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Development and assessment of an mHealth tool for healthcare professionals on breast cancer prevention

Desenvolvimento e avaliação de mHealth para profissionais de saúde sobre prevenção do câncer de mama

Desarrollo y evaluación de soluciones de mHealth para profesionales sanitarios en la prevención del cáncer de mama

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ABSTRACT

Objective: to develop and assess a mobile application on breast cancer prevention for Primary Health Care professionals. **Methods:** a technological development study grounded in User-Centered Design, conducted between 2019 and 2021. The content was based on scientific evidence and previous studies. The prototype was developed using the Scrum method and initially assessed with the target audience through the Wizard of Oz technique. Content and appearance validity involved 25 specialists, and interface assessment involved six information technology specialists. **Results:** MAMAprev was developed with 7,500 lines of code and 34 images, obtaining high agreement in the validity process (Content Validity Index = 0.95) and few interface-related problems. **Conclusions:** MAMAprev presented initial evidence of validity, indicating preliminary adequacy and potential applicability in Primary Health Care for breast cancer prevention and early detection actions.
Descriptors: Breast Neoplasms; Disease Prevention; Mobile Applications; Educational Technology; Primary Health Care.

RESUMO

Objetivo: desenvolver e avaliar um aplicativo móvel sobre prevenção do câncer de mama para profissionais da Atenção Primária à Saúde. **Métodos:** estudo de desenvolvimento tecnológico fundamentado no *User-Centered Design*, realizado entre 2019 e 2021. O conteúdo foi baseado em evidências científicas e estudos prévios. O protótipo foi desenvolvido através do método *Scrum* e avaliado inicialmente com o público-alvo utilizando a técnica Mágico de Oz. A validação de conteúdo e aparência envolveu 25 especialistas, e a avaliação de interface envolveu seis especialistas em informática. **Resultados:** desenvolveu-se o MAMAprev, com 7.500 linhas de código e 34 imagens, que obteve alta concordância na validação (Índice de Validade de Conteúdo = 0,95) e poucos problemas de interface. **Conclusões:** o MAMAprev apresentou evidências iniciais de validade, indicando a adequação preliminar e o potencial de aplicação na Atenção Primária à Saúde para ações de prevenção e detecção precoce do câncer de mama.
Descritores: Neoplasias da Mama; Prevenção de Doenças; Aplicativos Móveis; Tecnologia Educacional; Atenção Primária à Saúde.

RESUMEN

Objetivo: desarrollar y evaluar una aplicación móvil sobre prevención del cáncer de mama para profesionales de Atención Primaria. **Métodos:** Estudio de desarrollo tecnológico basado en el User-Centered Design, realizado entre 2019 y 2021. El contenido se fundamentó en evidencia científica y estudios previos. El prototipo se desarrolló utilizando la metodología Scrum y se evaluó inicialmente con el público objetivo mediante la técnica del Mago de Oz. La validación del contenido y la apariencia contó con la participación de 25 expertos, y la evaluación de la interfaz con la de seis expertos en informática. **Resultados:** se desarrolló MAMAprev, con 7.500 líneas de código y 34 imágenes, logrando una alta concordancia en la validación (Índice de Validez de Contenido = 0,95) y pocos problemas de interfaz. **Conclusiones:** MAMAprev presentó evidencia inicial de validez, lo que indica una idoneidad preliminar y una posible aplicación en la Atención Primaria de Salud para la prevención y detección temprana del cáncer de mama.
Descriptores: Neoplasias de la Mama; Prevención de Enfermedades; Aplicativos Móviles; Tecnología Educacional; Atención Primaria de Salud.

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INTRODUCTION

Digital information and communication technologies aimed at healthcare professionals offer a wide range of functionalities, improving the ability to collect, transmit, and share information[1]. As a result, these technologies significantly contribute to the safety and quality of care, ensuring that professionals have access to reliable and accurate data during clinical practice[2]. These tools can support and strengthen efforts to promote evidence-based information and, consequently, help professionals provide integrated healthcare services. In addition, they may address several health-related topics, such as disease prevention and health promotion[3].

Among these technologies, mHealth tools stand out, involving the use of mobile devices and applications (apps) to promote health and improve healthcare delivery. They provide evidence-based knowledge in a simple, rapid, and secure manner, supporting healthcare professionals' practice through accessible tools available for several hours a day[4].

