The development process of HyperHeart: A digital health app focused on tailoring health behaviors for elderly people suffering from hypertension.

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Contextual Inquiry

This project focusses on improving digital self-management and control for patients with hypertension. Hypertension is one of the biggest risk factors for developing cardiovascular diseases (CVDs), which are the leading cause of death around the world (World Health Organization, 2017). By managing hypertension, people can lower the risk of developing CVDs, which in turn decreases healthcare expenses.

The chance of getting hypertension increases with age, resulting in 2 out of 3 people older than 60 having high blood pressure (BP) (Hartstichting, 2023). This is why the target group is narrowed down to two key stakeholders: older individuals suffering from hypertension who recently retired from their job, and their general practitioners (GPs). When people retire from work, usually several lifestyle changes occur (American Heart Association, 2021; Vadeboncoeur et al., 2015). This offers a possibility for digital health applications which target modifying the behavior of their users and help improve self-management of hypertension.

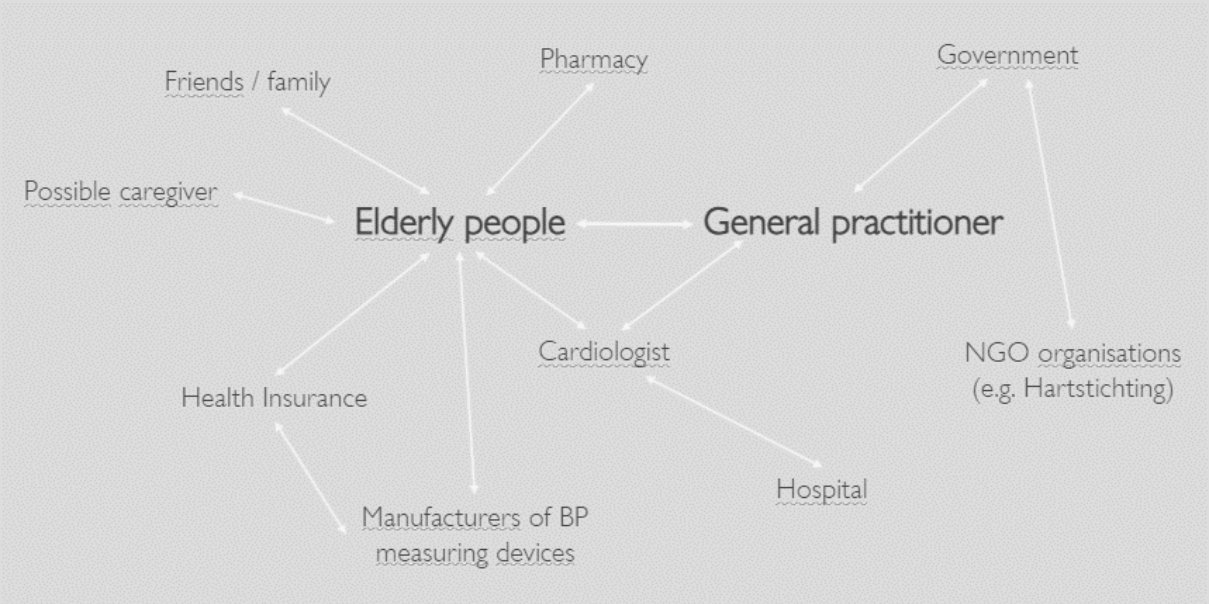
The second group of key stakeholders consists of GPs since digital health applications can enhance their care with more insight into the patient's status. Sharing more information between patients and GPs has the potential to improve the quality of the delivered care, possibly leading to more prevention of consequences of hypertension (Omboni et al., 2016).

Additional stakeholders (see Figure 1) include friends and family members of the patient and caregivers, who might have to assist the patient with the app. Furthermore, hospitals, cardiologists, and pharmacies might obtain medical information via the digital application and therefore are important. NGO organizations (e.g. Hartstichting) and governments could play a role in positively promoting the app. Lastly, contact with

manufacturers and developers of hypertension measurement devices is important to ensure compatibility with the app and measurement devices.

Figure 1

Stakeholder map



Currently, multiple, well-functioning digital BP measurement applications exist such as SmartBP and Thuismeten, which is an app developed by Maasstad Hospital (MacMillan, 2020; Maasstad Ziekenhuis Rotterdam, 2022). With the help of these applications, users can monitor their BP in a digital environment. SmartBP and Thuismeten have clinically approved trackers that check BP with an extensive explanation. The users have a positive experience with the applications, appreciate the guidance and clarity provided, and receive helpful assistance when requested (Patiëntenfederatie Nederland, n.d.). Some applications even provide the option for the patient to send their medical information to a GP or doctor.

Although the BP trackers work and are well received, the digital applications lack additional information and tools for the user to gain information on the causes of hypertension, tips for changing unhealthy behavior, possibilities for self-management, or any

other form of tailored communication (MacMillan, 2020). Tailored messages and the possibility to self-manage can be seen as effective strategies for changing unhealthy behavior. Research shows that tailoring may increase personal relevance, draw more attention to the app's content, and encourage users to elaborate on it (Lustria et al., 2016). Furthermore, self-management in digital health applications goes beyond providing information about hypertension. It also offers opportunities to modify the behavior of the user (Hoffman, 2013). These gaps in the design of hypertension applications make it difficult for patients to change and modify the behavior that might cause high BP.

