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ORIGINAL ARTICLE

Needs and demands for mHealth cardiac health promotion among individuals with cardiac diseases: a patient-centred design approach

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Aims Cardiovascular diseases are one of the main contributors to disability and mortality worldwide. Meanwhile, risk factors can be modified by lifestyle changes. mHealth is an innovative and effective way to deliver cardiac health promotion. This study aims to examine the needs and demands regarding the design and contents of an mHealth intervention for cardiac health promotion among individuals with cardiac diseases. Different clusters were determined and analysed in terms of the intention to use an mHealth intervention.

Methods and results A cross-sectional study was conducted via a web-based survey. Three hundred and four individuals with coronary artery diseases (CADs) and/or congestive heart failure (CHF) were included in the data analysis. Descriptive statistics were applied to evaluate needs and demands regarding an mHealth intervention. A *k*-medoids cluster analysis was performed. Individuals with CAD and CHF favoured an mHealth intervention that supports its users permanently and is easily integrated into everyday life. Handheld devices and content formats that involve active user participation and regular updates were preferred. Three clusters were observed and labelled high, moderate, and low burden, according to their psychometric properties. The high burden cluster indicated higher behavioural intention towards use of an mHealth intervention than the other clusters.

Conclusion The results of the study are a valuable foundation for the development of an mHealth intervention for cardiac health promotion following a user-centred design approach. Individuals with cardiac diseases report positive attitudes in the form of high usage intention regarding mHealth. Highly burdened individuals report a high intention to use such interventions.

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Structured Graphical Abstract

Key question

Needs and demands regarding the design and contents of an mHealth intervention for cardiac health promotion and stress management.

Key findings

mHealth intervention.

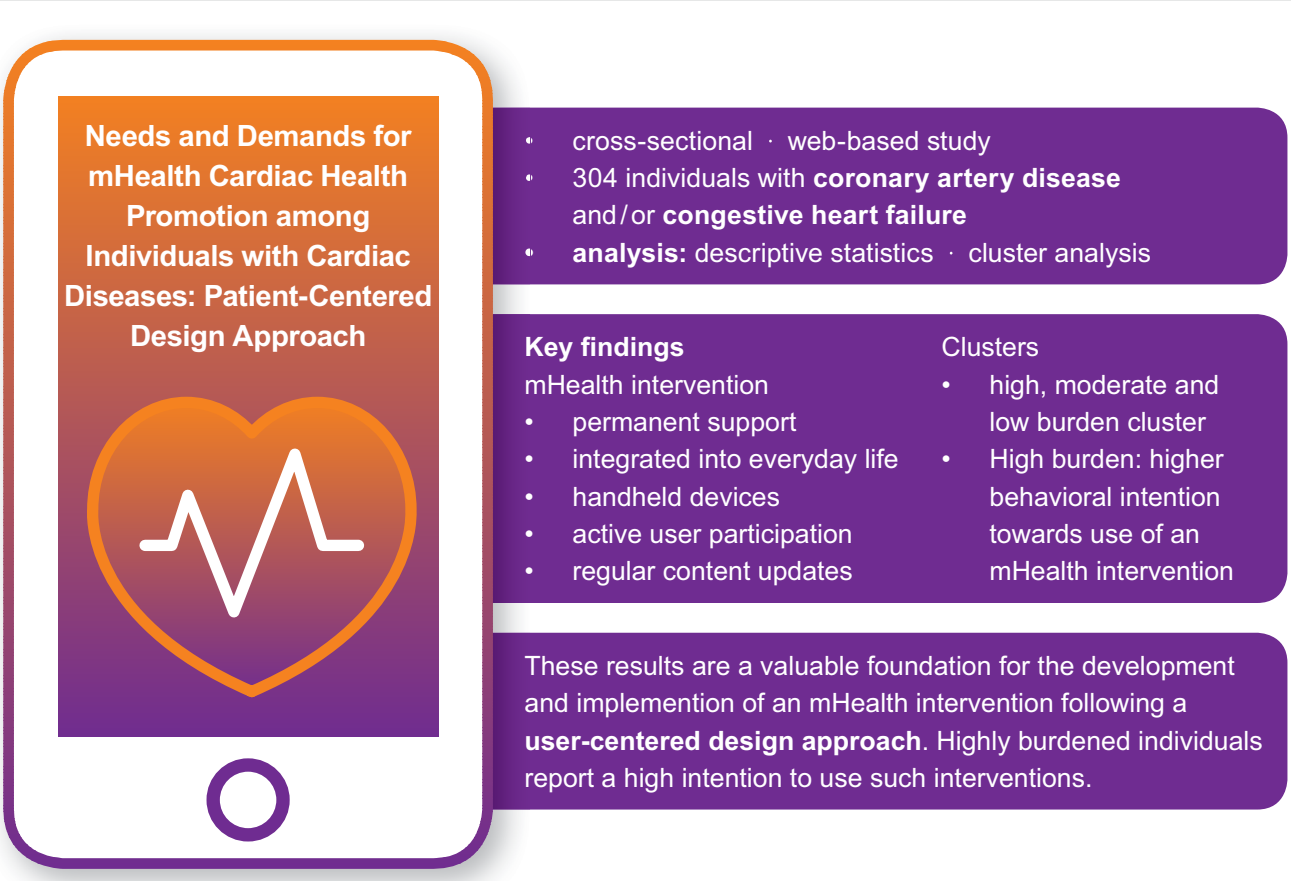
- Permanent support
- Integrated into everyday life
- Handheld devices
- Active user participation
- Regular content updates

