# Mobile application prototype for self-management of heart failure patients: construction and validation

## Protótipo de aplicativo móvel para autogerenciamento de pacientes com insuficiência cardíaca: construção e validação

## Modelo de aplicación móvil para la autogestión de pacientes con insuficiencia cardíaca: elaboración y validación

Haglaia Moira Brito de Sena Oliveira[1] https://orcid.org/0000-0002-3114-757X
Maria Elisabete Salvador[1] https://orcid.org/0000-0001-8692-5968
Rita Simone Lopes Moreira[1] https://orcid.org/0000-0003-3743-9044

**How to cite:**
Oliveira HM, Salvador ME, Moreira RS. Mobile application prototype for self-management of heart failure patients: construction and validation. Acta Paul Enferm. 2024;37:eAPE02474.

**DOI**
http://dx.doi.org/10.37689/acta-ape/2024AO00024744



**Keywords**
Heart failure; Mobile applications; Telemonitoring; eHealth strategies; Validation study

**Descritores**
Insuficiência cardíaca; Aplicativos móveis; Telemonitoramento; Estratégias de e-Saúde; Estudo de validação

**Descriptores**
Insuficiencia cardíaca; Aplicaciones móviles; Telemonitorización; Estrategias de eSalud; Estudio de validación

**Submitted**
16 December 2022

**Accepted**
1 April 2024

**Corresponding author**
Haglaia Moira Brito de Sena Oliveira
E-mail: haglaia.sena@unifesp.br

**Associate Editor**
Juliana de Lima Lopes
(https://orcid.org/0000-0001-6915-6781)
Escola Paulista de Enfermagem, Universidade Federal de São Paulo, São Paulo, SP, Brazil

## Abstract

**Objective:** To build and validate a prototype mobile application for self-management of patients with heart failure.

**Methods:** Methodological study conducted in three phases with methodological validation according to the Delphi technique for developing mobile technology, content validation of 18 items by judges (percentage of agreement ≥90%) and patient satisfaction survey (random randomization) for comparison between the application and an institutional manual with descriptive and inferential statistical analysis (Mann-Whitney U test and Fisher test) of four variables: age, sex, schooling and length of outpatient follow-up.

**Results:** The VivaCor-IC application contains 30 screens with information such as signs and symptoms, medications used, vaccines, impact of smoking, and physical and sexual activities, related to self-management and heart failure. The application's features include daily recording of fluids and meals, checking well-being, signs and symptoms of decompensation and adherence to treatment. The judges' evaluation obtained agreement greater than 90% and acceptability by patients' assessment was greater than 50% in all items. A statistically significant difference (p=0.024) was observed in relation to schooling. Although the educational level was higher in the group that evaluated the manual that in to the group that evaluated the application, no interference was observed regarding acceptability of the prototype.

**Conclusion:** The creation of the prototype included relevant functionalities for self-management and showed evidence of appropriate validity in the evaluation of specialists and patients.

## Resumo

**Objetivo:** Construir e validar um protótipo de aplicativo móvel para autogerenciamento de pacientes com insuficiência cardíaca.

**Métodos:** Estudo metodológico realizado em três fases, com validação metodológica segundo a técnica Delphi para desenvolvimento de tecnologia móvel, validação de conteúdo de 18 itens por juízes (porcentagem de concordância ≥90%) e pesquisa de satisfação dos pacientes (randomização aleatória) para comparação entre o aplicativo e um manual institucional, com análise estatística descritiva e inferencial (teste *U* de Mann-Whitney e Fisher) de quatro variáveis: idade, sexo, escolaridade e tempo de acompanhamento ambulatorial.

**Resultados:** O aplicativo VivaCor-IC contém 30 telas com informações, tais como sinais e sintomas, medicamentos utilizados, vacinas, impacto do tabagismo e atividades física e sexual, relacionadas ao autogerenciamento e à insuficiência cardíaca. As funcionalidades do aplicativo incluem registro diário de líquidos ingeridos e refeições, verificação de bem-estar, sinais e sintomas de descompensação e adesão ao tratamento. A avaliação dos juízes obteve concordância maior que 90% e aceitabilidade pela avaliação

[1]Universidade Federal de São Paulo, São Paulo, SP, Brazil.

