Know Your Lemons* mobile application in relation to early detection of breast cancer. It included pre- and post-intervention items covering key areas such as:

- Commonality and risk factors of breast cancer (e.g., age, obesity, family history).
- Warning signs and symptoms (e.g., painless lump, nipple discharge, skin changes).
- Screening recommendations (e.g., frequency of BSE, annual CBE after age 40, role of mammography).
- The impact of early detection on treatment outcomes and survival rates.

**Scoring System and Interpretation**
Each knowledge item was scored based on participants' responses as follows:

- **Correct and complete answer scored ( 2)**
- **Correct and incomplete answer scored ( 1)**
- **Incorrect or don't know scored (0)**

**The total knowledge score** ranged from **0 to 28 points**, which was categorized as:

- **High knowledge:** ≥75% of total score (≥21 points).
- **Moderate knowledge:** 50–74% of total score (14–20 points).
- **Low knowledge :**< 50% of total score (<14 points).

**Tool II: Women's Practices for Promoting Early Detection and Prevention of Breast Cancer:**
This tool assessed women's practices related to breast cancer early detection and preventive measures. **Based on (Fatiregun et al., 2024; Li et al., 2024; Mwendwa & Gathirua-Mwangi 2017)**. It included items such as:

- Practicing breast self-examination (BSE).
- Frequency of BSE.
- Examining all areas of the breast and armpit.
- Checking for physical changes in front of a mirror.
- Performing BSE in both lying and standing positions.
- Undergoing clinical breast examination (CBE) within the past year.
- Frequency of mammography every 1–2 years for women aged ≥50.
- Consulting a doctor upon noticing any breast changes.
- Discussing breast screening with a healthcare provider.

**Scoring System:**
Each item was rated on a three-point Likert scale to assess the frequency of appropriate screening practices.

- **Always = 2 points**.
- **Sometimes = 1 point**.
- **Never = 0 points**.

**The total practices scores** ranged from **0 to 18 points** and were categorized as follows:

- **Good practices:** ≥75% of total score (≥14 points).
- **Fair practices:** 50–74% of total score (9–13 points).
- **Poor practices :**< 50% of total score (<9 points).

**Tool III: App Usability and Engagement Scale (MAUQ Adapted)**
This tool adapted from **(Lee & Lee, 2020; Zhao et al., 2022; Zhou et al., 2019)** to assess participants' perceptions regarding the usability, clarity, motivation, and engagement features of the AI-based *Know Your Lemons* mobile application. Items included statements such as:

- "The app was easy to use."
- "The instructions were clear."
- "I felt confident using the app."
- "The information was easy to understand."
- "I plan to continue using the app."
- "The reminders motivated me."
- "I would recommend this app to others."

**Scoring System for the App Usability and Engagement Scale (MAUQ Adapted)**
Each item was assessed using a three-point Likert scale:

- **Agree = 2 points**.
- **Neutral = 1 point**.
- **Disagree = 0 points.**

The total scores ranged from **0 to 14 points**, and were interpreted as follows:

- **High usability and engagement:** ≥75% of total score (≥11 points).
- **Moderate usability and engagement:** 50–74% of total score (7–10 points).
- **Low usability and engagement :**< 50% of total score (<7 points).

Higher scores indicated more favorable perceptions of the application's design, ease of use, clarity of information, and motivational impact.

**Tool IV: Health Belief Model (HBM) Scale**

The Health Belief Model (HBM) scale was employed from **(Al-Khasawneh et al., 2016; Champion, Skinner, & Menon, 2020; Sardasht, Irani, Najmabadi, Hadiababd, and Fasanghari, 2022)** to assess changes in participants' beliefs, attitudes, and motivational factors regarding early breast cancer detection following the use of the AI-based *Know Your Lemons* mobile application. The scale comprised six key domains:

1. **Perceived Susceptibility (2 items):** Beliefs about personal vulnerability to breast cancer.
2. **Perceived Severity (2 items):** Beliefs about the seriousness of breast cancer and its consequences.
3. **Perceived Benefits (2 items):** Beliefs in the value of preventive behaviors such as BSE, CBE, and mammography.
4. **Perceived Barriers (2 items):** Beliefs regarding obstacles that hinder preventive actions.
5. **Self-Efficacy (2 items):** Confidence in performing recommended screening practices.
6. **Cues to Action (2 items):** Motivational triggers encouraging screening behaviors, such as reminders from the mobile application.

**Scoring System for the Health Belief Model (HBM) Scale**

Each item was rated using a 3-point Likert scale:

- **Agree = 2 points.**
- **Neutral = 1 point**.
- **Disagree = 0 points**.

The total scores ranged from **0 to 24 points**, categorized as follows:

- **High health belief level:** ≥75% of total score (≥18 points).
- **Moderate health belief level:** 50–74% of total score (12–17 points).
- **Low health belief level :**< 50% of total score (<12 points).

Higher scores indicated stronger positive health beliefs, greater perceived susceptibility and benefits, fewer perceived barriers, and higher motivation and confidence in performing breast cancer preventive behaviors.

**Validity and Reliability of the Tools**

To ensure the accuracy and consistency of the data collection tools, both **content validity** and **reliability** were rigorously assessed.

- **Content Validity:** The tools were reviewed by a panel of **five experts** in maternal and women's health nursing, oncology nursing, and community health. The experts evaluated each item for **clarity, relevance, comprehensiveness, and appropriateness** to the study objectives. Necessary modifications were made based on their feedback to enhance precision and clarity.
- **Reliability:** The internal consistency of the tools was tested using **Cronbach's Alpha coefficient**, yielding high reliability values:
  - Knowledge Questionnaire = **0.86**.
  - Practice questionnaire = **0.84**.
  - App Usability and Engagement Scale (MAUQ Adapted) = **0.88**.
  - Health Belief Model (HBM) Scale=**0.90.**

These results confirm that all tools demonstrated excellent internal consistency and measurement stability.

**Pilot Study**

A **pilot study** was conducted on **10% of the total sample (14 women)** to evaluate the clarity, feasibility, and applicability of the tools and to estimate the time required for data collection. Participants in the pilot study were selected from the same setting but were **excluded from the main study sample** to prevent contamination of results. Findings from the pilot study confirmed that the tools were clear, relevant, and easily understood by participants; only minor linguistic modifications were made accordingly.

**Ethical Considerations**

Ethical approval for the study was obtained from The Scientific Research Ethics Committee of Kafrelsheikh University (KFSIRB200-776) before data collection. Official permissions were also secured from the hospital administration.

- Participants were informed about the **purpose, procedures, and duration** of the study, as well as their **rights to withdraw at any time** without any negative consequences.
- **Informed verbal and written consent** was obtained from each participant before data collection.
- **Confidentiality and anonymity** were strictly maintained by coding participants' data and storing it securely for research purposes only.

**Data Collection Procedure**

Data collection was carried out over a period of twelve months, from **January 2024 to January 2025**, at the **outpatient clinic of Obstetrics and Gynecology, Kafr El-Sheikh University Hospital**. The process consisted of four main phases: **assessment (pre-test), planning, implementation (intervention), and evaluation (post-test)**

**1. Assessment Phase (Pre-Test)**

During this phase, eligible participants were identified based on the inclusion criteria (postmenopausal women aged 40–<55 years, owning an Android smartphone, and able to use it). The researcher explained the study purpose, obtained informed consent, and then administered the pre-test tools, which included Tool I, Tool II, Tool III and Tool IV.

This phase established the participants' initial levels of knowledge, practices, usability and engagement features of the AI-based *Know Your Lemons* mobile application, and health beliefs regarding early breast cancer detection.

