Perception and Evaluation of a Knowledge Transfer Concept in a Digital Health Application for Patients with Heart Failure: A Mixed Methods Study

Madeleine Flaucher, Sabrina Berzins, Katharina M. Jaeger, Michael Nissen, Jana Rolny, Patricia Trißler, Sebastian Eckl, Bjoern M. Eskofier, Heike Leutheuser

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Abstract

Background: Digital health education can enhance the quality of life of patients with heart failure by providing accessible and tailored information, which is essential for effective self-care and self-management.

Objective: This work aims to develop a mobile health knowledge transfer concept for heart failure in a user-centered design process grounded in theoretical frameworks. This approach centers on enhancing the usability, patient engagement, and meaningfulness of mobile health education in the context of heart failure.

Methods: A user-centered design process was employed. First, semi-structured stakeholder interviews were conducted with patients (n = 9) and medical experts (n = 5). The results were used to develop a health knowledge transfer concept for a mobile health application for heart failure. This concept was implemented as a digital prototype based on an existing German mobile health application for patients with heart failure. We used this prototype to evaluate our concept with patients with heart failure in a study composed of user testing and semi-structured patient interviews (n = 7).

Results: Stakeholder interviews identified five themes relevant to mobile health education: individualization, content relevance, media diversity, motivation strategies, and trust-building mechanisms. The evaluation of our prototype showed that patients value the adaptation of content to individual interests and prior knowledge. Digital rewards like badges and push notifications can increase motivation and engagement but should be used with care to avoid overload, irrelevance, and repetition.

Conclusions: Our findings emphasize the importance of tailoring mobile health education to the specific needs and preferences of patients with heart failure. At the same time, they also highlight the careful implementation of motivation strategies to promote user engagement effectively. These implications offer guidance for developing more impactful interventions to improve health outcomes for this population.

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Keywords: health literacy; mobile health; health promotion; patient education; digital literacy; information retrieval; patient empowerment

Introduction

In 2019, heart failure affected more than 56 million people worldwide [1]. The diagnosis of heart failure entails severe health consequences for patients and significant financial resources for public health systems [2]. In light of an aging population, heart failure is becoming increasingly important in society and requires new approaches for prevention, management, and therapy to mitigate health impact [3,4].

Heart failure requires a high level of active patient involvement [5]. Self-monitoring of physiological parameters, medication intake, nutrition, and physical activity are crucial factors in preventing

hospitalizations of patients [6,7]. In this context, health literacy plays a major role since high levels of health literacy in patients with heart failure promote patient empowerment, self-care practices, and medication adherence [8–10]. Health literacy can be described as the capacity of a person to access and understand health-related information, place it in context, and use it responsibly to promote and maintain good health [11]. With a focus on heart failure and other cardiovascular diseases, The American Heart Association concludes that health literacy is crucial for effective treatments for cardiovascular diseases and acknowledges information technology as a potential path to improving health literacy [12]. In the long-term, low health literacy is associated with an increased risk for hospitalizations and death in patients with heart failure [13].

To effectively deliver information to patients and achieve learning effects, mobile health technology offers great potential. This applies to populations with low health literacy in particular [14–16]. Enhancing health literacy requires attention not only to disease-specific content but also to digital health literacy, empowering users to navigate health-related inquiries online effectively [14,17,18]. However, several barriers have been identified, including the access to apps, the readability of content as well as the usability of digital health services [14,19]. In the context of heart failure, evidence for the effects of mobile health for promoting health literacy is still limited. Allida et al. identified no increase in heart failure knowledge through digital educational content and unclear evidence on self-efficacy, self-care, and health-related quality of life [20]. In contrast, several recent studies demonstrated positive effects on quality of life, hospitalization rates, and self-management abilities [21–23]. However, despite the potential benefits, these approaches lack the incorporation of theoretical frameworks for engaging, appealing, and effective knowledge transfer. Furthermore, patients with heart failure are hardly involved in the development process of mobile health interventions.

Thus, the aim of this work is to develop a concept for a sustainable and engaging knowledge transfer with a specific focus on the needs and preferences of patients with heart failure. Theoretical frameworks for mobile health knowledge transfer and the involvement of end-users throughout the design process build a strong foundation for an engaging, user-friendly, and effective mobile health intervention.

A digital prototype served as a tangible representation of our concept, which we evaluated with patients with heart failure.

Methods

Study Design Overview

Foundation of this work was the user-centered design (UCD) process, a common method in interaction design [24]. It emphasizes the involvement of the potential end-users throughout the developmental phases to ascertain that the resulting concepts align with their needs, preferences, and experiences of the target group. The graphical abstract (Figure 1) provides an overview of the methodology used.
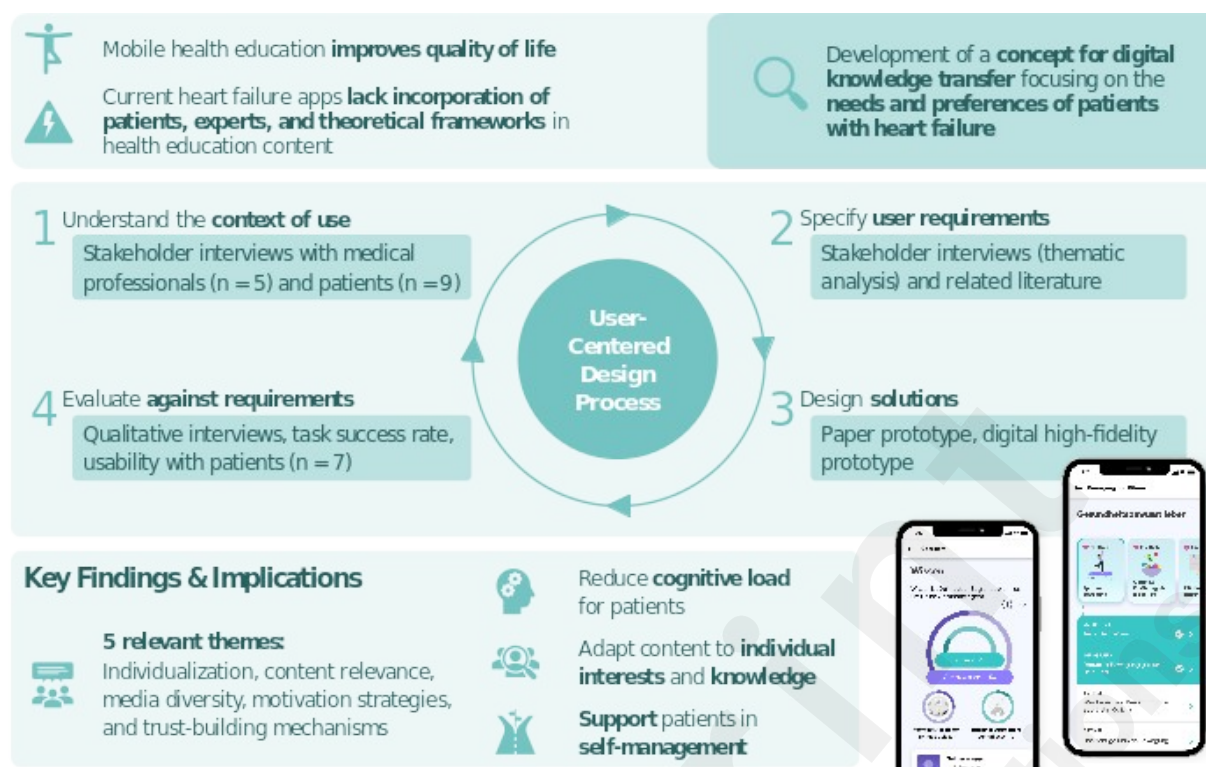
Figure 1: Graphical abstract illustrating the integration of the user-centered design process in the development of a health knowledge transfer concept for patients with heart failure.

