

Understanding the individual implementation process of eHealth technologies

Exploring critical factors that have a perceived impact on the sustained use of mHealth self-management applications by people with chronic diseases

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Abstract

Background

Chronic diseases which take up 41 million lives each year, are mostly prevented or treated by changing an individual's lifestyle behavior. People have used eHealth technologies, such as Mobile Health, to self-manage their lifestyle and chronic diseases. However, people with chronic diseases were the least inclined to use it. Non-adherence to mHealth self-management apps could lead to unhealthy choices, poor medication intake, and inadequate information for healthcare workers. Therefore, this study aims to identify critical factors that have a perceived impact on the sustained use of mHealth self-management applications in the daily lives of people with chronic diseases.

Method

People with chronic diseases (n=7) were semi-structurally interviewed about their usage patterns, motivations, barriers, and facilitators to using mHealth applications to manage chronic illness. The inclusion criteria were participants above 18 who use or have used mHealth apps for a longer period and have chronic lung disease, diabetes mellitus, and/or cardiovascular diseases. The interview scheme and thematic analysis were partly based on the Theoretical Domains Framework.

Results

Results showed that people with chronic diseases who use or have used mHealth apps self-manage by tracking and monitoring blood pressure, blood sugar, nutrition, medication, and activity. Beliefs about negative consequences when neglecting the apps and being in control motivate them to keep using the apps. Lack of skills, apps not adequately accommodating specific individual needs, and negative emotions were identified barriers. Reinforcing behavior,

convenience, and beliefs about positive consequences facilitated the use of apps. Social influences both stimulated and prevented the use.

Conclusions

Lack of skill, emotional difficulties, and technical issues are discussed as key barriers to the implementation of mHealth for the management of chronic illness, whereas the ease of use, social support, and outcome expectations for favorable results were noted as key facilitators. The results indicate the importance of addressing users' lack of skill, technological needs, and emotional responses in both healthcare and the application's features, which corresponds closely with the constructs identified in the Theoretical Domains Framework.

Introduction

Chronic diseases, also known as noncommunicable diseases (NCDs), take 41 million lives each year, equal to 74 percent of all deaths worldwide (World Health Organization: WHO, 2018). Chronic diseases cannot be passed from one person to another, have an extended duration, and have a gradual progression. The most common chronic diseases are diabetes, cancer, cardiovascular diseases, and chronic respiratory diseases, and they account for over 80 percent of all early chronic disease deaths (WHO, 2018). This main group of patients shares adjustable behaviors that count as behavioral risk factors; insufficient physical activity, smoking, unhealthful eating patterns, and overconsumption of alcohol, which could cause elevated blood pressure, obesity, elevated cholesterol levels, elevated blood glucose, and eventually illness (WHO, 2018).

According to Schmidt (2016), most strategies used to prevent or treat chronic diseases aim at changing individual lifestyle behaviors and helping to maintain them, as the main risk factors are adjustable behaviors. Teaching campaigns are examples of strategies to help inform people about how to act responsibly concerning their illness. These health promotion strategies are, therefore, not entirely determined by public or medical health visions but mainly by personal responsibility. Personal responsibility refers to the individual making behavioral decisions independently and having a choice (Minkler, 1999). Personal responsibility plays an essential role in self-management behavior patterns such as tracking one's healthy eating, physical exercise, medication intake, controlling alcohol/smoking, and seeking medical help in case of complications (Schmidt, 2016). Self-management is the capacity of a person, together with family and medical specialists, to handle symptoms, course of medication, modifications to lifestyle, and psychological effects of medical illnesses (Schulman et al., 2012). However,

effective self-management behavior requires considerable commitment and has its challenges which could often lead to people with chronic diseases having difficulty keeping track of their weight, exercise, and symptoms (Huygens et al., 2016). Furthermore, people with chronic diseases encounter bodily and emotional suffering that can lead to a lack of encouragement and self-discipline, a lack of power, or general fear (Liddy et al., 2014). This could prevent them from performing the regular day-to-day activities needed to optimally self-manage their chronic disease.