**2. Planning phase:** Telephone numbers were collected from all participating women. These women will then add to a WhatsApp group created specifically for women on mobile phones. The researchers used a power point presentation and videos to emphasize certain points and facilitate knowledge acquisition and preventive practices as BSE,CBE, and mammography.

**3.Implementation Phase (Intervention)**

In this phase, the researcher provided instructions to the participating women about knowledge, health beliefs and preventive practices regarding early breast cancer detection using the three online sessions through Zoom application. The duration of each session ranged from 30-45 minutes over a period of four weeks to prepare woman for AI-based application. The online sessions include one theoretical session and two clinical sessions for application of preventive measures regarding early breast cancer detection.

- The first online teaching session included information regarding mobile app application "know your lemons" detailed description, its benefits and how it works, breast cancer risk factors, warning signs and symptoms, (screening recommendations as; frequency of BSE, annual CBE after age 40, role of mammography), impact of early detection on treatment outcomes.
- The second online clinical session concerned with early breast cancer detection preventive measures as; practice of breast self-examination (BSE),

Frequency of BSE, examining all areas of the breast and armpit, Checking for physical changes in front of a mirror, Performing BSE in both lying and standing positions.

- The third online clinical session included performing clinical breast examination (CBE) within the past year, preparation and frequency of mammography every 1–2 years for women aged ≥50, consulting a doctor upon noticing any breast changes and discussing breast screening with a healthcare provider.

Also, participants were introduced to the **AI-based "Know Your Lemons" mobile application**. The researchers guided each participant on:

- Downloading and installing the app,
- Navigating **App** features, including educational videos, self-assessment tools, and reminders, (self-exam audio guides with monthly reminders timed to woman's body, custom screening plan based on her risk factors, how to identify and report symptoms to her doctor, prepare for mammograms, ultrasounds, breast MRI and biopsy, book a mammogram through the app).
- Early identification of breast cancer symptoms, screening methods, and risk factors.
- Using AI-based personalized feedback and visual learning tools.

Participants were encouraged to explore the application at home, engage with its educational modules, and apply learned practices over four weeks. Reminders and follow-up communication were maintained through phone calls or messages through WhatsApp group created specifically for women on mobile phones to ensure engagement and address any technical difficulties with app application.

**Explore the Application:** "Know Your Lemons App"

Is app number one for breast self-examination, sending monthly reminders about woman' breast cycle with Know Your Lemons App timer, helping understand her screening plan, learn about risk factors, find details about signs and symptoms, prepare for mammograms, and more. It's the world's first app designed to improve early detection of breast cancer and the only period-tracking app nominated for a Webby Award in 2023 that selected as one of the top 5 health and fitness apps in 2023, 2022, and 2019, it has saved lives. It does not collect woman' data

**4. Evaluation Phase (Post-Test)**

After one month of continuous app usage, participants were reassessed using Tool I part (3), Tool II, Tool III, and Tool IV.

The comparison between pre- and post-intervention results determined the **effectiveness of the AI-based educational tool** in improving women's knowledge, practices, and changing health beliefs.

**Statistical Design**

Data were coded, tabulated, and analyzed using the **Statistical Package for the Social Sciences (SPSS) version 26**. Descriptive statistics—including frequency, percentage, mean, and standard deviation—were used to summarize participants' demographic characteristics, clinical history, knowledge, practices, app usability, and health belief variables.

Inferential statistics were applied to test the study's hypotheses:

- The **Chi-square ($\chi^2$) test** was used to compare pre- and post-intervention categorical data (knowledge, practices, and health belief levels).
- The **paired sample t-test** was used to assess differences in mean scores before and after the intervention.
- The **Pearson correlation coefficient (r)** was employed to examine the relationship between total knowledge and total practice scores.
- A **p-value ≤ 0.05** was considered statistically significant, while **p < 0.001** indicated a highly significant result.

**Results:**

**Table 1**: The studied women had a mean age of 46.29 ± 5.7 years, with the largest group aged 45–<50 years. About one-third had secondary education, and most were married, employed, and residing in rural areas. The majority reported insufficient monthly income.

**Table (2):** More than half of women experienced menopause between 45–<50 years (57.6%), while only 15.8% reported a family history of breast/ovarian cancer and 14.4% had previous breast problems. Regarding screening practices, 36.7% performed BSE regularly, whereas about half had undergone CBE (49.6%) and mammography (50.4%). Notably, all participants reported smartphone use, though only 21.6% had prior experience with health-related mobile applications.

**Table 3:** There was a highly significant improvement in women's knowledge regarding early breast cancer detection after using the AI-based *Know Your Lemons* mobile application. Across all items, the proportion of women with complete knowledge answers increased markedly from pre- to post-intervention, with Chi-square tests showing statistically significant differences ($p < 0.001$) in every knowledge domain.

**Figure (1):** The findings revealed a significant improvement in knowledge scores after the intervention, with most women shifting from moderate or low total knowledge scores to high total knowledge scores across all items. All differences were statistically significant ($p<0.001$).

**Table (4):** The results demonstrated a significant improvement in breast cancer early detection practices following the use of the AI-based *Know Your Lemons* mobile application. The proportion of women performing BSE, checking all breast areas, attending CBE, and undergoing mammography increased substantially from pre- to post-use of the AI-based *Know Your Lemons* mobile application, with most changes reaching statistical significance ($p < 0.05$ to $p < 0.001$).

**Figure (2):** The results showed that the AI-based Know Your Lemons mobile application was highly usable and engaging for the participants. Before the use of the AI-based Know Your Lemons mobile application, nearly one-third of the women reported good practices; then this percentage improved to 79.1 % after using the app.

**Table (5):** The results demonstrated that the AI-based *Know Your Lemons* mobile application was well-received and effectively used by the participants. Post-intervention,there was a significant increase in positive responses for all usability and engagement items, including ease of use, clarity of instructions, confidence in using the app, understandability of information, motivational reminders, willingness to recommend, and intention to continue use ($p \leq 0.049–0.000$).

**Figure (3):** The findings depicted in the bar chart demonstrate a substantial improvement in women's app usability and engagement following the intervention. Before the intervention (pre-test), only 15% of participants exhibited high usability and engagement, whereas this proportion increased markedly to 85% post-intervention. Moreover, the proportion of users with moderate usability and engagement also increased from 30% to 70%, reflecting a positive shift toward greater user involvement. Conversely, the percentage of women reporting low usability and engagement decreased from 55% to 45%, after the intervention.

**Table (6):** The results indicated a significant positive change in health beliefs regarding breast cancer early detection following the use of the AI-based *Know Your Lemons* mobile application. After the use of the app., most participants reported higher agreement with items related to perceived susceptibility, severity, benefits, self-efficacy, and cues to

action, while perceived barriers decreased, with statistically significant differences ($p \leq 0.048$–$0.001$).