First, we used current literature and semi-structured qualitative interviews to understand the context of use and derive requirements. Based on the findings possible design solutions were drafted as a paper prototype. Thereafter, a digital high-fidelity prototype was implemented. This digital prototype was then evaluated in a study focusing on the identified requirements of the target group.

The exemplary application we used for the prototype design is the ProHerz app (ProCarement Gmbh, Germany), a medical-grade mobile application for heart failure. This app is intended to support patients in managing their health by tracking vital signs and medication intake. Additionally, the company provides a 'CareCenter', where, depending on the product used, medical experts regularly monitor the patients' health parameters and stay in personal contact via messages and phone calls.

Qualitative Interviews

Recruitment

Qualitative semi-structured interviews were conducted with patients (n = 9) and medical experts (n = 5). All patients were recruited from the ProHerz user base. Thus, all were patients with heart failure and previous experience with the ProHerz app. We chose this group because of their experience using a mobile health app for self-management. Medical experts were recruited through ProCarement, where they interact with the ProHerz users in their daily work. Their close exchange gives them a broad perspective on patients' characteristics, needs, and skills.

Procedure

The interview guidelines were based on our research aims and current literature. Both stakeholder interviews covered similar aspects (Figure 2). The guidelines aimed to identify patients' specific needs and requirements regarding content and features within a mobile health knowledge transfer.

The interviews with the medical experts targeted explicitly at their perspective on essential

knowledge and skill requirements that should be covered in a mobile health knowledge transfer concept. Besides, specific features, content presentation, and adaptation strategies for individual patient needs were discussed.

In the patient interviews, we inquired about experiences with specific features, their current interactions with the ProHerz app, and their expectations regarding knowledge transfer within a mobile health app designed for heart failure. Furthermore, the interviews included discussions on patients' health-related routines and goals and identifying requirements for trust-building and cogency. Additionally to the interview, patients were asked to complete the European Health Literacy Survey Questionnaire (EU-HLS-Q16) to assess their health literacy level [25,26]. Through this tool, participants rate general tasks related to health literacy based on their level of difficulty.

All interviews with medical experts were conducted via Microsoft Teams. Patient interviews were conducted in person.
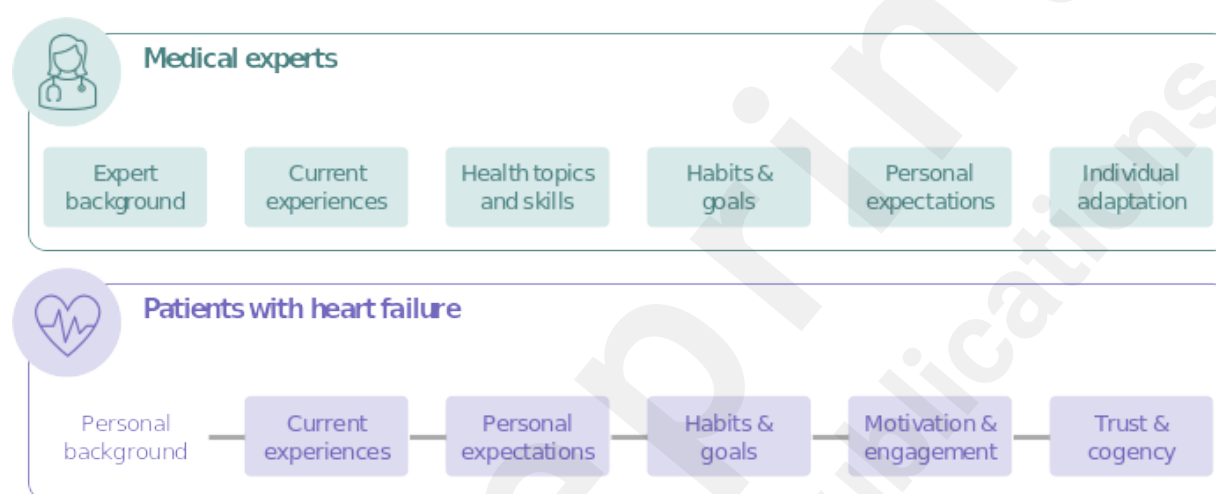

Figure 2: The topics included in the interview with both stakeholder groups.

Prototype Development

The development of the knowledge transfer concept was based on the findings from the interviews and related literature. We incorporated the framework of Riegel et al. to structure the topics [27]. The content categories in the prototype are oriented toward the three self-care processes for heart failure: maintenance, symptom perception, and management. Information in the prototype was structured based on the principles for effective e-learning by Clark and Mayer and the recommendations for designing health-literate mobile apps by Broderick et al. [28,29]. This included, for example, dividing information into manageable units, using different types of media, and writing in a conversational style.

Additionally, we considered possible cognitive limitations of users in the context of heart failure and reduced cognitive load accordingly to support the processing of health information [30–33].

The derived themes of the interviews were brought together with findings from the health literacy assessment that additionally revealed the needs of patients. We drafted a workflow for the mobile knowledge transfer and implemented this as a low-fidelity paper prototype.

