A multi-stakeholder approach to eHealth development: promoting sustained healthy living among cardiovascular patients

Breeman, L.D.; Keesman, M.; Atsma, D.E.; Chavannes, N.H.; Janssen, V.R.; Gemert-Pijnen, L. van; ... ; Evers, A.W.M.

International Journal of Medical Informatics 147 (2021) 104364

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

A multi-stakeholder approach to eHealth development: Promoting sustained healthy living among cardiovascular patients

Linda D. Breeman [a], Mike Keesman [a], Douwe E. Atsma [b], Niels H. Chavannes [c], Veronica Janssen [a,b], Lisette van Gemert-Pijnen [d], Hareld Kemps [e,f], Wessel Kraaij [g], Fabienne Rauwers [a], Thomas Reijnders [a], Wilma Scholte op Reimer [h,i], Jobke Wentzel [d], Roderik A. Kraaijenhagen [j,k], Andrea W.M. Evers [a,l,*], on behalf of the BENEFIT consortium

[a] Health, Medical, and Neuropsychology Unit, Leiden University, The Netherlands
[b] Department of Cardiology, Leiden University Medical Center, The Netherlands
[c] Department of Public Health and Primary Care, Leiden University Medical Center, The Netherlands
[d] Centre for eHealth and Wellbeing Research, Department of Psychology, Health and Technology, University of Twente, the Netherlands
[e] Department of Cardiology, Máxima Medical Center Veldhoven, The Netherlands
[f] Department of Industrial Design, Eindhoven University of Technology, The Netherlands
[g] Leiden Institute for Advanced Computer Science, Leiden University, The Netherlands
[h] Department of Cardiology, Academic Medical Center, The Netherlands
[i] Faculty of Health, Amsterdam University of Applied Sciences, The Netherlands
[j] Vital10, Amsterdam, The Netherlands
[k] NDDO Institute for Prevention and Early Diagnostics (NIPED), Amsterdam, The Netherlands
[l] Healthy Society, Medial Delta, Leiden University, TU Delft, Erasmus University, The Netherlands

ARTICLE INFO

Keywords:
eHealth
User-centered design
Cardiovascular disease
Health behavior
Lifestyle
Mobile application

ABSTRACT

Background: Healthy living is key in the prevention and rehabilitation of cardiovascular disease (CVD). Yet, supporting and maintaining a healthy lifestyle is exceptionally difficult and people differ in their needs regarding optimal support for healthy lifestyle interventions.
Objective: The goals of this study were threefold: to uncover stakeholders' needs and preferences, to translate these to core values, and develop eHealth technology based on these core values. Our primary research question is: What type of eHealth application to support healthy living among people with (a high risk of) CVD would provide the greatest benefit for all stakeholders?
Methods: User-centered design principles from the CeHRes roadmap for eHealth development were followed to guide the uncovering of important stakeholder values. Data were synthesized from various qualitative studies (i.e., literature studies, interviews, think-aloud sessions, focus groups) and usability tests (i.e., heuristic evaluation, cognitive walkthrough, think aloud study). We also developed an innovative application evaluation tool to perform a competitor analysis on 33 eHealth applications. Finally, to make sure to take into account all end-users needs and preferences in eHealth technology development, we created personas and a customer journey.
Results: We uncovered 10 universal values to which eHealth-based initiatives to support healthy living in the context of CVD prevention and rehabilitation should adhere to (e.g., providing social support, stimulating intrinsic motivation, offering continuity of care). These values were translated to 14 desired core attributes and then prototype designs. Interestingly, we found that the primary attribute of good eHealth technology was not a single intervention principle, but rather that the technology should be in the form of a digital platform disseminating various interventions, i.e., a 'one-stop-shop'.

Abbreviations: CVD, cardiovascular disease; BCTs, behavioral change techniques; PHA, Personal Health Application.

* Corresponding author at: Leiden University, Faculty of Social and Behavioural Sciences, Department of Health, Medical and Neuropsychology, Pieter de la Court Building, P.O. box 9555, 2300 RB Leiden, The Netherlands.

E-mail addresses: L.D.Breeman@fsw.leidenuniv.nl (L.D. Breeman), M.Keesman@fsw.leidenuniv.nl (M. Keesman), D.E.Atsma@lumc.nl (D.E. Atsma), N.H.Chavannes@lumc.nl (N.H. Chavannes), V.R.Janssen@lumc.nl (V. Janssen), J.vanGemert-Pijnen@utwente.nl (L. van Gemert-Pijnen), H.Kemps@mmc.nl (H. Kemps), W.Kraaij@liacs.leidenuniv.nl (W. Kraaij), F.Rauwers@BB.leidenuniv.nl (F. Rauwers), T.Reijnders@fsw.leidenuniv.nl (T. Reijnders), w.j.scholteopreimer@amsterdamumc.nl (W. Scholte op Reimer), M.J.Wentzel@utwente.nl (J. Wentzel), Roderik.Kraaijenhagen@cardiovitaal.nl (R.A. Kraaijenhagen), A.Evers@fsw.leidenuniv.nl (A.W.M. Evers).

https://doi.org/10.1016/j.ijmedinf.2020.104364
Received 10 July 2020; Received in revised form 7 December 2020; Accepted 8 December 2020
Available online 13 December 2020

Conclusion: Various stakeholders in the field of cardiovascular prevention and rehabilitation may benefit most from utilizing one personalized eHealth platform that integrates a variety of evidence-based interventions, rather than a new tool. Instead of a one-size-fits-all approach, this digital platform should aid the matchmaking between patients and specific interventions based on personal characteristics and preferences.