Additionally, the hypertension apps are more targeted towards younger individuals with high technological capabilities and understanding, while people with hypertension are usually 60 years or older. This age group did not grow up with modern technology and digital applications and can therefore be hesitant to adopt new technologies in their daily lives (Yang & Shih, 2020). This might further limit the capabilities of digital health applications to positively influence the behavior of the target group.

Current applications mainly focus on monitoring BP. However, patients using these apps often do not know what goals they should be aiming for or how well they are progressing (MacMillan, 2020). This lack of information makes it difficult for them to improve their unhealthy habits. Electronic healthcare services can help by involving patients more in their medical decisions and supporting them in managing their health. This, in turn, can support doctors' interventions (Caserini et al., 2016).

As the population gets older there are reasons to believe that it leads to older adults using technology more frequently to gain knowledge about health prevention (Alsswey & Al-Samarraie, 2020). Heightening and sustaining the age at which older individuals prioritize a healthy lifestyle requires ongoing effort. This can be facilitated by technologies designed to assist older adults with their daily routines, thereby expanding the circle of involvement

beyond just the patient's family and healthcare provider (Alsswey & Al-Samarraie, 2020). Since healthcare providers and families cannot consistently monitor patients daily, these applications offer a means for healthcare providers to conduct more frequent and streamlined monitoring of the patient's health status or improve patient outcomes (Caserini et al., 2016). Applications give users a convenient way to access medical information wherever they are at any time, which improves people's quality of life (Alsswey & Al-Samarraie, 2020).

To be able to change the behavior of the user, an understanding of the barriers to the aforementioned behavior and the current behavior of users is needed. Aside from BP monitoring, other health behaviors can help with reducing hypertension risk, such as being more active, reducing salt intake, and reducing alcohol intake (World Health Organization, 2017). A main issue that arises is that older individuals have notable issues with using digital tools, which affects their self-confidence in effectively managing their health (Alsswey & Al-Samarraie, 2020). Therefore, there is a need for these individuals to be supported when setting personal goals for lowering BP, including the health behaviors mentioned before.

To address these behavioral challenges, the target behavior selection process is crucial. This involves planning and selecting goals aimed at reducing high BP levels effectively. The specified target behavior entails the planning and monitoring of activity and nutritional goals to motivate patients to engage in behaviors conducive to lowering high BP. This includes fostering positive attitudes, beliefs, and awareness regarding health management (Van Gemert-Pijnen et al., 2011). Furthermore, interventions should incorporate feedback mechanisms to aid individuals in memorizing what their planning tells them to do, thereby promoting sustained engagement in self-management behaviors (Hoffman, 2013). Through a comprehensive understanding of the behavioral aspects involved, tailored interventions can be developed to support individuals in achieving optimal health outcomes (Van Gemert-Pijnen et al., 2011).

We firmly believe that an application that allows a holistic approach to target all health behaviors that improve health for individuals with hypertension, such as reducing sodium intake, reducing alcohol intake, and increasing movement, results in optimal treatment. Yet, due to time and budget constraints, design efforts will be focused on one health behavior. Literature has indicated that reduced sodium intake is important (Ha, 2014). Therefore, we will focus on this behavior. Based on a review by Henney et al. (2010), salt intake barriers were identified and categorized in a COM-B model (Table 1).

These tailored interventions need to adhere to rules, regulations, and ethical concerns including governmental approval for the measurement tool along with ethical concerns related to privacy. Firstly, government approval means that the hypertension measurement tool has been evaluated by certified organizations, and the tool's benefits outweigh any potential risks for the intended user (FDA, 2022). Secondly, since the application will contain sensitive medical information, privacy should be guaranteed.

Table 1
COM-B model

Capability	**Opportunity**	**Motivation**
Psychological	Physical	Reflective
• Forgetting to track • Unable to set attainable goals • Lack of resilience to make changes in behavior • Lack of knowledge of CVD risks • Ability and confidence to self-manage • Lack of knowledge of salt/sodium risks • Lack of knowledge about diet change to use less salt	• Access to a certified BP tracker • Lack of personal advice from GP • Having time to cook every day	• Expectations regarding the effect of lowering hypertension on wellbeing • Expectations regarding the effect of lowering hypertension on life expectancy • Beliefs of CVD risk from unhealthy eating behavior • Perceiving undersalted food as unpalatable ("Strategies to reduce sodium intake in the United States", 2010, p. 79)

Physical	Social	Automation
• Less mobile • Less capable of cooking each day	• Life changes due to retirement • Encouraging friends and family • Conflicting eating habits of family members	• Habits of tracking BP • Habits of adding salt to food intake • Habit of only tracking salt intake without being involved in the self-managing process

Value Specification

The contextual inquiry revealed why this project and its intervention were necessary. This was done by identifying (key) stakeholders, the context in which they perform their tasks, what currently goes well in doing so, and what could be improved. For this, necessary behavior changes and laws and regulations were identified.

The next step is the identification of guidelines for changing the target behavior and the intervention: value specification (Van Gemert-Pijnen et al., 2011). The value specification consists of statements by key stakeholders (older individuals and their GP) and findings in research, which can be linked to certain values (e.g. efficiency, transparency). These values can be grouped into attributes, which are translated into technical requirements. An extensive body of research concerning our key stakeholders already exists (e.g. Vergouw et al., 2020; Liu et al., 2021; Algera et al., 2024). Therefore, desk research, key literature reviews, reports of interviews, and experimental studies were used to make a list of values per key stakeholder (see Appendix A).

