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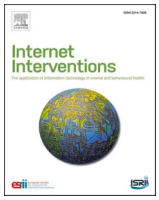

The "Breast-4Y" web app for breast cancer prevention at young age: Development, evaluation, and validation

Ruben Martin-Payo [a,b,*], Claudia Leirós-Díaz [b,c], Jo Armes [d], Mei Rosemary Fu [e], Judit Cachero-Rodríguez [a,b], María del Mar Fernandez-Alvarez [a,b]

[a] Facultad de Medicina y Ciencias de la Salud, Universidad de Oviedo, Spain
[b] PRECAM Research Group, Instituto de Investigación Sanitaria del Principado de Asturias, Spain
[c] Área Sanitaria 3, Servicio de Salud del Principado de Asturias, Spain
[d] School of Health Sciences, Faculty of Health and Medical Sciences, University of Surrey, United Kingdom
[e] The Dorothy and Dale Thompson School of Nursing, University of Missouri-Kansas, United States of America

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ABSTRACT

Background: Improving knowledge of risk factors, signs and symptoms positively influence an individual's intention to acquire healthy lifestyle behaviors to prevent breast cancer, to identify breast cancer risk early and seek health advice early. The aim of the present study was to develop and to assess the usability and quality of a web-app (Breast-4Y) designed specifically for younger women to improve their knowledge about breast cancer risk factors and symptoms as well as protective behaviors to reduce their risk.

Methods: The development of the Breast-4Y web-app, based on Health Belief Model and the Behaviour Change Wheel, comprised four steps: i) analysis of scientific literature regarding breast cancer risk factors, symptoms and preventive lifestyle behaviors; ii) design of web-app; iii) content review by experts; iv) quality and usability assessment by the end-users (n = 20). Web-app usability was evaluated using the Spanish version of the System Usability Scale for the Assessment of Electronic Tools and the quality using the Spanish version of uMARS.

Results: The contents were rated 4.25 or above, indicating high content quality. The mean usability score was 84.9 (SD 12.4), the mean rating for objective quality and subjective quality dimensions mean were 4.2 (SD 0.4) and 3.4 (0.777) respectively, indicating excellent usability and quality. Positive associations ($p < .05$) were observed between numbers of app used and attitudes to change ($r = 0.479$), and intention to change ($r = 0.539$). Strong positive associations ($p < .001$) were also observed between usability satisfaction and attitudes to change ($r = 0.584$), intention to change ($r = 0.656$), and help-seeking ($r = 0.656$).

Conclusions: This study provided evidence that Breast-4Y has adequate contents, high quality, and usability. Breast-4Y can be tested in pragmatic trials to assess their effectiveness to reduce the risk of breast cancer, raise women's awareness of breast cancer risk factors, increase women's knowledge of breast cancer symptoms, and adopt protective lifestyle behaviors.

1. Background

Breast cancer is the most common tumor diagnosed in women worldwide, with 2.3 million women diagnosed in 2020 (World Health Organization, 2021). In Spain, it is estimated that 34,750 new cases will be diagnosed in 2022 (Sociedad Española de Oncología Médica, 2022). Some risk factors for breast cancer can be modified by women to reduce the risk of developing breast cancer (Poorolajal et al., 2021). Improving knowledge about these risk factors is vital in preventing breast cancer (European Commission, 2022). Research demonstrated that improving knowledge about a health problem positively influence an individual's intention to acquire healthy lifestyle behaviors (Michie et al., 2011) and women's awareness of breast cancer signs and symptoms can help women to achieve early identification of breast cancer risk (Ginsburg et al., 2020; World Health Organization, 2021) and to improve the uptake of healthy behaviors.

There are several methods described in the literature to improve the adoption of healthy lifestyle and awareness and recognition of breast

* Corresponding author at: Facultad de Medicina y Ciencias de la Salud, Universidad de Oviedo, Campus del Cristo s/n., 33006 Oviedo, Asturias, Spain.
E-mail address: martinruben@uniovi.es (R. Martin-Payo).
https://twitter.com/@rubenmrtnpy (R. Martin-Payo)

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cancer symptoms (Han et al., 2018; Houghton et al., 2019; Mühlberger et al., 2021; O'Mahony et al., 2017; Thomas et al., 2022; Usher-Smith et al., 2018). During the past decade, digital health has consistently been shown to be useful to breast cancer prevention, management and care (Houghton et al., 2019; Jongerius et al., 2019). Evidence suggest that web-based cancer survivorship interventions are feasible and acceptable to breast cancer survivors (Post and Flanagan, 2016; Rees-Punia et al., 2022) and effective to improve lifestyle behaviors (e.g., physical activity, weight loss) (Yun et al., 2020). Yet, very limited digital health systems focus on primary prevention of breast cancer. Nonetheless, some effective interventions for young women without breast cancer diagnosis, delivered using a web-app, were found in the literature with the aim to improve the knowledge related with the tumor and to develop healthy behaviors (Gajda et al., 2018; Martín-Payo et al., 2023).