In this context, the growing complexity of healthcare requires professionals to be prepared to work in a multidisciplinary manner. In addition to their specific roles, they must integrate their knowledge with other fields through interdisciplinary approaches, favoring more comprehensive healthcare delivery[5,6].

Although physicians and nurses commonly play a more active role in disease prevention, it is noteworthy that, within the Brazilian Unified Health System (SUS – *Sistema Único de Saúde*), nurses are the professionals responsible for most prevention actions, especially in Primary Health Care (PHC), due to their direct involvement in educational actions, patient follow-up, and timely referrals. Nevertheless, with the inclusion of multiprofessional teams in PHC, it is essential that all healthcare professionals — and not only nurses and physicians — possess knowledge regarding different diseases and their related aspects so that comprehensive and high-quality care can be provided and prevention actions can be effectively strengthened[5-7].

In the context of breast cancer (BC), there has been growth in the development of mHealth tools ranging from educational resources and self-assessment instruments to the use of social networks for sharing experiences related to breast disorders. However, developing these technological tools in healthcare requires the use of systematized methods to ensure effectiveness and efficiency, both in the creation process and in usability so that the product's proposed objectives can be achieved with quality.

Despite the growth of BC-related mHealth tools, there are still gaps in the development of specific resources aimed at training healthcare professionals in BC prevention, especially in PHC, where the demand for preventive actions and health education is greater. Therefore, developing and assessing an app on BC prevention targeted at PHC healthcare professionals may constitute a relevant strategy to qualify preventive actions at this level of care by providing a mobile technology based on scientific evidence, capable of supporting professional practice, strengthening early detection, and contributing to improved care delivery within the SUS[7,8].

OBJECTIVE

To develop and assess an app on BC prevention targeted at PHC healthcare professionals.

METHODS

Ethical aspects

The study complied with ethical principles for research involving human beings. Initially, the research project was submitted to Platform Brazil and subsequently reviewed and approved by the Research Ethics Committee involving Human Beings of *Universidade Federal do Maranhão*, under Opinion 4,424,050, with funding provided by *Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão* (FAPEMA). All study participants signed an Informed Consent Form (ICF).

Study design, period, and setting

This is a technological development study of the prototyping type[9], based on the development and assessment of the content, appearance, and interface of an app on BC prevention for multiprofessional use. This manuscript presents the app development and validity phases, corresponding to the prototyping and assessment stages of the User-Centered Design (UCD) methodological model[10-12]. The study was conducted in the city of Imperatriz, Maranhão, Brazil, with healthcare professionals working in PHC, between August 2019 and September 2021.

Study protocol

The app content was structured based on updated scientific evidence and information on BC prevention grounded in the Guidelines for Early Detection of Breast Cancer in Brazil, the Brazilian Society of Mastology Consensus, the American College of Radiology[5,8,13,14], and previous studies[12,15] conducted with PHC professionals. These studies made it possible to identify training needs, knowledge gaps, and interest in mobile technology for BC prevention.

After defining the content, the prototype development process began by adapting the software development method known as Scrum, which enables greater flexibility, shorter development time, small work teams, frequent progress reviews, and mutual collaboration through the definition of small goals that, as they are completed, are discussed among the team to provide feedback and possible suggestions for changes, culminating in the final software development[16]. In this study, the Scrum team consisted of five members, including two programmers and one designer. The programmers had degrees in Computer Engineering, while the designer was an undergraduate student in Computer Science and Design. In addition, the development team included two researchers from the health field: one with a background in nursing and the other in physical education (product owner and scrum master)[16].

The app creation phase took place through the analysis of requirements related to prior knowledge regarding what the app should perform. In this regard, the prototyping technique was adopted for requirement collection[9,17]. In this technique, disposable prototypes are developed together with the clients requesting the system. The researchers created an interface prototype on the Figma platform to improve understanding of the app's functioning and navigation.

The app prototype was assessed using the "Wizard of Oz" prototyping technique, which consists of simulating the functionalities of the final system, allowing the initial proposal to be tested and validated with the target audience at low cost[17]. Six PHC healthcare professionals who provided care to women participated in this stage and were selected by convenience sampling.