**Table (1): Distribution of the studied women according to their demographic characteristics (n=139)**

| **Women's Demographic characteristics** (n=139) | **No.** | **%** |
|---|---|---|
| **Age/year** | | |
| 40-<45 | 42 | 30.2 |
| 45-<50 | 52 | **37.4** |
| 50-<55 | 30 | 21.6 |
| ≥ 55 | 15 | 10.8 |
| Mean ± SD | 46.29 ±5.7 year | |
| **Educational level** | | |
| Not read or write | 34 | 24.5 |
| Read and write | 20 | 14.4 |
| Basic education | 18 | 12.9 |
| Secondary education | 46 | **33.1** |
| University and more | 21 | 15.1 |
| **Marital status** | | |
| Married | 97 | **69.7** |
| Widowed | 15 | 10.7 |
| Single | 6 | 4.4 |
| Divorced | 21 | 15.2 |
| **Residence** | | |
| Urban | 66 | 47.5 |
| Rural | 73 | **52.5** |
| **Occupation** | | |
| Employed | 99 | **71.3** |
| Housewife | 25 | 17.9 |
| Retired | 15 | 10.8 |
| **Monthly income** | | |
| Sufficient | 30 | 21.6 |
| Insufficient | 100 | **71.9** |
| Sufficient and saved | 9 | 6.5 |

the overall health beliefs of postmenopausal women following the use of the AI-based *Know Your Lemons* mobile application. Prior to the intervention, only about one-third of responses reflected positive health beliefs. After the intervention, positive HBM responses increased markedly to more than

**Table (7):** Revealed that women's knowledge levels after the use of the AI-based *Know Your Lemons* mobile application were significantly associated with several demographic factors, including age, marital status, education, residence, occupation, and

with higher education (secondary and university levels), urban residence, and sufficient income were more likely to demonstrate high knowledge, while illiteracy, rural residence and economic insufficiency

were linked to low knowledge outcomes.

**Table (8):** Showed a significant association between women's practices after the use of

application regarding breast cancer early detection and their demographic characteristics. Younger, more educated, urban, employed women as well as

those with sufficient income, were more likely to demonstrate high levels of recommended practices ($p < 0.01$).

**Table (9):** Demonstrated a statistically significant relationship between women's total knowledge, total practices, and total health belief, regarding the use of the AI-based *Know Your Lemons* mobile application for early breast cancer detection (**p = 0.000**). Women who had a **high level of knowledge** showed markedly **good practice levels** and **higher health beliefs** compared to those with moderate or low knowledge.

**Table (2): Distribution of the studied women according to their clinical and gynecological history (n=139)**

| Clinical and Reproductive History (n=139) | No. | % |
|---|---|---|
| **Age at menopause** | | |
| 40-<45 | 17 | 12.2 |
| 45-<50 | 80 | **57.6** |
| 50-≤55 | 42 | 30.2 |
| **Family history of breast/ovarian cancer:** | | |
| Yes | 22 | 15.8 |
| No | 117 | 84.2 |
| **Previous breast problems (lump, discharge, biopsy)** | | |
| Yes | 20 | 14.4 |
| No | 119 | 85.6 |
| **Past screening practices:** | | |
| **Breast Self-Examination (BSE):** | | |
| – Regularly | 51 | 36.7 |
| – Occasionally | 28 | 20.2 |
| – Never | 60 | **43.1** |
| **Clinical Breast Examination (CBE):** | | |
| Yes | 69 | 49.6 |
| No | 70 | **50.4** |
| **Mammography:** | | |
| Yes | 70 | **50.4** |
| No | 69 | 49.6 |
| **Smartphone use**: | | |
| Yes | 139 | 100.0 |
| **Prior use of health-related mobile apps** | | |
| Yes | 30 | 21.6 |
| No | 109 | 78.4 |

**Table (3): Distribution of the studied women according to their knowledge regarding early breast cancer detection before and after the use of the AI-based 'Know Your Lemons' Mobile app. (n=139).**

| Knowledge Items | Pre | | | | | | Post | | | | | | $X^2$ | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Correct and complete | | Correct and incomplete | | Incorrect or don't know | | Correct and complete | | Correct and incomplete | | Incorrect or don't know | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | |
| - Breast cancer is the most common cancer in women. | **45** | **32.4** | 80 | 57.5 | 14 | 10.1 | **134** | **96.4** | 5 | 3.6 | 0 | 0.0 | 8.360 | .000** |
| - Postmenopausal women are at higher risk for breast cancer. | 25 | 18 | 100 | 71.9 | 14 | 10.1 | 129 | 92.8 | 10 | 7.2 | 0 | 0.0 | 7.768 | .000** |
| - Obesity increases the risk of breast cancer. | 40 | 28.8 | 72 | 51.8 | 27 | 19.4 | 124 | 89.2 | 15 | 10.8 | 0 | 0.0 | 5.791 | .000** |
| - Family history (mother/sister) increases risk. | 35 | 25.2 | 85 | 61.1 | 19 | 13.7 | 124 | 89.2 | 15 | 10.8 | 0 | 0.0 | 5.930 | .000** |
| - A painless breast lump may be a sign of cancer. | **21** | **15.1** | 101 | 72.7 | 17 | 12.2 | **129** | **92.8** | 10 | 7.2 | 0 | 0.0 | 5.099 | .000** |
| - Nipple discharge (blood-stained) is a warning sign. | 34 | 24.4 | 86 | 61.9 | 19 | 13.7 | 125 | 89.9 | 14 | 10.1 | 0 | 0.0 | 6.379 | .000** |
| - Skin changes such as dimpling/redness can indicate cancer. | 25 | 18 | 96 | 69.1 | 18 | 12.9 | 120 | 86.3 | 19 | 13.7 | 0 | 0.0 | 6.547 | .000** |
| - Pain is always the first symptom of breast cancer. | 15 | 10.8 | 104 | 74.8 | 20 | 14.4 | 120 | 86.3 | 19 | 13.7 | 0 | 0.0 | 7.650 | .000** |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - BSE should be performed monthly. | 55 | 39.6 | 70 | 50.3 | 14 | 10.1 | 113 | 81.3 | 22 | 15.8 | 4 | 2.9 | 6.589 | .000** |
| - CBE should be done every year after age 40. | 40 | 28.8 | 85 | 61.1 | 14 | 10.1 | 115 | 82.7 | 22 | 15.8 | 2 | 1.5 | 5.999 | .000** |
| - Mammography can detect breast cancer before symptoms appear. | 45 | 32.4 | 24 | 17.3 | 70 | 50.4 | 124 | 89.2 | 15 | 10.8 | 0 | 0.0 | 9.934 | .001** |
| - Only women with symptoms need mammography. | 50 | 36 | 14 | 10.1 | 75 | 53.9 | 0 | 0.0 | 18 | 12.9 | 121 | 87.1 | 10.08 | .000** |
| - Early detection improves survival rates. | 20 | 14.4 | 25 | 18 | 94 | 67.6 | 0 | 0.0 | 5 | 3.6 | 134 | 96.4 | 11.64 | .000** |
| - Treatment is easier when cancer is detected early | 45 | 32.4 | 20 | 14.4 | 74 | 53.2 | 0 | 0.0 | 10 | 1.2 | 129 | 92.8 | 11.90 | .000** |

Note: $X^2$ = Chi-square test; $p < 0.05$ is significant; $p < 0.001$ is highly significant**.**