To maintain a focus during the project three core values were selected; two concerned the older individual suffering from hypertension, and one concerned the GP. As mentioned earlier, tailoring the advice to the individual characteristics of the patient increases personal relevance, draws more attention to the app's content, and is more encouraging for users to elaborate on, which in turn can lead to changes in behavior (Lustria et al., 2016; Hoffman,

2013). On the other hand, generic advice can lead to unfeasible plans, which can lead to disappointments, which are detrimental to self-efficacy and motivation (Hoffman, 2013). Therefore, tailoring is an indispensable value of our app (see Table 2).

Additionally, older individuals usually have specific psychical and psychological characteristics that come with age, like reduced motor skills, impaired vision, and reduced cognitive capacity (Liu et al., 2021). Thus, to make our application usable for our target group, these characteristics should be taken into account. Based on our list of values, nine criteria concerning the usability of the app for older individuals were selected (see Table 3).

Lastly, the lack of tailored advice from GP is not only caused by a lack of knowledge about the individual patient but also by a lack of consultation time (Sarradon-Eck et al., 2021). Therefore, the app should not take extra time from the GP, and ideally, it should increase the GP's efficiency (see Table 4). This could be achieved by automatically providing basic tailored advice via the app without the intervention of the GP, providing real-time access to the data of the patient, and being only notified by the platform when problems arise.

Table 2
Requirement form Tailoring

Requirement #: 1	**Requirement type**: Service
Value: Individualization for older individuals (Tailoring)	**Attribute**: Advice and app functions should be adjusted to the individual's dynamic context.
Description: Health advice is based on the individual needs of the user. These needs and advice are based on dynamic data on the current condition of the user, which are tested using short questionnaires and self-monitored data. GPs can access this data and adjust advice where needed. Health advice presentation is based on the user's physical needs and activity, meaning that the depth of information is adjusted based on the user's focus, where base advice is always shown.	

Rationale: Target group (older individuals with hypertension) is in an ever-changing context, information that is supplied should represent this context. As they have multiple levels of health goals, technological skills, and other determinants of how well they can execute health behavior (mobility, living situation, environment, allergies, etc.), the app should take this into account.	
Source: Ethnographic and experimental studies (Algera et al., 2024; Bandura et al., 1999)	
Fit criteria*	
Priority: High	**Conflicts**: Possible conflict with Security (see Appendix A). Individualized app experience requires frequent monitoring and storing of health data.
History: Created on February 22, 2024	

Table 3
Requirement form Usability

Requirement #: 2	**Requirement type**: Usability and User Experience
Value: Usability	**Attribute***:* The app should be easy to use for older individuals (60 years and older) who are suffering from hypertension.
Description: The application is made usable by implementing a high contrast, bigger fonts and buttons, simple and age-appropriate language, navigation that requires only a few different screens.	
Rationale: With age often comes decline in physical and psychological skills, which presents itself in visual, cognitive, and motorial impairments. Additionally, the target group grew up in a different time when digital applications were less abundant or not present.	
Source: Systematic Reviews and Experimental Studies (Liu et al., 202; Paez & Del Pilar Zapata Del María Río 2019; Ubam et al., 2021)	
Fit criteria: *	
Priority: High	**Conflicts**: Possible conflict with Individualisation (Value #1). High-risk patients/app users who receive health advice that requires extensive usage of the app. This might result in

	the app either being too overwhelming due to frequent use, or the app being too limited/simplistic for the user's need.
History: Created on February 22, 2024	

Table 4:
Requirement form Efficiency

Requirement #: 3	**Requirement type**: Organizational
Value: Efficiency	**Attribute**: Minimize additional workload for the GP
Description: App should be able to give general advice that a GP would also give in a day-to-day, non-critical context. This way, the GP can focus on situations that require the expertise of a GP.	
Rationale: GPs express concerns about mHealth apps being time-consuming to understand and use and thereby being disruptive to their workflow. When the additional workload of the app is minimized, GPs are more likely to prescribe the app to their patients and include them in their consultations.	
Source: Systematic review (Sarradon-Eck et al., 2021; Gagnon et al., 2015; Byambasuren et al., 2020)	
Fit criteria*	
Priority: High	**Conflicts**: Possible conflict with Individualization (Value #1) as some patients' tailoring might be more based on the advice of the GP, therefore asking more from the GP.
History: Created on February 21, 2024	

Design

Now that the behaviors are identified and the most important values are known, suitable intervention functions can be mapped. These intervention functions are based on the previously identified barriers in the COM-B model while considering the values (see Table 5). One of the barriers identified for older individuals with hypertension was the lack of

knowledge on risks and experiences regarding salt intake and CVD. Therefore, the first intervention type to focus on is Education.

The second intervention type mapped was Enablement, which focuses on enhancing capabilities and emphasizing the value of elderly-friendly design was also considered. For older individuals, there might be barriers such as having to cook every day, conflicting eating habits with a partner, or simply not having a habit of cooking. Therefore, reducing barriers to help increase their capability not only helps to change behavior but also focuses on tailoring.

The identification of the last intervention type was prompted by a lack of awareness regarding methods to reduce salt intake. Therefore, tailored training is necessary, aiming to impart new skills in a comprehensible manner, thereby facilitating behavior change.