**Conflicts of interest:** article extracted from the master's thesis "Construction and validation of a mobile application for self-management in patients with heart failure" by Haglaia Oliveira; 2022.

dos pacientes maior que 50%, em todos os itens. A diferença estatisticamente significante ($p$=0,024) foi observada em relação à escolaridade: o nível de escolaridade do grupo que avaliou o manual era maior que aquele do grupo que avaliou o aplicativo, porém não foi observada interferência na aceitabilidade do protótipo.

**Conclusão:** A criação do protótipo incluiu funcionalidades relevantes para o autogerenciamento e mostrou evidências de validade adequadas na avaliação de especialistas e pacientes.

## Resumen

**Objetivo:** Elaborar y validar un modelo de aplicación móvil para la autogestión de pacientes con insuficiencia cardíaca.

**Métodos:** Estudio metodológico realizado en tres fases: validación metodológica de acuerdo con el método Delphi para desarrollar la tecnología móvil, validación de contenido de 18 ítems realizada por jueces (porcentaje de concordancia ≥90 %) y encuesta de satisfacción de los pacientes (aleatorización) para comparar la aplicación con un manual institucional, con análisis estadístico descriptivo e inferencial (prueba *U* de Mann-Whitney y Fisher) de cuatro variables: edad, sexo, escolaridad y tiempo de seguimiento ambulatorio.

**Resultados:** La aplicación VivaCor-IC tiene 30 pantallas con información relacionada con la autogestión y la insuficiencia cardíaca, como por ejemplo signos y síntomas, medicamentos utilizados, vacunas, impacto del tabaquismo y actividad física y sexual. Las funcionalidades de la aplicación incluyen el registro diario de líquidos ingeridos y comidas, verificación de bienestar, signos y síntomas de descompensación y adherencia al tratamiento. La evaluación de los jueces obtuvo una concordancia mayor a 90 % y la aceptabilidad mediante la evaluación de los pacientes fue mayor a 50 %, en todos los ítems. Se observó una diferencia estadísticamente significativa ($p$=0,024) respecto a la escolaridad: el nivel de escolaridad del grupo que evaluó el manual era mayor que el del grupo que evaluó la aplicación, pero no se observaron interferencias en la aceptabilidad del modelo.

**Conclusión:** La creación del modelo incluye funcionalidades relevantes para la autogestión y mostró evidencias de validez adecuadas en la evaluación de especialistas y de pacientes.

## Introduction

Heart failure (HF) is a complex syndrome that results from structural and/or functional abnormalities of the heart and currently affects more than 23 million people worldwide.[1] Heart failure has a survival rate of 35.0% after five years diagnosis, which may reach 17.4% in individuals aged 85 years or over. Considering the low investments in health, inadequate patient access and insufficient monitoring of health services in Latin America, the risk factors are maximized and consequently, the pathophysiological processes favor the development and progression of the disease.[2]

In Brazil, data from the Brazilian Registry of Acute Heart Failure showed low adherence to medication treatment or changes in lifestyle habits as the main causes of readmission. This can lead to a significant reduction in quality of life and daily activities, in addition to high mortality. Therefore, planning and applying early and appropriate interventions in the basic health service is important to reduce the reversible causes of HF and inequalities in access to healthcare.[2]

Furthermore, poor management of the disease results in increased spending on hospital admissions, emergency care, early retirement and high socioeconomic costs. As this is a chronic condition, prioritizing the effective use of resources is essential to improve functional status and increase life quality and expectancy.[2]

The complexity of HF goes beyond the pathophysiology of the syndrome, is associated with poor prognosis, frequent comorbidities and polypharmacy, which alter the style and quality of life.[2] Therefore, self-management strategies and home programs are recommended to reduce hospitalization risks and mortality (evidence I).[1]