1. Introduction

Cardiovascular disease (CVD) reduces quality of life, accounts for 45 % of all deaths in Europe, and annually costs €211 billion in productivity losses and healthcare provision [1]. In Europe alone, 85 million people live with CVD [1]. On the upside, modifying behavioral risk factors such as smoking, unhealthy diet, physical inactivity, stress and lack of sleep strongly improves prognosis of CVD [1,2]. However, initiating and maintaining a healthy lifestyle is exceptionally difficult with many people relapsing into old habits [2,3]. Over the past years, various technological solutions have become available to provide support anywhere and at any time [4,5], in addition to face-to-face counseling [6] and lifestyle modification programs [7]. Unfortunately, in eHealth development, the technology is all too often developed first, and content and context of use is only considered afterwards [8,9]. This leads to technological solutions that are not intuitive for its users – and thereby frustrating and time consuming – resulting in less effective interventions, uptake problems and costly developmental processes [8–10]. Thus, already in the early development phase, researchers should focus on stakeholder acceptance and engagement to ensure a good fit with user needs and preferences [11,12]. The CeHRes roadmap provides a guideline for eHealth development, implementation and evaluation, and emphasizes stakeholder involvement [10]. According to this guideline, technology design is always intertwined with business modeling in such a way that design choices influence technology implementation, technology acceptance, and sustainable use. Therefore, throughout the development and implementation phases, the various needs, preferences and abilities of stakeholders (including end-users) need to be weighed and balanced.

1.1. The current paper

The research described in this paper had three aims: First, guided by the notion of value-based healthcare [13], to explore various stakeholders' (i.e., patients, healthcare professionals, eHealth developers) needs and preferences concerning eHealth usage. Second, to translate these needs and preferences to a set of core stakeholder values. Three, iteratively design and evaluate eHealth technology to support healthy living based on these core values and insights from scientific research. In the current paper, we describe all steps taken during the research and development processes and summarize various research activities to answer the question *"What type of eHealth technology to support healthy living among people with CVD would provide the greatest benefit for all stakeholders?"*.

2. Methods

2.1. Stakeholder consortium and core team

We followed the widely used CeHRes roadmap for eHealth development and founded the nationwide *BENEFIT-for-all* consortium, consisting of academic research centers, cardiac rehabilitation centers, a patient federation for people with CVD, and eHealth entrepreneurs [14]. In addition, the multidisciplinary core research and development team included clinically and/or research oriented professionals and entrepreneurs (e.g. psychologists, physicians, cardiologists, internists, IT specialist) of all career levels (PhD students to full professors) with academic and/or clinical expertise in health and medical psychology, behavior change techniques, and user-centered design principles. This study has been approved by the Psychology Research Ethics Committee (registration number 2020-04-14-A.W.M.Evers-V2-2271) and the BMS Ethics Committee (registration number BCE18142).

2.2. Research approach and iterative development

We followed the iterative approach to eHealth development as proposed in the CeHRes roadmap. With an iterative approach, results and data-analysis procedures are intertwined.

2.2.1. Phase 1: contextual inquiry

Goal of this phase was to gather information from stakeholders and the context in which the technology will be implemented, to identify important values and requirements to which eHealth technology to support healthy living in the context of CVD prevention and rehabilitation should adhere to (i.e., 'co-creation phase'). Activities included examining existing knowledge, conducting a series of stakeholder interviews, and conducting a competitor review.

2.2.1.1. Existing knowledge. To learn more about developing effective eHealth interventions to promote lifestyle changes, literature was examined concerning the following topics: 1. General mechanisms important in supporting a healthy lifestyle (e.g., literature regarding behavioral change techniques (BCTs) such as the 'Integrated Behavior Change Model') [15,16]. 2. Characteristics of existing eHealth applications that support a healthy lifestyle, determinants of adherence to these applications and their effectiveness (e.g., literature regarding Persuasive System Design) [17,18]. 3. Conditions under which rewards contribute to adherence and effectiveness of eHealth interventions (e.g., literature regarding intrinsic and extrinsic incentives) [19–21].

2.2.1.2. Stakeholder activities. We recruited participants from various backgrounds, differing in needs and (technological) abilities. All participants were fully disclosed on the purpose of the studies before the start of each study. All qualitative data were analyzed with a content analysis approach [22], where the interpretation depends merely on the data and not on theoretical or technological models. As such, transcripts of the interviews were coded and clustered into meaningful themes. In total, six stakeholder activities were performed: 1. An interview study with 10 CVD patients to identify important aspects of lifestyle change for which patients may need support, their self-management skills and needs, and how their healthcare could be improved by eHealth technology [23]. 2. The same 10 patients participated in a usability test of a beta version of an eHealth application, in order to assess how such an application is used by this population, as well as identifying requirements for supporting and motivating chronically ill patients in self-care management and program adherence [23]. 3. An interview study with 16 healthcare professionals involved or specialized in the prevention and rehabilitation of CVD (i.e., CVD nurse practitioners, physician-scientists, physical therapists, and a lifestyle coach, physician assistant, general practitioner, psychologist and neurologist) to uncover professionals' needs regarding helping patients achieve a healthy lifestyle, their perspective regarding patients' support needs, the use of eHealth, and its implementation in routine care. 4. A focus group with 10 stakeholders (e.g., patients with a history of CVD, patient representatives, a general practitioner, the CEO of a healthy eating initiative), to discuss the biggest barriers and potential game-changers to support healthy living among people with CVD. 5. Interviews with 6

representatives of CVD healthcare facilities (e.g., hospital, cardiac rehabilitation center, general practice) to discuss their needs when supporting a healthy lifestyle in their patients, their current use of eHealth, and what - to them - would constitute a successful eHealth application. 6. Discussions with commercial eHealth developers concerning their needs when developing commercially viable eHealth interventions.