For a first usability test, we embedded the paper prototype in Useberry (Useberry User Testing Technologies IKE, Greece). Useberry is a tool to test the usability of the paper-based prototype digitally. We aimed to find usability issues as early as possible in our design. For this initial testing,

we invited healthy participants through personal contact. Test users (n = 5) were asked to perform different navigation-related tasks within the prototype. Outcome measures were the task completion rate and the recorded clicks.

After this initial usability testing, the paper prototype was then transferred into a digital high-fidelity prototype using Figma (Figma GmbH, Germany). This prototype included an example questionnaire for individualizing the information content based on the date of diagnosis, the New York Heart Association (NYHA) functional class, implanted devices (pacemaker, defibrillator), smoking habits, topics of interest and the preferred media formats (Figure 3). After the questionnaire, the basic landing page of the application was presented with an additional link to the health knowledge section. Main part of our prototype was the knowledge section with an overview and link to the available courses and the short information messages. Additionally, badges for learning-related achievements can be found there. Finally, an example course was implemented on the topic of sports and exercise (Figure 4).
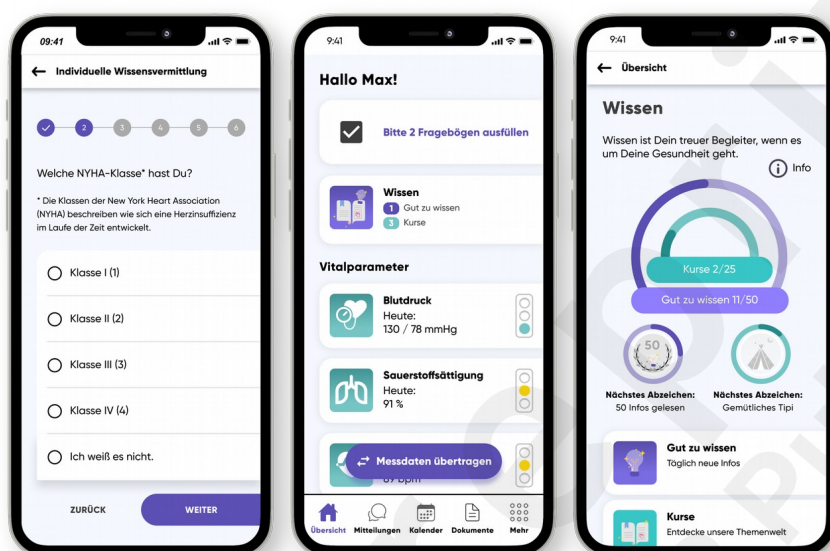

Figure 3: Questionnaire for individual adaptation (left), home screen of the app with the link to the knowledge section (middle) and the main page of the knowledge section (right) of the digital prototype.
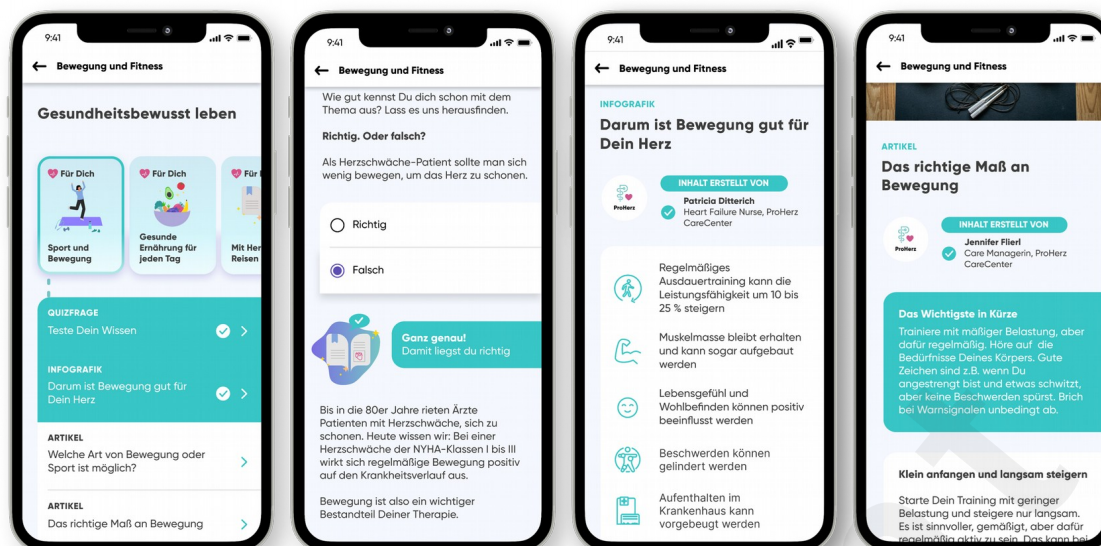
Figure 4: Structure of one exemplary course with (1) the overview of the content, (2) a quiz question, (3) an infographic presenting key facts, and (4) an article starting with information about the author of the text and a summary of the most important aspects of the article.

Concept Evaluation

Recruitment

For evaluating the knowledge transfer concept, we recruited patients with heart failure (n = 7), that were already experienced in using a mobile health app. Therefore, all participants were recruited from the user base of ProCarement. Four participants already took part in the previous stakeholder interviews.

Procedure

After being instructed about the study procedure, participants were asked to complete 11 tasks with the digital prototype. Due to feasibility reasons, patients accessed the prototype on a computer interface. Tasks included small, simple tasks and more complex, time-consuming tasks. An overview of all tasks is listed in Table 1. Afterwards, semi-structured interviews were conducted to obtain the participants' overall impression and to identify features and characteristics that have the potential to improve engagement and increase health literacy.

Table 1: Tasks given to participants in the evaluation of the digital prototype of the knowledge transfer concept.

No.	Description
1	Navigate to the questionnaire for individualization
2	Complete the questionnaire for individualization
3	Navigate to the knowledge section
4	Navigate to informative notifications, read first unread notification
5	Navigate to the educational courses
6	Navigate to the course category 'symptoms'
7	Navigate to completed courses
8	Select a course within a course category
9	Navigate to recommended courses and select a recommended course

| 10 | Complete one educational course |
| 11 | Navigate to the overview of badges |

Analyses

All qualitative data obtained during interviews were analyzed using thematic analysis based on the approach of Braun & Clarke [34].

Ethics Approval

All presented sub-studies were approved by the institutional review board of the Friedrich-Alexander-Universität Erlangen-Nürnberg (22-233-S), and we obtained written informed consent from all participants.

Results

Stakeholder Interviews

Demographics

The stakeholder interviews with patients and medical experts were conducted in August 2022. We recruited 9 patients with a mean age of 67 ± 7 years. Patients received their diagnosis between 15 and 3 years prior to this study. All patients were using the ProHerz app for at least 4 months (Table 2). Seven identified as women, and two identified as men. Additionally, five medical experts were recruited (Table 3) with work experience between 6 and 11 years.