Table 5
COM-B to Intervention Options

COM-B component		**Identified barriers**	**Intervention functions**
Capability	Psychological	- Lack of knowledge of CVD Risks. - Lack of knowledge on salt intake risks. - A need for tailored health advice.	Education Enablement
	Physical	- Less capable of cooking every day	Training
Opportunity	Physical	- Having time to cook every day	Training Enablement
	Social	- Conflicting eating habits of family members.	Enablement
Motivation	Reflective	- Perceiving under-salted food as unpalatable. - Beliefs of CVD risk from unhealthy eating behavior	Education
	Automatic	- Habit of only tracking salt intake without	Training Enablement

		being involved in the self-managing process - Habit of always salting food.	

From these three most important intervention functions, five BCTs were identified using the BCT's taxonomy (see Table 6) (Michie et al, 2013). The first step involves providing users with information about health consequences, aiming to enhance their awareness of associated risks and opportunities. Subsequently, action planning is implemented to give the user a sense of autonomy and customization. Additionally, feedback on behavior and the review of behavioral goals are added to assist users gain insight into their salt intake and adjusting their goals. Lastly, instruction on how to perform the behavior is included to help the users feel more capable by learning new skills, potentially enhancing their perceived self-efficacy, a factor associated with positive health outcomes (Warner & Schwarzer, 2020).

Table 6
Intervention option for BCTs

Intervention Options	**Specific BCT's**
Training	Feedback on behavior (2.2) Instruction on how to perform the behavior (4.1)
Education	Feedback on behavior (2.2) Info about health consequences (5.1)
Enablement	Action planning (1.4) Review behavior goals (1.5)

BCT's as Features

As described earlier, to provide a tailored experience and feasible self-management goals to the user, our design will extend what is common in BP trackers that already exist, with relevant data of the user, starting with salt intake. Thus, to operationalize the selected BCTs as features of an app, one must look at how these can be integrated into the tracking experience. This interconnectedness in turn helps with keeping the overall navigation structure simple as prescribed by the usability requirement. Below we describe per BCT how it is translated into features and how it is integrated with other parts of the application. The Figures are visible in Appendix B.

Because research has shown that people in general are not aware of the health consequences of salt intake, we provide that information (Henney et. al, 2010). The simplest operationalization of this feature is providing this information via knowledge pages and modules. A more direct approach might be to provide this information while reviewing current salt intake (See Figure B.1), or after notifying the user about their salt intake (See Figure B.2).

As people are not aware of the consequences of salt intake, they most likely are also not aware of how to change this. Examples of possible changes in diet are heightening calcium intake to reduce craving for salt, and lowering salt intake in small steps which go unnoticed (Henney et al., 2010). These instructions can be provided as single tips or even be integrated into recipes, thus providing a solution ready to be implemented. This information can be provided on a standalone page, to which links might be provided while reading about health consequences, or while planning actions and setting intake goals (See Figure B.3).

After reading about how to change salt intake, this information needs to be translated into concrete plans. This means setting salt intake goals, tracking current intake, and being able to review whether you are still headed for completing your goals (See Figure B.4)

Research has shown that gradually reducing salt intake is more feasible than doing it at once. Thus, it might be also fruitful to provide a sequence of periodic goals in which this gradual reduction is achieved. This dynamic goal setting could then also be reviewed by GPs and be used as a basis for providing humanly tailored advice if needed.

While trying to achieve the goals the user should be provided with feedback to give insight into their progress and reinforce the reasoning behind their goals. This feedback could be given while logging salt intake (See Figure B.4), while monitoring current goals (See Figure B.5), and by notifications at a fixed time of day (See Figure B.5).

Finally, salt intake goals should be reviewed on a fixed-time basis. While doing so two things should be reviewed: the feelings of the user about their current self-management plans, and the extent to which their behavioral goals were reached. The combination of both can then be used to set new goals or adjust current ones (See Figure B.5). Additionally, a link to contact the GP can be added to ask for advice when the patient is unable to establish achievable goals independently. For the link to the complete prototype, see Appendix C.

Heuristic evaluation

An expert-based usability inspection ($N = 5$) has been conducted through a heuristic evaluation to identify usability problems in the interface of the mHealth application (Nielsen, 2024). This method was chosen because the evaluation technique makes it possible to gain valuable insights into potential shortcomings in the usability of the application that might otherwise have been overlooked, without recruiting users. Eight of the ten heuristics were used for the evaluation, with a selection based on criteria that best align with the application, wherein various focus points were established for each criterion (see Appendix D). After each expert independently performed the heuristic evaluation, all identified issues were recorded in a list, and points of improvement were concluded (see Appendix E).

Most issues concerned the Visibility of System Status, Consistency and Standards, and Flexibility and Efficiency of Use, especially in the details of the prototype, such as the navigations, the colors of the action buttons, and a personal welcome at the home page. Language issues were improved after the evaluation to ensure that the same words were used for the same concepts. For improving Recognition and Recall a help button has been added to the prototype together with a settings button, including a FAQ page, for the Flexibility and Efficiency of Use, and Help and Documentation. For the Aesthetic and Minimalist Design, some issues about button size were found, which made it less clear what the important features were in the app. All points of improvement were implemented in the latest prototype.