After accepting the invitation sent by email, participants accessed an electronic form containing the ICF, professional characterization questions, a link to the prototype on the Figma platform, and an instrument for recording suggestions and comments. This instrument included open-ended questions regarding the app's visual identity and name, the organization and functionality of the professional area screen, design aspects (colors, typography, images, screen layout, and navigation), as well as the assessment of the content available in each tab. Suggestions for general improvement of the app's design and content were also requested. Participants navigated through the prototype to verify whether the created proposal was clear and whether anything should be added.

Based on the adjustments made after prototype assessment, the prototype was updated, and image examples were sent to the designer so that they could be illustrated. After the creation of the images and logo, the definition of fonts and colors, the organization of the required information, and the definition of the layouts, the app construction process began in a specific graphical interface environment called "Expo". This is a tool in which developers can create native apps using JavaScript and React Native.

The content and appearance stages were assessed by specialists in gynecology, mastology, oncology, BC prevention, professional training, and educational technologies. These specialists were selected through searches on the Brazilian National Council for Scientific and Technological Development portal Lattes Platform and through the snowball technique[18], in which eligible specialists could recommend others who met the selection criteria, thus ensuring broader coverage. Judges were selected based on eligibility criteria totaling 13 points, with a minimum score of seven points required for participation. Criteria included academic degree (master's degree: one point; doctoral degree: two points), education or scientific production in the field (thesis, dissertation, or specialization: two points; participation in research groups or projects: one point), professional practice in PHC (two points), published studies in the field (one point), technical experience with validity (two points), and development of educational technology (two points). Twenty-five participants responded to the assessment questionnaires as content and appearance specialists.

For content and appearance assessment, an adapted questionnaire containing a suggestion option was applied, including items related to content, language, illustrations, motivation, and relevance[19,20], which were assessed using a Likert-type scale[21].

For interface assessment, six programmers and web designers participated. Specialists were selected through the Lattes Platform and the snowball technique, considering Brazilian researchers with experience in the field. Participation required a minimum score of five points out of a total of eight according to the following eligibility criteria: academic degree (master's degree: one point; doctoral degree: two points); published studies in the field of health-related software (one point); technical experience with validity (two points); and development of educational technology (two points). Nielsen's heuristics, which propose ten principles of user interface design, were used during and after software design to support the identification of existing problems in the developed product[22].

Data analysis and statistics

The collected data were stored in a specific database created using Microsoft Office Excel®, version 2016. After checking for errors and inconsistencies, descriptive statistical analysis was performed for the profile variables of the content, appearance, and interface specialists.

Instrument validity was performed by specialists using a seven-point Likert-type scale defined by the following descriptors: 1. Strongly disagree; 2. Disagree; 3. Partially disagree; 4. Neutral; 5. Partially agree; 6. Agree; and 7. Strongly agree.

For the operationalization of the Content Validity Index (CVI), responses were dichotomized. Responses scoring 5 (partially agree), 6 (agree), or 7 (strongly agree) were considered valid agreement responses. The remaining responses were categorized as disagreement.

Based on these binary data, the CVI was calculated both by item and globally, considering items with agreement among specialists equal to or greater than 0.78 as validated, as recommended by researchers[23]. Analyses were performed using IBM Statistical Package for the Social Sciences[24].

RESULTS

Previous studies conducted with the target audience revealed gaps in healthcare professionals' knowledge regarding BC and disease screening, as well as inconsistencies in adherence to recommendations from official agencies[12,15]. These findings, corroborated by the literature, supported the definition of the MAMAprev content and functionalities, guiding the organization of clear, updated information aligned with national guidelines and scientific consensuses on BC prevention and early detection[5,8,13,14]. Thus, the app construction was guided by the educational needs identified in PHC practice, seeking to support decision-making and improve prevention actions.

The development of the MAMAprev prototype in Figma made it possible to integrate users through the assessment stage for prototype development. One nurse, one physical education professional, one physician, one social worker, one physical therapist, and one psychologist participated in this stage. Among these professionals, four were female and two were male. Four worked in the Family Health Support Center, and two worked in Basic Health Units. They were between 22 and 42 years old, with time working at their institution ranging from eight months to 14 years (Figure 1).

Thus, the first version of the app was created, and the scrolling mechanism was adopted to reduce the number of screens, taking advantage of the current habit of scrolling through social media timelines. In addition, the name "MAMAprev" was chosen because it combines the word "*mama*" ("breast"), referring to BC, with the abbreviation "prev", referring to prevention. The logo proposal included the app name together with a stethoscope, representing healthcare professionals and forming a pink awareness ribbon, the symbol of the BC prevention campaign.