From this perspective, the self-management term acquires a broad interpretation. In a review study, its definition ranges from the skills to solve problems (or make changes in one's own behavior) and obtain certain results to the application of self-control techniques. The promotion of "autonomous and continuous learning" that favors both the reduction of health risk behaviors and prevention in the context of chronic conditions is a consensus and a global trend.[3]

When following the trends related to monitoring chronic diseases (arising from digital health strategies and resulting from the COVID-19 pandemic), the use of mobile technologies has shown a promising cost-effectiveness ratio, especially for telemonitoring and health education. It is possible to identify and monitor adherence to treatment, reduce readmissions and improve quality of life.[2,4]

Expanding and strengthening such actions are the objectives of the Digital Health Strategy (Ministry of Health). This initiative has nine priorities and aims to promote greater access to health services and information for the population (via interoperability) and integrate health systems, thereby favoring continuity of care. Engaging in treatment and encouraging co-participation of family members and caregivers are the expected results, so they can take on the protagonist role and manage their own health.[5]

We highlight that the American Heart Association (AHA) has been promoting the importance of integrating health service delivery systems with the practice of telehealth since 2017, increasing access and use of technologies, thus overcoming barriers for patients and providers. The strategies include the development of more intuitive and profitable platforms to reduce costs, specific evidence-based interventions and increased continuing education for staff and patients.[6]

The use of mHealth (or mobile technologies for health education) is a complex system that still presents considerable challenges, although it is versatile and has potential to generate transformations. As an example, we highlight the teaching-learning process based on different profiles, tools and functionality for self-care, internet connectivity, users' self-monitoring capacity, presence of comorbidities and personalized health. This is a multifactorial and multifaceted process that goes beyond the simple transmission of information.[6]

In the scenario of chronic diseases, where self-management requires relevant aspects of maintenance, monitoring and management,[7] the significant technological and methodological advances of mobile applications can offer adherence to self-care anytime anywhere. This technology uses sensors and artificial intelligence (for data analysis and risk prediction) and can support the collection and study of real-time physiological data, feedback, reminders, alerts, adherence control, behavioral assessment and information exchange with the multidisciplinary health team.[8]

On the other hand, given the popularization of this technology, it is necessary to consider social, cultural and behavioral aspects, including digital literacy, as there are still significant challenges that hinder the population's health equity.[9,10] It is urgent to evaluate the transformation of mobile technologies in the era of digital health. Therefore, the objective of the present study was to develop and validate a prototype mobile application (app) for self-management of patients with HF.

## Methods

In this technological and methodological validation study for the construction and evidence of validity of a mobile app, the following steps were followed: 1) Construction and development of the app prototype; 2) Validation (by judges) of the content related to self-management of the disease (Delphi technique) and 3) Evaluation of satisfaction and acceptability of the app by patients, including the comparison between two guidelines (app and institutional manual of a public hospital).

The first step, construction and development of the prototype, included the creation of layout, visual identity, logo, navigation and functionalities of the app prototype that were developed in cooperation with the Department of Health Informatics at the Escola Paulista de Medicina (EPM), Universidade Federal de São Paulo (UNIFESP). The theoretical content was based on Brazilian and international HF guidelines.[2] To this end, meetings were held with authors, a team of nurses and Information Technology professionals (computing, medical IT and design) to define the technical and methodological steps of development.

The guidance of the teaching-learning planning and the app's navigation items and functionalities were discussed between users and the healthcare team based on instructional design guidelines and aspects related to objective, target audience, theme, forms of data storage and communication. The steps of this development included analysis, design and development, implementation and evaluation phases, making it possible to periodically update and adapt the app.[11] The Android® system was the technological platform chosen to develop the prototype because of the technical team's expertise.

The creation of the layout, visual identity and logo was based on literature to identify the best color and shape options, correlating the target audience and the app's theme.