Table 2. Characteristics of patients with heart failure included in the stakeholder interviews.

Interviewee ID	Age	Identified as	Years since heart failure diagnosis	Months of app experience with ProHerz
P1	60	female	5 years	9
P2	58	female	3 years	5
P3	75	female	3 years	15
P4	78	female	5 years	15
P5	63	female	4 years	16
P6	75	female	9 years	4
P7	69	female	15 years	5
P8	60	male	3 years	4
P9	68	male	9 years	6

Table 3. Characteristics of medical experts included in the stakeholder interviews.

Interviewee ID	Identified as	Expert experience	Years of work experience
Expert 1	female	Heart failure nurse, licensed practical nurse	11 years
Expert 2	male	Licensed practical nurse	6 years
Expert 3	female	Licensed practical nurse	6 years
Expert 4	female	Bachelor of Science in Nursing, specialist in anesthesia and intensive care	9 years

| Expert 5 | male | State-qualified nurse | 8 years |

Thematic Analysis

We derived five themes relevant to a knowledge transfer concept from the stakeholder interviews with patients with heart failure and medical experts.

1 Individual Adaptation of Health Information: The interviews revealed a positive perspective towards the adaptation of content and push notifications to the different levels of knowledge of the users (4/5 experts, 2/9 patients). Our results suggest the individualization based on different information such as NYHA class, walking distance, app usage duration, physical condition age, prior knowledge, or personal preferences that could be determined for example through a quiz within the app.

2 Relevant Health Topics for Patients with Heart Failure: Several relevant health topics were identified within the stakeholder interviews (Figure 5). Health topics most requested by both patients and medical experts included nutrition (4/5 experts, 4/9 patients), physical activity (3/5 medical experts, 4/9 patients), symptom perception and reaction (4/5 medical experts, 3/9 patients) and app functionality (3/5 medical experts, 3/9 patients).
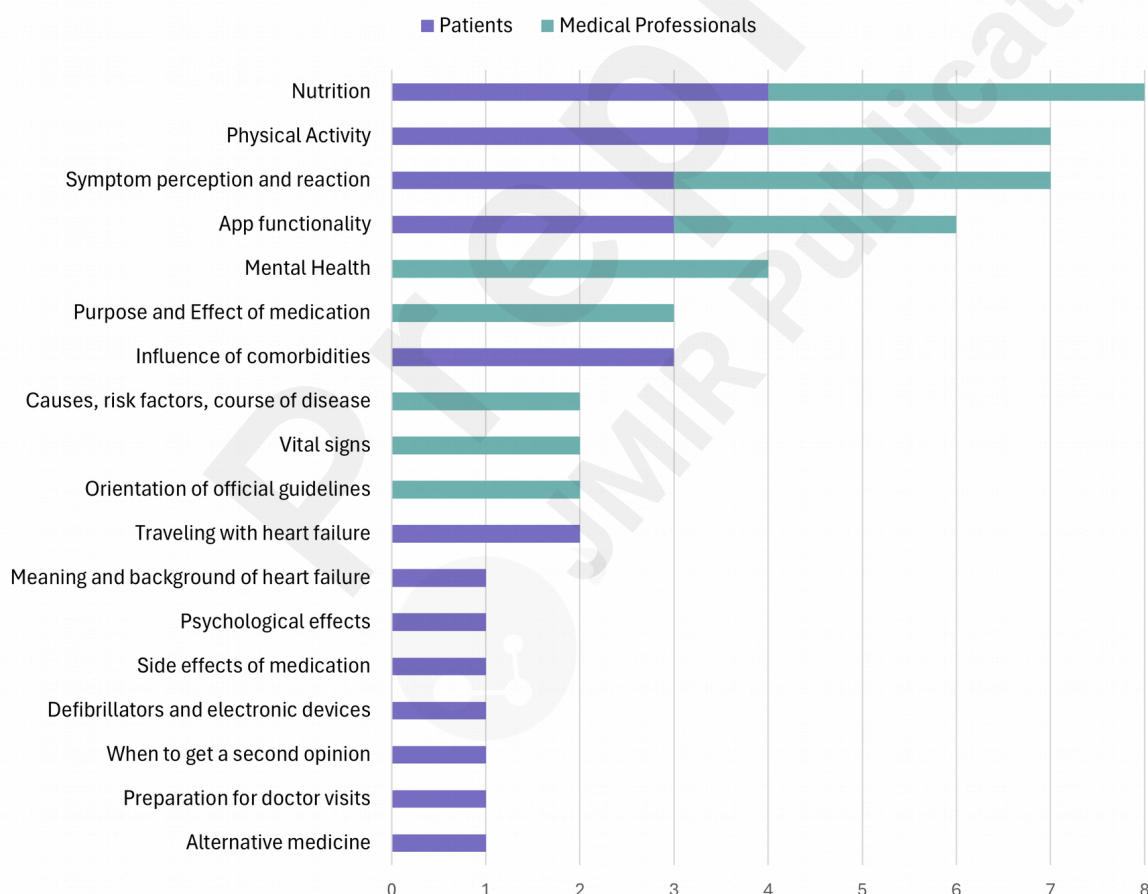

Figure 5: Health topics mentioned in the stakeholder interviews with patients and medical experts and that were considered relevant to be included in a digital knowledge transfer concept.

3 Diversity of media formats: Most of the interviewed patients (7/9 patients) preferred information in text format. Additionally, videos were perceived as useful by all medical experts but only desired by 2 patients. Related to the presentation of the information, patients mentioned using only a few

technical terms (2/9 patients) and shortly highlighting the most important aspects (2/9 patients). This can support easy comprehension of contents, which was also mentioned as a factor for the trustworthiness of health information (3/9 patients).

4 Promotion of motivation, engagement, and joy: Medical experts (4/5 experts) suggested a reward system to increase engagement with the information contents. However, it should be ensured that this reward system is suitable for the specific target group of users (2/5). Three patients also mentioned the wish to receive positive feedback for progress within the application. Personal interest in the content was also mentioned (3/9) to have a positive influence on engagement.

5 Credibility and Trust: From the interviews with patients, we identified several factors related to the credibility of information. Positively perceived was the specification of authors (3/9 patients), especially if the authors are physicians (2/9 patients) or authors with an academic background (2/9 patients). In addition, the provider of the mHealth application should have a good reputation (3/9 patients). Factors restraining trust and credibility could be advertising (1/9 patients), authors without medical background (1/9 patients), or irrelevant information (1/9 patients).