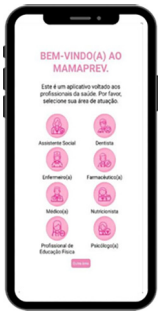
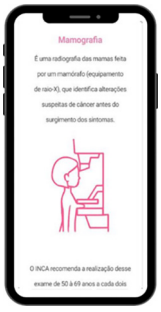
Prototype	Suggestions and/orcomments	Conducts	First version
	Application logo and name "The name is very interesting, however the logo needs to be more illustrative (vibrant colors)"	The color tones were modified to be stronger and more vibrant	
	Professional field of activity screen "The order of the professionals on the screen could follow alphabetical order, according to the names of the professions so that those using the tool realize that there is no distinction between the professions"	The professions were organized in alphabetical order	
	Application design "The colors just need to be more vibrant (stronger shades)"	The color tones were modified to be stronger and more vibrant	

Figure 1 - Recommendations and/or suggestions from healthcare professionals regarding the mobile application prototype, including guidelines and screens after modifications to the first version. Imperatriz, Maranhão, Brazil, 2021

Regarding the main menu of MAMAprev, three access buttons were included: assessment tools, containing the BC risk assessment instrument and the mammography adherence scale revised for Brazil (added after the Figma stage); information access, containing content on the disease, risk factors, prevention, and the Breast Imaging-Reporting and Data System (BI-RADS®); and about the app, presenting the app and information about the research.

The "*Doença*" (Disease) screen addressed what BC is, how it manifests, and the most common types, using representative texts and images. In "*Fatores de risco*" (Risk factors), environmental and behavioral factors, reproductive and hormonal history factors, genetic and hereditary factors, as well as protective factors, were listed. In the "BI-RADS®" tab, the concept of this term was included, and the categories (0 to 6), recommended management, and probability of cancer were presented.

The "*Prevenção*" (Prevention) screen opens another menu in which the buttons "primary" and "secondary" are presented. Under "*Prevenção primária*" (Primary prevention), concepts, modifiable risk factors, protective behaviors, prophylactic mastectomy, and the use of chemopreventive agents are addressed. Under "*Prevenção secundária*" (Secondary prevention), its definition and three buttons composing this level of prevention are presented, namely screening for the general population, screening for the high-risk population, and early diagnosis.

The specialists participating in the content and appearance assessment had a mean age of 42.16 (±10.78) years; 84% were female, 80% had degrees in nursing, and 72% held doctoral degrees. The remaining 20% were trained in pharmacy, medicine, physical education, nutrition, and physical therapy, with one specialist representing each field.

In this assessment, MAMAprev achieved an overall CVI of 0.95, demonstrating high agreement among specialists. In the individual analysis, all 17 items reached indices above the minimum reference value (0.78), ranging from 0.88 to 1.00 (Table 1), confirming the content validity of the material.

In the overall assessment of the app's content and appearance, the highest concentration of specialists' responses was in the categories "agree" (39.8%), "strongly agree" (35.5%), and "partially agree" (19.5%). Regarding the sections "content", "language", "illustrations",

"motivation", and "relevance", most specialists' responses were concentrated in agreement categories, which justifies the high CVI both by item and overall.

For the interface analysis, six information technology specialists participated, with a mean age of 40.17 (±6.22) years. Among them, five were men. Regarding academic background, five held doctoral degrees and one was a specialist. In terms of undergraduate training, three had degrees in computer science, one in electrical engineering, one in systems analysis, and one in nursing (with technical training in information technology).

After analysis by the researchers, it was decided to immediately accept important suggestions for improving the app's design and interface problems, as described in Figure 2 and Chart 1.

The suggestions that were not accepted included: in the "Error prevention" screen, the inclusion of a tab to report app errors; in the "Recognition rather than recall" screen, the inclusion of a help button for users, since the app does not provide online support or frequently asked questions forums. Regarding the possibility of increasing font size in "Flexibility and efficiency of use", this was not possible due to screen layout adjustments that would be compromised, potentially causing overlapping elements and impairing navigation. In "Help users recognize, diagnose, and recover from errors", the suggestion to indicate the user's professional category was not accepted because the app provides the same content regardless of the professional background selected at the beginning.