In the second stage, validation, the selection of judges was defined based on the following inclusion criteria: being a member of a multidisciplinary health team and a specialist in cardiology.

Recruitment was carried out by analyzing CVs on the Lattes Platform and searching for the terms "Cardiology" and "Heart Failure". Invitations were sent to 80 professionals by email. Within two months, response from 21 professionals with an average experience of five years in their respective professional fields was received. These professionals were nurses (15), physiotherapists (3), physicians (2) and a nutritionist (1). All had specialist degrees in cardiology, including PhD (11), Master (8) and Post-doctorate (2). By using an electronic form, professionals in four regions of the country were reached, as follows: Northeast (5); Central West (1); South (1) and Southeast (14).

The validation process was carried out in a single round, and 18 items related to the Objective, Structure and/or Presentation and Relevance of the app were analyzed using the Health Educational Content Validation Instrument (Portuguese acronym: IVCES)[12] to obtain a scientific basis for the validation of health educational material. A Likert scale containing the possibilities - 0: Disagree; 1: Partially agree and 2: Totally agree - was used for responses.

The third stage was carried out in a public hospital, where patients were selected adopting the following criteria: having heart failure, undergoing follow-up treatment at the institution's outpatient clinic, age over 18 years and literate.

Simple random sampling was used in the selection through the website random.org. The draw among 25 eligible patients took place at the institution outpatient clinic during routine consultations and resulted in ten participants who agreed to participate (five for each group after randomization).

The evaluation of satisfaction resulted from a subjective analysis of the intervention.[13] For the evaluation of satisfaction with the educational tools, the app was presented and printed screens were displayed. This was the initial prototype phase (mock-up). In the control group, the printed institutional heart failure manual was analyzed. This process took place between November 2021 and April 2022.

The recruited patients were allocated into two groups: the app group (average age; 54 years); and the manual group (average age; 57 years), which analyzed the hospital's educational material. Regarding outpatient follow-up time, the longest time reported by patients was 76 months, and the shortest time was 44 months. The group that evaluated the app through randomization had the longest length of outpatient follow-up.

Patients were met at the institution during routine consultations so their responses could be obtained. Material evaluation lasted 10-15 min; patients answered 13 items of the IVCES using the Likert scale (0: Disagree; 1: Partially agree and 2: Completely agree).[12] Only part of the instrument was chosen for both groups of patients; items 1, 2, 6, 9, 13 and 14 were not used because they required a more critical analysis of the material and judgment of information based on scientific evidence.

We highlight that patients did not evaluate the app by browsing the mobile device to avoid the need to train them to use it, as this would require prior assessment of their digital literacy, in addition to the analysis and response stages.[13] Ethical issues were also considered, as access to the app would require the provision of sensitive patient information.

We chose to use the content validity method by adopting the percentage of agreement in relation to an item equal to or greater than 90%. In this method, useful information is calculated by considering an agreement rate equal to or greater than 90% as acceptable among experts.[14]

Patients were assessed using descriptive statistical analysis and non-parametric U tests (Mann-Whitney and Fisher) due to the ordinal qualitative nature of responses. In both groups, the total organized sample was used to compare the following variables: age, sex, schooling and length of outpatient follow-up at the institution. The effect size difference between groups was estimated by calculating the Pearson coefficient ($r$).[15]

Data obtained were stored and organized in electronic spreadsheets. We highlight that the study and participant data were processed based on the guidelines and standards of the General Data Protection Law, which also guided the methodological processes.[16]

The study was evaluated and approved by the Research Ethics Committee of the Universidade Federal de São Paulo under number 3.006.852 (CAAE: 95310518.7.0000.5505).

