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Breaking the digital gap to reduce cardiovascular risk in primary care

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Abstract

Objective: The goal of this study was to report on the development and early usability of a new interactive mHealth app for reducing cardiovascular risk in primary care patients of low socioeconomic status attending clinics in Chile.

Design: Mixed-methods design with qualitative and quantitative components.

Setting: Three Chilean primary care clinics located in one urban (Santiago) and two rural areas (San Clemente and Chiguayante). Each clinic serves a population of about 24,000 people of generally low socioeconomic status with an average of 8.5 years of education.

Methods: A qualitative co-design participatory framework was used to develop the *Mi Salud-APS* mHealth app. Three iterations of virtual workshops were held with healthcare providers and patient participants to develop the new app. Once developed, the usability phase identified, invited and followed up for 3 months a sample of primary care patients with moderate ($N = 119$) or high ($N = 329$) cardiovascular risk.

Results: A total of 24 healthcare providers and 24 patients participated in the developmental workshops. Three emergent categories represented the core attributes for the mHealth app design: 'Friendly', 'Interactive' and 'Pertinent'. In the usability phase of the sample of 448 patients, 98% downloaded the app, and 64.6% of them logged in and used it for an average of 1.46 (0.5–10) times weekly.

Conclusion: Findings suggest that patient and healthcare provider contributions to the development of the mHealth app accurately reflect the interests and experiences of both groups and together helped achieve the high usability levels observed among primary care patients enrolled in clinics in underserved communities.

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Introduction

Cardiovascular disease is a growing epidemic in Latin America and remains the leading cause of death in the region (Lloyd-Sherlock et al., 2019). In Chile, cardiovascular disease is also the leading cause of death and accounts for 14% of premature deaths in the population (Bächler et al., 2017; OECD/The World Bank, 2023). According to a Chilean National Health Survey, 51% of the adult population is at moderate or high risk of cardiovascular disease (Ministerio de Salud, 2017).

The prevalence of cardiovascular risk factors is very high in the Chilean population. According to the most recent National Health Survey, 33.3% of the population smoke, 31.2% of Chileans are obese and 86.7% of them are physically inactive (Ministerio de Salud, 2017). Only about 30% of patients with diabetes and 50% of patients with high blood pressure had their conditions well controlled at the public primary care level, where 75% of the Chilean population receives care services. Low adherence to regular checkups and medication are key factors seen as responsible for the low level of chronic disease control in the Chilean population (Veliz-Rojas et al., 2015).

The lack of effective strategies to reduce cardiovascular risk at the primary care level in Chile is similar to that observed in other countries in the region and affects underserved populations more dramatically than those of higher socioeconomic status (Avezum et al., 2018). Social health disparities associated with cardiovascular disease are increasing in Latin America (Serón and Lanas, 2019). In Chile, individuals of lower socioeconomic status have between 1.5 and 2 times higher risk of dying from cardiovascular disease than those of higher socioeconomic status (Haase et al., 2016). Patients of low socioeconomic status are most likely to be seen in public primary care clinics, and therefore, effective strategies implemented at this care level could contribute significantly to reduce health disparities.

New strategies that use digital health are gaining traction in the healthcare field. Digital health encompasses a great variety of technology tools including mobile apps (mHealth apps), web-based portals, telemedicine interactions, electronic records and big data analysis (Mora et al., 2023). Building on the need for the self-management of disease and partnership between patients and providers, a number of mHealth apps have been developed and subsequently recommended by international experts to improve disease control, especially at the primary care level (Arnett et al., 2019; Ministerio de Salud, 2017; Piepoli et al., 2016). The evaluation of such technology however indicates the success of such strategies is variable.

In a meta-analysis conducted by Widmer et al. (2015), the authors found a 31% reduction in cardiovascular risk profile with the use of mobile technologies. However, there was high variability in the magnitude of the effects observed and in the design of the interventions developed. In a systematic review by Pérez-Jover et al. (2019), the authors found that medication adherence improved between 7% and 40% in a group of patients that had access to mHealth Apps compared to those that received standard care. The Cochrane systematic review on the use of mobile phone-based interventions for improving adherence to medication for cardiovascular disease in adults conducted by Palmer et al. (2021) found high heterogeneity in the nature and delivery of the interventions in the 14 trials analysed, preventing the drawing of consistent conclusions.