Operationalization

The Diffusion of Innovation Theory describes how technology is adopted in several phases (knowledge and awareness, persuasion, decision, implementation, and confirmation) and emphasizes five attributes of the technology in doing so (Miller, 2015).

First, relative advantage is inherent to our app and thus forms the backbone of explaining why one would use the app. As our app is freely available, trialability is relatively less relevant for our context. Our app aims to improve both the self-management capabilities of the patient and the efficiency of the GP. Nonetheless, direct health improvements cannot be promised. Thus, observability is only relevant in managing expectations. However, to ensure optimal conditions to achieve both goals, the app should be perceived as compatible with the context of both the GP and the patient and as being simple enough to use, thus ensuring efficiency benefits. In the section below, we will describe how both compatibility and complexity should be addressed when operationalizing our app.

Knowledge and awareness

In the knowledge and awareness phase, important stakeholders will be informed about Hyperheart, particularly GPs. GPs will have an important role in communicating the app's benefits to retired individuals with high BP. To activate GPs for this role, we provide information during training conferences. During these training conferences, it is key to enable GPs to explain and recommend the app to their patients. Therefore, the training conference will provide information that GPs need for app explanation and recommendation and aim to motivate GPs by showing them what their benefits will be.

GPs must explain key functions of HyperHeart to patients, motivated by the Theory of Planned Behaviour (Ajzen, 1991). Expert recommendations (in our context: the GP) can be used to influence attitudes positively (Van Gemert-Pijnen et al., 2011). Perceived behavioral control could be addressed by explaining how the app adjusts to the patient's context, avoiding unfeasible self-management plans, and facilitating small steps towards nutritional or exercise change. Descriptive social norms could be addressed by explaining that the app adapts existing self-management strategies to the patient's context, confirming common self-management behavior. Finally, injunctive social norms can be addressed by confirming that the exact self-management plans indeed differ per person and that the app supports this.

To further motivate GPs to fulfill their communication role, we suggest using an authoritative recommendation to convince the GP of the advantages (Byambasuren et al., 2020). We wish to use an important medical figure, such as Riccardo Cocchieri, to convince the GPs of the benefits of recommending the app, such as more efficient time usage. Additionally, providing flyers (wherein the points outlined in the previous paragraph are mentioned) in the GPs' offices or waiting rooms, outlining the app's benefits, can prompt patient-GP discussions or serve as a reminder for patients to download the app.

Persuasion

Persuasion is the stage where the user develops a favorable or unfavorable attitude towards Hyperheart. Clarity and guidance are appreciated by the elderly, and usability is an important need to persuade the elderly for technology adoption. To fulfill these needs the four core determinants of UTAUT were implemented (Chang, 2012).

HyperHeart enhances performance expectancy by offering personalized advice and quick support via the chat function, aided by the GP and the FAQ section. Effort expectancy, in which ease of use of the system is important, is addressed through a consistent interface design, color scheme, and clear instructions. Users receive reminders and clear instructions for easier app usage and improved performance without needing to rely on memory. Implementation of advanced security measures and privacy protection will be provided within HyperHeart to enhance facilitating conditions as the third factor.

The app will share success reviews to let the user perceive the social influence of using the app. We believe that these app functions should be visible or apparent to potential users, before app usage. Additionally, informational flyers should be created and provided during training conferences and at GP practices, which can serve as conversation starters or reminders.

Decision

In this stage, the user chooses to adopt or reject the innovation. To make sure that the elderly will decide to adopt Hyperheart and use the app, the values and preferences of the elderly must be fulfilled. Furthermore, medical facts also influence the decision. By providing users with sufficient and truthful information, all the benefits can be emphasized during the aforementioned training sessions and in the earlier mentioned flyers.

Implementation

Implementation is the phase where the user puts HyperHeart into (initial) use. As our target group consists of older individuals unfamiliar with modern technology, they may be hesitant to start using HyperHeart initially (Yang & Shih, 2020). Hence, it is crucial to help them reduce their perceived complexity of HyperHeart and provide support for their comfort with the technology. Additionally, having access to both technical and emotional assistance is essential throughout the implementation stage (Barnard et al., 2013).

We propose organizing HyperHeart practice sessions with the GPs for older individuals with hypertension. These sessions offer a chance to practice and the needed support. These practice sessions should integrate UTAUT factors. First of all, the GP demonstrates the app's simplicity to reduce concerns regarding effort and performance. Additionally, the GP should decide together with the patient to which data the GP gets access. Finally, the GP shares success stories of other patients to foster acceptance.

Confirmation

The confirmation stage marks the user's final decision to use HyperHeart. Research into older individuals and technology use showed that older individuals often worry about their ability to keep up with new technologies as they age, fearing a decline in their skills (Wilson et al., 2021). They also expressed concerns about the rapid technological developments and continuing their technology use without support from external groups. Therefore, HyperHeart should not incorporate drastic technological changes in its design, so users can keep up with the application. Additionally, the practice session we proposed during the implementation phase should therefore be regular, so that our target group keeps getting the chance to keep their technological capabilities up to date. Moreover, it is essential to keep incorporating support from the GP. When the GP keeps reminding the user to keep using

HyperHeart, there is a higher chance of adopting the technology. This could be supported by sending regular educational flyers with HyperHeart updates to the GP.