Clusters

- High, moderate, and low burden clusters
- High burden: higher behavioural intention towards use of an mHealth intervention

Take-home message

These results are a valuable foundation for the development and implementation of an mHealth intervention following a user-centred design approach. Highly burdened individuals report a high intention to use such interventions.



Keywords eHealth • Mobile health • Cardiac diseases • Secondary prevention • Cardiac rehabilitation

Introduction

Cardiovascular diseases (CVDs) account for 17.9 million global deaths in 2019.[1] According to the Global Burden of Disease Study, CVDs 'are the leading cause of global mortality and a major contributor to disability,' and its burden is still rising worldwide.[2] Coronary artery disease (CAD) and congestive heart failure (CHF) are key players in CVD development. Risk factors include behavioural factors such as tobacco and alcohol use, lack of physical activity, unhealthy diet, and obesity.[1]

CAD and CHF are not limited to physical burden. Anxiety, depression, and chronic stress have been linked to both diseases[3] and the underlying mechanisms of these connections are multifaceted.[4,5] Poor mental health is related to adverse cardiac outcomes.[6] An important risk and prognostic factor for the development of both CAD and CHF is stress, which is, therefore, a main focus for preventive measures.[7] European guidelines for CVD prevention underline the significance of stress management.[7] Despite their importance, only a few validated interventions focusing on stress management for affected individuals are currently available.[7]

Electronic Health (eHealth) is an innovative way of healthcare provided by information and communication technology, which includes telemedicine, mobile health (mHealth), and health informatics.[8] eHealth interventions have been developed for a number of somatic diseases and mental health disorders and have been found to be effective tools to positively influence health-related outcomes.[9–14] Further, web- and computer-based interventions for stress management were able to reduce stress in a significant way, thus impacting the outcome for stress-related diseases.[15]

In a scientific statement by the American Heart Association, eHealth is considered a promising tool for secondary CVD prevention.[16] The positive effect of eHealth on health-related outcomes and health behaviour among individuals affected by different CVDs has been reported in a number of studies.[17–22] Smartphone applications (mHealth) might be especially feasible platforms for providing eHealth interventions because of their established use among patients.[23]

Despite its proven positive influence on health outcomes, barriers to use exist, especially for older individuals. Obstacles are affordability, usability, privacy, and security concerns.[16] Adherence to eHealth interventions focusing on CVD risk reduction in men was reported to be poor.[24] In a qualitative study of individuals with heart failure patients' refusal rate to use telehealth was high, and similar barriers were reported.[25] In another study, 20% of patients with heart failure or chronic obstructive pulmonary disease discontinued telehealth treatment.[26] These barriers need to be adequately addressed in the development of future eHealth interventions.

In recent years, the importance of user-centred design approaches in the field of digital health innovations has become more and more apparent.[27] A systematic review revealed that patients are only involved at a very late stage of the development process of digital health technologies and are therefore unable to meaningfully influence content and design decisions.[28] Centring patients' needs can therefore only be achieved if their interests are identified and taken into account at the earliest possible stage.

Patient characteristics presumably mediate the effects of eHealth on health-related outcomes and behaviour change and are therefore of high relevance during the development of new eHealth offers.[29] Cardiovascular and mental health are closely related.[30] Anxiety is associated with poor short-term and long-term outcomes in patients with myocardial infarction.[31] Higher mortality in patients with stable CAD is connected to both anxiety[32] and distress.[33] Health locus of control (HLoC) is an important determinant of health-related behaviours.[34] High internal HLoC is associated with a reduced risk of myocardial infarction[35] and increased physical activity in patients with HD.[36] Anxiety, distress, and HLoC are therefore essential influencing factors for cardiac health promotion and potentially shape the utilization of healthcare offers. Therefore, these different patient characteristics need to be examined with regard to their effects on behavioural intention towards use of an mHealth intervention.