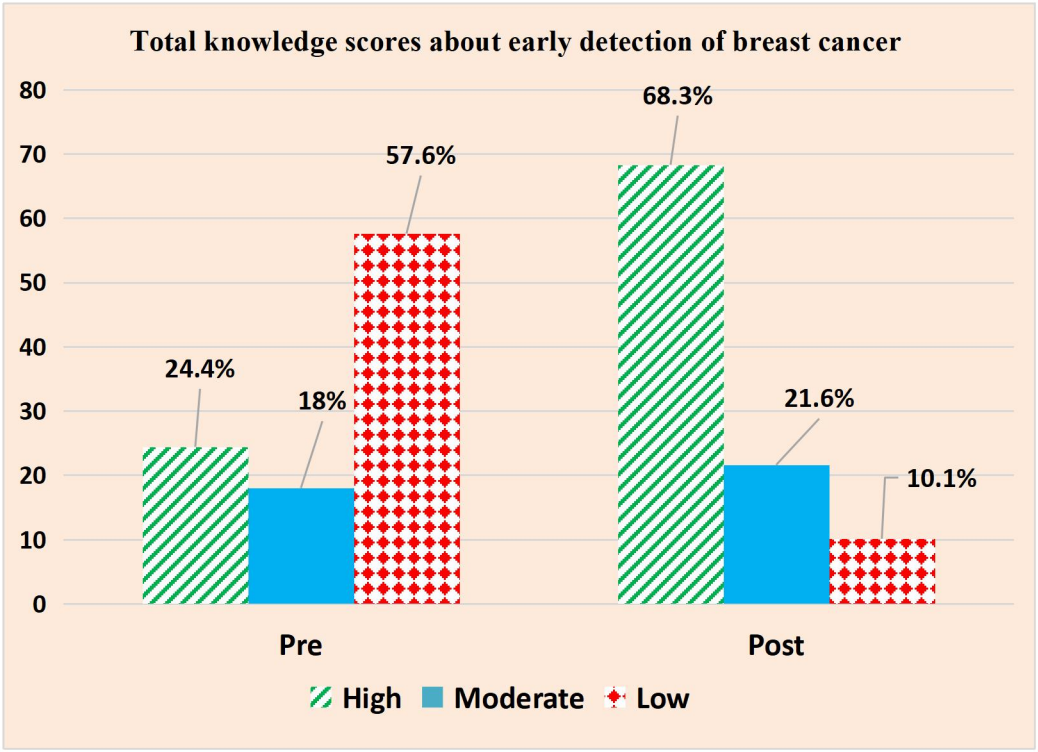


**Figure (1): Percentage distribution of the studied women according to their total knowledge scores regarding early breast cancer detection before and after using the AI-based *Know Your Lemons* mobile application (n = 139).**

**Table (4):Distribution of the studied women according to their practices regarding early detection of breast cancer before and after the use of the AI-based *Know Your Lemons* mobile application(n = 139).**

| Practices Items | Pre | | | | | | Post | | | | | | $X^2$ | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Always | | Sometimes | | Never | | Always | | Sometimes | | Never | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | |
| Do you practice breast self-examination (BSE) | 20 | 14.4 | **69** | **49.6** | 50 | 36 | 0 | 0.0 | 20 | 14.4 | **119** | **85.6** | 7.958 | .000** |
| Frequency of (BSE) | 18 | 12.9 | 62 | 44.6 | 59 | 42.5 | 0 | 0.0 | 18 | 12.9 | 121 | 87.1 | 8.117 | .000** |
| Do you examine all areas of the breast and armpit? | 35 | 25.2 | 52 | 37.4 | 52 | 37.4 | 26 | 18.7 | 50 | 36 | 63 | 45.3 | 4.284 | .049* |
| Do you check for changes in front of a mirror? | 22 | 15.8 | **65** | **46.8** | 52 | 37.4 | 4 | 2.9 | 36 | 25.9 | **99** | **71.2** | 7.558 | .001** |
| Do you perform BSE lying down and standing? | 36 | 25.9 | 78 | 56.1 | 25 | 18 | 25 | 18 | 55 | 39.6 | 59 | 42.4 | 6.990 | .004** |
| Have you had aClinical Breast Examination (CBE)in the past year? | **20** | 14.4 | 90 | 64.7 | 29 | 20.9 | 5 | 3.6 | 34 | 24.5 | 100 | 71.9 | 8.005 | .000** |
| **History of mammogram:** | | | | | | | | | | | | | | |
| Do you have mammography every 1–2 years (age ≥ 50)? | 12 | 8.6 | **60** | **43.2** | 67 | 48.2 | 0 | 0.0 | 15 | 10.8 | **124** | **89.2** | 9.990 | .000** |
| Would you consult a doctor if you noticed a change? | 20 | 14.4 | 70 | 50.4 | 49 | 35.2 | 0 | 0.0 | 10 | 7.2 | 129 | 89.2 | 10.27 | .000** |
| Have you discussed breast screening with your doctor? | 18 | 12.9 | 80 | 57.6 | 41 | 29.5 | 0 | 0.0 | 10 | 7.2 | 129 | 89.2 | 10.05 | .000** |

*(**) highly statistically significant at p<0.01.*

*BSE =breast self-examination*

*CBE = clinical breast examination*

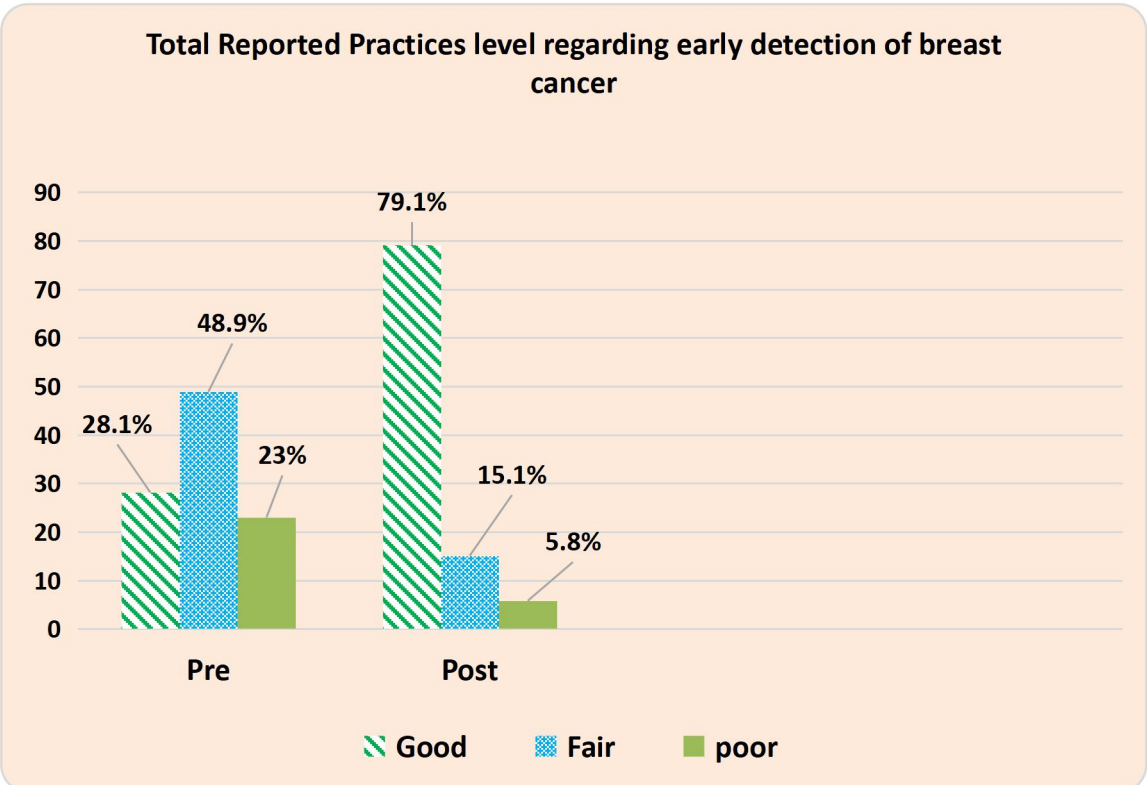


**Figure (2): Percentage distribution of the studied women according to their total practice scores regarding early detection of breast cancer before and after using the AI-based *Know Your Lemons* mobile application (n=139).**