## Results

As a result of the aforementioned technical and methodological processes, the VivaCor-IC mobile application resulted in 30 screens, including specific navigability characteristics, functionalities, layout, visual identity and logo. We emphasize that the name VivaCor-IC was created based on the acronym IC, the initials of *Insuficiência Coronária*, which is Heart Failure in Portuguese. The production of this series may continue considering the self-management of other pathologies (e.g., VivaCor-IAM, initials of heart attack, or VivaCor-HAS, initials of hypertension). The prototype video is available on YouTube® through the link: https://youtu.be/n1rKS4W_wWU.

### Prototype features

The initial screens of the prototype are focused on user registration, requiring full name, contact email, CPF number (similar to social security number), age and sex. Data related to fluid restriction will be required after the initial registration, when the healthcare team and medications used by the user are defined. The app features a section with informative topics related to HF (such as main signs and symptoms, pharmacological and non-pharmacological measures) for better control of the chronic condition. The objective of these topics is to reinforce knowledge about the disease as a form of health education, in addition to promoting adherence to treatment (Figure 1). Information on vaccinations, smoking (and its impact on heart disease) and safe sexual activity is also available.

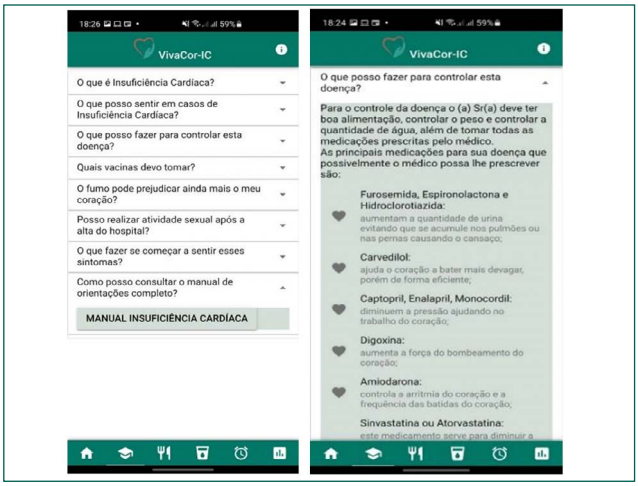


**Figure 1.** Graphical representation of the HF guidance screen on the VivaCor-IC prototype

The Fluid Control functionality makes it possible to enter the volume of fluid intake during the day, as well as water or fluid present in food (in units and/or slices). It is also possible to record the foods consumed and classify them as "good" or "bad" for an assessment according to their benefit, and to organize and record meals for monitoring by the healthcare team during routine consultations (Figure 2).

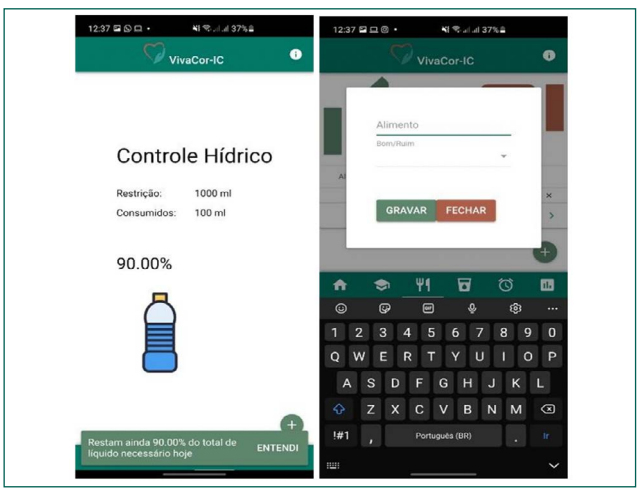


**Figure 2.** Graphical representation of the Fluid Control screen on the VivaCor-IC prototype

Adherence to medications, fluid restriction, volume of diuresis, daily weight and physical activity are also checked, as well as the presence of

symptoms such as weakness, dyspnea at rest, sudden weight gain, edema and perfusion of the lower limbs (Figure 2). Another feature is the daily check of signs and symptoms, which can be correlated to the general perception of well-being based on a face scale (Figure 3).