2.2.1.3. Competitor review. Much can be learned from studying other eHealth applications. Therefore, members of the core research team were asked to list the, to them, best-known eHealth applications for healthy living for the following lifestyle domains; physical activity, smoking cessation, alcohol reduction, healthy dieting, stress reduction, and sleep improvement. In addition, per lifestyle domain, the two most popular applications in the Google Play Store were selected (October 2018) resulting in a list of 33 eHealth applications. A new application evaluation tool (see Appendix A) was designed by combining elements from the following instruments: 1. Dutch Municipal Medical and Health Care Service app checker "GGD" [24], 2. Mobile App Rating Scale "MARS" [25] and 3. Dutch Medical App Checker "MAC" [26]. Our newly developed evaluation tool was innovative in the sense that it provided the possibility to evaluate eHealth applications according to functionality, aesthetics, presentation of information, engagement, customization, and reliability, combined with the evaluation of fundamental BCTs (i.e., goal setting, action planning, monitoring behavior, feedback on progress, goal revision) to assess their potential quality and effectiveness [27]. For one week, each app was used on a daily basis by two nursing students (out of six students total) specialized in technology-based healthcare, who then evaluated these applications.

2.2.2. Phase 2: value specification

Based on the contextual inquiry, the aim of this phase was to identify how most value could be created for all stakeholders. This was done by synthesizing all findings (i.e., eHealth technology values and requirements) from all research activities and then translating these values and requirements into desired core attributes of the technology. Activities in this phase included data synthesis, creation of 'personas', developing a customer journey, and validation of findings with stakeholders.

2.2.2.1. Data synthesis. Data from the previous research activities were synthesized to uncover how most value could be added– within the possibilities of the project– to support healthy living in the context of cardiovascular prevention and rehabilitation by use of eHealth technology. During a research team meeting, a list of core values, derived from the various stakeholders interviews, and insights from the competitor and literature review, was drafted.

2.2.2.2. Personas and customer journey. A user-centered design method that makes sure to take into account all end-users is creating 'personas' [28–30]. Each persona (i.e., user archetype) represents a target group and consists of a description of the future user. Based on multiple guidelines [30,31] we created personas from a holistic viewpoint, and defined relevant characteristics for our population, such as demographics (e.g., age, sex), medical and psychological profile (e.g., health status, motivation), abilities (e.g., lifestyle, technology use), and needs (e.g., autonomy, simplicity). These characteristics were mapped on different user profiles and after refinement of characteristics, eight personas were developed (see Appendix B). Taking into account these personas with their respective characteristics, core values were

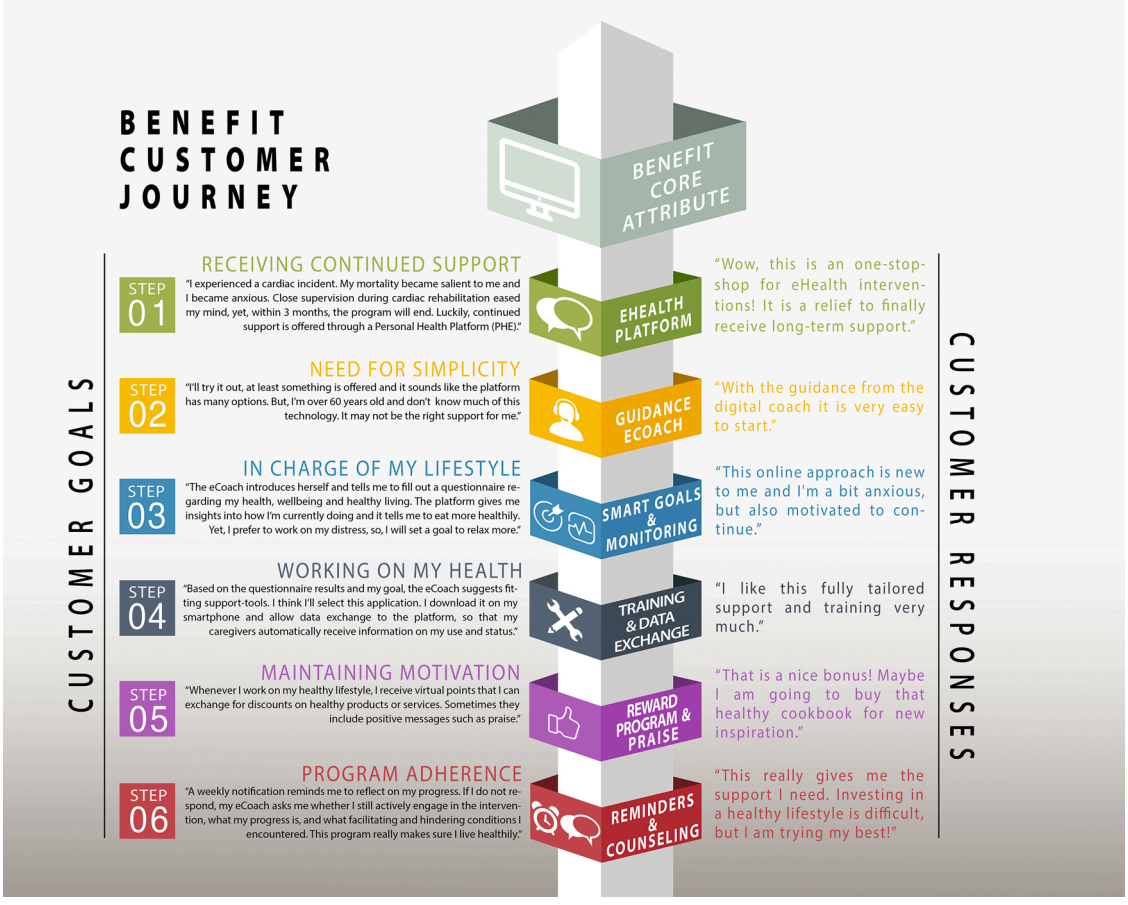

Fig. 1. BENEFIT Customer Journey.

translated to eHealth requirements. To provide the technology development team with an overview of the purpose of each eHealth requirement, core values and requirements were logically structured and a customer journey was created, i.e. a potential scenario of the context and use of the technology (see Fig. 1). The customer journey describes one end-user's process and experiences with the intervention trajectory as a whole. Although all personas are expected to follow the same core activities in the customer journey (e.g. filling out lifestyle questionnaires, measuring blood pressure values), frequency of use, goals, interactions with healthcare professionals, resulting emotions and (health) behaviors are expected to differ between personas.