Health Literacy

Health literacy levels based on the EU-HLS-Q16 were between 10 and 16 with an average of 13.6 ± 2.1. Participants mostly had difficulties deciding on preventive actions based on media information (5/9 patients) and determining whether information about health risks in media is trustworthy (4/9 patients).

Evaluation of the Digital Prototype

Demographics

We evaluated the proposed digital prototype of the knowledge transfer concept with seven patients with heart failure (Table 4). The mean age was 65 ± 6 years. Patients received their diagnosis between two and 24 years prior to this study. All patients were using the ProHerz app for at least 5 months. Four participants identified as women, three as men.

Usability

The mean task completion rate was 84 %, five of the 11 tasks given during the study were completed by all participants. The lowest completion rate occurred with task 4, which was completed by four of seven participants.

Table 4. Characteristics of patients included in the evaluation study of the knowledge transfer concept.

Interviewee ID	Age	Gender	Years since heart failure diagnosis	Months of app experience
P1	60	female	5 years	9
P2	58	female	3 years	5
P3	75	female	3 years	15
P5	63	female	4 years	16
P10	59	male	9 years	15
P11	71	male	2 years	15
P12	69	male	24 years	10

Interview Results

The thematic analysis of the semi-structured interviews with patients within the evaluation of our proposed concept resulted in 3 main themes:

Knowledge Transfer: In the evaluation of the digital prototype, the majority of participants (4/7 patients) classified the prospective range of information as valuable. The organization and structure of contents received positive feedback from most participants (5/7 patients). Specifically, the clear arrangement of information (3/7 patients) and the definition of specific categories (2/7 patients) were highlighted. Patients also perceived the individual adaptation as positive, because personally irrelevant content would be hidden (4/7 patients).
To further improve the concept, participants indicated the necessity to update contents in response to potentially evolving needs over time due to lifestyle or health condition changes (2/7 patients).

Motivation and Engagement: A majority (5/7 patients) expressed an intention to utilize the course content in the future. Notably, reminders about feasible health-promoting measures were identified as a motivational factor by 3 out of 7 patients, with a specific emphasis from 2 participants on messages related to physical activity.

Concerns were raised about the potential negative impact of irrelevant, repetitive, or overly frequent notifications (4/7 patients). Conversely, aligning information with individual interests was identified as a key factor in promoting joy and sustaining engagement among users.
Quiz questions demonstrated the potential to increase engagement (2/7 patients). There was a suggestion to place quiz questions at the end of a course to assess the comprehension of the content effectively.

Participants generally responded positively to medical staff monitoring of progress, considering it a supportive element in their engagement with the course. However, 1 participant viewed social comparison negatively. Furthermore, intangible rewards, such as badges, were not universally well-received, with 1 out of 7 participants expressing a negative opinion, suggesting that virtual badges were not perceived as a substantial reward.

Ease of Use: 3/7 patients explicitly mentioned the app as easy to use. Concerns regarding ease of use included potential initial overload when first using the app and potential individual difficulties with the technology and navigation.

Discussion

Principal Findings and Implications

With this study, we developed a concept for mobile health knowledge transfer for patients with heart failure. We grounded this concept on the requirements of patients with heart failure and current theoretical frameworks. From the patient and caregiver perspectives, we derived five central themes for a health knowledge transfer concept.
Our findings contribute to the understanding of user preferences and content organization in digital health interventions targeted at users with heart failure. The integration of diverse methodologies, including qualitative interviews, usability testing, and participant feedback, fortifies the study's comprehensiveness, providing insights into user engagement, health literacy promotion, and the practical implications for digital health interventions. The results of this work support the development of an effective mobile health knowledge transfer for heart failure and provide

orientation towards relevant features and characteristics, ultimately aiming at promoting health literacy.

Synthesized, it becomes evident that a concept should focus on individualization, topic relevance, media diversity, motivation strategies, and trust-building mechanisms to optimize its impact on health literacy and engagement of patients with heart failure. Based on these findings, we developed a concept for knowledge transfer in a digital health application for patients with heart failure.

We evaluated our concept with a digital prototype and identified features and characteristics that are perceived as supportive in increasing health literacy, that can promote motivation, engagement, and joy, and that are able to convince patients of a mobile health knowledge transfer. Most prominent was the wish for content that is individually adapted and balanced regarding the topics covered as well as media formats used to present those topics.

Comparison With Prior Work

The need for individualization is in line with the findings of Giordan et al., calling for further customization especially related to the educational level and digital literacy of users [35]. Our results additionally highlight the need for customization regarding personal interests and lifestyle and the importance of regular adaptation to changing circumstances in the life and knowledge of users. Future applications require new strategies to individually adapt educational content that can change over time. This can include regularly soliciting user feedback through surveys, using quizzes to assess understanding, or adaptive learning algorithms based on user behavior within the mobile app [36].

The topics covered in our knowledge transfer concept are in line with the recommendations of the European Society of Cardiology. They included information about heart failure, symptom monitoring, self-management, medication, fluid intake, implantable devices, physical activity, nutrition, smoking, sleep mental health, and traveling [37]. The information was presented using different media formats, which relates to current literature emphasizing the benefits of this approach. A variety of formats can support users with different health literacy levels and can deepen the learning effects [28,37,38].

Strengths and Weaknesses

Several limitations apply to this study. Firstly, the participant pool featured a restricted number of individuals, all German-speaking and resident in Germany. Moreover, participants were well-acquainted with the ProHerz app, potentially influencing their perspectives and feedback, especially regarding ease of use. Given the advanced health literacy levels of the participants, our findings may not comprehensively represent the needs of individuals with lower health literacy. Lastly, during the evaluation phase, participants accessed the app on a laptop rather than a mobile phone, introducing a potential discrepancy, as some users reported difficulties with computer usage. These limitations underscore the necessity for cautious interpretation and highlight avenues for future research refinement.

Our study combines several strengths: we were the first to conceptualize a mobile health knowledge transfer within a user-centered design approach. By prioritizing patient needs and requirements, and involving healthcare professionals to ensure relevance and meaningfulness, the study sets a precedent in fostering impactful and patient-centric digital health interventions. The incorporation of theoretical frameworks for mobile health education enriches the conceptual foundation, contributing to the overall robustness of the study and its potential impact on the enhancement of patient-centered care.