### Validation of the app by judges

The content validation of the VivaCor-IC application was performed by 21 judges through the IVCES. A percentage of agreement greater than 90% was achieved in the 18 items. The average agreement between domains reached high values for prototype objectives (98.0%), structure and/or presentation (99.0%) and relevance (98.0%) (Table 1).

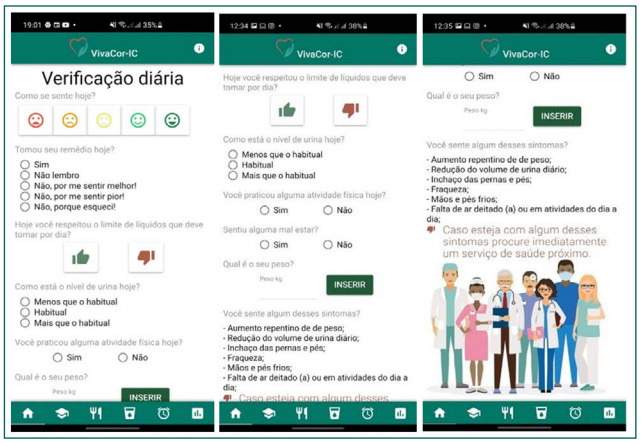


**Figure 3.** Record of fluid intake, meals eaten and daily check of general well-being based on signs and symptoms

### Analysis of the app by patients

The satisfaction of patient groups was evaluated based on the presentation and analysis of the institution's manual and the app screens. When comparing the manual and the app, no statistically significant difference was observed between the groups in relation to answers to questions of the IVCES ($p>0.05$). However, all items achieved total or partial agreement >90.0% in both groups. No statistically significant differences were observed in relation to the variables age, sex and length of follow-up at the outpatient clinic, except for schooling; its level was higher in the manual group compared to its level in the app group (Table 2). In the app group, the schooling variable was composed of patients with incomplete (60.0%) and complete (40.0%) primary education, showing that functional literacy did not hinder understanding and a statistically significant satisfaction rating ($p=0.024$) was obtained (Table 2).

## Discussion

Mobile technologies are a growing strategy in Digital Health, increasing access to health services

**Table 1.** Agreement values between judges based on the evaluation with the Health Educational Content Validation Instrument (IVCES)

| IVCES domains | IVCES items | Agreement | | | Agreement (mean %) |
|---|---|---|---|---|---|
| | | Partial | Total | % | |
| Objectives | 1. Includes the proposed theme | 4 | 17 | 100 | 98 |
| | 2. Suitable for the teaching-learning process | 6 | 15 | 100 | |
| | 3. Clarifies doubts about the topic covered | 4 | 17 | 100 | |
| | 4. Provides reflection on the topic | 4 | 17 | 100 | |
| | 5. Encourages behavior change | 6 | 13 | 90 | |
| Structure and/or Presentation | 6. Appropriate language to the target audience | 5 | 16 | 100 | 99 |
| | 7. Appropriate language for educational material | 4 | 17 | 100 | |
| | 8. Interactive language, allowing active involvement in the educational process | 7 | 14 | 100 | |
| | 9. Correct information | 4 | 17 | 100 | |
| | 10. Objective information | 4 | 17 | 100 | |
| | 11. Clarifying information | 6 | 15 | 100 | |
| | 12. Necessary information | 6 | 15 | 100 | |
| | 13. Logical sequence of ideas | 2 | 19 | 100 | |
| | 14. Contemporary topic | 1 | 20 | 100 | |
| | 15. Suitable text size | 6 | 13 | 90 | |
| Relevance | 16. Stimulates learning | 4 | 16 | 95 | 98 |
| | 17. Contributes to knowledge in the area | 2 | 19 | 100 | |
| | 18. Arouses interest in the topic | 4 | 17 | 100 | |