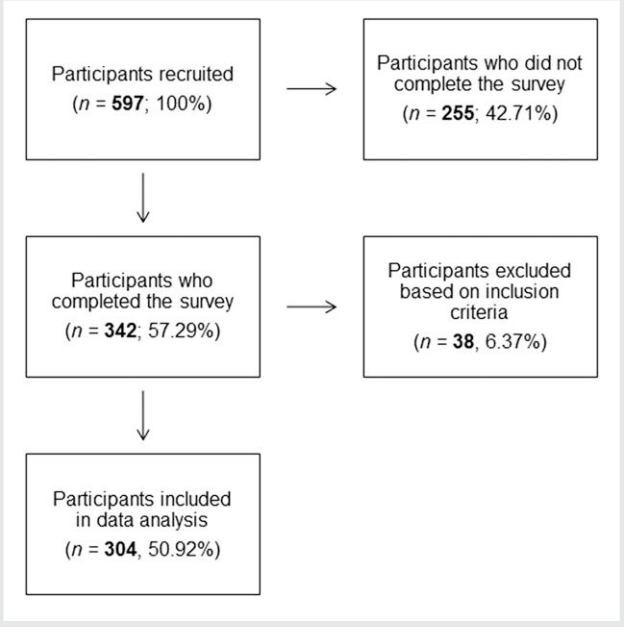


Figure 1 Flow chart of sample selection.

Objectives

The integration of patients' perspectives and preferences ensures that innovative mHealth interventions provide a relevant benefit to the subsequent target group and their health. Therefore, the aim of this study was to examine the needs and demands regarding design and contents of an mHealth intervention for cardiac health promotion and stress management in individuals with CAD and CHF. Furthermore, different clusters in the population of individuals with CAD and CHF, based on anxiety, distress, and internal HLoC, were determined, and their behavioural intention to use an mHealth intervention was compared between clusters.

Methods

Study design and participants

The cross-sectional study was conducted via a web-based survey on the platform Unipark from 21 November 2021 to 8 December 2022. Participants were recruited at the Department of Cardiology, West German Heart and Vascular Center, University Hospital Essen, in doctors' offices, self-help groups, and via social media channels targeted towards individuals with CAD and/or CHF. Eligibility requirements for participation in the study were a diagnosis of CAD and/or CHF, age of or above 18 years, good command of the German language, and internet access. Electronic informed consent was obtained before the beginning of the study and participation was anonymous and voluntary. No compensation was offered for participation. Sample selection is shown in *Figure 1*. Five hundred and ninety-seven individuals were reached by the recruitment. A total of 57.29% ($n = 342$) of the participants who started the survey completed the questionnaire. The highest number of dropouts (11.79%, $n = 68$) took place on the page determining medical history. A total of 6.37% ($n = 38$) participants were excluded because they did not fulfill the inclusion criteria, which resulted in $n = 304$ participants who were included in the final data analysis. Sample characteristics of the excluded participants are given in the Supplementary material online, *Table S2*.

The survey was conducted in accordance with the Declaration of Helsinki, and the Ethics Committee of the Essen Medical Faculty (19-89-47-BO) agreed to conduct the study.

Measures

The assessment consisted of sociodemographic, medical, and psychometric data. Further, the participants' needs and demands regarding an mHealth intervention for cardiac health promotion and stress management, as well as their behavioural intention to use such interventions were investigated. A summary of all items can be found in the Supplementary material online, *Table S1*.

Sociodemographic and medical data

Sociodemographic data included age, gender, marital status, level of education, occupational status, and community size by place of residence. Furthermore, medical history was obtained, which included diagnoses of CAD and CHF, experience of myocardial infarction and heart failure, use of medication, and smoking.

Psychometric data

Generalized anxiety symptoms were assessed with the Generalized Anxiety Disorder Scale-7 (GAD-7).[37] The scale is composed of seven items, which are rated on a four-point Likert scale (0 = 'not at all' to 3 = 'nearly every day'). Mild, moderate, and severe anxiety symptoms are indicated by cut-off scores of ≥5, ≥10, and ≥15, respectively. Internal consistency was high (Cronbach's $\alpha = 0.89$).

The visual scale of the Distress Thermometer (DT)[38] was used to measure distress (0 = 'no distress' to 10 = 'extreme distress'). Elevated distress is indicated by a score of ≥4 points.