Using web-app on interventions for primary breast cancer prevention has some benefits, for example, enable users to access information at anytime and anywhere for different purposes and topics with low-cost (Rogers et al., 2017) and reduces inequalities (Murray, 2012).

In Spain, the breast cancer screening program is target at women ≥50 years (Ministerio de Sanidad, 2022). To our knowledge there are no preventive public health programs in Spain that informs and reduces the risk of developing breast cancer, focusing on modification of the risk factors, for young women (<50 years). However, many women younger than 50 years old are diagnosed with breast cancer each year in Spain (Sociedad Española de Oncología Médica, 2022). This lack of preventive programs deprives young women of the advantage of being able to access information, which highlights its priority to allow breast cancer early prevention in this population (Del Carmen et al., 2021). Thus, the aim of the present study was to develop and to assess the usability and quality of a web-app (Breast-4Y) designed specifically for younger women to improve their knowledge about breast cancer risk factors and symptoms as well as protective behaviors to reduce their risk.

2. Methods

2.1. Phase 1: development of the Breast-4Y web-app

The development of the Breast-4Y web-app, based on Health Belief Model (Ghaffari et al., 2019; Rosenstock, 1974; Shubayr et al., 2022; Ştefănuţ and Vintilă, 2022) and the Behaviour Change Wheel (Anderson et al., 2020; Michie et al., 2011), comprised four steps: i) systematic analysis of scientific literature regarding breast cancer modifiable risk factors, symptoms and preventive lifestyle behaviors; ii) design a Breast-4Y web-app; iii) Breast-4Y web-app content review by experts; iv) quality and usability assessment by a sample of women.

2.1.1. Development step 1: analysis of the scientific literature

The determination of the content to be included in the Breast-4Y web app was based on literature review and expertise recommendations. The contents included: i) information regarding modifiable breast cancer risk factors that can help women to evaluate their susceptibility to developing the breast cancer; ii) information to increase the women's perceived competence and autonomy to carry out preventive strategies (Poorolajal et al., 2021; Rainey et al., 2018); (iii) breast cancer signs and symptoms to enable early identification to promote timely health care upon the onset of the first symptoms and; iv) healthy lifestyle behaviors that can be modified by the women to reduce breast cancer risk, including healthy diet and being physically active (Centers for Disease Control and Prevention, 2022a; Poorolajal et al., 2021; Schüz et al., 2019).

2.1.2. Development step 2: design of Breast-4Y web-app

Breast-4Y was developed in collaboration with professional software developers. The web-app was designed with intention to improve the physical and psychological capability (Michie et al., 2011), the susceptibility of developing breast cancer and the benefits of developing healthy behaviors to prevent breasts cancer (Rosenstock, 1974). The web-app comprises five sections: breast cancer risk and protective factors, self-examination, nutrition, physical activities, and news (Fig. 1). The contents of the first two sections did not need to be modified throughout the usability and feasibility testing. Breast cancer risk factors and protective factors section includes information about both non-modifiable and modifiable breast cancer risk factors (Centers for Disease Control and Prevention, 2022a) and those that reduce breast risk (Centers for Disease Control and Prevention, 2022b). The information was presented as short messages describing positive or negative associations of healthy behaviors and risk factors and with breast cancer development. The behavior change techniques were delivered through the detailed "instruction on how to perform a behavior", "information about health consequences" and "credible source" for each behavior (Michie et al., 2013).

The self-examination section was designed to help women to recognize symptoms related to breast cancer with disclamation that it cannot be used as diagnostic technique. Although self-breast exam is controversial, no other forms of screening are usually offered for young women (Karimian et al., 2022; Ştefănuţ and Vintilă, 2022), and some researchers suggest this method as adequate for young women when other screen methods are not available (Karimian et al., 2022; Ştefănuţ and Vintilă, 2022). The American Society of Clinical Oncology highlights the importance that women know their breasts well in order to be able to recognize any changes and report the changes to the clinicians (American Society of Clinical Oncology, 2020). To help women to know their body and to detect changes or anomalies that may occur early, the section includes a video in which a model shows women how to do self-examination and an image of the signs that should be known by women (Breast Cancer.Org, 2022; Karimian et al., 2022).