Conclusions

We were the first to develop a mobile health knowledge transfer for heart failure grounded on theoretical frameworks within a user-centered design process. Through this approach our mobile health knowledge transfer concept is characterized by strong usability and enhanced patient engagement. The active involvement of healthcare professionals ensures that the resulting intervention is meaningful and aligned with relevant healthcare aspects. Our results are paving the way to more personalized and effective mobile health education for individuals managing heart failure.

Future research opportunities should focus on longitudinal studies to assess the sustained impact of this knowledge transfer concept on health literacy, self-care behavior and patient outcomes. Additionally, possible strategies for better individualization of health information should be further explored. This presents an opportunity to investigate adaptive learning algorithms that dynamically tailor content based on user progress and preferences.

Acknowledgments

Authors' Contributions

MF conceived the study, developed the study design, analyzed data, assisted in interviews, and wrote the manuscript draft. SB and JR assisted in developing the study design, interview conduction, and data analysis. KMJ, MN, and HL assisted in writing the manuscript. PT, SE, BME, and HL initiated and supervised the project. All authors reviewed the final manuscript.

Conflicts of Interest

Jana Rolny, Sebastian Eckl, and Patricia Trißler are employees of ProCarement GmbH. All other authors declare no conflict of interest.

Abbreviations

UCD: User-Centered Design
NYHA: New York Heart Association

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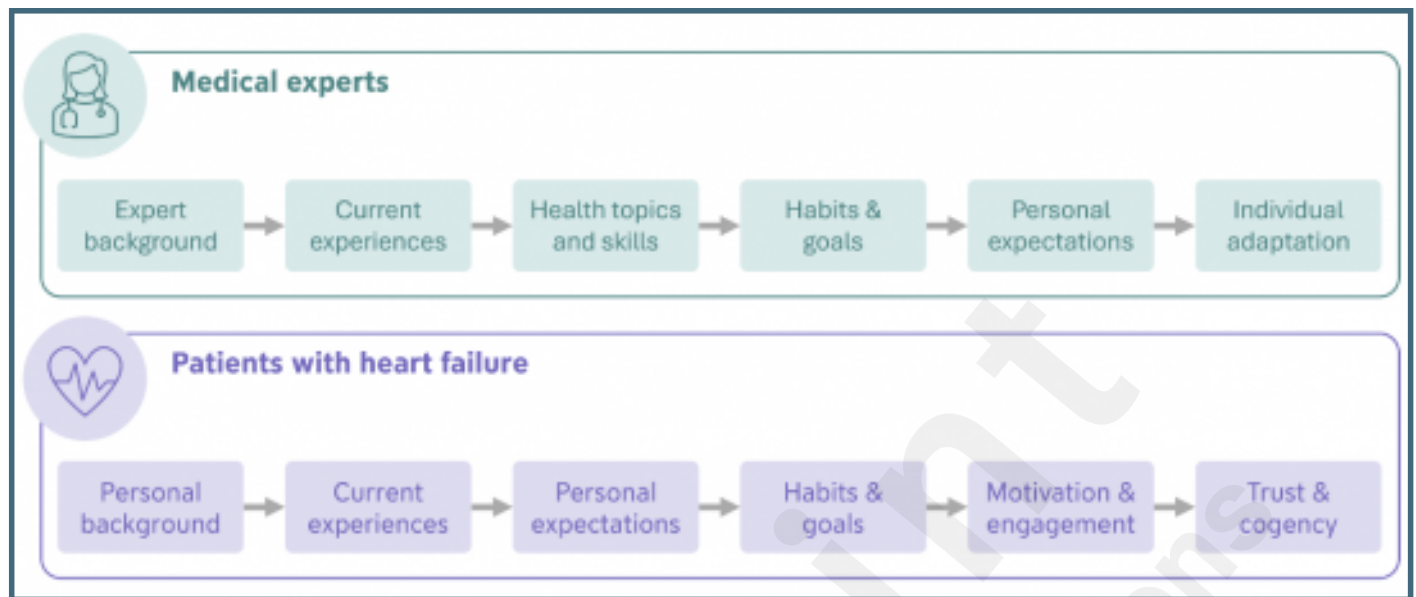
Supplementary Files

Figures

Graphical abstract illustrating the integration of the user-centered design process in the development of a health knowledge transfer concept for patients with heart failure.
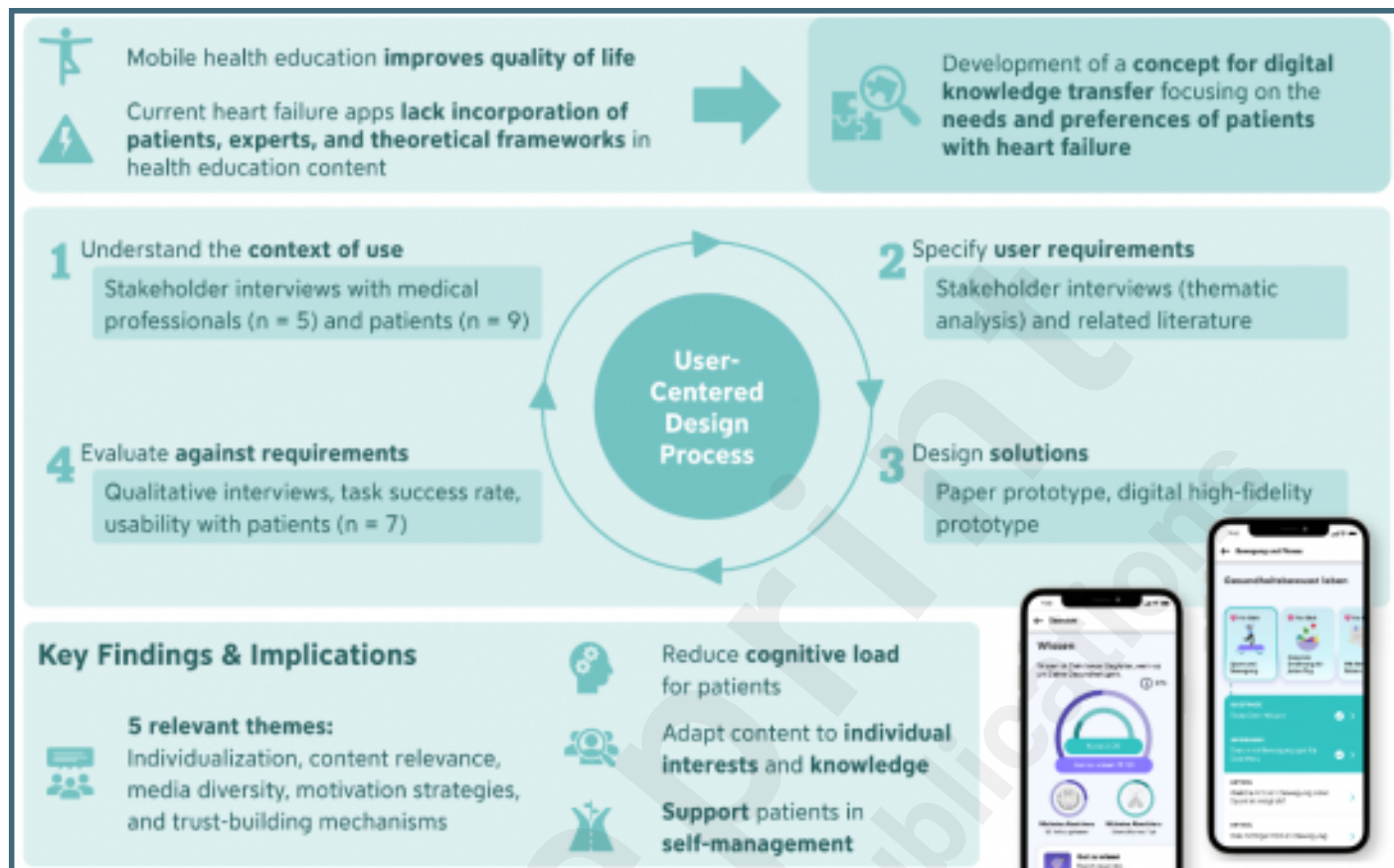
The topics included in the interview with both stakeholder groups.