**Table 2.** Descriptive values and comparative analysis of the groups in relation to the schooling variable

| Schooling | Group | | Total n(%) | p-value | E.S. |
|---|---|---|---|---|---|
| | Application n(%) | Manual n(%) | | | |
| PS | 5(100.0) | 1(20.0) | 6(60.0) | 0.024* | 0.781 |
| SS | 0(0.0) | 1(20.0) | 1(10.0) | | |
| HE | 0(0.0) | 2(40.0) | 2(20.0) | | |
| PS | 0(0.0) | 1(20.0) | 1(10.0) | | |

Notes - Mann-Whitney U test; PS – primary school; SS – secondary school; HE – higher education; PS – postgraduate studies; E.S. – Effect size; *: statistically significant value at the 5% level ($p \leq 0.05$)

in a heterogeneous society with unequal conditions. Mobile applications occupy a position of notoriety amid advances in the use of technology for health promotion, and contribute to strengthen the educational actions by users in a more attractive way and to overcome psychosocial, economic and geographic barriers.[4,17,18]

Overcoming psychosocial, cultural, behavioral, economic and geographic barriers to ensure patient access to specialized HF treatments is a major challenge. However, advances in telemedicine (such as telehealth and telemonitoring) can significantly overcome such difficulties through the effective use of technological resources.[4]

The new generation of mobile health applications currently presents benefits such as reduced cost and increased accessibility for users with low digital literacy. These are instruments that disseminate and multiply education for the treatment of chronic conditions and adoption of healthy habits, in addition to promoting communication with the healthcare team.[18,19] Furthermore, they promote care safety by systematizing information for the better diagnostic judgment and effective decision-making.[20]

The present study offers alternative forms of monitoring. They make it possible to explore the potential of the multidisciplinary team and adapt technological interventions compatible with the reality of patients with HF to obtain better health results, such as self-management and quality of life. In relation to our results, we highlight the features of the VivaCor-IC app related to recording fluid intake during meals and daily checking of signs and symptoms, as they are important for self-management and the information is valuable for the healthcare team. Checking and recording sudden changes in weight, congestion, signs of anxiety, depression, quality of diet and level of physical activity are part of the teaching-learning proposal, in addition to the early detection of signs of HF deterioration (relevant records for reducing mortality). However, patients' adherence to technologies covers aspects beyond their functionalities and largely depends on their attitude towards treatment.[21]

In a study on behavioral changes conducted through a conversational interface, 72.0% of participants mentioned that the application could improve their self-care, becoming an additional support tool for treatment. During the recording time (10-12 days) of responses, the most selected mood options were "happy" and "calm", while at other times, "irritated" and "nervous" were selected due to technical flaws of the application, and privacy issues associated with the user's health condition. The authors highlighted that positive or negative emotions guide the acceptance of a new product. If they do not identify sufficient health benefits or present difficulties in using and/or understanding the information, users stop using or reduce the frequency of access to the application.[21]

In a systematic review by Cestari *et al.* (on HF mobile applications), the authors concluded that although the content of applications varies, more topics are needed, such as health vulnerabilities, palliative care and sexual activity.[22] We emphasize that the development of the VivaCor-IC app was based on high-level scientific evidence, daily challenges faced by patients with HF and recommendations indicated by national and international guidelines. The significant changes needed in lifestyle were considered, such as adapting eating habits, self-management and adherence to medication therapy, in addition to self-care through adequate exercise and energy conservation. This shows the incorporation of essential content to the self-management of these individuals, which guides health education interventions resulting in better health results.[6,23]

In another study by Souza et al. with a group of specialist nurses in the northeast region of Brazil, the prototype of an application was developed and validated, and it is added to the progress for im-

provement of self-care for people with HF using health technologies.[24] Aspects from different areas of health were considered, aiming to cover the various challenges and aspects of living with a chronic illness (such as coping with smoking, guidance on sexual relations, recording fluid intake according to restrictions). Furthermore, the prototype has a food guide (with percentage of fluids) for better control, as well as daily checking of signs and symptoms, involving the general perception of well-being and warning signs for consultation at a health service. Therefore, the differential of the VivaCor-IC prototype is that it was developed with multidisciplinary content to offer improvements for people living with HF, and it can be used by the different professionals monitoring the person with HF.