Health locus of control was assessed with the German modified short version[39] of the Multidimensional Health Locus of Control Scale.[40] Internal consistency for the internal HLoC scale was acceptable (Cronbach's $\alpha = 0.71$).

Needs, demands, and behavioural intention of individuals with coronary artery disease and congestive heart failure

Needs and demands regarding an mHealth intervention for cardiac health promotion and stress management were assessed via different items, including dichotomous and Likert-scaled assessments, as well as open-ended questions. The self-generated items were well-established in a previous study.[41]

Participants expressed their preferences regarding availability of the mHealth intervention (e.g. computer, mobile phone), format of the content (e.g. application, material for download), session length (e.g. 1 week, permanently), availability of new content (e.g. daily, monthly), and duration of one session (e.g. 1–10 min, over 45 min). Additionally, participants were asked to rate the probability of using strictly technical support in case of problems with the mHealth intervention (service centre) on scale from 0 to 10 (0 = 'very unlikely' to 10 = 'very likely'). They also chose which contact channel they preferred for technical support (choice between telephone, e-mail, and in person).

Moreover, participants rated different topics that should be addressed by an mHealth intervention on a five-point Likert scale (0 = 'not relevant' to 4 = 'very relevant'). The list of topics was compiled by experts in the field of psycho-cardiology. Additional topics could be added by the participants via open-ended questions.

Behavioural intention to use an mHealth intervention for cardiac health promotion and stress management was measured according to the validated UTAUT model.[42] Four items were used to assess behavioural intention, and responses were given on a five-point Likert scale (e.g. 'I would use such an mHealth intervention if it were offered to me'., 1 = 'does not apply' to 5 = 'does fully apply'). Internal consistency was excellent (Cronbach's $\alpha = 0.90$).

Statistical analyses

Statistical analyses were conducted using R (4.0.3). Descriptive statistics were computed in the form of distributions, mean scores, and standard deviations for the respective items. Sum scores were calculated for GAD-7 and internal HLoC. For behavioural intention to use an mHealth intervention, a mean score was calculated. Three psychometric constructs assessing patients' burden and internal HLoC (GAD-7, DT, HLoC) were used to perform a cluster analysis. Hopkins' *H* statistic was used to evaluate the clustering tendency of the three constructs. The *k*-medoids algorithm was applied for its robustness against outliers. The *parameters* package[43] was used to identify the optimal number of clusters, which resulted in a three-cluster *k*-medoids cluster analysis. The model's overall cluster performance and classifiability were evaluated using a R^2 statistic and linear discrimination analyses, respectively. Differences in behavioural intention to use a mHealth intervention with a Wilcoxon signed-rank test. The level of significance was set to $\alpha = 0.05$, and *P*-values were adjusted for multiple testing via Bonferroni correction.

Results

Study population

Of $N = 304$ participants, 51.0% ($n = 155$) were female. The age ranged between 18 and 94 years, with a mean age of $M = 57.35$ ($SD = 13.35$). A total of 40.1% ($n = 122$) participants had experienced a myocardial infarction and 41.1% ($n = 125$) suffered from heart failure. For a further description of the study population, see *Table 1*.

A total of 25.3% ($n = 77$) reported being affected by mental illness. Individuals with CAD and CHF reported elevated distress levels of $M = 6.10$ ($SD = 2.84$, range 1–10). A total of 35.2% ($n = 107$) of the

Table 1 Sociodemographic and medical characteristics of individuals with coronary artery disease and congestive heart failure

	N (%)
Marital status	
Single	35 (11.5)
In a relationship	46 (15.1)
Married	156 (51.3)
Divorced/separated	42 (13.8)
Widowed	23 (7.6)
Other	2 (0.7)
Education	
No to lower secondary education/other	68 (22.4)
Secondary education	107 (35.2)
Higher education entrance qualification	56 (18.4)
University education	73 (24.0)
Occupational status	
In education	6 (2.0)
Unemployed	18 (5.9)
Sick leave	19 (6.2)
Partially employed	36 (11.8)
Fully employed	91 (29.9)
Retired	103 (33.9)
Other	31 (10.2)
Place of residence (population size)	
Large city (>100 000 residents)	198 (65.1)
Medium sized city (>20 000 residents)	55 (18.1)
Small town (>5000 residents)	27 (8.9)
Rural area (<5000 residents)	24 (7.9)
Medication: yes	211 (69.4)
Smoking: yes	50 (16.4)
Total	304 (100.0)

Table 2 Needs and demands regarding an mHealth intervention for cardiac health promotion and stress management in individuals with coronary artery disease and congestive heart failure