2.2.2.3. Validation. Stakeholder values as derived from the data synthesis were thoroughly discussed until consensus was reached. First during a stakeholder committee meeting consisting of potential end-users and a representative of the Dutch Cardiac Patient Association ($N = 4$) and second, during a meeting with all BENEFIT consortium members; ranging from researchers in the field of health psychology and eHealth to private parties in eHealth, nurses, cardiologists, game designers, and an economist ($N = 34$).

2.2.3. Phase 3: iterative prototype design and evaluation

The goal of this phase was to use the identified core attributes to iteratively design prototype applications and testing these prototypes with intended end-users and other stakeholders (i.e., 'agile development phase'). Thus, the core research and development team continuously collaborated together in iteratively creating and improving the eHealth's technology content and design. Together, they translated each of the core attributes into tangible prototype designs, while also creating the underlying data architecture and functional requirements (e.g., registration process, user login, safe data storage, and smooth exchange of healthcare information).

During this iterative process, four more activities were undertaken to evaluate and further improve the technology. 1. A clickable demo of the application was evaluated using a cognitive walkthrough, based on three scenarios of how end-users would use the technology [32]. The evaluation was conducted by experts in persuasive health technology ($N = 6$) who provided advice regarding persuasive design elements. 2. A heuristic (i.e., expert) evaluation was conducted among the core research team ($N = 7$) to assess functionality, aesthetics, engagement, BCTs, and potential bugs in the system. 3. To improve future uptake, the technology was tested among patients who currently participate in ($N = 5$) and recently completed ($N = 8$) cardiac rehabilitation. Patients received prototypes of a 'very brief advice' (i.e., an information-based intervention delivered by health professionals aimed to entice patients to improve their lifestyle using the application) [33] and responded to questions concerning when and how they would like to be approached to use the application. 4. A 'think aloud study' [34] was conducted with the same patients currently participating in cardiac rehabilitation ($N = 5$). Patients were provided with a clickable demo of the technology and asked to use it so as to suit their own needs. During usage, they were asked to speak out loud about what they saw, what they did within the application, and why. Based on all feedback, the technology was further refined and beta-tested.

3. Results

With all research activities performed, we achieved the three goals of this study: to uncover stakeholders' needs and preferences, to translate these to core values, and develop eHealth technology based on these core values. Thus, it was also possible to answer our research question '*What type of eHealth technology to support healthy living among people with CVD would provide the greatest benefit for all stakeholders?*' The data synthesis yielded a long list of needs and preferences from the various stakeholder activities. During the validation phase, consensus was reached regarding 10 core values for eHealth development based on these stakeholders needs, preferences and abilities. Next, information on core values, insights from scientific studies regarding BCT principles, insights from persuasive system design, and insights from the competitor analysis, were used to translate the 10 core values into 14 core attributes for eHealth development (please see Table 1 for an overview of all core values and attributes and Appendix C for screenshots and information on integration of core attributes). We will now elaborate more on these core values and according attributes.

Values 1−2: Patients indicated that to support sustained healthy living, interventions should become and remain accessible, irrespective of current point of care (e.g. primary, secondary, tertiary care). An eHealth application can provide in this, for example, by offering a personal membership independent of a specific healthcare provider. In addition, many healthcare professionals indicated that providing support for healthy living was mostly a peripheral activity for them, and although healthcare professionals expressed the wish to receive an overview of eHealth applications to promote healthy living, they neither have time nor receive reimbursements to keep track of current developments. Since a shift in healthcare professionals' work towards prevention and lifestyle management are not foreseen in the near future, support may best be (partly) outsourced to external parties and interventions. Then, support should focus on easing referral to the right interventions to increase patient enrollment, engagement and decrease drop-out. Also, new eHealth technology will only be used on a large scale if it automatically exchanges data with the current Health Information System (e.g., information on smoking status or blood pressure), to avoid producing 'double' administrative work for healthcare professionals. From these values and the insights from the competitor analysis that there already is an abundance of eHealth applications to support healthy living, we reached the conclusion that creating a new eHealth application incorporating similar BCTs may be of little value for people with CVD. For healthcare professionals, the development of new applications is also difficult to keep track of. For entrepreneurs, eHealth development is a competitive market. From their perspective, applications have a need for more users, especially users who use the application for an extended period of time. Thus, the crucial lesson here was that value for stakeholders would not be created by reinventing the wheel (i.e., developing yet another application aimed at inspiring behavior change). Rather, there was more need for one central Personal Health Application (PHA), i.e., the connective tissue that brings together various (evidence-based) lifestyle modification programs, apps and devices from various providers in one central place. Such a 'one-stop-shop' or ecosystem for healthy living would make it possible to match lifestyle interventions to the right users based on end-users' needs and preferences, thereby stimulating engagement and active use.

Value 3: Patients with CVD are put off by being treated as a patient or number and luckily eHealth offers possibilities for a personalized approach. In addition, whether a person will benefit from a specific intervention depends both on the intervention's characteristics (e.g. group vs individual, phone-counselling vs smartphone application) and the person's characteristics (e.g. literacy, motivation, amount of time available). The intervention should thus be tailored to the end-user as much as possible.

Value 4−5: Both patients and healthcare professionals indicated the importance of autonomy support and providing means for patients to stay healthy, feel safe, and help prevent new CVD incidences. This can be accomplished among others by: 1. Increasing intervention effectiveness. Scientific literature on goal setting and self-control theory suggest that there are key components such as goal setting, action planning, health and behavior monitoring, feedback on progress, and goal revision, that a health intervention needs to bring forth actual behavior change [35–39]. From the competitor analysis, it became clear that many eHealth interventions already incorporated (some) of these components. These components were further supported by stakeholder interviews. For example, goal setting was valued by patients as a way to strengthen

Table 1
Core values and according core attributes for eHealth development.