In Chile, 92% of the population has access to the Internet, one of the highest rates in Latin America (Rosgaby-Medina, 2022). However, a digital gap is still prevalent in Chile, with less than 50% of the population of low socioeconomic status using their mobile phones for interactive tasks (Leon et al., 2020). The design process of an mHealth app, its cultural sensitivity and its interactive or gamification features are important factors in achieving better levels of usability and, therefore,

higher probabilities of health behaviour change (Dawson et al., 2020; Meixner et al., 2020). Identifying key components of an mHealth app by potential users, that is, patients and healthcare team members, points to the importance of achieving ownership and usability at the primary care level (Molina-Recio et al., 2020; Swallow et al., 2016). In Latin America in general, and in Chile specifically, few studies have assessed the design process and usability of mHealth apps to reduce cardiovascular risk at the primary care level. This study presents the design process, final product and initial usability rate of a new interactive mHealth app based on a participatory model that integrated the perspectives of patients and primary care health team members.

Methods

Design

In this study, we used Sanders and Stappers' (2014) Co-design Participatory Framework as adapted by Noorbergen et al. (2021). This model emphasises the active participation of the different stakeholders in the development of a new solution. In this model, the early involvement of key players – in this case, the patients – is essential to gain ownership, familiarity and meaning of the new solution being developed. The framework was particularly appropriate for our project given that ownership, familiarity and meaning are essential attributes if the use of a new mHealth technology is to be encouraged in our target population of patients.

The framework includes six phases. This study reports on the first three phases of the framework. The pre-design phase aimed to explore and understand the context in which the application is being developed and patients' experiences. The generative phase (phase 2) focused on the collaborative development of a mobile health product, including its interface with patients, functions and contents. The third prototyping phase consisted of assessing the application in the real world in terms of its usability and adoption. The fourth, fifth and sixth phases, which are not described here, will incorporate an evaluation of the effectiveness of the application on health practices, integration into complex systems and post-design assessment to improve adoption.

A qualitative approach was used to develop the framework's first (pre-design) and second (generative) phases. It included three sets of sequential and iterative workshops with patients and healthcare team members. The third prototyping phase was assessed using a quantitative approach of a longitudinal follow-up to assess the adoption and usability of the mHealth app over a 3-month period.

This study was reviewed and approved by the institutional research board of Health Universidad Católica de Chile, ID: 200117003, and the Regional Health Care Systems (Servicio de Salud de Maule, Servicio de Salud de Concepción), ID: 20-12-65. The study was also registered as a Randomized Controlled Trial with the US National Institutes of Health (Reference: NCT05395806).

Participants

The study was conducted in three primary care clinics located in Santiago, the capital city of Chile, San Clemente and Chiguayante. The sites were selected because they represent a blend of urban and rural populations and, therefore, allowed us to test the mHealth app in populations with different cultural backgrounds. Santiago has a largely urban population, San Clemente; on the other hand, is a rural area located 300 km south of Santiago and Chiguayante is a semi-urban area located about 500 km south of Santiago. The selected clinics in each site serve a population of about 24,000 people of generally low socioeconomic status with an average of 8.5 years of education.

Healthcare team members of each centre were also invited to participate in the qualitative phase of the study.

We used a purposive sampling method, which aimed to involve participants that could contribute their knowledge and experience of the phenomenon (Creswell and Poth, 2016). Thus, the selection criteria included patients with moderate or high cardiovascular risk attending one of the clinics involved in the project who were smartphone users. The selection criteria also included healthcare team members working at a primary care clinic involved in the project: These members included nurses, kinesiologists, nurse technicians and physicians. Each contributing member had a role in the cardiovascular programme at the primary care clinic.

For the prototyping phase, we used a cross-sectional design and drew a random sample of 448 patients between 35 and 65 years of age from a population of about 3,000 patients with moderate to high cardiovascular risk according to the Framingham score (Anderson et al., 1991) registered at the participating clinics. A stratified random sample was produced using a random number generator (IBM-SPSS) and grouping by clinic.

Selected patients and healthcare team members were trained in the use of the new mHealth app, and the use rate/time (usability) was recorded and analysed over a period of 3 months.