	N (%)
Availability	
Smartphone	284 (93.4)
Tablet	137 (45.1)
Laptop	89 (29.3)
Computer	83 (27.3)
Other	9 (3.0)
Format	
Application	258 (84.9)
Interactive training	192 (63.2)
Audio or video materials	145 (47.7)
Downloadable materials	135 (44.4)
Informative website	98 (32.2)
Other	10 (3.3)
Duration of use	
1 week	7 (2.3)
1 week to 1 month	18 (5.9)
1–3 months	44 (14.5)
Permanently	235 (77.3)
Frequency of new content	
Daily	50 (16.4)
Weekly	116 (38.2)
Every other week	36 (11.8)
Monthly	45 (14.8)
All content should be available from the beginning	57 (18.8)
Session length, min	
1–10	77 (25.4)
10–20	132 (43.6)
20–30	61 (20.1)
30–40	24 (7.9)
Over 45	9 (3.0)
Total	304 (100.0)

participants reached GAD-7 scores indicating mild generalized anxiety symptoms, 23.7% ($n = 72$) reported moderate generalized anxiety symptoms and 7.6% ($n = 23$) of the participants reached levels of severe generalized anxiety symptoms. In this sample of individuals with CAD and CHF, internal HLoC was high ($M = 11.13$, $SD = 2.18$, range 3–15). Overall, behavioural intention towards use of an mHealth intervention was high ($M = 4.04$, $SD = 0.93$).

Needs and demands regarding an mHealth intervention for cardiac health promotion and stress management in individuals with coronary artery disease and congestive heart failure

Individuals with CAD and CHF reported a variety of preferences regarding an mHealth intervention for cardiac health promotion and stress management. Responses are shown in *Table 2*. The mean probability of contacting technical support in the face of problems with the mHealth intervention was $M = 5.01$ ($SD = 3.14$, range 0–10). A total of 58.2% ($n = 177$) of the individuals with CAD and CHF preferred contacting technical support via e-mail, while 36.2% ($n = 110$) preferred contact via telephone. Only 5.6% ($n = 17$) indicated a preference for face-to-face support.

Relevant and irrelevant content for an mHealth intervention for cardiac health promotion and stress management

The most relevant topics for an mHealth invention for cardiac health promotion and stress management were 'Identifying situations causing heart-related stress' (89%), 'Personalized offers for coping with this situation' (86%), '24/7 self-assessment via app' (85%), 'Self-diagnosis via wearables (e.g. electrocardiograms)' (85%), and 'Information about how intensively I can exert myself or do sports' (85%). The topics 'Support to stop smoking' (60%), 'Reminder function for medication' (39%), and 'In-app communication with other heart patients' (30%) were considered to be the least relevant topics by individuals with CAD and CHF. For a detailed overview of responses, see *Figure 2*.

Participants provided additional answers regarding contents (e.g. professional information, contact addresses, support groups, guided meditation) and features (e.g. medical data management and transfer to a doctor, support via telephone, reminder function for daily exercise, emergency call with location recognition) and requested integration of existing apps and devices (e.g. wearables).

Cluster analysis of individuals with coronary artery disease and congestive heart failure

The available data (i.e. GAD-7, DT, internal HLoC) was suitable for clustering (Hopkins' $H = 0.42$). Fourteen out of 30 procedures (46.67%) for determining the number of clusters supported the choice of three clusters. A three-cluster analysis was performed based on the *k*-medoids method. Further evaluation of the model revealed a cluster performance of $R^2 = 0.517$ and an overall accuracy of classification of 94.41%. In order to make the results easier to comprehend, the following labels were chosen for the three clusters based on the psychometric characteristics: low burden (no anxiety, low distress, and high internal HLoC), moderate burden (mild anxiety, moderate distress, and moderate internal HLoC), and high burden (moderate anxiety, high distress, and moderate to high internal HLoC). A visualization of the three clusters is shown in *Figure 3*.

Behavioural intention to use an mHealth intervention was high for all three clusters (high burden cluster: $M = 4.33$, $SD = 0.65$; moderate burden cluster: $M = 3.73$, $SD = 1.13$; low burden cluster: $M = 3.84$, $SD = 0.97$). The high burden cluster reported a significantly higher behavioural intention towards use of an mHealth intervention than the low burden cluster ($P_{adj} < 0.001$) and the moderate burden cluster ($P_{adj} < 0.001$). Further characteristics of the different clusters, as well as their needs and demands, are given in the *Supplementary material online, Tables S3, S4*, and *Figure S1A–C*.