Evaluation

For the final evaluation, we not only want to find out if the technology works but also which features of the technology impact the stakeholders and their values as well as the targeted health behavior. Additionally, the final evaluation should reveal insights into the uptake of the app HyperHeart. Thus, the evaluation should answer the question of which features of the technology are used and how the technology is adopted by the users within the context of hypertension management.

To answer these questions two evaluation methodologies are used (Van Gemert-Pijnen et al., 2018). The first method, factorial designs, will help determine the added value of each intervention feature and the effect on the target behavior. The second method, log data analysis, will help analyze the use of technology and users' adoption of the technology. By combining factorial design and log data analysis, not only can the effectiveness of individual components be determined, but the results can also be supported by log data analysis, as this determines how users use the technology based on objective data.

During the evaluation, participants are asked to use a version of the application. For this report, condition 32 is made as the prototype (see Appendix F for the full schematic). If a component does not occur in the condition, this component is deleted from the app for that particular condition. For example, if the health consequences component should not appear for that condition, the health consequences pages are not visible anymore for that condition. This way possible insights are revealed of what each component's influence is on the effectiveness of the intervention as a whole.

The data on the effectiveness of the intervention components is then combined with the log data. Log data is gathered from participants during the course of their usage, providing objective and continuous insight. It can provide insight into usage, which features are used at what time, the action the user takes, and how often each action is taken. By also gathering log data, we might find what combination of elements are used and which patterns emerge. With the log data insight might be found on adherence and adoption of the technology.

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Appendices

Appendix A:

Value Map Stakeholders

Table 1

Key stakeholder: Older individuals with hypertension

Stakeholder expression/ finding in desk research	**Value**	**Attribute(s)**	**Requirement(s)**
Positive experiences were reported by patients who experimented with self-management. DOI: https://doi.org/10.3399/bjgp19X705101	Self-management	Involving the patients more in the process by supporting self-management behaviors	More knowledge of how to do it for older patients. They need to get familiar with it. There should be an explanation in the app.
"Yes, if call in the morning, you can be waiting on hold for quite a while before you get an answer." (R15, male, 69 years) *"Yes, the advantage is that I can go on my device at my own leisure in my own time, without being limited to the allotted 10 minutes of the physician's time. At my leisure, I can review previous results and information." (R11, male, 69 years)* DOI: 10.1017/S1463423620000547	Immediate availability	Availability of results and contact with the GP anytime anywhere.	There should be an option in the app to easily contact the GP when needed
If older adults found an application to be efficient and convenient, they were more likely to use it.	Convenience/ efficiency	Elderly patients need to use health applications	The design should not be too difficult to understand

DOI: 10.1017/S1463423620000547			
"Patients may interpret symptoms as signs of vulnerability or a worsening of their condition. This interpretation commonly leads to a loss of PSE for managing symptoms and fear avoidance behavior in which the patient limits any activity that might lead to increasing symptoms. Patients should be taught to judge and monitor their symptoms realistically from a positive perspective on their ability to reach goals. " DOI: 10.1891/0889-8391.13.2.158	Understandable and affirmative information	The app should not use difficult language and help the patients with a realistic perspective of the information	Do not use medical terms but explain them in simple and clear language. Show the patients the positive consequences of their actions
To feel secure and supported in the face of medical needs, attachment, and hospitality are crucial. DOI: https://doi.org/10.1590/S0080-62342012000100014	Security	The app must secure the patient's data	Passwords are required
Information that makes sense in the context of the patient thus enhancing intention (tailored to). *"In particular, aging people are people in transition: from a condition of self-management to the need of depending on caregivers, they constantly experience changing conditions that force them to renegotiate their self-image."* *("mHealth and Human-*	Individualization for the elderly (Tailoring)	Advice and app functions should be adjusted to the individual's dynamic context.	-Dynamically adjustable health advice. -Visible functions based on current health goals. -GPs can view, check, and adjust health advice.

Centered Design Towards Enhanced Health, Care, and Well-being", 2023, p. 42) *"Most professionals (n = 7) mentioned patients' growing wariness towards hormonal contraceptives and/ or patients' preference for hormone-free contraceptives. Some professionals invalidated patients' wariness of hormones and their side effects and argued that." (Algera et al., 2024, p. 5)*			
Visual impairment comes with age and makes reading from screens harder. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Visibility	Ensure high contrast and use bigger fonts.
Visual impairment makes reading longer texts harder or impossible. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Readability	Use concise and simple language. Provide narrated options for longer texts.
Using familiar and understandable language reduces cognitive strain. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Simple and Clear	Use clear, common, and age-appropriate language.
Cognitive strain makes integrating and structuring information harder. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Findability	Organize topics into groups. Use a home screen with big buttons for the main functions.

With age motorial functions deteriorate. Precision and control are reduced. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Psychomotor barriers, physical barriers	Focus on tapping gestures instead of scrolling. Limit repetitive actions. Minimize text input. Use bigger labeled buttons.
Using a simple and consistent layout supports creating a mental model of the app. DOI: https://doi.org/10.1093%2Fjamia%2Focab151	Usability	Easy Navigation and memorability.	The different menus/screens should be logically structured without having to remember too many steps. Use a "flat" navigation structure
Non-significant visual elements (icons, animations, decorations) cause confusion and unnecessary cognitive strain. DOI: https://doi.org/10.1007/978-3-030-23570-3_31	Usability	No non-meaningful elements	Only add and show elements for the current task at hand. Don't add redundant functionality.
Not being grown up with digital services makes the threshold to use higher. DOI: https://doi.org/10.1007/978-3-030-23570-3_31	Usability	Guidance due to lack of experience	Provide options for guidance throughout the app. (e.g. use onboardings, tutorials, or popups)
The most important feature of a mobile banking application according to senior users is fast loading time. DOI: https://doi-org.tilburguniversity.idm.oclc.org/10.1109/ICEEI52609.2021.9611136	Usability	Performance	Loading time, security, feedback on input, responsiveness.