Procedures and analysis

Qualitative component

The co-design model is based on a series of participatory iterated workshops that seek to engage participants, developers and researchers in a collaborative process to confront a challenge (Davis et al., 2021). In this study, this component included a first round of iterative workshops with patients and health team members to define the main features and functionalities of the mHealth app. The number of workshops that took place was defined by the saturation of the categories that emerged during the process. Second and third rounds of workshops were offered for those participants who wanted to follow up and contribute to refining the mHealth app. Given COVID-19 pandemic restrictions at the time of the app development, these activities were implemented through an online platform. Workshops were led by two researchers (KG-S and KP). Sessions were audio-recorded and fully transcribed for analysis.

In the first workshop series (first iteration), participants were invited to share their ideas for an mHealth app to help them control cardiovascular disease and risk factors. Four principal themes were explored: appearance, functions, content and incentives. In the second iteration, patients and health team members discussed a prototype for a new mHealth app based on the suggestions shared in the first workshop. In the third workshop series, patients reviewed a revised prototype of the mHealth app projected on the shared screen of each video conference and on their cellphones. They tested the mHealth app by entering information and interpreting health status through the features and functionalities of the mHealth app. Feedback from this exercise was analysed under the same themes and categories as the first two workshop series.

Qualitative content analysis was conducted in Atlas.ti, version 9.0 (ATLAS.ti Scientific Software Development Retrieved from https://atlasti.com). First, we conducted a *deductive content analysis* since the four main themes (appearance, functions, content and incentives) were pre-defined for each phase and iteration. In a second level of analysis, we used an *inductive approach*. Participants were asked to adopt a broader perspective, beyond the four main themes initially suggested so as to identify new emerging concepts and categories that gave a deeper understanding of the features that the app should contain (Hsieh and Shannon, 2005).

To enhance the credibility of the analysis, the procedures were conducted by one researcher and one research assistant. Workshop discussions were fully transcribed, and open coding took place following a comprehensive reading of texts, selecting content units according to pre-defined themes (pre-design and generative phases) and assigning code labels to each content unit. A

co-occurrence table was generated to determine the frequency and relationships between codes. Information obtained was organised into categories, and a framework that described the main features that an mHealth app should have was developed. Where coders disagreed on codes, discussion took place until consensus was reached.

Quantitative component

A cross-sectional design was used to describe the population profile and test the usability of the mHealth app (prototyping phase). The sample size was estimated based on a weekly usability rate of at least 33% (*p1*) with a precision of 0.05 (*d*) and a type I error rate (alpha) of 0.05.

Participants between 35 and 65 years of age with moderate or high cardiovascular risk and access to a mobile phone were invited to participate. General information was gathered through personal interviews (in person or by phone) using a standardised questionnaire comprising 35 questions. The questionnaire elicited demographic information as well as digital experience such as regular use of digital phones or previous use of social media applications.

Clinical information such as risk factors control, cardiovascular events and medications indicated was obtained from electronic charts. All participants read and signed an informed consent document prior to participation.

The data from the study were collected and registered in the Research Electronic Data Capture (RedCap) platform (https://projectredcap.org/software/). Descriptive and analytic statistics were conducted using IBM-SPSS software (//www.ibm.com/es-es/products/spss-statistics). Usability rate was analysed based on the number of entrances into and interactions with the mHealth app by the sample-identified participants.

Results

Pre-design and generative phase – qualitative component

In the three pre-design iterations, a total of 48 individuals participated, 24 patients and 24 team members in 13 online workshops that totaled 14.6 hours (876 minutes) in length. Of the total participants, 17 patients and 17 healthcare team members were women. The participants' average age was 47 years, and the average age of the team members was 35. Participants who attended the first iteration were invited to attend the second and third iterations. During the first iteration, eight workshops were held with 21 patients and 21 team members. During the second iteration, four workshops were held with 13 patients and seven team members. The third iteration included one workshop with six patients.

Emerging categories. Through the inductive approach of content analysis, we identified three main emerging categories representing the core attributes that this mHealth app was supposed to achieve: 'Friendly', 'Interactive' and 'Pertinent'. In the following sections, the qualitative analysis that led to the identification of these categories, including the codes that enabled the identification of each category and quotations, is presented.

Figure 1 shows the schema with the three emerging categories and codes that appeared across the three iterations. Tables 1 and 2 summarise the emerging categories, codes and sample quotes, across the three iterations.