Questionnaire for individual adaptation (left), home screen of the app with the link to the knowledge section (middle) and the main page of the knowledge section (right) of the digital prototype.
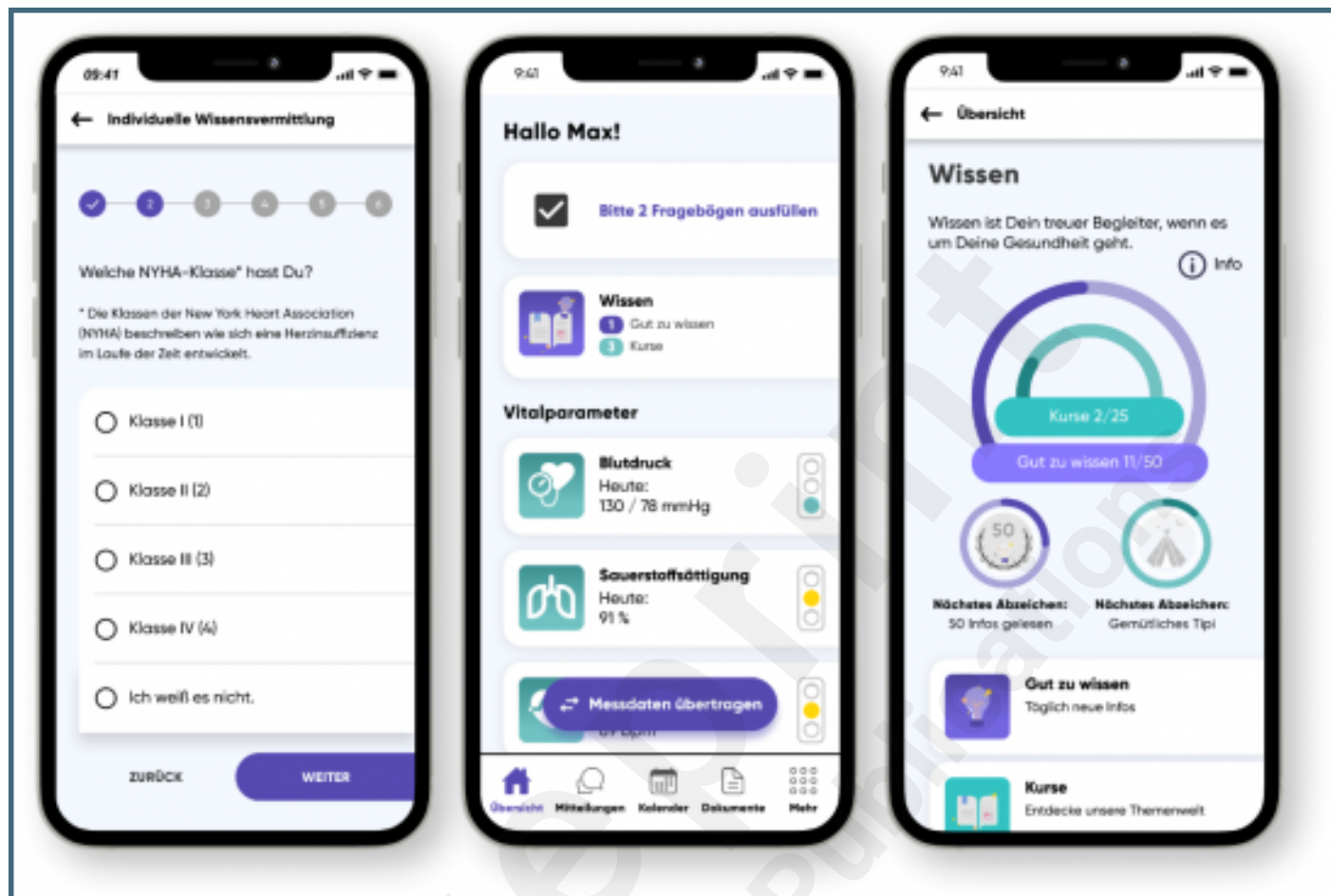
Structure of one exemplary course with (1) the overview of the content, (2) a quiz question, (3) an infographic presenting key facts, and (4) an article starting with