Recently, technologies made for healthcare (i.e. eHealth technology), have been used to aid people in optimally self-managing. EHealth technology includes a broad range of technological creations in healthcare and aims to improve health assistance, provide information about monitored health data, and give recommendations (Huygens et al., 2016). One eHealth technology often used in aiding people with self-managing healthy behaviors is mobile wireless technology (mHealth) (Chiarini et al., 2013; Rowland et al., 2020). This healthcare technology uses mobile wireless technologies and a broad span of applications to aid in the self-management of health behaviors. MHealth self-management applications have been shown to significantly enhance health outcomes for people with chronic illnesses such as chronic lung disease, diabetes mellitus, and cardiovascular disease by improving symptom management (Whitehead & Seaton, 2016). mHealth self-management applications contain features such as; activity and level monitoring, medication tracking, communication with healthcare workers, and wellness tracking (Chiarini et al., 2013). Programs for behavior modification using mHealth self-management apps that contain features that could be personalized could increase adherence to proven methods for illness prevention and treatment (Rowland et al., 2020). The results of mHealth self-management

application usage could empower the users, impact their behavior and mindset and, in turn, enhance their medical state (Huygens et al., 2016; Rowland et al., 2020).

Previous studies showed the effectiveness of using mHealth self-management technologies by people with chronic diseases for self-management. A systematic review by Debon et al. (2019), searched and examined applications with matching characteristics such as reminder utilization and self-monitoring regarding chronic diseases, including hypertension, asthma, diabetes mellitus, cardiovascular diseases, and neoplasms, for their effects on behavior. For example, the application ‘Care4Heart’ provided a daily reminder, and relaxation exercises and made it possible to calculate one’s coronary heart disease risk score (Zhang et al., 2017). This application improved medication devotion and communication between the patient and patient-physician as well as informed and motivated the patients. Crucial keys to changing a lifestyle were consistent monitoring and reminders (Debon et al., 2019). The examination outcomes demonstrate modifications in the way of living such as; adequate management of insulin levels, improvement in the management of weight, glycemic ranks, and blood pressure, and making healthier food choices. Overall, they state that behavior changes with the utilization of applications are impressive.

Although mHealth self-management applications can aid in self-management and have various benefits, studies show that people with chronic diseases do not always adhere to such applications. According to Robbins et al. (2017), people who mainly profit from mHealth self-management applications –those who exercise and self-monitor health inadequately– were the least inclined to use them. Robbins et al. (2017) explain this as being mainly due to not knowing that these applications exist or not believing that they are helpful. However, few studies have

tried to comprehensively understand this lack of adherence to mHealth by people with chronic illness.

A framework that can help in understanding why chronically ill people do not adhere to self-managing apps is the Theoretical Domains Framework (TDF) (De Leo et al., 2021). To better understand the underlying barriers to and enablers of evidence-based change, different constructs are discussed in the Theoretical Domains Framework (De Leo et al., 2021). The TDF offers an extensive arrangement of the overlapping components found in behavioral theories. These constructs are extended over 14 domains of individual components and environmental influences that pose barriers to or facilitate behavior change. One of the domains in the TDF framework is the individuals' beliefs about the consequences, such as the use of mHealth self-management applications. One of the reasons for non-adherence, therefore, could be the belief that self-management apps simply would not be helpful (Sanders et al., 2012). Another domain is the individuals' belief in one's capabilities to perform tasks that achieve a specific goal, such as successfully using self-management apps. One lacking or feeling one lacks technological competence and mastery to use self-management apps could also be a reason for non-adherence (Sanders et al., 2012).

Still, with high intentions, one does not always change behavior, as Sniehotta et al. (2005) explained this as the "intention-behavior gap". The factors of believing in one's ability (perceived self-efficacy), planning how one will conduct a behavior, and monitoring one's behavior (self-regulatory techniques) could intervene between behavior and intention. A person not planning how to conduct their intended behavior of healthy eating, for example, and failing to self-monitor whether this behavior is reached, may influence the transition from intention to behavior. These factors are included and explained in the TDF framework as well as being

required for the implementation of new practices (De Leo et al., 2021). The domains of the TDF framework should be taken into account as they can play an important role in the implementation of self-management apps. Non-adherence to mHealth self-management applications that are intended to aid could lead to adverse behaviors such as unhealthy choices, poor medication intake, and inadequate information transmission between patients and healthcare workers (Gandapur et al., 2016). Therefore, it could be worth investigating why people with chronic diseases do not adhere to the mHealth self-management applications, as global treatment for chronic diseases could be greatly impacted by the mHealth self-management applications.