#	Core values	Source	Rationale	#	Core attributes
1	Providing continuous care	•patients	Interventions should become and remain accessible, irrespective of current point of care. Support for professionals should focus on easing referral to the right interventions to increase patient enrollment, engagement and decrease drop-out.	**1**	Ecosystem for healthy living: An integral Personal Health Platform (PHA) that provides access to a variety of (evidence-based) interventions, independent of care provider (design slide 2*)
2	Reduce burden on healthcare professionals	•healthcare professionals	The technology should automatically exchange data with current Health Information Systems to avoid producing 'double' administrative work for healthcare professionals.	**2**	Automatic exchange of data between Health Information Systems and interventions (design slide 3–4*)
3	Providing a human-centered approach	•patients	The intervention should be tailored to personal characteristics as much as possible.	**3**	Personalization and human centered approach (design slide 5–6*)
4	Supporting the patients' autonomy	•patients •healthcare professionals	*Increasing intervention effectiveness*. The scientific literature on goal setting and self-control theory suggest that there are key components a health intervention needs to bring forth actual behavior change.	**4**	Incorporating the following key components: goal setting, action planning, monitoring health and behavior, feedback on progress, and goal revision (design slide 7–8*)
5	Providing means for patients to stay healthy, feel safe, and help prevent new CVD incidences	•patients •healthcare professionals	*Increasing motivation*. The scientific literature on motivation suggests that providing external contingencies can help improve short-term motivation for behaviors that are not inherently interesting.	**5**	Reward program (design slide 9*)
				6	Praise messages (design slide 10*)
			Increasing program adherence. To promote program adherence, it may help to send reminder messages for unperformed tasks not inherently interesting.	**7**	Reminder messages (design slide 11*)
			Providing education and skills training. To live healthily, people need more than the right mindset, they need the skills to do so.	**8**	Education and skills training (design slide 12–15*)
6	Inclusion of patients' social environment, improving social support	•patients	It is important to include the social environment in healthy living initiatives. It is important to highlight healthy initiatives in the patients' environment that may increase a healthy behavior change.	**9**	Involving social environment to maintain health goal or outcome (design slide 16*)
				10	Ecosystem of healthy living: Salience of healthy living initiatives in the environment (design slide 17*)
7	Simplicity and guidance	•patients	The usability and attractiveness of eHealth technology can be increased by design simplicity and design strategies.	**11**	Tunneling: guidance through a digital coach (design slide 18*)
				12	Simulation: modeling the right behavior (design slide 19*)
8	Personal contact	•patients •healthcare professionals	To increase therapeutic alliance and adherence, personal contact through eHealth may be less burdensome and flexible than face-to-face contact.	**13**	Chat, phone, and/or video counselling (design slide 20*)
9	Trustworthy	•eHealth developers	The use of eHealth can be supported by increasing its surface credibility and perception of trustworthiness.	**14**	Cues of trustworthiness (design slide 21*)
10	Financially self-supporting	•eHealth developers	The eHealth application should be financially self-supporting.		N/A

* For the design templates of core attributes, see Appendix C.

their autonomy and to help remind them of their ultimate goal (e.g., to see the grandkids grow up), thereby increasing motivation and maintenance of health outcomes. Also, health monitoring (i.e., providing the means for taking objective measures) and progress monitoring (e.g., by means of activity tracker) was valued by patients to meet their need to feel safe. 2. Increasing motivation. Scientific literature on motivation suggests that providing rewards can help improve short-term motivation for behaviors that are not inherently interesting (e.g. taking the stairs, eating a carrot) [19,40,41]. However, providing praise and rewards in eHealth interventions is only effective when the program requires active engagement from users (e.g. goal setting, coaching), rather than being a passive intervention. 3. Increasing program adherence. To promote program adherence, it may help to send reminder messages for unperformed tasks not inherently interesting. 4. Providing education and skills training. To live healthily, people need more than the right mindset (e.g., motivation for healthy diet), they need the skills to do so.

Value 6: Patients indicated the importance of the social environment in initiating and maintaining health behaviors and their preference for the inclusion of their social environment in their healthy living initiatives. Also, stimuli in the environment can induce distress or cravings, which may in turn elicit unhealthy behaviors. It is thus important to also highlight healthy initiatives in the patients' environment that may increase a healthy behavior change.

Value 7: Patients value simplicity and guidance. The platform should therefore have a coaching and support system to help coordinate each patient's journey and monitor patients' progress. In addition, the usability and attractiveness of eHealth technology can be increased by design simplicity and design strategies such as reduction (e.g., clear design, not providing too much information), tunneling (e.g., guiding the user with a digital coach), and simulation (e.g., modeling the right behavior).

Value 8: A strong preference was indicated by both patients and healthcare professionals for personal contact to increase therapeutic alliance and adherence. Chat, phone or video counselling may be less burdensome than face-to-face contact, as it is flexible, requires no travel time for the patient, and less office space is required for professionals.

Value 9−10: Two core values were deducted from input by eHealth developers, being the trustworthiness of the application and the fact that the technology should be financially self-supporting in order to remain accessible for all end-users. This last value requires a successful business model.

4. Discussion

A user-centered and iterative design approach was undertaken to uncover what type of eHealth application to support healthy living among people with CVD would provide the greatest benefit for all stakeholders. Insights from a wide range of stakeholders (i.e., CVD patients, nurses, medical specialists, patient representatives, eHealth entrepreneurs) and scientific researchers were incorporated from the conception stage to final design. In line with other research, it became clear that our various stakeholders had both overlapping and unique needs and preferences [42]. For example, unique for healthcare professionals was the need that eHealth technology should help reduce their (administrative) workload and increase patient contact, while patients indicated a need for a more human-centered approach and more continuity in care. Although a reduced workload for professionals may seem contradictory with more patient contact, the overlapping value here is that both these stakeholders find personal contact important. Although challenging [42,43], connecting stakeholder needs to scientific evidence concerning BCT principles, insights from persuasive system design and feasibility considerations to compose a list of stakeholders' core values and according core technology attributes may be essential to stimulate the required behavior change [8,10,42,44]. Similar approaches have been described previously [44,45], stressing the need to create an overview of the various needs and preferences of stakeholders involved.