Discussion

In this study, the needs and demands regarding the design and contents of an mHealth intervention for cardiac health promotion and stress management were examined in individuals with CAD and CHF. Further, a cluster analysis was performed in order to examine different clusters in the sample population and to investigate the different clusters' behavioural intentions towards use of an mHealth intervention.

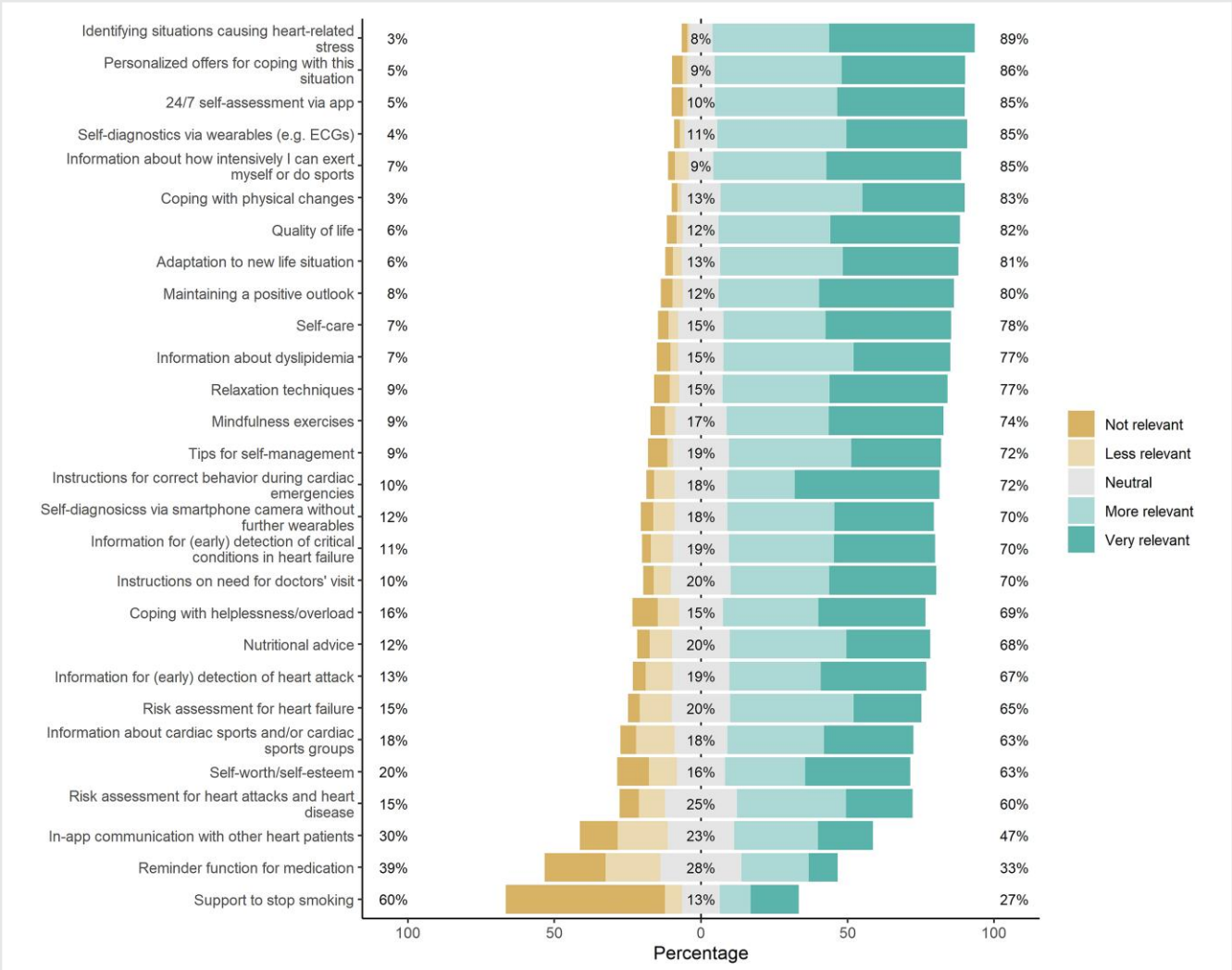


Figure 2 Relevant and irrelevant content for an mHealth intervention for cardiac health promotion and stress management.

In regards to the demands and needs of an mHealth intervention for cardiac health promotion and stress management, the overall preferred devices were smartphones, followed by tablets, while laptops and computers were in lower demand. In a sample of patients with peripheral arterial disease, similar preferences for smartphone applications were found, even for individuals who did not use smartphones.[44] This preference suggests that individuals with CAD and CHF favour handheld devices that are easily integrable into everyday life. This point is further underlined by the positive response towards an mHealth intervention that could be used permanently instead of an intervention that only accompanies them for a limited time period. In contrast to participants' demands, a meta-analysis revealed that apps used to increase physical activity are more effective when they are used in the short term.[45] The disparity between future users' preferences compared with the actual use and effectiveness of the intervention needs to be explored in the future.