Table 2

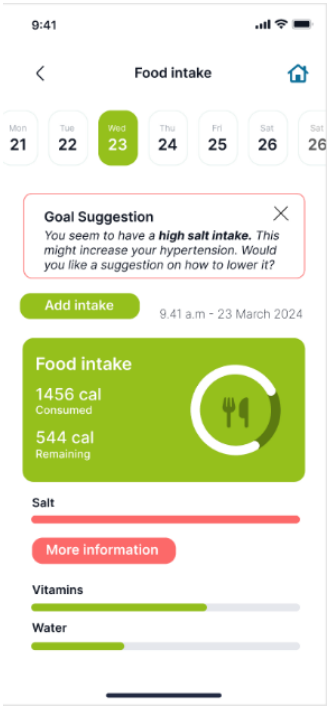
Key stakeholder: Older individuals with hypertension

Stakeholder expression/ finding in desk research	**Value**	**Attribute(s)**	**Requirement(s)**
- GP A: "For an app to work, you have to enter the name, the age, and a certain number of other things that will take up too much of my time! That is what I fear!" (Sarradon-Eck et al., 2021). - GP B: "This is just adding yet another thing to think about (...) during the consultation, we just don't have the time." (Sarradon-Eck et al., 2021). - Systematic review: However, some general practitioners pointed out that m-health may be time-consuming by being disruptive to their workflow (Gagnon et al., 2015). GP C: "And it's time-consuming to learn about these things. It's hard enough just keeping up with what medicine is doing without this app and that app etc." (Byambasuren et al., 2020).	Efficiency	The additional workload of the hypertension mHealth app should be minimized for the general practitioner.	- The mHealth app should provide the general practitioner with a quick tutorial on how to use the app. - The interface needs to provide the general practitioner quickly and clearly with all the information needed. - The mHealth app should be able to easily integrate into consultations.
The most important barrier to recommending the app to their patients is the lack of knowledge of effective apps.	More knowledge about Health apps	The app should be easy to understand for the GP and explain the benefits, so they get more	There should be an additional tab for the GP where he can find specific information.

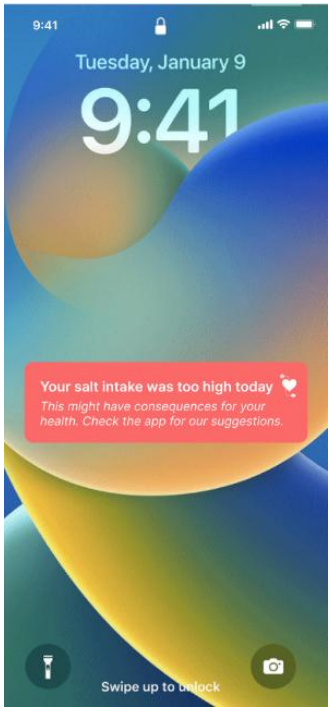
DOI: 10.2196/13199		confident with using it.	
Data protection is one of the three positions for resistance to recommend the apps. *"An app, proposed by a Lab [pharmaceutical industry]: NO! I would not trust it! [the risk would be] targeting, collecting patient data in their favor, to promote their products (...) because I think that the Lab collects patient data because the patients enter the data. To what end will they use this data? I am also there to protect my patients' DATA, and I want to guide them in the use of applications that will not put their data protection at risk."* DOI: 10.2196/21795	Patient protection	The app should cover the privacy and security of the patient's data	The data should be blocked with a password
Longitudinality of care is time-saving and increases the sense of responsibility towards their patients. DOI: https://doi.org/10.1016/0277-9536(94)E0074-3	Longitudinally of care	Patients do not have more than one GP in the app	One GP is linked to the patient on the app.