This study aims to explore the possible barriers and facilitators people with chronic diseases stumble upon when trying to use mHealth self-management applications on mobile devices to track their health and self-manage their chronic disease. This study could give insight into why patients do or do not adhere to mHealth self-management applications and could guide the development and implementation of these technologies in daily life. The following research question is formulated; *What critical factors have a perceived impact on the sustained use of mobile health self-management applications in the daily lives of people with chronic diseases?*

The following sub-questions could help to answer the research question:

1. *In what way do people with chronic lung disease, diabetes mellitus, and/or cardiovascular diseases self-manage their disease with mHealth application(s)?*
2. *What motivates people with a chronic disease to use mHealth application(s) to manage their disease?*
3. *What are the barriers to the sustained use of mHealth self-management application(s) in daily life according to people with a chronic disease?*

4. *What are facilitators or supportive strategies for the sustained use of mHealth self-management application(s) in daily life according to people with a chronic disease?*

Method

Design

This study used semi-structured interviews to obtain information to answer the research questions. Semi-structured interviews permit in-depth exploration of people's emotions, experiences, underlying motives, and behaviors and are regarded as an appropriate research methodology (Horton et al., 2004). Furthermore, conducting interviews with participants provides flexibility in exploring certain elements of their experiences, thereby enabling a thorough knowledge of the characteristics that support or demotivate prolonged usage of self-management applications among individuals with chronic illnesses (Horton et al., 2004). This study was approved by the Ethical Committee (Domain Humanities and Social Sciences) of the University of Twente, with approval number 240282.

Participants

For this study, the general target group was people with chronic diseases who use or have used mHealth self-management applications for a longer period of time. Inclusion criteria specified; (1) participants above 18 years old, (2) people with chronic diseases; chronic lung disease, diabetes mellitus, and/or cardiovascular diseases, (3) people who use or have used self-management applications for managing their chronic disease for a longer period of time. There were no specific exclusion criteria. Participants were recruited via convenience sampling. This sampling method gathers data from whoever is willing to participate, those easily reachable, or otherwise readily available to the researcher (Scholtz, 2021). Individuals who were most likely to

provide relevant and helpful information were chosen through the use of purposive sampling. A message was formed with information about the study's background, aim, and the process of participating in it. It was communicated through various platforms such as WhatsApp, Instagram, and forums (<https://www.longforum.nl/>, <https://www.diabetes.nl/>) where people with diabetes mellitus/lung diseases communicate. Contact details such as a phone number and email address were provided to contact the researcher if a person was interested in participating. The participants were invited to participate in an interview that could be done both in person and online via Zoom, Teams, or WhatsApp video/audio call.

Nine participants were invited of whom three were personally contacted by the researcher, and six reacted to the message on social media and in forums. Two participants did not meet the inclusion criteria, while seven participants did meet the inclusion criteria. Zero participants dropped out. Seven participants were interviewed and were aged between 22- 78 ($M=50.85$, $SD=21.03$). The demographic characteristics of the participants can be found in Table 1.

Table 1

Demographic characteristics of the seven participants.

Baseline characteristic	Full sample	
	n	%
Gender		
Female	3	42.9
Male	4	57.1

Chronic disease		
Diabetes mellitus	3	42.9
Cardiovascular disease	2	28.6
Lung disease	1	14.3
Diabetes mellitus and cardiovascular disease	1	14.3
Highest educational level		
University of Applied Sciences degree	5	71.4
University degree	2	28.6
Employment		
Unemployed	1	14.3
Employed	1	14.3
Student	2	28.6
Retired	3	42.9

Note. N= 7.

Materials

The researcher developed a semi-structured interview scheme for the interviews. The interview scheme consisted of 25 open-ended questions, as seen in Appendix A. The interview scheme was created based on the Theoretical Domains Framework (TDF) (Buchanan et al., 2021). The interview questions were divided between the main themes of motivation, barriers, and facilitators. The subtopic questions for each theme were based on the constructs explained in the TDF framework. Besides, the interview was pilot-tested with another researcher and the interview scheme was improved based on the feedback derived from the pilot test. Questions

were asked regarding the sub-topic; (1) demographic information, (2) self-management/ usage pattern/ motivation, (3) thoughts behind the usage, (4) barriers, and (5) facilitators. Sub-topic (1) questions consisted of demographic characteristics, such as age, gender, occupation, education level, and type of disease. Sub-topic (2) questions were about how they managed their chronic disease, how mHealth self-management applications aided in this, their usage patterns, and motivations behind the usage. For example, *'Can you describe how you use self-management applications to manage your health or chronic disease?'* Sub-topic (3) questions were about how the participants felt regarding their capability, knowledge, skills, intention, and environment regarding using self-management applications. For example, *'Do you feel capable of using self-management apps for health monitoring? Why or why not?'* Sub-topic (4) questions were about possible difficulties, barriers, and challenges leading to non-adherence to these applications, and possible negative outcomes from using these applications. For example, *'What demotivates you or makes it difficult for you to continuously use these apps/features daily?'* Besides, sub-topic (5) questioned what makes it easier to keep adhering to these applications and what factors/strategies help to keep using them. Lastly in this sub-topic, the participants were asked about their opinions regarding improvements in the application and provision of health care. For example, *'How can healthcare providers or app developers better assist you in using mHealth apps daily?'*