Moreover, the preferred formats for the intervention were applications and interactive trainings. Participants also reported interest in audio and video formats and materials for download, while only a third expressed a need for an informative website. These results indicate that individuals with CAD and CHF favour content formats that involve active user participation in contrast to the passive presentation of information. A diverse combination of different content types should be sought, as there is generally a high interest in different options.

Over a third of individuals with CAD and CHF favoured weekly updates for the availability of new content. Less than a quarter of the participants thought that all content should be available from the beginning. Regular updates might be important for keeping users of mHealth interventions interested in continuous use and therefore increasing adherence to the intervention. Users might consider an mHealth intervention that provides a lot of information and content at once overwhelming. In a randomized controlled trial examining an app for health promotion in pregnant women regular updates and feedback increased use of the app and health behaviours.[46] Furthermore, a large part of the participants stated that they would use an mHealth intervention for 10–20 min per session, which highlights the need for a concise and purposeful presentation of content. The preferred time span might put some limitations on certain formats, e.g. videos. These results also demonstrate that individuals with CAD and CHF want the intervention to be integrated in a way that is suitable for everyday use and can be used without much additional effort. A study examining patients' experiences with an app for self-management of heart failure showed

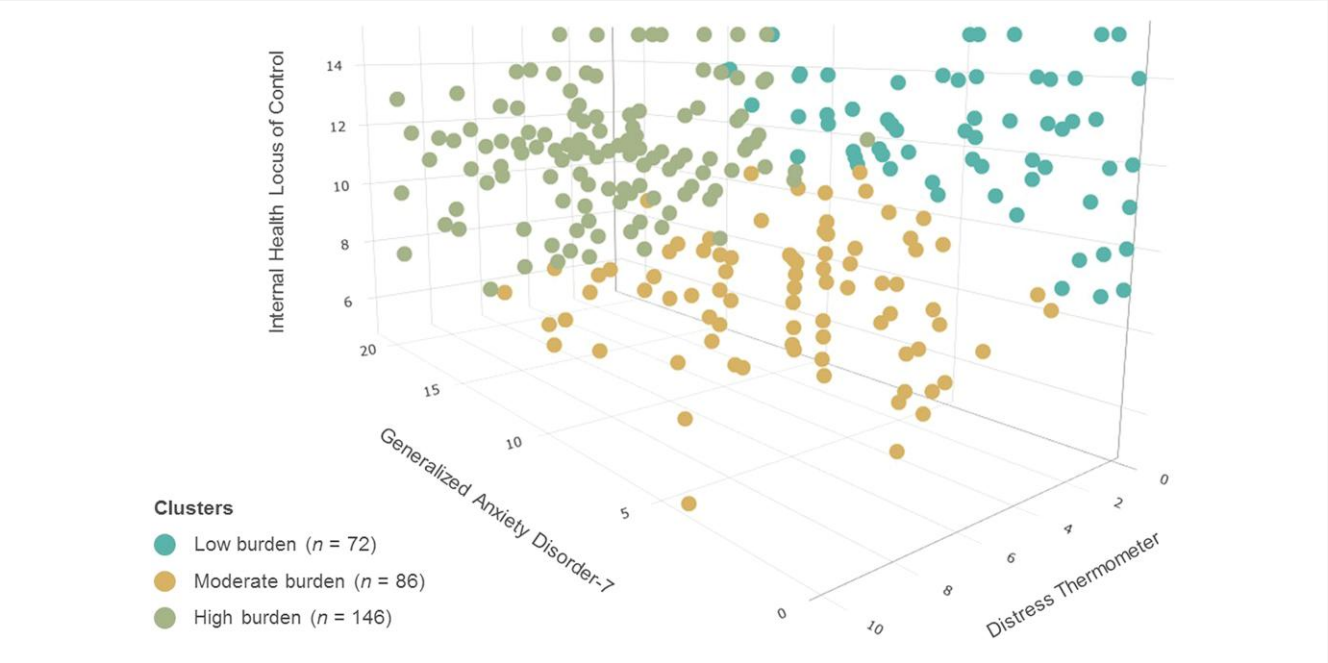


Figure 3 Three-cluster solution of individuals with coronary artery disease and congestive heart failure.

that an important barrier to actual app use is the failure to integrate new technology into patients' daily routines.[47] Integration into everyday life is therefore a key driver for increasing adherence to new mHealth interventions.