Friendly. The category 'Friendly' referred to features that might attract patients to use the mHealth app and was represented through 13 codes. In the first workshop iteration, participants were concerned with making the avatar – in the form of a character that represented the health status of the patient – look friendly and including videos that were easy to understand. Much was said about the

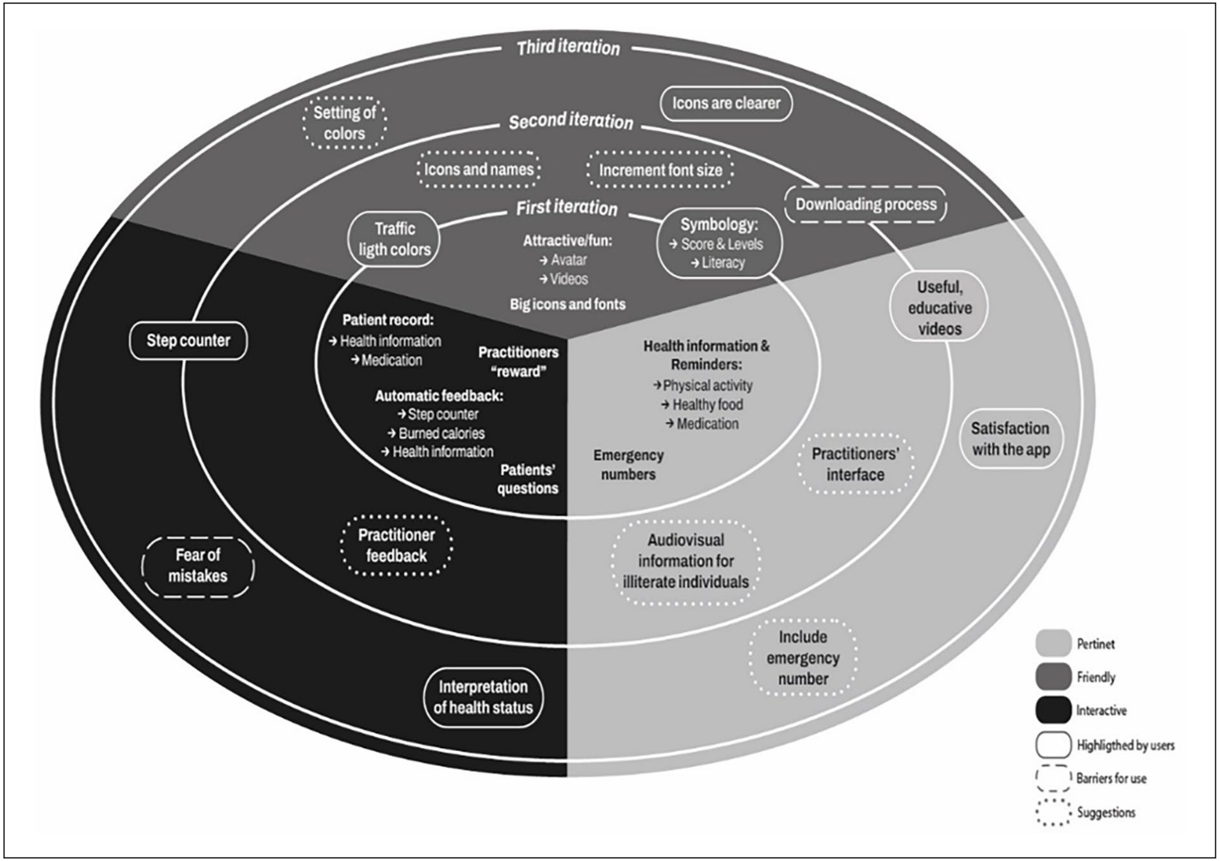

Figure 1. Qualitative categories and codes that emerged during the three iterations representing features and suggestions for the app.

Table 1. Summary of the mHealth app development process: friendly category.