One of the main results from the various studies is that providing a one-stop-shop PHA for lifestyle interventions may be key to support healthy living in the context of cardiovascular prevention and rehabilitation. A PHA would form the connective tissue that brings together various (evidence-based) lifestyle modification programs, apps and devices in one central place. This enables tailoring interventions to patient's needs and preferences and thus a personal approach which is in line with values such as personalized and participatory care, also put forward in the notion of P4 medicine [46]. The solution to create an ecosystem for healthy living is not unique. For example, an ecosystem (referred to here as 'toolkit') in the field of infection prevention and antimicrobial stewardship was put forward because of the complex situation calling for tailored interventions that utilize the same overarching infrastructure [45]. Also, a health services ecosystem has also been implemented in Trento (Italy), to take advantage of modern technology to enable various stakeholders to exchange intervention resources and patient monitoring with the goal to produce mutual benefits for all [47]. Collaboration is indeed vital, also because different interventions may support one another as they focus on interrelating aspects of healthy living. For example, a smoking cessation program may indicate that their users could benefit from healthy eating support, as weight-gain is a primary reason for relapse after smoking cessation [48].

For CVD patients, it makes sense to offer the eHealth technology the moment they are highly motivated to make (lasting) behavioral changes, which is usually soon after a CVD event. This is why we choose to introduce the PHA during cardiac rehabilitation, which additionally provides the opportunity to help and train patients in eHealth usage and involve the patients' social network to improve motivation for sustained behavior change. During cardiac rehabilitation, the PHA's focus should be on self-management, yet providing support and personal contact if needed, to bridge the gap between care and prevention.

4.1. Strengths and limitations

Strengths of this study are the value-based research and user-centered design principles that formed the basis for the eHealth technology development from the very beginning of the project, the involvement of a large variety of stakeholders, and the numerous studies undertaken to distill eHealth technology values and requirements. This study also had limitations. First, the number of participants of some studies was relatively small. Yet, the iterative nature of the developmental process prescribed stopping participant inclusion when no new information came forward and studies were partly repeated when testing the redesign. According to Barnum [49] even only five participants per study may be enough when there is close cooperation between research and development team, the results are clearly communicated and when the results are used for diagnostic purposes. Second, it may be noted that more healthcare professionals were interviewed than patients, but this is mostly because we included a wide range of healthcare professionals such as nurses, general practitioners, cardiologists, lifestyle coaches, etc. In addition, user involvement is still ongoing. As the prototype and incorporated health interventions keep evolving, it is important to continuously evaluate these changes against stakeholder values by performing usability tests to maintain a good connection with stakeholders and to ensure true user-centered development [50]. Finally, the developed personas that were needed to work out the eHealth requirements and customer journey were mostly based on stakeholder interviews. Now that the PHA is ready for use in cardiac rehabilitation, persona validation will be the next step.

4.2. Conclusion

This research project shows that stakeholder involvement in eHealth development is crucial from the conception stage onwards. When patients, healthcare professionals and entrepreneurs gain from an eHealth product to support healthy living, the likelihood of development,

implementation, use, and user-engagement is increased, ensuring a 'benefit for all'.

Summary table.

What was already known on this topic:

- Maintaining a healthy lifestyle is exceptionally difficult and individuals differ in their needs and preferences regarding optimal support for healthy lifestyle interventions.
- eHealth technology can provide support for healthy living anywhere, at any time, and tailored to individual needs.
- Stakeholder involvement is key in the design of new eHealth applications to ensure technology uptake and acceptance by end-users and user engagement.

What this study added to our knowledge:

- Development of eHealth technology may benefit from integrating multiple stakeholders' needs and preferences with insights from scientific evidence and taking into account design elements such as functionality, aesthetics and engagement.
- Stakeholders in the field of cardiovascular prevention and rehabilitation may benefit most from a personalized digital platform that integrates a variety of evidence-based (eHealth) interventions.
- This eHealth platform should aid the matchmaking between end-users and specific interventions based on personal characteristics and preferences.

;1;

Author contributions

MK, VJ, RK, and AWME contributed to the conception and design of the work. MK, JW, and RK contributed to the acquisition and/or analysis of the data and all listed authors were involved in the interpretation of the data. LDB and MK drafted the initial version of the manuscript and all provided critical feedback to revise and improve the manuscript. Finally, all authors gave their final approval of this version's manuscript to be submitted an agree to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Competing Interest

Roderik Kraaijenhagen is the executive director and cofounder of Vital10 where the eHealth platform is being developed. All other authors declare no conflict of interest.

Acknowledgements

We acknowledge the support from ZonMw (The Netherlands Organization for Health Research and Development) and the Netherlands Cardiovascular Research Initiative: An initiative with support of the Dutch Heart Foundation, CVON2016-12 BENEFIT. In addition, we like to thank the Dutch Cardiac Patient Association, the BENEFIT stakeholder committee, and members of the BENEFIT consortium for their helpful advice and feedback. Finally, we want to acknowledge the help of everyone involved in data collection and data analysis, in particular Floor Sieverink, David de Buisonjé, Jessica van der Geer, Renée IJzerman, Talia Cohen Rodrigues, Vincent Keizer, Isra Al-Dhahir, Margo Weerts, Mirjam Ruigrok, Milon van Vliet, Rik Groeneveld, Pauline van Wolferen, Jinell Besselink, Loes Embsen, Famke Grobben, Rosanne Heurman, Kim Knoef, Melissa Koetter, Anja Sherjon and Britt Straatman.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijmedinf.2020.104364.

References

[1] E. Wilkins, L. Wilson, K. Wickramasinghe, P. Bhatnagar, J. Leal, R. Luengo-Fernandez, R. Burns, M. Rayner, N. Townsend, European Cardiovascular Disease Statistics, 2017 edition ed., European Heart Network, Brussels, Belgium, 2017.