Table 1 – Content Validity Index of the items assessed by specialists regarding the content and appearance of the MAMAprev app (n=25). Imperatriz, Maranhão, Brazil, 2021

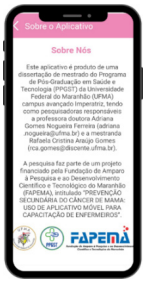
Item	IVC
1. Is the content appropriate for healthcare professionals?	1.00
2. Is the division of titles and subtitles in the material relevant?	0.96
3. Is the content sufficient to meet the needs of healthcare professionals?	0.88
4. Is the text sequence logical?	1.00
5. Is the writing style compatible with healthcare professionals?	0.96
6. Is the writing style engaging?	0.88
7. Is the language clear and objective?	0.92
8. Are the illustrations relevant to the application's content and do they elucidate the content?	1.00
9. Are the illustrations clear and easy to understand?	0.92
10. Is the number of illustrations adequate for the application's content?	0.92
11. Is the content motivating and does it encourage continued reading?	0.92
12. Will the content spark the reader's interest?	0.92
13. Does the content address, clarify, and assist the professional during breast cancer prevention practices?	0.96
14. Do the topics portray key aspects that should be reinforced?	1.00
15. Does the application allow for the transfer and generalization of learning to different contexts (school, home, and health unit)?	0.92
16. Does the application propose that the professional acquire the necessary knowledge to prevent breast cancer?	0.96
17. Is the application applicable to healthcare professionals' daily lives?	1.00
Overall	**0.95**

Note: CVI - Content Validity Index.

First version	Suggestions and/or comments	Conducts	Second version
	Application logo and name 1. "The stethoscope symbol is not appropriate" 2. "Change the font of the word 'prev'"	Accepted	
	Main menu 1. "Replace '*acesso à informação*' (access to information) with '*sobre prevenção do câncer de mama*' (about breast cancer prevention)" 2. "Replace '*ferramentas de avaliação*' (assessment tools) with '*ferramentas úteis*' (useful tools)" 3. "Make '*sobre o aplicativo*' (about the app) the first button on the main menu"	Accepted	

To be continued

Figure 2

First version	Suggestions and/or comments	Conducts	Second version
	About the application **Content:** 1. "Include contact information for the authors and the logos of UFMA, PPGST, and FAPEMA" 2. "Replace '*redução das taxas de incidência*' (reduction of incidence rates) with '*auxiliar em uma possível redução das taxas de incidência*' (assist in a possible reduction of incidence rates) (something similar)" 3. "Change the term '*mulheres*' (women) to '*pessoas*' (people) (or person with breasts and emphasize that women are the most frequently affected so that men and transgender men are not excluded)"	Accepted Suggestions 2 and 3 have been modified in the body of this screen	
	Mammography adherence scale **Appearance:** 1. "To make it clear that the Brazilian version is being used"	Accepted	
	Disease **Content:** 1. "Talking about breast cancer in men" **Appearance:** 2. "Translate images into Portuguese" 3. "Include the word '*das vezes*' (of the times) or '*dos casos*' (of the cases) in '*como se manifesta?*' (how does it manifest?), resulting in '*Na maioria das vezes* (...)' (Most of the time (...)) or '*Na maioria dos casos* (...)' (In most cases (...)); and the word '*aspecto*' (aspect) in the symptom (orange peel), resulting in '(*aspecto casca de laranja*)' ((orange peel appearance))'" 4. "Add captions to images"	Accepted Suggestions 2 and 4 have been adjusted and can be found at the bottom of this screen	
	Risk factors **Content:** 1. "Include risk factors for breast cancer in men" 2. "Include any previous personal history of breast and/or ovarian cancer" **Appearance:** 3. "Separate protective factors from risk factors"	Accepted Suggestion 1 was included at the bottom of this screen	
	BI-RADS® **Appearance:** 1. "Similar to the chemoprevention chart, I suggest including a table summarizing the BI-RADS® classification"	Accepted	

To be continued

Figure 2 (concluded)