Iterations	Codes	Sample quotes
First	Attractive/fun →Avatar	'A cartoon doing physical activity, because there are many applications where to find endurance physical activity, that always is set aside, and that is very important, and decreases cardiovascular risk factors, and you don't have to go out home to do it'. (P5/HT/WS1/It1).
First/Second	Symbology →Score & levels	'I thought in prizes like stars or unblocking levels so that the patients feel that go forward while they are achieving their goals' (P7/HT/WS2/It1).
First/Second	Symbology →Literacy	'. . . we have seen a high rate of analphabet people and the app for the medication should have these features with illustrations . . .' (P2/HT/WS3/It1).
First/Second	Traffic lights colours	'. . . that tells you if you are well or bad. It is like I said, that marks the colours like a traffic light, and if I am in red it's because I am bad, and if I am green, it's because I am a little bit better . . .' (P2/Pt/WS5/It1).
First/Second	Symbology →Literacy	'It is good the idea for people that don't read, because with traffic light colors all of we know thar red means danger, yellow is at the limit, and green is good'. (P1/Pt/WS9/It2)
Second	Icons and names	'Yes, a red heart that is like the most normal, that one is used to see [. . .] it's easier [than this figure], I think' (P2/Pt/WS9/It2).
		'If the font is not clear, the figures should be clear [. . .] I don't understand well, I see the shape of a book, but I don't understand the figure inside it' (P6/Pt/WS9/It2).
Second	Downloading process	'No, I couldn't [download it], even though I attemted to do it' (P3/Pt/WS9/It2).
Second	Downloading process	'The truth is that I didn't understand [. . .] how to download the app'. (P2Pt/WS11/It2)
Third	Downloading process	'My daughter couldn't download it and I am interested on it, it is important to me'. (P2/Pt/WS12/It3).
Third	Downloading process	'Yes, I downloaded it [the app] but I could not enter on it, I might have made a mistake in the email address'. (P3/Pt/WS12/It3)
Third	Setting of colours	'What happens here is that the arterial pressure 140-90 is high! –sure, that person is about a hart attack [the colour in the pie chart continues to be green, which is a setting mistake]'(P3 & P4/Pt/WS12/It3).
Third	Icons are clearer	'[the avatar] make sense due to the faces [happy, sad]'. (P2/Pt/WS12/It3)
Third	Icons are clearer	'[interviewer asks the participants by pointing at each of the icons] Is it understandable that this is for medication, this is for health indicators, this is the gym, and the library? —yes [several voices answer]'. (P1, P2, P3, P4 & P5/Pt/WS12/It3)

appearance of the mHealth app, with the priority of making sure icons and fonts were large and easy to see. Participants suggested using traffic lights to indicate favourable behaviours (green) and unfavourable behaviours (red). The second iteration focused almost exclusively on appearance, with participants wanting larger font and icon sizes and larger visual representations. There was approval of the traffic light colours, and the symbology was considered approachable. It was also noted that a number of participants had difficulty downloading the app. The third iteration led to approval of much of the visual material.

Table 2. Summary of the mHealth app development process: interactive and pertinent categories.

Iterations	Codes	Sample quotes
Interactive		
First	Automatic feedback →Step counter	'[that the app may] record how many steps the patient did and when the goal is achieved, they accomplish the stage or mission'. (P3/HT/WS3/It1).
First	Automatic feedback →Calories burned	'It could be an app [that reports you] how many calories you burn, or the steps that you take [and tells you] the equivalent to eat 8 eggs, or to eat a hamburger, or chips'. (P3/Pt/WS7/It1).
First	Automatic feedback →Health information	'That [the app] reports me when my arterial pressure is not well'. (P8/Pt/WS4/It1).
First	Practitioner 'reward'	'I thought that we, as health team members, may send to the patients . . . through the app . . . an emoji or happy face . . . some "like" so that they realise that they are participants and that we are following all the changes they are achieving'. (P5/HT/WS3/It1).
First	Patients' questions	'Because sometimes the patients could have a question any moment and they don't have whom to ask, and they can make a mistake, doing what they believe in the moment . . . having the possibility of some chat or messenger [. . .] it won't be an immediate way . . .' (P1/HT/WS1/It1).
Second	Practitioner feedback	'Will the app have some type of communication with the clinic, for example with the nutritionist? Sometimes one have questions . . .— yes, [. . .] If you click on the telephone icon you will be able to ask a question [. . .] you may not receive the answer immediately but the team will work on that answer'. (P3&Interviewer/Pt/WS9/It2).
Third	Interpretation of health status	'I see that in physical activity it is in zero, tobacco is good, it supposed that the person is not using tobacco and she is not doing physical activity. And the medicines are zero percent, so I suppose she is not taking them; that's what I see'. (P3/Pt/WS12/It3).
Third	Fear of mistakes	'I press buttons and I am scared to spoil it'. (P2/Pt/WS12/It3).
Pertinent		
First	Health information and reminders →Physical activity	'To use things like one kilo pack of rice, doing movements with the arms with a one kilo pack of rice, one kilo pack of sugar, with things that they have at home, to do physical activity with informative videos that are shown to patients'. (P3/HT/WS4/It1).
First	Health information and reminders →Physical activity	'Making reminders, [for example] "have you do any physical activity?" or "have yo gone for a walk"'. (P1/HT/WS1/It1).
First	Health information and reminders →Physical activity →Healthy food	'that [the app] has a reminder that says "you should use less salt; remember to do physical activity, walking or biking"'. (P5/Pt/WS4/It1).
First	Health information and reminders →Medication	'that [the app] has an alarm system that help us to remember the times for taking medicines'. (P3/Pt/WS6/It1).