The nutrition section has 2 subsections: 1) "your nutritionist" and 2) recipes. The 'Your nutritionist' subsection includes videos a nutritionist making dietary recommendations. The second subsection includes healthy recipes made by chefs, including the ingredients and the cooking techniques and procedures. A new video and new recipe were added each week into the web-app.

The physical activity section consists of three subsections: 1) 30 min a day; 2) nature walks; and 3) options in your area of residence. The first subsection recommends women do 30 min of exercise a day, i.e., light walking. It also includes videos, developed by personal trainers, to guide women to do exercise in their own homes. The second and third subsections include links to resources, green areas around their cities and options for doing exercise in cities respectively (Fig. 2). Thirty minutes and options in your area of residence content remained the same during the study but new walks were added to the web app on a bi-weekly basis.

The last section, news, included press or social media news about breast cancer. Before being uploaded to the web app the information was verified by the research team. Fig. 3 includes an overview of the web-app.

2.1.3. Development step 3: Breast-4Y web-app content review by experts

The content of Breast-4Y web app was reviewed by four clinicians who work in breast clinical areas (2 nurses, 1 oncology doctor and 1 surgeon). They were invited to review the content and assess it is appropriateness. The experts were asked to provide their evaluation via a digital questionnaire. It included an item for each section and each item was formulated as statements with the structure "Please, indicate if this content is pertinent and appropriate to be included in the Breast-4Y web app". In addition, items were rated on a 5-point Likert scale, responses ranged from 1 (totally inadequate) to 5 (totally adequate) and a free text box for each item allowed experts to add comments and/or suggestions. Consensus was achieved among the research team members that any content that were ranked 2 or lower by the experts without providing suggestions to modify or improve were deleted.

Fig. 1. Breast-4Y web-app sections.

Fig. 2. Example of a route around a city. It includes a short explanation of the basic characteristics and the link to full information.

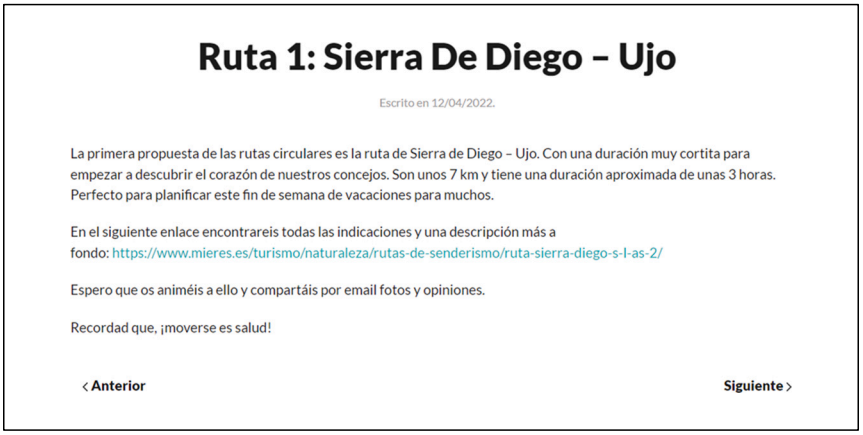

Fig. 3. Overview of the web-app.

2.2. Phase2: Breast-4Y web-app usability and quality assessment

The Breast-4Y web app was created to be used in a pragmatic randomized controlled trial (Breast-4Y Project), for women living in the province of Asturias (Spain) aged 25 to 40, to investigate the effects of online information and lifestyle intervention on improved knowledge about the risk factors and symptoms of breast cancer, the adoption of preventive lifestyle behaviors, and increased awareness of one's own risk of developing breast cancer.

2.2.1. Study design

A cross sectional design was used to assess the web-app usability and quality.

2.2.2. Sampling and recruitment

For the web-app usability and quality evaluation, a minimum of 16 end-users, was considered an appropriate sample size (Mandracchia et al., 2022). For this porpoise, women were recruited by convenience. Inclusion criteria were: i) women of younger than 50 years old; and ii) being willing to sign the informed consent to participate. Exclusion criteria were: i) previous diagnosis of breast cancer; and ii) professional

software developers or similar professional expertise.