**Table (5): Frequency distribution of the studied women according to the AI-based *Know Your Lemons* mobile application usability and engagement regarding early detection of breast cancer before and after its use (n=139).**

| App Usability and Engagement items | Pre | | | | | | Post | | | | | | $X^2$ | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Agree | | Neutral | | Disagree | | Agree | | Neutral | | Disagree | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | |
| The app was easy to use. | 30 | 21.6 | 35 | 25.2 | 74 | 53.2 | 8 | 5.8 | 25 | 18 | 106 | 76.3 | 8.624 | .001** |
| The instructions were clear. | 80 | 57.6 | 31 | 22.2 | 28 | 20.2 | 88 | 63.3 | 25 | 18 | 26 | 18.7 | 3.329 | .049* |
| I felt confident using the app. | 32 | 23 | 25 | 18 | **82** | **59** | 0 | 0.0 | 8 | 5.8 | **131** | **94.2** | 9.937 | .000** |
| The information was understandable. | 40 | 28.8 | 25 | 18 | 74 | 53.2 | 5 | 3.6 | 14 | 10.1 | 120 | 86.3 | 8.567 | .001** |
| The reminders motivated me. | 53 | 38.1 | 16 | 11.5 | 70 | 50.4 | 0 | 0.0 | 0 | 0.0 | 139 | 100 | 10.30 | .000** |
| I would recommend this app. | 35 | 25.2 | 32 | 23 | 72 | 51.8 | 40 | 28.8 | 28 | 20.2 | 71 | 51.1 | 3.099 | .049* |
| I plan to continue using the app. | 74 | 53.2 | 30 | 21.6 | 35 | 25.2 | 124 | 89.2 | 15 | 10.8 | 0 | 0.0 | 11.57 | .000** |

(**) highly statistically significant at $p<0.01$.

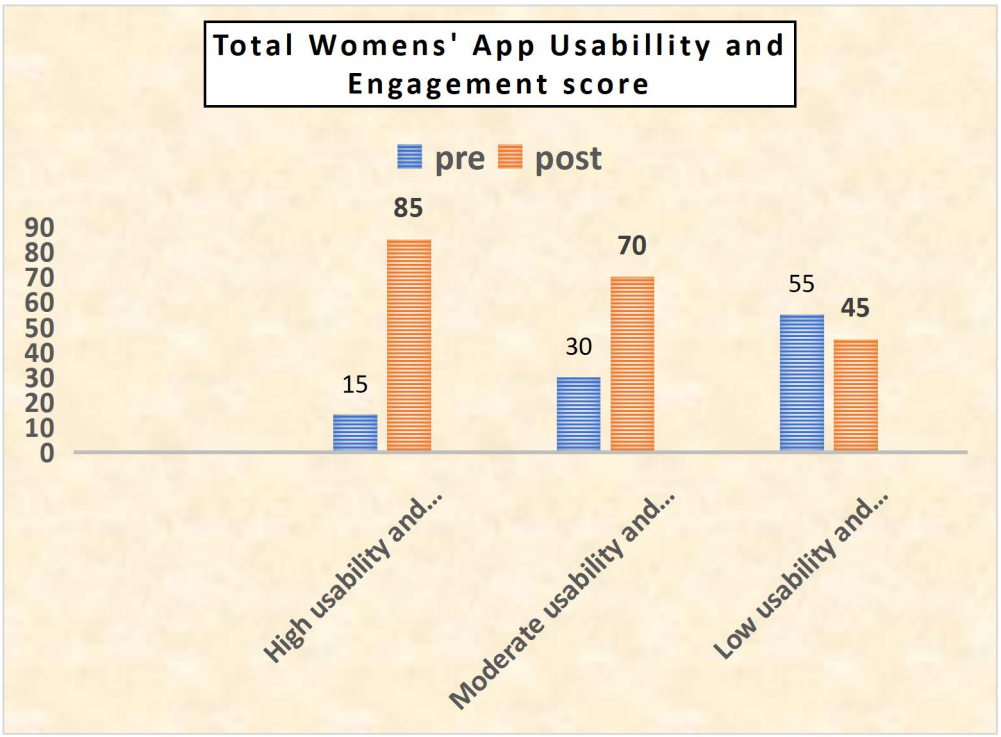


**Figure (3): Percentage distribution of the studied women according to their total App Usability and Engagement score regarding early detection of breast cancer before and after using the AI-based *Know Your Lemons* mobile application (n=139).**

**Table (6): Frequency distribution of the studied women according to their health beliefs regarding early detection of breast cancer before and after using the AI-based *Know Your Lemons* mobile application (n=139).**

| HBM Items | Pre | | | | | | Post | | | | | | $X^2$ | p-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Agree | | Neutral | | Disagree | | Agree | | Neutral | | Disagree | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | |
| **A. Perceived Susceptibility** | | | | | | | | | | | | | | |
| I may get breast cancer in the future. | 30 | 21.6 | 70 | 50.4 | 39 | 28.1 | 0 | 0.0 | 15 | 10.8 | 124 | 89.2 | 8.667 | .001** |
| My chance of getting breast cancer is higher because of my age. | 35 | 25.2 | **75** | **54** | 29 | 20.9 | 0 | 0.0 | 12 | 8.6 | **127** | **91.4** | 8.995 | .000** |
| **B. Perceived Severity** | | | | | | | | | | | | | | |
| Breast cancer would threaten my life. | 32 | 23 | 80 | 57.6 | 27 | 19.4 | 0 | 0.0 | 12 | 8.6 | 127 | 91.4 | 9.064 | .000** |
| Breast cancer would disrupt my family and social life. | 22 | 15.8 | **69** | **49.6** | 48 | 34.5 | 0 | 0.0 | 8 | 5.8 | **131** | **94.2** | 8.652 | .001** |
| **C. Perceived Benefits** | | | | | | | | | | | | | | |
| BSE can help detect breast cancer early. | 6 | 4.3 | 30 | 21.6 | 103 | 74.1 | 0 | 0.0 | 4 | 2.9 | 135 | 97.1 | 11.66 | .000** |
| Mammography increases the chance of survival. | 5 | 3.6 | 30 | 21.6 | 104 | 74.8 | 0 | 0.0 | 0 | 0.0 | 139 | 100 | 14.08 | .000** |
| **D. Perceived Barriers** | | | | | | | | | | | | | | |
| I am embarrassed to do BSE. | 10 | 7.2 | 59 | 42.4 | **70** | **50.4** | 0 | 0.0 | 15 | 10.8 | **124** | **89.2** | 11.65 | .000** |
| I am worried mammography will be painful | 12 | 8.6 | 60 | 43.2 | **67** | **48.2** | 0 | 0.0 | 8 | 5.8 | **131** | **94.2** | 11.05 | .000** |
| **E. Self-Efficacy** | | | | | | | | | | | | | | |
| I am confident I can perform BSE correctly. | 8 | 5.8 | 55 | 39.6 | 76 | 54.7 | 0 | 0.0 | 15 | 10.8 | 124 | 89.2 | 11.91 | .000** |
| I can arrange to attend CBE/mammography. | 45 | 32.4 | 20 | 14.4 | 74 | 53.2 | 0 | 0.0 | 10 | 1.2 | 129 | 92.8 | 11.90 | .000** |
| **F. Cues to Action** | | | | | | | | | | | | | | |
| App reminders encourage me to perform BSE. | 35 | 25.2 | 22 | 15.8 | 82 | 59 | 0 | 0.0 | 12 | 8.6 | 127 | 91.4 | 11.57 | .000** |
| Information from the app motivates me to seek screening. | 52 | 37.4 | 24 | 17.3 | 63 | 45.3 | 50 | 36 | 20 | 14.4 | 69 | 49.6 | 3.647 | .048* |

(**) highly statistically significant at $p<0.01$.