(Continued)

Table 2. (Continued)

Iterations	Codes	Sample quotes
Second	Practitioners' interface	'Would it be possible to add dates of next check-ups, and pick-up medicines in the pharmacy? so that they [the patients] don't forget when they have to pick them up [the medicines]'. (P2/HT/WS13/It2).
Second/ Third	Useful, educative videos	'I could saw that it had some interesting videos, several interesting themes, like tobacco, how much one has to walk, how to treat anxiety . . .' (P5/Pt/WS12/It3).
Third	Satisfaction with the app	'I saw the medicines, the pressure . . . well, physical activity, the hours that we have to walk, many things appear, and it was like we had talked before, when we had met the other times'. (P3/Pt/WS12/It3).
Third	Satisfaction with the app	'This is a very good application, I like it, it is easy to understand, after this explanation, and for me it would be easy to explain it to someone else that use it, and I would use the app'. (P3/Pt/WS10/It2).

Interactive. The category 'Interactive' described patients' and healthcare team members' experience when entering information in the mHealth app and receiving feedback either automatically or from another part of the app and was represented through 13 codes. An important feature of the app was the opportunity for healthcare providers to report back to the user. Participants were interested in receiving feedback on several issues including reminders to take their medication, engage in physical activity and eat healthy food and information regarding calories burned. The idea was that patients could enter health information and medication in the mHealth app which might lead providers to interact with them or with other health team members. This was also seen as advantageous to the clinic as answers provided on the app might solve problems without a clinic visit. During the second iteration, patients asked for the inclusion of a step counter and a chat function with the health team; however, these additional facilities were not built into the app because of resource constraints. The third iteration focused on interpreting patients' health status. Participants read examples of health information recorded on the app and interpreted the meaning of what they read. Some participants expressed a fear of making a mistake when interacting with the app. Figure 2 illustrates some of the screens in the app along with their interpretation.

Pertinent. The category 'Pertinent' was represented by 10 codes and referred to the suitability of the content displayed in the mHealth app to each user. Patients and health team members highlighted that the content in the app should be appropriate to the user and sensitive to their characteristics and needs in terms of chronic illnesses, capabilities and preferences. For example, they suggested that patients might receive reminders according to their own life circumstances and have access to information related to their health needs and difficulties.

During the second iteration, patients valued the fact that the mHealth app contained useful and educative videos, and both patients and practitioners suggested that audiovisual information for individuals who were illiterate should also be included. Health team members added some suggestions about the practitioners' interface. During the third iteration, patients highlighted their satisfaction with the app, suggesting that they considered that prior conversations had been taken into account in its development and that they would use it. Finally, news referring to the usability of the app became evident during the second and third iterations, when patients used phrases such as 'I would use the app' reflecting positive opinions after reviewing the prototype.