[2] M.F. Piepoli, A.W. Hoes, S. Agewall, C. Albus, C. Brotons, A.L. Catapano, M. T. Cooney, U. Corra, B. Cosyns, C. Deaton, I. Graham, M.S. Hall, F.D.R. Hobbs, M. L. Lochen, H. Lollgen, P. Marques-Vidal, J. Perk, E. Prescott, J. Redon, D.J. Richter, N. Sattar, Y. Smulders, M. Tiberi, H.B. van der Worp, I. van Dis, W.M. M. Verschuren, S. Binno, 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts). Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR), Eur. Heart J. 37 (2016) 2315–2381.

[3] V. Janssen, V. De Gucht, E. Dusseldorp, S. Maes, Lifestyle modification programmes for patients with coronary heart disease: a systematic review and meta-analysis of randomized controlled trials, Eur. J. Prev. Cardiol. 20 (2013) 620–640.

[4] C. Granja, W. Janssen, M.A. Johansen, Factors determining the success and failure of eHealth interventions: systematic review of the literature, J. Med. Internet Res. 20 (2018), e10235.

[5] J.G. Thomas, D.S. Bond, Review of innovations in digital health technology to promote weight control, Curr. Diab. Rep. 14 (2014).

[6] V. Janssen, V. De Gucht, H. van Exel, S. Maes, A self-regulation lifestyle program for post-cardiac rehabilitation patients has long-term effects on exercise adherence, J. Behav. Med. 37 (2014) 308–321.

[7] A.L. Ahern, A.D. Olson, L.M. Aston, S.A. Jebb, Weight Watchers on prescription: an observational study of weight change among adults referred to Weight Watchers by the NHS, BMC Public Health 11 (2011).

[8] L. Velsen, J. Wentzel van, J.E. Gemert-Pijnen van, Designing eHealth that matters via a multidisciplinary requirements development approach, JMIR Res. Prot. 2 (2013) e21.

[9] L. Velsen, M. Evers van, C.D. Bara, H. op den Akker, S. Boerema, H. Hermens, Understanding the acceptance of an eHealth technology in the early stages of development: an end-user walkthrough approach and two case studies, JMIR Form. Res. 2 (2018), e10474.

[10] J.E. Gemert-Pijnen, N. Nijland van, M. van Limburg, H.C. Ossebaard, S.M. Kelders, G. Eysenbach, E.R. Seydel, A holistic framework to improve the uptake and impact of eHealth technologies, J. Med. Internet Res. 13 (2011) e111.

[11] S.M. Kelders, L.E. van Zyl, G.D.S. Ludden, The concept and components of engagement in different domains applied to eHealth: a systematic scoping review, Front. Psychol. 11 (2020) 926.

[12] S. Hennemann, M.E. Beutel, R. Zwerenz, Ready for eHealth? Health professionals' acceptance and adoption of eHealth interventions in inpatient routine care, J. Health Commun. 22 (2017) 274–284.

[13] M.E. Porter, What is value in health care? N. Engl. J. Med. 363 (2010) 2477–2481.

[14] M. Keesman, V. Janssen, H. Kemps, M. Hollander, W.S.O. Reimer, L.V. Gemert-Pijnen, A. Hoes, W. Kraaij, N. Chavannes, D. Atsma, R. Kraaijenhagen, A. Evers, BENEFIT consortium, BENEFIT for all: an ecosystem to facilitate sustained healthy living and reduce the burden of cardiovascular disease, Eur. J. Prev. Cardiol. 26 (2019) 606–608.

[15] M.S. Hagger, N.L. Chatzisarantis, An integrated behavior change model for physical activity, Exerc. Sport Sci. Rev. 42 (2014) 62–69.

[16] T.M. Marteau, G.J. Hollands, P.C. Fletcher, Changing human behavior to prevent disease: the importance of targeting automatic processes, Science 337 (2012) 1492–1495.

[17] S.M. Kelders, R.N. Kok, H.C. Ossebaard, J.E. Van Gemert-Pijnen, Persuasive system design does matter: a systematic review of adherence to web-based interventions, J. Med. Internet Res. 14 (2012) e152.

[18] H. Oinas-Kukkonen, M. Harjumaa, Persuasive Systems Design: key issues, process model, and system features, Commun. Assoc. Inf. Syst. 24 (2009) 485–500.

[19] E.L. Deci, R.M. Ryan, Self-Determination Theory: A macrotheory of human motivation, development, and health, Can. Psychol. 49 (2008) 182–185.

[20] C.P. Cerasoli, J.M. Nicklin, M.T. Ford, Intrinsic motivation and extrinsic incentives jointly predict performance: a 40-year meta-analysis, Psychol. Bull. 140 (2014) 980–1008.

[21] M.H.M. Vliet, M. Keesman, R.A. Kraaijenhagen, V.R. Janssen, A.W.M. Evers, Material Incentives and Active Health Behavior Change Interventions to Promote Short-Term and Long-Term Weight Loss: A Meta-Analysis, manuscript in preparation, 2020.

[22] H.F. Hsieh, S.E. Shannon, Three approaches to qualitative content analysis, Qual. Health Res. 15 (2005) 1277–1288.

[23] R.G.A. Groeneveld, Master Thesis: How Technology Can Be Supportive and Motivating for Patients With Chronic Heart Failure, Science and Technology, University of Twente, 2018. https://essay.utwente.nl/77885/.

[24] Municipal Medical and Health Care Service, GGD AppStore, Available at:, 2019 https://www.ggdappstore.nl/Appstore/OverGGDappstore.

[25] S.R. Stoyanov, L. Hides, D.J. Kavanagh, O. Zelenko, D. Tjondronegoro, M. Mani, Mobile app rating scale: a new tool for assessing the quality of health mobile apps, JMIR Mhealth Uhealth 3 (2015) e27.

[26] K. Artsenfederatie, Medical App Checker: A Guide to Assessing Mobile Medical Apps, Available at:, 2019 https://www.knmg.nl/actualiteit-opinie/nieuws/nieuwsbericht/medical-app-checker-a-guide-to-assessing-mobile-medical-apps.htm.