*BSE =breast self-examination*

*CBE = clinical breast examination*

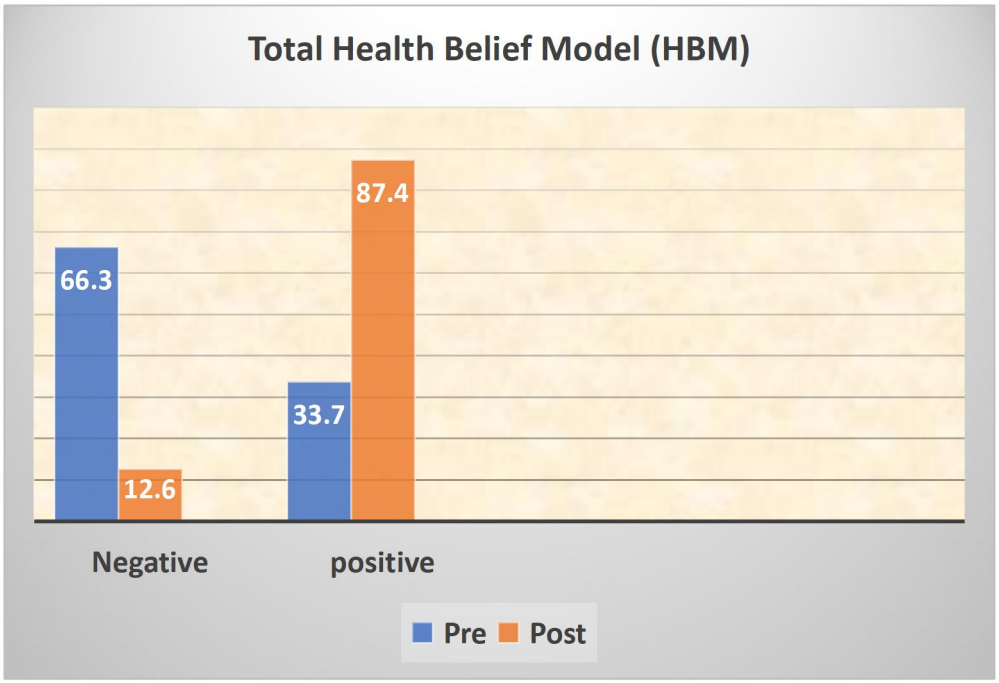


**Figure (4): Percentage distribution of the studied women according to their total health belief model regarding early detection of breast cancer before and after using the AI-based *Know Your Lemons* mobile application (n=139).**

**Table (7): Relation between the studied women's sociodemographic characteristics and their total knowledge score regarding early detection of breast cancer before and after the use of the AI-based *Know Your Lemons* mobile application (n=139).**

| Variables | | Total knowledge score after the use of the AI-based *Know Your Lemons* mobile application | | | | | | X2 | P-Value |
|---|---|---|---|---|---|---|---|---|---|
| | | High (n=95) | | Moderate (n=30) | | Low (n=14) | | | |
| | | No | % | No | % | No | % | | |
| **Age (year)** | 40-<45 | 38 | 40 | 4 | 13.3 | 0 | 0.0 | **10.37** | **.021*** |
| | 45-<50 | 40 | 42.1 | 12 | 40 | 0 | 0.0 | | |
| | 50-<55 | 12 | 12.6 | 12 | 40 | 6 | 42.9 | | |
| | ≥ 50 | 5 | 5.3 | 2 | 6.7 | 8 | 57.1 | | |
| **Marital status** | Married | 74 | 77.8 | 14 | 46.6 | 9 | 64.3 | **17.52** | **.000**** |
| | Widowed | 8 | 8.4 | 7 | 23.4 | 0 | 0.0 | | |
| | Single | 3 | 3.2 | 3 | 10.0 | 0 | 0.0 | | |
| | Divorced | 10 | 10.6 | 6 | 20.0 | 5 | 35.7 | | |
| **Educational Level** | Not read or write | 0 | 0.0 | 22 | 73.3 | 12 | 85.7 | **21.66** | **.000**** |
| | Read and write | 10 | 10.5 | 8 | 26.7 | 2 | 14.3 | | |
| | Basic education | 18 | 19 | 0 | 0.0 | 0 | 0.0 | | |
| | Secondary education | 46 | 48.4 | 0 | 0.0 | 0 | 0.0 | | |
| | University and more | 21 | 22.1 | 0 | 0.0 | 0 | 0.0 | | |
| **Residence** | Urban | 50 | 52.6 | 14 | 46.7 | 2 | 14.3 | **15.50** | **.001**** |
| | Rural | 45 | 47.4 | 16 | 53.3 | 12 | 85.7 | | |
| **Occupation** | Employed | 55 | 57.8 | 20 | 66.6 | 7 | 50.0 | **19.87** | **.000**** |
| | Housewife | 31 | 32.7 | 10 | 33.4 | 5 | 35.7 | | |
| | Retired | 9 | 9.5 | 0 | 0.0 | 2 | 14.3 | | |
| **Monthly income** | Sufficient | 30 | 31.6 | 0 | 0.0 | 0 | 0.0 | **17.85** | **.000**** |
| | Insufficient | 65 | 68.4 | 30 | 100 | 5 | 35.7 | | |
| | Sufficient and save | 0 | 0.0 | 0 | 0.0 | 9 | 64.3 | | |

* Significant < 0.05 ** High significant P= < 0.01

**Table (8): Relation between the studied women's sociodemographic characteristics and their total practices score regarding early detection of breast cancer before and after the use of the AI-based *Know Your Lemons* mobile application (n=139).**

| Items | | Total practices after the use of the AI-based *Know Your Lemons* mobile application | | | | | | X2 | P-Value |
|---|---|---|---|---|---|---|---|---|---|
| | | Poor (n=8) | | Fair (n=21) | | Good (n=110) | | | |
| | | No | % | No | % | No | % | | |
| **Age (year)** | 40- <45 | 0 | 0.0 | 2 | 9.5 | 40 | 36.4 | **13.88** | **.001**** |
| | 45- <50 | 0 | 0.0 | 2 | 9.5 | 50 | 45.4 | | |
| | 50- <55 | 0 | 0.0 | 10 | 47.6 | 20 | 18.2 | | |
| | ≥ 55 | 8 | 100 | 7 | 33.3 | 0 | 0.0 | | |
| **Educational Level** | Not read or write | 8 | 100 | 21 | 100 | 5 | 4.5 | **23.67** | **.000**** |
| | Read and write | 0 | 0.0 | 0 | 0.0 | 20 | 18.2 | | |
| | Basic education | 0 | 0.0 | 0 | 0.0 | 18 | 16.4 | | |
| | Secondary education | 0 | 0.0 | 0 | 0.0 | 46 | 41.8 | | |
| | University and more | 0 | 0.0 | 0 | 0.0 | 21 | 19.1 | | |
| **Residence** | Urban | 0 | 0.0 | 6 | 28.6 | 60 | 54.5 | **17.85** | **.000**** |
| | Rural | 8 | 100 | 15 | 71.4 | 50 | 45.5 | | |
| **Occupation** | Work | 0 | 0.0 | 0 | 0.0 | 40 | 36.4 | **23.07** | **.000**** |
| | Housewife | 7 | 87.5 | 21 | 100 | 60 | 54.6 | | |
| | Retired | 1 | 12.5 | 0 | 0.0 | 10 | 9.0 | | |
| **Monthly income** | Sufficient | 0 | 0.0 | 0 | 0.0 | 30 | 27.3 | **15.84** | **.000**** |
| | Insufficient | 8 | 100 | 21 | 100 | 71 | 64.5 | | |
| | Sufficient and save | 0 | 0.0 | 0 | 0.0 | 9 | 8.2 | | |