After the third iteration, the mHealth app developers amended the features that had been suggested by participants, such as improving the colour settings (green and red) to make them

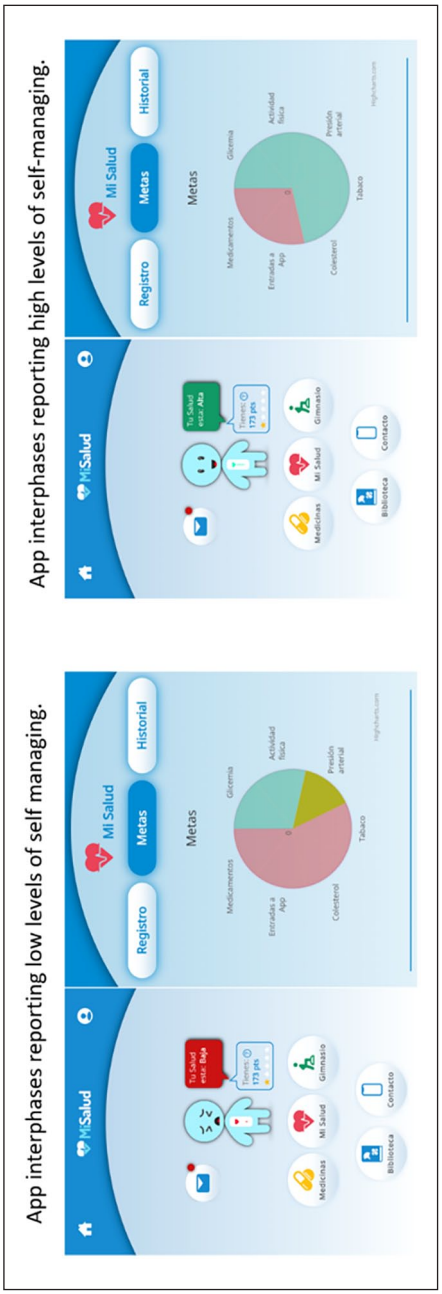

Figure 2. Screenshots of the mHealth app.

Table 3. Baseline characteristics of primary care patients.

Characteristics	*N* = 448	%
Age		
30–50	105	23.4
51–65	343	76.6
Gender (female)	312	69.6
Ethnicity		
Mestizo	170	37.9
White	169	37.7
Amerindian	34	7.6
Black	4	0.9
Non reported	71	15.8
Educational level		
Primary education incomplete (<8 years)	75	16.7
Primary education complete (8 years)	104	23.2
Secondary education incomplete (9–11 years)	54	12.1
Secondary education complete (12 years)	158	35.3
Tertiary education (⩾13 years)	57	12.7
Income level		
Very low (Chilean Pesos [CLP] $ < 300.000/month)	205	45.8
Low (CLP $ > 300.000–<500.000/month)	130	29.0
Medium (CLP $ > 500.000–1 Mill/month)	37	8.3
High CLP $ (>1 Mill/month)	8	1.8
Not reported	68	15.2
Risk factors		
Smoking	100	22.3
Excessive alcohol consumption	53	11.8
Sedentarism	354	79.0
Hypertension	324	72.3
Diabetes	297	66.3
Cardiovascular risk		
High	329	73.4
Moderate	119	26.6

Note: 1 US Dollar = 900 CLP.

consistent with good or bad and the inclusion of emergency contact numbers for each clinic which had not been available at the time of the third iteration. In addition, as some patients reported difficulty downloading the mHealth app, patients suggested including instructions on how to do so. The research and development team created workshops – to be implemented by primary care teams – to train participants in downloading and using the mHealth app.

Prototyping phase – quantitative component

As Table 3 shows, a total of 448 patients enrolled in the intervention group. Participants were between 30 and 65 years of age, with the majority (76.6%) being in the category of 51 to 65 years of age. Almost 70% were women, 75% identified themselves as white or mestizo, 52% had achieved less than 12 years of education, and almost 75% reported having a low or very low income level. Among risk factors, diabetes, hypertension and sedentarism were reported by more than

Table 4. Usability indicators of three first months of app use.

Indicators of 3-month use	*N*	%
Users	441	98.4
Users logged in	285	64.6
Total visits	4,900	
Average visits per week	408	
Average visits per user (0.5–10)	1.43	

66% of participants. Although the majority (73.4%) reported having moderate cardiovascular risk, 26.6% reported high cardiovascular risk.

First three months of usability. As shown in Table 4, a total of 441 out of 448 (98.4%) participants downloaded and installed the mHealth app on their mobile devices. During the 3 months that followed, 285/441 participants (64.6%) used the platform for cardiovascular risk factor and disease control, and a total of 4,900 visits were reported. Of this 64.6%, the average number of weekly visits per user during that period was 1.43 (range 0.5–10).