2.2.3. Measures

Demographic information was collected to include age, educational level, and previous experience of using apps.

Web-app usability was evaluated using the Spanish version of the System Usability Scale for the Assessment of Electronic Tools (SUS) (Cronbach α = 0.812) (Sevilla-Gonzalez et al., 2020). The questionnaire consists of 10 items, rated on a 5-point Likert scale ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). The questionnaire alternates positive and negative statements. The score of the odd items resulting to subtract 1 from the item-score given by the user and the score of the even elements results in subtracting the score-item given by the user from 5. The overall score is calculated from the sum of the odd and even scores multiplied by 2.5. The final score ranges from 0 (worst usability) to 100 (best usability), with excellent usability comprising a score > 85 and good usability a score of 68–84 (Sevilla-Gonzalez et al., 2020).

Web app quality was evaluated using the Spanish version of the User Version of the Mobile Application Rating Scale (uMARS) (Cronbach α = 0.90) (Martin-Payo et al., 2021). uMARS consists of 20 items assessing objective and subjective quality, rated on a 5-point Likert scale ranging from 1 ("poor") to 5 ("excellent") and items 13–16 include an additional option "not applicable" (no score). The objective quality score is calculated as the mean of the scores of 4 dimensions: engagement (items 1–5), functionality (items 6–9), aesthetics (items 10–12), and information (items 13–16). The subjective quality score is obtained as the mean of 4 subjective items (17–20). The final score, for both objective and subjective quality, ranges from 1 (worst quality) to 5 (best quality). uMARS includes another 6 items, designed to assess the perceived impact of the app on the user's awareness, knowledge, attitudes, intention to change, help seeking, and the probability of changing the target health behavior, also rated on a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

2.2.4. Data analysis

We summarized categorical variables as percentages (range) and continuous variables as means and standard deviations (SD). We assessed the normality of the distribution of continuous data with the Kolmogorov-Smirnov test and, since the assumption of normality was met, we used pertinent parametric tests for the different analyses.

Student's *t*-test for independent samples was used to compare usability and uMARS scores between level of studies. The correlation between usability, age and previous app usage experience was calculated using Pearson's correlation coefficient. Statistical analysis was performed using IBM SPSS software v.27, and the significance level was at $p \leq .05$.

3. Results

3.1. Breast-4Y web-app content review by experts

All sections were rated 4.25 or above. All experts gave the highest rating to the sections "options in your city" and "self-exploration" (Table 1). Experts made one suggestion using the free text boxes regarding the section of risk and protective factors which was modified to differentiate between risk factors and protective factors.

Table 1
Appropriateness content: mean (SD) punctuation of each section (n = 4).

Section	Mean (SD)
Breast cancer risk factor and protective factors	4.3 (1.0)
Self-exploration	5.0 (–)
Your nutritionist	4.5 (0.6)
Recipes	4.8 (0.5)
30 min a day	4.3 (1.0)
Routes in nature	4.8 (0.5)
Options in your city	5.0 (–)

3.2. Breast-4Y web-app usability and quality assessment

Twenty women were recruited to assess the usability and quality of Breast-4Y web-app. Their mean age was 37.5 (SD = 6.2), 60 % had completed university education and the mean number of apps they were 9.4 (SD = 6.2).

The mean usability score was 84.9 (SD = 12.4), indicating excellent usability. The mean objective quality dimensions rating was 4.2 (SD = 0.4) and the subjective quality mean was 3.4 (SD = 0.8) (Table 2). The lowest rating was for the subjective quality item assessing whether women would pay to use the app (mean = 2.2; SD = 1.4). The last six items scored over 4.0 (Table 2).

There were no significant differences in usability between women had completed education at university and women who only had primary and secondary education (Table 3).

Medium (from 0.3 to 0.5) and strong (≥0.5) associations were observed between number of apps used. Positive associations ($p < .05$) were observed between numbers of app used and attitudes to change (r = 0.479), and intention to change (r = 0.539). Strong positive associations ($p < .001$) were also observed between usability satisfaction and attitudes to change (r = 0.584), intention to change (r = 0.656), and help-seeking (r = 0.656) (Table 4).