* Significant < 0.05 ** High significant P= < 0.01

**Table (9): Correlation between the studied women's total knowledge, total practices, and total health belief, regarding early detection of breast cancer while using the AI-based *Know Your Lemons* mobile application (n=139).**

| Variables | | Total knowledge | | | | | | X2 | P-Value |
|---|---|---|---|---|---|---|---|---|---|
| | | High (n=95) | | Moderate (n=30) | | Low (n=14) | | | |
| | | No | % | No | % | No | % | | |
| Total practices | Good | 95 | 100.0 | 15 | 50.0 | 8 | 57.2 | 14.99 | .000** |
| | Fair | 0 | 0.0 | 15 | 50.0 | 6 | 42.8 | | |
| | Poor | 0 | 0.0 | 0 | 0.0 | 0 | 0.00 | | |
| Total health belief | High | 80 | 84.2 | 20 | 66.6 | 4 | 28.5 | | |
| | Moderate | 10 | 10.5 | 5 | 16.7 | 6 | 42.8 | | |
| | Low | 5 | 5.3 | 5 | 16.7 | 4 | 28.5 | | |
| Pearson correlation coefficient | | r= -.488 p= .000** | | | | | | | |

**highly significant at p ‹ 0.01. r=Correlation Coefficient

## Discussion

The health care providers can serve as key platforms for prevention, early detection, and treatment support of breast cancer particularly during menopause. They offer accessible screening through CBEs and facilitate referrals for mammography, contributing to early diagnosis and improved survival. They can also promote health education, empowering women with knowledge about risk factors and BSE as well as preventive practices **(Singh, Bhange , Jain , Arora, Meena 2025)**. Research indicates that AI-based applications improve adherence to screening recommendations, change health perceptions, and improve knowledge retention as well as practices (**Nguyen et al., 2021; Zhao et al., 2022)**. Therefore, this study was carried out to evaluate the effectiveness of an artificial intelligence-based mobile application on perception and practices regarding early breast cancer detection among postmenopausal women.

Table 1 presents the demographic characteristics of the studied women. The mean age was 46.29 ± 5.7 years, with the largest proportion in the 45–<50-year group. This aligns with previous studies indicating that middle-aged women are a key target population for breast cancer awareness and screening interventions, as the risk increases with age **(American Cancer Society, 2023)**. About one-third of participants had secondary education, and nearly a quarter were illiterate, which may affect comprehension of health-related information and adoption of preventive behaviors **(Panahi , Ramezankhani , and Tavousi 2018; Panahi et al 2020)**.

Most of the participants were married, aligning with findings that marital status can influence health-seeking behaviors, social support, and adherence to screening recommendations **(Cheng et al., 2019)**. Residence was nearly evenly divided between urban and rural areas, highlighting the need to consider geographic factors in program planning, as rural women often have limited access to health services **(Jones et al., 2018)**. Additionally, most participants were employed, while a smaller number were housewives or retired, indicating potential differences in time availability and exposure to health education campaigns. Finally, the majority reported having insufficient monthly income, which may act as a barrier to accessing preventive services, since economic constraints have been shown to limit participation in cancer screening programs **(Yabroff et al., 2011)**.

Overall, the sample mainly included middle-aged, married, employed women with varied educational backgrounds and socioeconomic challenges. These factors likely influence both health awareness and the practical use of breast cancer preventive behaviors, underscoring the need to tailor educational programs to address literacy, financial, and access issues.

Table 2 presents the clinical and gynecological features of the women studied. Most participants experienced menopause between ages 45 and 50, which corresponds with the typical menopausal age range in the literature, signaling a period when women are more prone to hormone-related conditions, including breast cancer **(Santoro et al., 2015)**. Just over 10% had a family history of breast or ovarian cancer and reported previous breast issues, indicating a relatively low prevalence of high-risk conditions in the sample, which may influence both perceived risk and screening behaviors **(Pal1, Das and Pandey 2024)**.

Regarding past screening practices, only one-third of women performed regular BSE, while about half had undergone CBE or mammography. These findings align with prior studies indicating suboptimal adherence to recommended breast cancer screening, especially in populations with

limited awareness or resources **(Akar et al., 2016; Tabar et al., 2011)**. Notably, all participants reported using smartphones, yet only 21.6% had previous experience with health-related mobile applications. This presents a significant opportunity to leverage mobile health interventions, such as the AI-based Know Your Lemons application, to increase awareness and encourage preventive practices among postmenopausal women **(Free et al., 2013)**.

Table 3 highlights a highly significant increase in women's knowledge about early breast cancer detection after using the AI-based Know Your Lemons mobile app. The proportion of participants who answered all questions correctly rose substantially from before to after the intervention, with Chi-square tests confirming the differences were statistically significant. This showed that the app effectively improved awareness, corrected misconceptions, and boosted understanding of breast cancer risk factors and symptoms. These results align with previous studies indicating that mobile health programs can greatly enhance knowledge and health literacy about breast cancer, especially among women with limited exposure to educational efforts **(Chen et al., 2018; Denny et al., 2017; Free et al., 2013)**.

Figure 1 showed a notable increase in overall knowledge scores among the women studied after using the AI-based Know Your Lemons mobile app. Most participants moved from a moderate or low knowledge level to a high level, with all differences being statistically significant. These results confirm the app's effectiveness in raising awareness and understanding of early breast cancer detection in postmenopausal women. Similar outcomes have been reported in earlier studies, suggesting that mobile health interventions can effectively improve knowledge and correct misconceptions among women **(Chen et al., 2018; Denny et al., 2017; Free et al., 2013)**.

Table 4 demonstrated a significant improvement in early breast cancer detection among postmenopausal women following the use of the AI-based Know Your Lemons mobile app. The percentages of women performing BSE, checking all areas of the breast, attending CBE, and undergoing mammograms increased notably from before to after the intervention, with most changes being statistically significant. These results indicate that mobile health interventions can effectively translate knowledge into action, promoting adherence to recommended screening practices **(Boulos et al., 2014; Free et al., 2013)**. This aligns with earlier research demonstrating that digital health tools enhance women's participation in preventive health behaviors, especially in populations with limited exposure to formal education programs **(Chen et al., 2018; Denny et al., 2017)**.

Figure 2 showed that the AI-based Know Your Lemons mobile app was seen as very usable and engaging by participants. After the intervention, most women reported good practices regarding early detection of breast cancer. These results highlight the importance of well-designed mobile health apps in increasing user engagement and helping maintain breast cancer awareness, aligning with evidence that usability and acceptability are key factors in the success of mHealth solutions (**Maramba et al., 2019; Singh et al., 2022; Zhou et al., 2019)**.

Table 5 showed that the AI-based Know Your Lemons app was well-received and effectively used by postmenopausal women. After the intervention, there was a significant improvement across all areas of usability and engagement, including ease of use, clarity of instructions, confidence, understanding, motivation, willingness to recommend, and continued use. These findings underline that the app is not only accessible and easy to use but also motivational and supportive of behavior change in breast cancer awareness. They are consistent with previous studies showing

that the success of mHealth interventions relies heavily on usability, engagement, and acceptability **(Maramba et al., 2019; Zhou et al., 2019)**. Additionally, evidence indicates that high usability in mobile health tools encourages ongoing behavior change and proactive health practices **(BinDhim et al., 2018; Singh et al., 2022)**.