Discussion

The mHealth app development described on in this paper represents an innovation for Latin America in general, specifically for the Chilean primary healthcare system. The use of mHealth apps has been widespread in high-income countries (Yeung et al., 2023) where they have been used to provide health education to patients with chronic health conditions and to enhance clinical skills among health professionals (Hou et al., 2018; Huang et al., 2019). In these settings, the use of digital technologies – including mHealth apps as part of healthcare – has been so successful that it has even been suggested as a new social determinant of health with the potential to contribute to reducing health disparities (*The Lancet Digital Health*, 2021). Despite this, information about the development and use of mHealth apps in Latin America remains limited. In a recent systematic review of factors influencing adherence to mHealth apps for the management of noncommunicable diseases, Jakob et al. (2022) assessed 351 articles, but none of them came from Latin America. Our study helps reduce this gap in information and shows that mHealth apps may be successfully used in primary care in Chile.

The use of mHealth apps has been considered an empowering health education strategy given that it seeks to apply adult learning principles to patients who are placed at the centre of the learning process (Affinito et al., 2022). Adult learning principles as applied to health education emphasise the relevance of making patients central characters in their own care and not merely receptors of health information (Mukhalalati and Taylor, 2019). This person-centred approach sees health education as implying a continuous 'dialogue' between patients and health professionals in pursuit of better ways to improve health (Puschel, 2004). The participatory strategy used in this study utilised the person-centred approach described by Melles et al. (2021) and is consistent with adult learning principles. This approach highlights three key steps. First, developing an understanding of people and their needs; second, engaging key stakeholders from early on and third, adopting a systems approach to transition from individual to collective interests.

In this study, the co-design procedures involved the active participation of potential users very early on in the process. The pre-design phase of our study aimed to understand patients' needs and motivations. The generative phase engaged the main stakeholders – patients at cardiovascular risk,

health team members and researchers – in the development of a meaningful product. As a result, an ongoing 'dialogue' between patients, healthcare providers and researchers took place leading to the development of the mHealth app.

The results of our study are consistent with those reported in the systematic review conducted by Jakob et al. (2022) that emphasise the relevance of personalisation of mHealth apps to individual needs and a user-friendly design. Jakob et al. (2022) identified social and gamification features as key drivers of mHealth apps use and adherence across several health domains. In our study, improvements were made after the first and second iterations of the generative phase to functions, appearance, icons, language and colours of the mHealth app interface. These improvements were based on participants' suggestions and aimed to create a friendly, pertinent and interactive mHealth app.

The development of mHealth applications is particularly challenging when the aim is to engage socially vulnerable populations. However, they are considered a good strategy to reduce the health access gap and to improve the empowerment of underserved communities (Anderson-Lewis et al., 2018; Sharma et al., 2022). Our study population was of low socioeconomic status, and about half of the participants had not completed high school. Barriers to implementing mobile health technologies in communities with a low education level not only relate to low levels of literacy but also to cultural factors associated with the healthcare model that mHealth applications represent and which underserved communities may not initially trust (Sharma et al., 2022; Soto et al., 2018). Despite these barriers, the prototype phase of our study revealed that 64.6% of participants used the mHealth app regularly. This usability rate compares very favourably with the 56.0% reported by Jakob et al. (2022) in their systematic review.

Limitations

This study has some limitations that it is important to recognise. First, the study population comprised participants from underserved communities seeking care from public primary care facilities in Chile. We cannot generalise from this to other groups in different settings. However, underserved populations are precisely those at higher cardiovascular risk and those who are most affected by social health disparities. Second, the study focused on the development and initial usability of an mHealth app. It did not provide information on long-term adherence or health outcomes. This is a common limitation in this kind of study. In the systematic review conducted by Jakob et al. (2022), the average follow-up time of mHealth use was 3.7 months.

Conclusion

In conclusion, this study shows that a co-designed participatory framework can be very useful in developing a friendly, interactive and pertinent mHealth app that can achieve a high usability rate in a socially vulnerable primary care population. The high usability rate in this population suggests that this mHealth app may be an effective health education strategy in other primary care settings in the region. Future research should focus on long-term adherence and its effects in reducing cardiovascular risk.

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