The aim of the information and functionalities of the prototype is to improve patients' understanding and influence their health literacy. Education is one of the most important elements in the management of HF and promotes "development of care skills to reduce the likelihood of hospitalization and to improve quality of life".[25]

Functional health literacy (FHL) corresponds to the use of knowledge by patients, combined with motivation and skills for their understanding, evaluation and application of health information to "make judgments and make everyday decisions regarding self-care" and carry out actions of disease prevention and health promotion. The protagonist role becomes the target of actions defined by the World Health Organization as "one of the social determinants of health" and key to reducing inequality. The FHL is also responsible for effective social participation in the deliberations of the Unified Health System, as the individual integrated into self-care actions becomes involved in decisions related to public policies and oversight of the system.[26]

This literacy can be achieved through health education interventions to improve both knowledge about the disease and treatment, and involvement in self-care activities, resulting in effective management of HF.[6,27] In fact, self-management of this disease challenges the traditional paradigm of health education, requiring active partnership from the patient, particularly when a technological innovation resource is used.

From this perspective of clinical practice, health professionals must understand that patients need encouragement to build a relationship of trust and partnership, so they can translate the knowledge acquired into daily actions of decision-making and self-care.[6]

Authors list the characteristics of competence, correspondence and relevance as important aspects of the health service for the acceptance of mobile applications in this area. Competence (psychological aspect) refers to the emotional responses that occur during the interaction between user and environment. Differently, correspondence refers to the ability of the service to meet the needs perceived by the users, and relevance refers to their perception of the service. These factors influence the trust and autonomy of users, who express their acceptance, including through privacy and security.[28]

Another study (follow-up of 30 patients with HF in the testing phase of an application to check its impact on quality of life and hospitalization rate) showed an average increase in quality of life (5.6%) and self-care (4.4%) after three months using the app. During the follow-up period, only one patient was hospitalized due to HF decompensation.[28]

In this context, the VivaCor-IC app presents several features, including signs and symptoms that alert to the need to seek urgent or emergency care and show when care can occur during a routine appointment. To improve patients' understanding and involve them in adherence to self-care, such features can promote appropriate support, stimulate behavioral changes and expand social skills.[29]

Regarding content validation of the VivaCor-IC app by judges, the results showed an agreement greater than 90.0% in all items of the instrument (Table 1), which not only suggests approval of this technology by cardiology specialists, but also agrees with the AHA trends that encourage the use of Digital Health to support treatment.[6]

Regarding the acceptance of the app by patients, the measurement instrument used showed agreement greater than 90.0%,[12] indicating that this public can also accept a mobile app as an integrating element into their treatment routine. It was

discussed that low education may be a reason for the lower adherence to technology observed.[30] On the other hand, our study showed that 60.0% of patients had incomplete primary education and this variable did not exert influence on the appropriate understanding and satisfaction with the VivaCor-IC, obtaining a significant statistical evaluation (p=0.024) (Table 2).

In fact, the scientific literature shows that a well-designed and coherent technology can overcome significant barriers such as digital literacy or educational level.[20,26,31] The development of the VivaCor-IC app was based on self-management programs developed by experts in the field, from significant evidence-based data related to readmissions and mortality due to HF.[29]

The limitations of the present study are related to the analysis of usability of the prototype.

## Conclusion

The VivaCor-IC app was created to contribute to the health education of users with heart failure, presenting essential features for self-management of this pathology. Validation by experts obtained appropriate agreement in all items evaluated in both groups, and good agreement was also achieved in relation to satisfaction with the manual and app, demonstrating its validity in all populations included in the study.

## Collaborations

Oliveira HMBS, Moreira RSL and Salvador ME contributed to the design of the project, relevant critical review of the intellectual content, analysis, interpretation of data, writing of the article and approval of the final version to be published.

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