[27] E. de Korte, N. Wiezer, M.B. Roozeboom, P. Vink, W. Kraaij, Behavior change techniques in mHealth apps for the mental and physical health of employees: systematic assessment, J. Med. Internet Res. 20 (2018) 98.
[28] R. Achterkamp, M.G. Dekker-Van Weering, R.M. Evering, M. Tabak, J. G. Timmerman, H.J. Hermens, M.M. Vollenbroek-Hutten, Strategies to improve effectiveness of physical activity coaching systems: development of personas for providing tailored feedback, Health Informatics J. 24 (2018) 92–102.
[29] L. Velsen van, L. Gemert-Pijnen van, N. Nijland, D. Beaujean, J. Steenbergen van, Personas: the linking pin in holistic design for eHealth, in: The Fourth International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED) Valencia, Spain, 2012.
[30] C. LeRouge, J. Ma, S. Sneha, K. Tolle, User profiles and personas in the design and development of consumer health technologies, Int. J. Med. Inform. 82 (2013) e251–e268.
[31] R.J. Holden, A. Kulanthaivel, S. Purkayastha, K.M. Goggins, S. Kripalani, Know thy eHealth user: development of biopsychosocial personas from a study of older adults with heart failure, Int. J. Med. Inform. 108 (2017) 158–167.
[32] J. Wentzel, F. Sieverink, R. Groeneveld, Lv. Gemert-Pijnen, Internal Document: Results of a Cognitive Walkthrough of the Personal Health Environment, University of Twente, Centre for eHealth and Wellbeing Research, Department of Psychology, Health and Technology, Netherlands, 2018.
[33] P. Aveyard, A. Lewis, S. Tearne, K. Hood, A. Christian-Brown, P. Adab, R. Begh, K. Jolly, A. Daley, A. Farley, D. Lycett, A. Nickless, L.M. Yu, L. Retat, L. Webber, L. Pimpin, S.A. Jebb, Screening and brief intervention for obesity in primary care: a parallel, two-arm, randomised trial, Lancet 388 (2016) 2492–2500.
[34] M.W.M. Jaspers, T. Steen, C. van den Bos, M. Geenen, The think aloud method: a guide to user interface design, Int. J. Med. Inform. 73 (2004) 781–795.
[35] S. Michie, S. Ashford, F.F. Sniehotta, S.U. Dombrowski, A. Bishop, D.P. French, A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy, Psychol. Health 26 (2011) 1479–1498.
[36] M.S. Hagger, N.L. Chatzisarantis, An integrated behavior change model for physical activity, Exerc. Sport Sci. Rev. 42 (2014) 62–69.
[37] D.P. French, E.K. Olander, A. Chisholm, J. Mc Sharry, Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review, Ann. Behav. Med. 48 (2014) 225–234.
[38] M.K. Shilts, M. Horowitz, M.S. Townsend, Goal setting as a strategy for dietary and physical activity behavior change: a review of the literature, Am. J. Health Promot. 19 (2004) 81–93.
[39] T.L. Webb, J. Joseph, L. Yardley, S. Michie, Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy, J. Med. Internet Res. 12 (2010) e4.
[40] M.S. Mitchell, S.L. Orstad, A. Biswas, P.I. Oh, M. Jay, M.T. Pakosh, G. Faulkner, Financial incentives for physical activity in adults: systematic review and meta-analysis, Br. J. Sports Med. 54 (2020) 1259.
[41] E.L. Giles, S. Robalino, E. McColl, F.F. Sniehotta, J. Adams, The effectiveness of financial incentives for health behaviour change: systematic review and meta-analysis, PLoS One 9 (2014), e90347.
[42] A.F.G. van Woezik, L.M.A. Braakman-Jansen, O. Kulyk, L. Siemons, J.E.W.C. van Gemert-Pijnen, Tackling wicked problems in infection prevention and control: a guideline for co-creation with stakeholders, Antimicrob. Resist. Infect. Control 5 (2016) 20.
[43] R.R. Cruz-Martinez, J. Wentzel, R.A. Asbjornsen, P.D. Noort, J.Mv. Niekerk, R. Sanderman, J.E.W.C. van Gemert-Pijnen, Supporting self-management of cardiovascular diseases through remote monitoring technologies: metaethnography review of frameworks, models, and theories used in research and development, J. Med. Internet Res. 22 (2020), e16157.
[44] R.A. Asbjørnsen, J. Wentzel, M.L. Smedsrød, J. Hjelmesæth, M.M. Clark, J.E. van Gemert-Pijnen, L. Solberg-Nes, Design for long-term weight loss maintenance: identifying persuasive design principles and behavior change techniques supporting end-user values and needs in eHealth Interventions, J. Med. Internet Res. (2020) preprint.
[45] N. Beerlage-de Jong, L. van Gemert-Pijnen, J. Wentzel, R. Hendrix, L. Siemons, Technology to support integrated antimicrobial stewardship programs: a user centered and stakeholder driven development approach, Infect. Dis. Rep. 9 (2017) 6829.
[46] M. Flores, G. Glusman, K. Brogaard, N.D. Price, L. Hood, P4 medicine: how systems medicine will transform the healthcare sector and society, Per. Med. 10 (2013) 565–576.
[47] A. Botti, A. Monda, Sustainable value co-creation and digital health: the case of trentino eHealth ecosystem, Sustainability 12 (2020) 5263.
[48] K.K. Harris, M. Zopey, T.C. Friedman, Metabolic effects of smoking cessation, Nat. Rev. Endocrinol. 12 (2016) 299–308.
[49] C. Barnum, The 'magic number 5': is it enough for web-testing? Inf. Des. J. 11 (2002).
[50] A. Holzinger, M. Errath, G. Searle, B. Thurnher, W. Slany, From extreme programming and usability engineering to extreme usability in software engineering education (XP+UE /spl rarr/ XU), 29th Annual International Computer Software and Applications Conference (COMPSAC'05) Edinburgh (UK) (2005) 169–172.