In terms of utilization of technical support, a moderate probability of contacting technical support could be observed, preferably via e-mail. As mentioned before, technical problems are not only barriers to use telehealth services, they often lead to withdrawal from study trials.[26] These findings underline the importance of streamlining contact channels for technical issues in a way that is convenient for the user. Preliminary testing of the technical functionality of the mHealth intervention may also be beneficial.

Regarding contents of an mHealth intervention, individuals with CAD and CHF stated the importance of identifying situations causing heart-related stress. Stressful life events have long been associated with a risk of CVD[48–50] and are therefore an important target for interventions that aim to prevent its worsening. Further, participants expressed a demand for personalized offers for coping with their situation, which confirms the need for user-centred design approaches. Two other important topics were self-assessment via app and self-diagnosis via wearables. Clinical benefits of wearables might include innovative preventative options and personalized disease management.[51] mHealth applications for self-management of CVDs are able to provide features such as parameter monitoring, real-time warnings ahead of changes in vital signs, or detection of atrial fibrillation.[52] Overall, a majority of the suggested topics were deemed important by patients with CVD. For this reason, an mHealth intervention for cardiac health promotion and stress management should offer a variety of individualized content.

Three clusters of individuals with pre-existing heart disease could be observed: low burden, moderate burden, and high burden. While the overall behavioural intention to use an mHealth intervention for cardiac health promotion and stress management was high, the high burden cluster reported a significantly higher behavioural intention towards use than the other two clusters. Studies investigating behavioural intention to use eHealth in different patient populations could show that a higher psychological burden predicted a higher level of behavioural intention.[53,54]

Limitations

The following limitations of the present study need to be considered for the interpretation of the results. As the data collection was conducted in a web-based form, sampling bias and self-report bias must be taken into account. Individuals who are already more aligned with digital devices might have been reached in a higher capacity than individuals who are resistant to innovative technologies. However, this group with resistance towards innovative technology should be factored into the development of mHealth interventions targeted towards individuals with cardiac disease. Only a small percentage of participants lived in rural areas or small towns. This demographic group is of high interest in the advancement of eHealth tools, as digital technologies may bridge a healthcare supply gap that is particularly present beyond large cities.[55] This study explored different clusters of the study population based on reported burden. Additional patient characteristics, such as e.g. differences in medical characteristics, might influence the needs and demands towards mHealth interventions. These factors should potentially be considered in subsequent research. Although this study took considerable efforts to be particularly attentive to the specific needs of patients, a broad spectrum of diverse patients was targeted. However, individual and disease-specific requirements need to be incorporated into the design and implementation of mHealth interventions. User-centred design approaches should be maintained during the whole process towards innovative healthcare tools and, if necessary, further specified in future steps. A third of the participants who started the survey dropped out before finishing the questionnaire. The highest number of dropouts was observed in the section assessing medical history, which might be explained by participants realizing that they did not fulfil the inclusion criteria of the study. However, there is no follow-up on the reason for drop out, which might amplify the selection bias.

Despite these limitations, this study provides a user-centred approach to examine the needs and demands of individuals with CAD and CHF for an mHealth intervention for cardiac health promotion and stress management.

Conclusions

This study outlines the needs and demands regarding the contents and design of an mHealth intervention for cardiac health promotion and stress management. Individuals with CAD and CHF favour an mHealth intervention presented on handheld devices. The intervention should support its users permanently and be easily integratable into everyday life. Content formats that involve active user participation and regular updates were preferred. The results of this study offer an opportunity to develop and implement interventions that are oriented towards the needs of their future users, which contributes to the improvement of specialized patient care in an evidence-based manner. It could be shown that individuals with cardiac diseases possess promising attitudes regarding innovative health technologies, which should be utilized in future research. A high intention to use mHealth interventions can be observed among highly burdened individuals, in particular.

Supplementary material

Supplementary material is available at *European Heart Journal – Digital Health*.

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Conflict of interest: None declared.

Data availability

Data available on request.

Authors' contributions

L.M.J., J.L., and A.B. conceptualized the study. Project administration was performed by L.M.J., J.L., C.M., and A.B. Statistical analyses were conducted by L.M.J. L.M.J. and A.B. interpreted the data. L.M.J., J.L., and A.B. wrote the original draft of the manuscript. T.R., C.R., C.M., E.-M.S., and M.T. supervised the project and contributed to the study design, data collection, and critical revision of the manuscript. All authors reviewed and approved the final manuscript.

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