4. Discussion

The development of Breast-4Y follows rigorous process of developing the web-app based on best-practice methodology employed by other researchers (Guilabert et al., 2022; Mandracchia et al., 2022). Content of an app is the most important key criterion that must be considered when developing health-related apps (Llorens-Vernet and Miró, 2020). The content topics of Breast-4Y were developed according to the highest standard, that is, the content topics were evidence-based information based on systematic analysis of literature and experts' judgement that the content topics were deemed to appropriate.

There is a growing trend in the design of digital health systems that are aimed to promote physical fitness for individuals with chronic conditions. However, the use of digital health, such as our Breast-4Y is limited to help women reduce the risk of breast cancer, especially women under age 50. The efficacy of digital health interventions can be considerably enhanced through a more systematic approach to designing, developing, and reporting of the interventions (Domin et al.,

Table 2
SUS (usability) and uMARS (quality) mean punctuation (SD) (n = 20).

Factor	Mean (SD)
Usability	84.9 (12.4)
Objective quality	4.2 (0.4)
Section A (engagement)	3.6 (0.7)
Section B (functionality)	4.6 (0.4)
Section C (aesthetics)	4.4 (0.5)
Section D (information)	4.5 (0.5)
Subjective quality	3.4 (0.8)
Would you recommend this app to people who might benefit from it?	4.3 (1.0)
How many times do you think you would use this app in the next 12 months if it was relevant to you?	3.6 (0.7)
Would you pay for this app?	2.2 (1.4)
What is your overall (star) rating of the app?	3.8 (0.7)
Awareness	4.6 (0.6)
Knowledge	4.6 (0.6)
Attitudes	4.2 (0.8)
Intention to change	4.1 (0.8)
Help-seeking	4.3 (0.7)
Behavior change	4.0 (0.8)

Table 3
SUS (usability) and uMARS (quality) mean punctuation (SD) according to level of studies (n = 20).

Factor	Mean (SD)		p
	Primary or secondary	University	
Usability	82.2 (15.5)	86.7 (10.2)	.43
Objective quality	4.3 (0.3)	4.2 (0.4)	.42
Section A (Engagement)	3.7 (0.5)	3.5 (0.7)	.62
Section B (Functionality)	4.6 (0.3)	4.7 (0.4)	.56
Section C (Aesthetics)	4.6 (0.4)	4.3 (0.4)	.12
Section D (Information)	4.7 (0.4)	4.4 (0.6)	.33
Subjective quality	3.8 (0.6)	3.2 (0.8)	.06
Would you recommend…	4.8 (0.5)	4.0 (1.1)	.09
How many times…	3.8 (0.5)	3.4 (0.8)	.30
Would you pay…	2.9 (1.5)	1.7 (1.2)	.06
Overall (star) rating…	4.0 (0.8)	3.6 (0.7)	.21
Awareness	4.9 (0.4)	4.4 (0.7)	.06
Knowledge	4.8 (0.5)	4.4 (0.7)	.24
Attitudes	4.3 (0.9)	4.2 (0.7)	.82
Intention to change	4.1 (0.8)	4.1 (0.8)	.91
Help-seeking	4.3 (0.7)	4.3 (0.8)	1.00
Behavior change	4.0 (0.9)	3.9 (0.8)	.83

Student's *t*-test.

2021; Fu et al., 2016).

The content was judged by experts as highly appropriate and based on systematic analysis of existing scientific literature (Campos et al., 2022; Shin et al., 2023). This approach was supported by similar research that delivered interventions using digital media (Anthis and Kavanaugh-Lynch, 2020; Masso-Calderón et al., 2018) and research that used theoretical models commonly used on preventive interventions specifically designed to prevent breast cancer (Michie et al., 2011; Rosenstock, 1974).

Usability refers to "*the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use* (International Organization for Standardization, 2018)." Assessing usability of digital resources is essential because of the relationship between high usability and easier tool usage (Maramba et al., 2019; Sinabell and Ammenwerth, 2022), adherence to web-app based interventions (Jakob et al., 2022), effectiveness and efficiency to achieve the expected goals (Klaassen et al., 2016) and increase patient safety (Kushniruk and Borycki, 2015; Kushniruk and Borycki, 2017; Marcilly et al., 2019). Results of our study showed that no differences were observed in the quality and usability scores due to educational level nor age. It implies that the Breast-4Y web-app could be used by a high percentage of women independently of their level of education and age, thus demonstrating adequate usability for the targeted population.