information about the author of the text and a summary of the most important aspects of the article.
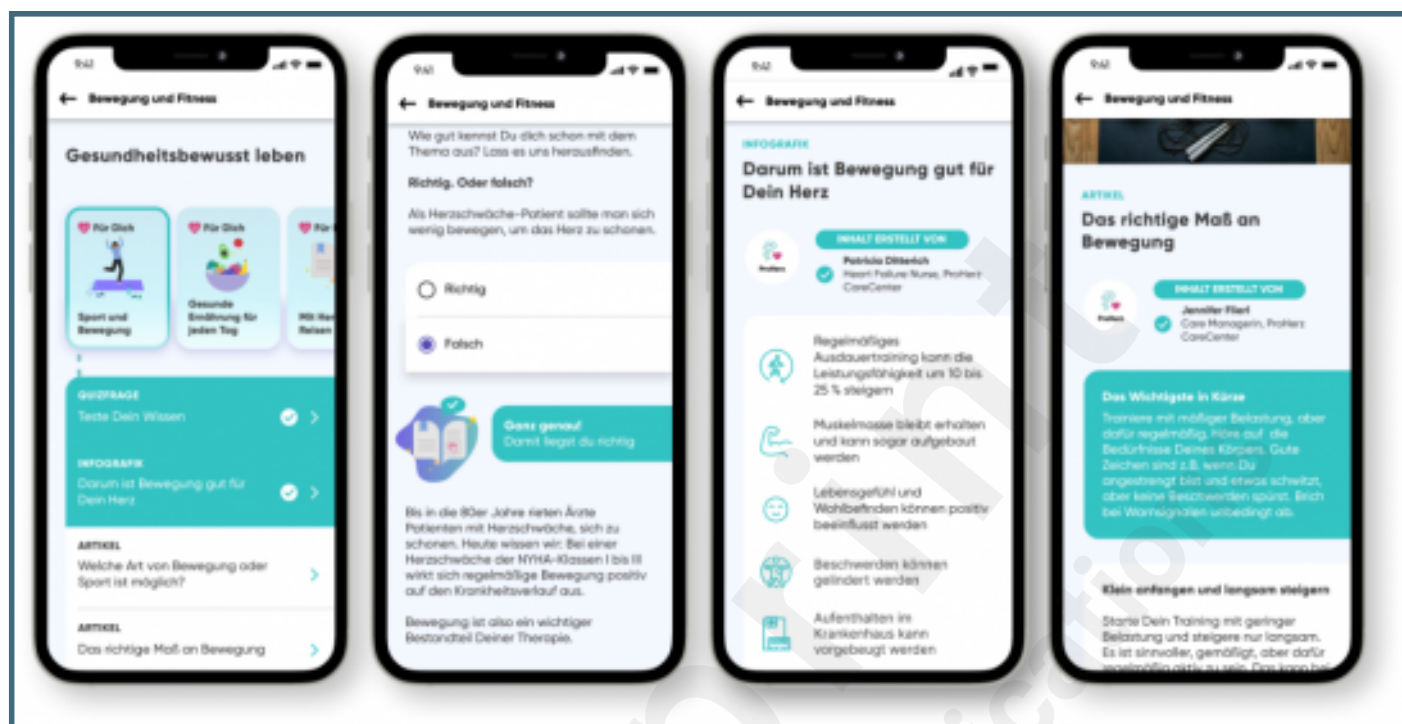
Health topics mentioned in the stakeholder interviews with patients and medical experts and that were considered relevant to be included in a digital knowledge transfer concept.
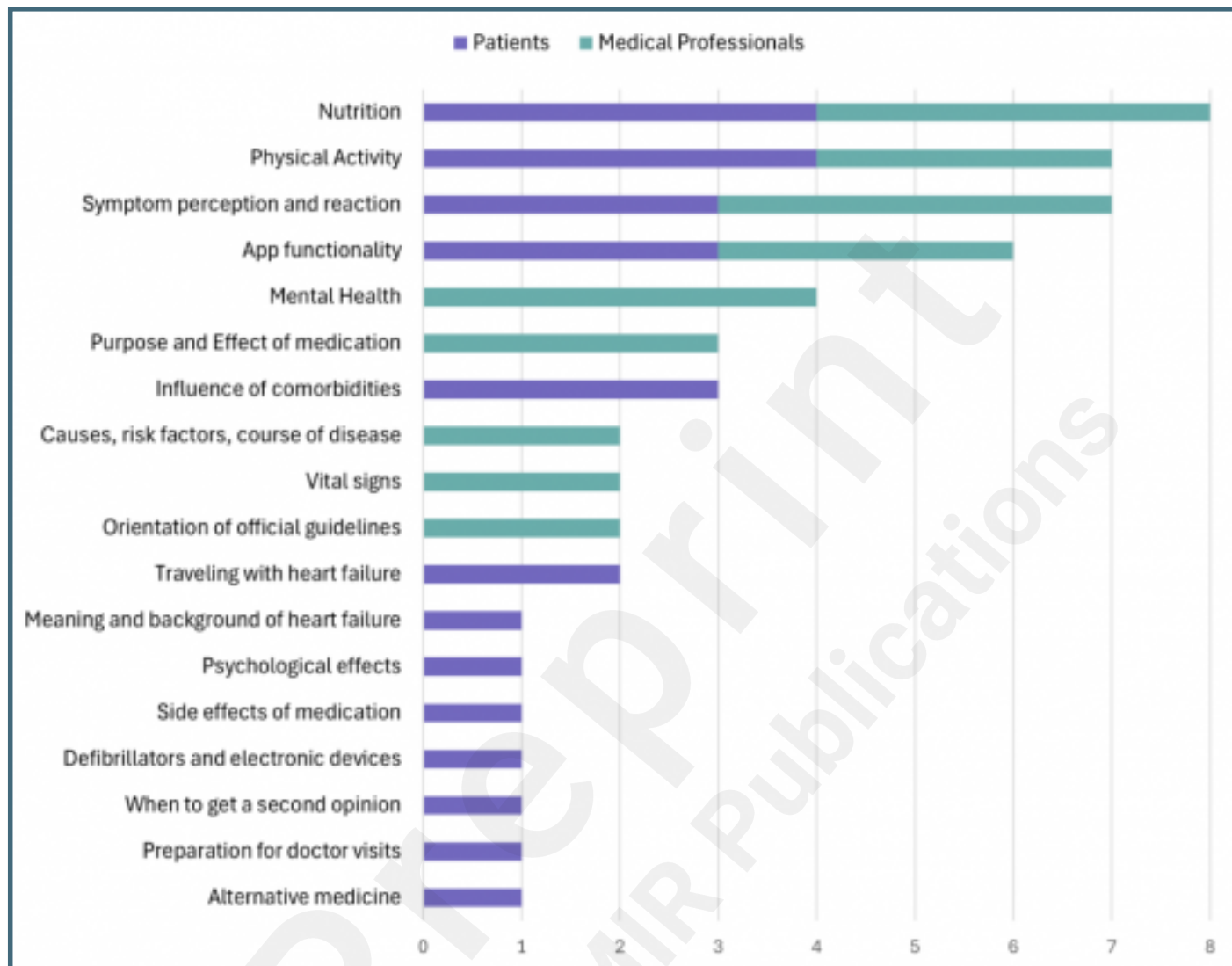
TOC/Feature image for homepages

Untitled.