First version	Suggestions and/or comments	Conducts	Second version
	Screening for the general population **Content:** 1. "Change '*recomenda contra*' (recommends against) to '*não recomenda*' (does not recommend)" 2. "Correct information regarding the clinical breast exam, since the term nipple is prohibited" 3. "Remove the Tomosynthesis and Thermography exam or place it in a subtopic with OTHER EXAMS for informational purposes only, as it is not recommended by INCA and is not mentioned by SBM and may cause confusion" 4. "Bring up the discussion about women's taboos regarding knowing their own bodies"	Accepted Suggestions 1 and 2 have been included throughout this screen. Suggestion 4 has been included in the "*Saiba mais*" (Learn more) tab for breast self-examination	

Note: UFMA - Universidade Federal do Maranhão; PPGST - Graduate Program in Health and Technology; FAPEMA - Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão; BI-RADS® - Breast Image Reporting and Data System; INCA - Instituto Nacional de Câncer; SBM - Sociedade Brasileira de Mastologia.

Figure 2 - Recommendations and/or suggestions from healthcare professionals regarding the mobile application prototype, including actions taken and prototype screens after modifications for the first version. Imperatriz, Maranhão, Brazil, 2021

Chart 1 - Analysis by information technology specialists regarding interface problems based on Nielsen's heuristics, severity level of identified problems, comments, and actions taken. Imperatriz, Maranhão, Brazil, 2021

Nielsen's heuristics	Severity level of identified problems	Suggestions	Conducts
Visibility of system status	Minor	1. "Include a top menu indicating which part of the system you are in"	1. Accepted
Match between system and the real world	Not found	No comments	
User freedom and control	Severe	1. "Include navigation buttons"	1. Accepted
Consistency and standards	Not found	No comments	
Error prevention	Minor Catastrophic	1. "Include a tab in the app's about section to report errors" 2. "Allow users to correct errors in indicating answers to questions in the breast cancer risk assessment tool"	1. Not accepted 2. Accepted
Recognition rather than recall	Minor	1. "Include a help button for users" 2. "Reduce excessive text; use more visual information"	1. Not accepted 2. Accepted
Flexibility and efficiency of use	Minor Severe	1. "Include navigation buttons" 2. "Include the option to increase the font size"	1. Accepted 2. Not accepted
Aesthetic and minimalist design	Cosmetic Minor Severe	1. "Reduce the excess text" 2. "Translate text from the image of 'most common types' of breast cancer"	1. Accepted 2. Accepted
Help users recognize, diagnose, and recover from errors	Minor	1. "Indicate which professional category they are in at the top of the application"	1. Not accepted
Help and documentation	Minor	1. "Reduce the amount of text" 2. "In the references, provide a link to access the studies" 3. "Include a help button for users"	1. Accepted 2. Accepted 3. Not accepted

After the final corrections, the system was considered to have initial adequacy and is currently in the process of being made available in app stores and undergoing usability assessment with the target audience. The MAMAprev app was developed with approximately 7,500 lines of code and 34 images.

DISCUSSION

In this study, the MAMAprev app on BC prevention for PHC healthcare professionals was developed based on the UCD model, agile development methodologies, and native programming language. The adoption of UCD aligns with international recommendations for the development of digital health technologies centered on users' needs, which are considered determinants for acceptability and practical applicability[10,11,25]. Unlike studies using traditional linear development models, the present study integrated iterative prototyping (Wizard of Oz), the Scrum methodology, and expert assessment, a strategy similar to that employed in apps focused on breastfeeding and prenatal care[26], which also reported improvements in content adequacy through successive adjustment cycles.

Content and appearance validity, with an overall CVI of 0.95, showed results comparable to national investigations that used the CVI as the main measure of consensus among specialists[19,20].

Studies employing the Delphi technique or structured consensus validity also reported high agreement indices, reinforcing the methodological robustness of expert assessment as an initial stage in the qualification of educational technologies[27,28]. However, unlike studies that advanced to clinical validity or effectiveness testing, the present study focused on preliminary validity of content and interface, characterizing it as an initial stage in the technological assessment cycle.

Developing technologies grounded in the needs of end users (target audience) and scientific recommendations ensures a product with relevant information delivered through appropriate language, leading to more successful outcomes[10,17,29]. Therefore, the development of tools such as BC-related apps is a promising strategy with the potential to improve technical knowledge and support decision-making within the PHC context[8,25,26,28,30]. Evidence from clinical studies reinforces this potential, such as a non-randomized controlled clinical trial conducted in Thailand that assessed the ChemoPro mobile app in women with BC undergoing chemotherapy and demonstrated significant improvement in quality of life and symptom monitoring among users[30], indicating that well-structured digital interventions can produce relevant clinical impacts.