Figure (3) revealed a substantial enhancement in women's app usability and engagement following exposure to the AI-based mobile application. The results demonstrated a marked improvement from the pre- to post-intervention stages, with the proportion of participants reporting *high usability and engagement* increasing from 15% to 85%. Concurrently, those with *moderate usability* rose from 30% to 70%, while *low usability* declined from 55% to 45%. These findings indicate that the application significantly improved user interaction, satisfaction, and perceived ease of use, aligning with the principles of the Technology Acceptance Model (TAM), which posits that *perceived usefulness* and *perceived ease of use* are primary predictors of user adoption and sustained engagement **(Schorr, 2023)**.

The observed increase in engagement reflects the effectiveness of user-centered design elements embedded within the application. Prior studies emphasize that mHealth tools designed with consideration for usability, personalization, and feedback mechanisms lead to higher user satisfaction and adherence **(Maramba et al., 2019; Zhao et al., 2022)**. In the current study, the significant post-intervention gains may be attributed to the integration of interactive features, culturally relevant content, and intuitive navigation, all of which contribute to enhanced engagement among women users **(Alessa et al., 2019)**.

Furthermore, the decrease in low usability levels indicates a positive shift in digital literacy and acceptance of health technologies within the target group. Previous research supports that simplifying app interfaces and providing clear instructions boost self-efficacy and willingness to participate in health-promoting behaviors **(Zhou et al., 2019)**. The results therefore align with broader evidence showing that AI-based mobile health applications can effectively

Table 6 demonstrated that the *AI-based Know Your Lemons* mobile application significantly improved participants' health beliefs regarding breast cancer early detection. After the intervention, women showed higher agreement with statements reflecting perceived susceptibility, severity, benefits, self-efficacy, and cues to action, while perceived barriers decreased significantly. These findings align with the Health Belief Model (HBM), which posits that health-related behaviors are more likely to occur when individuals perceive themselves at risk, believe in the seriousness of the condition, recognize the benefits of preventive actions, feel confident in their ability, and receive motivating cues while facing fewer barriers **(Champion & Skinner, 2008)**. Similar outcomes have been reported in mHealth interventions designed to promote screening behaviors, where enhancing health beliefs led to greater adherence to BSE, CBE, and mammography **(Al-Khasawneh et al., 2016; Lee & Lee, 2020)**. Thus, the current results suggest that the mobile application was effective not only as an educational tool but also as a behavioral change facilitator by strengthening psychological determinants of preventive practices.

Figure 4 revealed a substantial improvement in the overall health beliefs of postmenopausal women following the use of the AI-based *Know Your Lemons* mobile application. Before the intervention, only about one-third of responses reflected positive health beliefs, indicating limited awareness, perceived susceptibility, and confidence toward early breast cancer detection. After the intervention, positive HBM responses increased markedly to more

than four-fifths of all responses, signifying a significant shift in participants' attitudes and perceptions. This remarkable improvement suggests that the mobile-based educational approach effectively enhanced women's understanding of breast cancer risk, benefits of screening, and self-efficacy in performing BSE and attending CBE. The concurrent decline in negative health beliefs—such as fear, embarrassment, and misconceptions about screening—further supports the intervention's role in reducing psychological and cultural barriers.

Table 7 demonstrated that women's knowledge levels regarding early breast cancer detection post-program were significantly associated with demographic characteristics such as age, marital status, education, residence, occupation, and monthly income. Consistent with previous studies, higher educational attainment, urban residence, and sufficient income were positively correlated with better knowledge, reflecting the critical role of socio-economic resources and literacy in enabling women to comprehend and adopt health information **(Al-Mahmoud et al., 2020; Gebremariam et al., 2019)**. Conversely, illiteracy, rural residence, and financial insufficiency were linked to poorer knowledge outcomes, supporting evidence that disadvantaged populations face barriers to accessing and benefiting from health education interventions **(Sankaranarayanan et al., 2019)**. These findings highlight that although AI-based mobile applications like *Know Your Lemons* can effectively enhance knowledge, their impact is shaped by underlying socio-demographic determinants, emphasizing the importance of tailored interventions to reach vulnerable groups and reduce health disparities.

Table 8 indicated a significant association between women's post-program practices of breast cancer early detection and their demographic characteristics, with younger, more educated, urban, and employed women, as well as those with sufficient income, demonstrating higher levels of recommended practices. These findings align with prior studies showing that socio-demographic factors such as age, education, and economic status strongly influence women's engagement in breast health practices **(Akhtari-Zavare et al., 2015; Gebremariam et al., 2019)**. Higher education and income likely enhance access to health information, confidence, and resources needed for screening, while urban residence provides greater exposure to health services and awareness campaigns **(Al-Mahmoud et al., 2020)**. Conversely, disadvantaged groups—such as women with low literacy, rural residence, or insufficient income—remain at risk of poor adherence to screening, underscoring the need for tailored interventions to address structural and social barriers for early detection.

The findings presented in Table 9 revealed a statistically significant relationship between women's total knowledge, health belief model scores, and their total practices regarding the use of the AI-based *Know Your Lemons* mobile application for early breast cancer detection. Women with higher knowledge levels demonstrated good practice scores and higher health beliefs compared to those with average or poor knowledge. This association underscores the critical role of knowledge enhancement in fostering favorable attitudes and proactive behaviors toward breast cancer screening. Moreover, the negative but significant Pearson correlation ($r = –0.488$, $p = 0.000$) implies that as women's knowledge and belief levels improve, perceived barriers and misconceptions decline, resulting in increased engagement in preventive practices. These results align with the Health Belief Model, which posits that informed individuals with greater perceived benefits and self-efficacy are more likely to adopt healthy behaviors. Hence, the AI-based application proved effective as an educational and motivational tool, contributing to the promotion of early detection behaviors among postmenopausal

women.

**Conclusion**

The findings of this study demonstrate that the AI-based *Know Your Lemons* mobile application significantly improved postmenopausal women's knowledge, practices, and health beliefs regarding early breast cancer detection. The AI-based *Know Your Lemons* mobile application enhanced usability, engagement, and confidence in adopting screening behaviors, while socio-demographic factors such as education, residence, and income influenced outcomes. These results highlight the potential of mobile health technologies as effective, accessible tools for empowering women and promoting preventive health behaviors, particularly in resource-limited settings. Integrating such applications into public health programs may contribute to earlier detection, improved survival, and reduced burden of breast cancer. The research aim and hypotheses have been achieved.

**Recommendations**

Based on the study findings, the following recommendations are proposed:

1. **Integration into Public Health Programs:** The AI-based *Know Your Lemons* mobile application should be incorporated into national breast cancer awareness and screening initiatives to enhance women's knowledge and practices, especially among postmenopausal women.
2. **Targeting Vulnerable Groups:** Special attention should be directed toward women with lower education, rural residence, and insufficient income through tailored interventions and culturally sensitive educational strategies to reduce health disparities.
3. **Continuous Engagement:** Regular updates, reminders, and interactive features should be maintained in the application to sustain motivation and long-term engagement in preventive practices.
4. **Further Research:** Longitudinal studies and randomized controlled trials are recommended to evaluate the long-term impact of AI-based mobile applications on breast cancer detection and health outcomes across diverse populations.

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