The objective and subjective quality of Breast-4Y scored highly. A slightly lower score was observed in the subjective quality, due to the low score observed in the item "Would you pay for this app?". A potential explanation for this score is that the Spanish health system is public, universal, and financed through taxation. It may create the feeling that health care should be free and, therefore, most would not pay to access to health resources. However, since uMARS – Spanish version is a relatively new tool there is no other research from Spain to compare our results with (Martin-Payo et al., 2021). However similar results have been reported in research conducted in countries with similar health systems (Agher et al., 2022; Deady et al., 2020; Wan et al., 2021).

The high scores of usability and quality of Breast-4Y web-app indicate the web-app can be classified as excellent which may lead to positive effects for the targeted population. However, cautions should be exercised. For example, the results of the study developed by Eden et al. (2020) shows that younger women take less time to complete tasks included in the web-app MammoScreen designed to assess breast cancer personal risk. In contrast, other authors suggest that both variables could have a negative effect, depending on the health condition targeted in the tool (Jakob et al., 2022). These discrepancies suggest that it is important to assess the usability stratified according both variables. It seems reasonable that if the web-app does not fit the users' characteristics or if they feel unable/unwilling to perform the web-app tasks, they could unsubscribe from using the web-app.

It is also important to highlight the medium to strong associations observed between usability and uMARS dimensions. First, this demonstrates that it is a well-designed tool in terms user-rated usability and has the potential to improve attitudes and to promote the adoption of healthy behaviors. Secondly, Breast-4Y web-app is a usable tool to be used in a pragmatic trial to improve the knowledge about the risk factors and symptoms of breast cancer, develop preventive behaviors, and increase awareness of one's own risk of breast cancer development. These results are consistent with the literature where a relationship between the perception of breast cancer risk and health protection behaviors is described and the importance of developing strategies to improve women's knowledge of their risk and what behaviors they can change to protect their health (O'Mahony et al., 2017; Paalosalo-Harris and Skirton, 2017).

Finally, the results show that previous experience in the use of apps correlated with usability. It is consistent with the results of previous research (Jakob et al., 2022), and, to a certain extent, it is logical that experience acquired using other tools contributes to the perception that it is easier to use new similar tools. This issue is important since, if the women who are going to use the app in the intervention report limited prior experience in using apps, the usability of the tool could be affected.

4.1. Strengths and limitations

As strengths of the present study, our results highlight the potential of Breast-4Y web-app to be used in a pragmatic trial, designed for young women, to contribute to raise awareness of risk factors associated with developing breast cancer and promote early detection of symptoms.

Although results of our study demonstrated proper acceptance and usability of Breast-4Y web-app, future research still needs to assess the web-app quality and usability in pragmatic trials what includes more women and in real contexts. Also, nutrition and physical activity sections probably would be to be adapted in future intervention to the cultural components and geographical possibilities respectively.

5. Conclusion

This study provided evidence that Breast-4Y has adequate contents, high quality, and usability. Breast-4Y can be tested in pragmatic trials to

Table 4
Correlations between age and number of apps used previously, SUS (usability) and uMARS (quality) punctuation.

	US	Objective quality	Subjective quality	Awareness	Knowledge	Attitudes	Intention to change	Help-seeking	Behavior change
Age	0.023	0.157	0.219	0.119	0.237	0.112	0.108	0.357	0.436
Number of apps used previously	0.525**	0.279	0.257	0.209	0.267	0.479*	0.539*	0.286	0.280
Usability (US)	–	0.196	0.440	0.170	0.291	0.584**	0.513*	0.656**	0.359

Pearson's correlation coefficient; *p < .05; **p < .001.

assess their effectiveness to reduce the risk of breast cancer, raise women's awareness of breast cancer risk factors, increase women's knowledge of breast cancer symptoms, and adopt protective lifestyle behaviors.

CRediT authorship contribution statement

R. Martin-Payo: Conceptualization, methodology, web-app design, development and evaluation, data analysis & writing – original draft; **MdM. Fernandez-Alvarez**: conceptualization, methodology, web-app design, development, and evaluation & writing – original draft; **M. R. Fu & J. Armes**: conceptualization, methodology, writing – review & editing; **C. Leiros-Diaz**: data acquisition, web-app design, development, Writing – review & editing; **J. Cachero-Rodriguez**: web-app design, development, Writing – review & editing.

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Ethical approval

The study was approved by the Principality of Asturias Research Ethics Committee, Spain (ref. 2022.201).

Declaration of competing interest

The Authors declares that there is no conflict of interest.

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