Regarding interface assessment, the application of Nielsen's heuristics made it possible to identify problems classified at different severity levels, a strategy widely described in the literature for heuristic assessment of digital health systems. Similar studies demonstrate that heuristic analysis conducted by information technology specialists constitutes a cost-effective method for the early detection of interface flaws before large-scale implementation[22,29].

Other apps described in the literature have demonstrated similar results during the interface assessment process, highlighting the relevance of specialist participation and the application of systematic methods, such as Nielsen's heuristics, for improving digital technologies. In this context, a study that developed a digital sexual health intervention also conducted interviews with information technology specialists to assess a high-fidelity prototype, and the feedback obtained supported adjustments to the architecture, design, and interface, contributing to the refinement and consolidation of the program's final version[29].

The use of the user-centered methodology adopted in the development of MAMAprev contributed to the high agreement demonstrated by the CVI. This indicates that understanding the needs and interests of the target audience regarding the subject and involving them in the development stages ensures greater acceptance of the product and, consequently, its use[26,29]. In this context, the development of digital health resources has shown that considering users' needs, doubts, interests, and suggestions constitutes a fundamental strategy for increasing the adequacy, usability, and potential use of these technologies[26-30].

However, the present study differs from investigations that used standardized instruments, such as the System Usability Scale, or observational testing with end users in real environments, stages representing more advanced levels of assessment that confirm acceptability and usability. Therefore, the use of UCD up to the stage covered in this research only indicates MAMAprev as a potentially applicable tool within the PHC context, capable of contributing to professional practices in BC prevention and early detection, which may be confirmed through effectiveness studies.

The integration between the scientific foundation based on *Instituto Nacional de Câncer* guidelines and national consensuses[5,8,13,14] and the user-centered approach[10,11,25] constitutes a relevant contribution of this study by aligning scientific evidence with the needs of professional practice. Scientific support is essential for the adoption of any digital tool in clinical practice, since healthcare professionals must trust the information provided in order to use it effectively and safely[26]. Thus, MAMAprev contributes by systematically describing a methodological process that integrates evidence, iterative prototyping, and specialized validity, offering support for future stages of effectiveness assessment and implementation in real contexts.

Study limitations

The limitations of this study include conducting the development and assessment stages exclusively in an online environment due to the COVID-19 pandemic, which may have limited face-to-face and observational interactions; difficulties accessing the app on the iOS system through the Expo platform, which led to participant withdrawal; and the use of contacts from the Lattes Platform for recruiting specialists, which may have reduced the response rate due to outdated email addresses.

From a methodological perspective, another limitation was the absence of usability testing with end users in real contexts of use, preventing the measurement of possible impacts on knowledge, attitudes, and professional practices. These impacts should be investigated in future studies assessing effectiveness through the application of specific usability scales, real-context use assessments, and outcomes related to healthcare practice.

Contributions to nursing, health, or public policies

This study has the potential to contribute to the training of PHC healthcare professionals by providing a BC prevention app capable of guiding care practices and strengthening women's health promotion.

CONCLUSIONS

MAMAprev, an app on BC prevention targeted at PHC professionals, was developed based on the UCD method, specifically the prototyping and assessment stages. The app showed high agreement in specialist validity regarding content, appearance, and interface, indicating initial adequacy of both the material and the system. The results support the content validity and initial adequacy of MAMAprev, highlighting its potential applicability in the PHC context as a support tool for professional practices related to BC prevention and early detection, an aspect that should be confirmed in future studies.

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CONTRIBUTIONS

Araújo-Gomes RC and Ferreira AGN contributed to study/research conception or design, data analysis and/or interpretation, and final review with critical and intellectual participation in the manuscript. Pinheiro PNC, Reis AS, and Bezerra JM contributed to data analysis and/or interpretation and final review with critical and intellectual participation in the manuscript. Santos LH contributed to study/research conception or design and data analysis and/or interpretation. Júnior ALC contributed to the final review with critical and intellectual participation in the manuscript.

AVAILABILITY OF DATA AND MATERIALS

Research data are only available upon request.

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