Appendix B

Design app

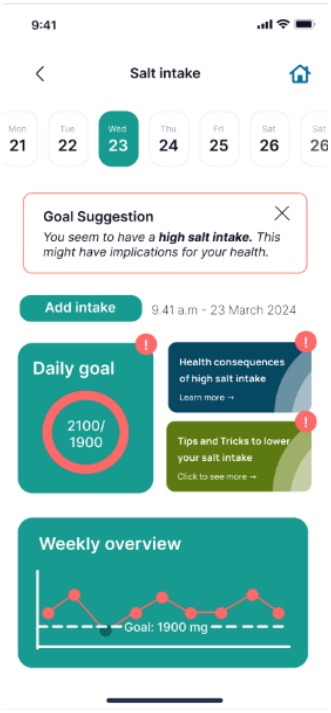


B.1

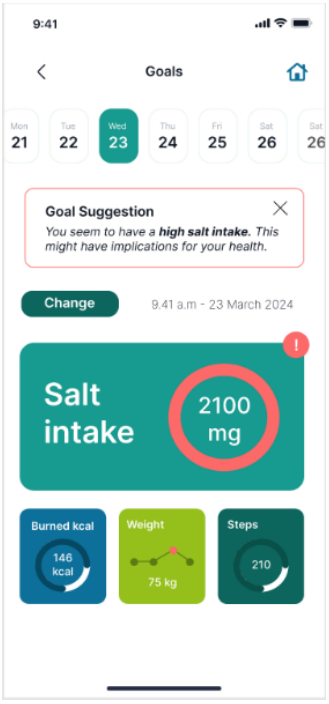


B.2

B.3



B.4



B.5

Appendix C

Link to HyperHeart prototype

https://www.figma.com/proto/gU5BH2KV6ar7Qwn5R0ZXPd/C1---Digital-Health-Communication-V2?type=design&node-id=4-806&t=HRjnFoYixI9LEk1D-1&scaling=min-zoom&page-id=0%3A1&starting-point-node-id=4%3A806&show-proto-sidebar=1&mode=design

Appendix D

Heuristic evaluation form

Heuristic (Nielsen, 2024)	**Focus points**	**Reasoning**
1# Visibility of System Status	- The communication about the user status within the app is clear - The feedback to the users is clear.	Match with the required User Experience
2# Match Between the System and the Real World	- Words, phrases, and concepts are familiar to the user, rather than internal (health) jargon. - Information appears in a natural and logical order.	Match with value "Usability" and requirement "Usability and User Experience"
#4 Consistency and standards	- Improve learnability by maintaining both types of consistency: internal and external. - Maintain consistency within a single product or a family of products (internal consistency).	Lower cognitive load as much as possible by being consistent internally and externally
#6 recognition and recall	- Let people recognize information in the interface, rather than forcing them to remember ("recall") it. - Offer help in context, instead of giving users a long tutorial to memorize. - Reduce the information that users have to remember.	Match "Usability Requirement": cognitive impairment, flat navigation, etc.
7# Flexibility and Efficiency of Use	The app provides personalization by tailoring content and functionality for individual users.	Match with requirement "Service" and value

	The app allows for customization, so users can make selections about how they want the app to work.	"Individualization for older individuals (Tailoring)"
8# Aesthetic and Minimalist Design	- The content and features prioritize the main goal of the app.	Match with value "Usability" and requirement "Usability and User Experience"
9# Help Users Recognize, Diagnose, and Recover from Errors	- The app tells users what went wrong in a language they will understand - The app offers the users a solution.	Match with value "Usability" and requirement "Usability and User Experience"
10# Help and Documentation	- The app provides support to help users understand how to complete their tasks.	Match with value "Usability" and requirement "Usability and User Experience"

Appendix E

Summarized heuristic evaluation form

Heuristic	Issue	Severity of issue	Points of improvement
1# Visibility of System Status	'Monitor blood pressure' cannot fill in blood pressure		
	Was lost in the pages at some point.		Check the navigations (and copy some pages to fix the navigations to the right page)
	The weight page is unclear.		
	GP form is not completely clear.		
	Bullets in the form and you can't confirm with the narrow to the next question		You need to select an option instead and then you see which option is selected, and then you need to confirm your choice by clicking on the narrow
2# Match Between the System and the Real World	Nutrition is not the right language		Improve to 'food intake'
	Salt and sodium are mixed up		Only use salt
#4 Consistency and standards	Colors are not consistent in the call- to action buttons and other buttons		Use the same colors for call-to-action buttons, information buttons, and error buttons. Make sure that this is consistent.
	The pages have too many different colors which makes them less consistent.		Use the same colors on a page.

	The steps and calories in goals are not clear enough, what the difference is between these two goals		Point out more that calories are about intake or burning.
#6 recognition and recall	No help button if the user does not know anymore what to do.		Make a help button
	The action plan page is hard to reach		The action plan page can also be reached at goals
7# Flexibility and Efficiency of Use	No integration with the suggestions page and action plan		Integration with these two pages
	The home page is not personal		Welkom the person, like 'Good afternoon, Joep'
	The priority is not clear enough		Make sure on the homepage that the priority of the person is highlighted more
	There is no settings button		Add a settings button with the option, where you can change the tracker and the focus
8# Aesthetic and Minimalist Design	Some buttons are too small		Make the buttons bigger so that older people with bigger fingers can click on them.
	It is not clear what the most important things are on the home screen		The notifications need to be at the top of the page
9# Help Users Recognize, Diagnose, and Recover from Errors	With the pop-up notifications, there needs to be a back button (x mark)		Add an 'x'
10# Help and Documentation	There is no FAQ page		This can be added in the settings

	Pop-ups are not asking but are statements		Ask if they want to see suggestions

Appendix F

Conditions in factorial design

Condition	Component				
	Behavior feedback (goal suggestions)	Health consequences (information pages)	Action planning	Review behavior goals (weekly questionnaire)	Instruction on how to perform behavior (recipes + tips)
1					
2					X
3				X	
4				X	X
5			X		
6			X		X
7			X	X	
8			X	X	X
9		X			
10		X			X
11		X		X	
12		X		X	X
13		X	X		
14		X	X		X
15		X	X	X	
16		X	X	X	X
17	X				
18	X				X
19	X			X	
20	X			X	X
21	X		X		
22	X		X		X
23	X		X	X	
24	X		X	X	X
25	X	X			
26	X	X			X
27	X	X		X	
28	X	X		X	X
29	X	X	X		
30	X	X	X		X
31	X	X	X	X	
32	X	X	X	X	X