Procedure

When participants indicated interest in the study, they were sent an information letter that included detailed information about the study (see Appendix B). Participants were informed that participation and being audio-recorded are voluntary. If the inclusion criteria were met and

the participant agreed to participate, they were asked for their availability and the preferred platform or way to participate in the interview. Five out of seven interviews were done via online platforms and two were done in person. The platforms Zoom, Teams, and WhatsApp were used. In-person interviews were conducted in private meeting rooms booked at the University of Twente.

During an interview, participants first got an introduction about who the researcher was, what the study was about, the purpose, and the consent form. The participant got the opportunity to ask questions before signing the informed consent, which can be found in Appendix C. The interview and recording started only after the participant indicated having received sufficient information and being ready to start the interview. After this, the participant was asked questions that were provided in the interview scheme and had the opportunity to bring in other information regarding the topic and new experiences or insights that would help answer the research questions. Lastly, the participants got the opportunity to share their opinions about what could be improved in general. The last questions were answered and only after the participant indicated they had no more questions or thoughts to share with the researcher, did the interview come to an end. The researcher thanked the participant and indicated that any future questions or uncertainties could be sent to the contact details listed on the consent form of which participants were given a copy. The interview in total took around 36 minutes.

Data analysis

All audio recordings of the interviews were transcribed verbatim by the researcher. Transcripts were uploaded on Atlas.ti Web version 7.7.1. Transcripts were coded deductively

based on the themes related to the research questions and based on the constructs from the TDF framework. Based on the research questions a coding scheme was developed, containing the main codes of (1) *Behavioral regulation*, (2) *Motivation*, (3) *Barriers*, and (4) *Facilitators*. When deductive thematic analysis was conducted on the transcript, segments that provided information for these main themes were highlighted. Throughout this procedure, the Constant Comparison Method, in which every piece of data gets compared with the other pieces of data, was used to modify the coding scheme (Boeije, 2002). Answers to a single question were compared using constant comparison. Subcodes were created deductively for each of the main themes based on this (deductive thematic analysis). The subcodes were based on segments that were important for answering the research questions and should propose a summary of these segments.

Transcriptions were coded and compared until no new themes related to the research questions were found, thus until the saturation point was reached (Constantinou et al., 2017). The subcodes were, furthermore, named and categorized based on the TDF framework. The main codes, subcodes, their definitions, and related quotes can be found in Tables D1-4 in Appendix D.

Results

This study aims to explore the possible barriers and facilitators people with chronic diseases stumble upon when trying to use mHealth self-management applications on mobile devices to track their health and self-manage their chronic disease. To explore this aim, the following research question was formulated; *What critical factors have a perceived impact on the sustained use of mobile health self-management applications in the daily lives of people with chronic diseases?* Answering the following sub-research questions could help answer this main research question.

To answer the first sub-research question; *In what way do people with chronic lung disease, diabetes mellitus, and/or cardiovascular diseases self-manage their disease with mHealth application(s)?*, the **Behavioral regulations** were explored. This main code refers to anything aimed at managing or changing objectively observed or measured actions. The related codes mentioned by participants are reported and defined in Table 2. As can be seen, the subcode **Monitoring sugar levels** was created, which entails independently supervising a chronic illness through regularly observing the blood sugar level. One participant explained: *“An app has been created that you can set up on your phone. You can open this app and then hold it on your sticker, when it scans it you will receive your current blood sugar.”* (participant C). Four out of seven participants mentioned regulating their chronic disease by monitoring sugar levels.

In addition, the subcode **Tracking Nutrition** was created, which entails independently supervising a chronic illness through regularly keeping a trace of one’s food intake and making healthier food choices. One participant explained: *“I have a calorie counter app.”* (Participant G). Three out of seven participants mentioned regulating their chronic disease this way. Furthermore, the subcode **Monitoring blood pressure** was created, which entails independently supervising a chronic illness through regularly observing the blood pressure. One participant explained: *“I measure my own blood pressure. And yes when he starts showing outliers, that is the reason to call the doctor.”* (Participant A). Two out of seven participants mentioned regulating their chronic disease this way. Besides, the subcode **Medication intake** was created, which entails independently supervising a chronic illness through regular prescription intake. One participant explained: *“I use reminders that remind me to take medication.”* (Participant G).

Lastly, the subcode **Activity monitoring** was created, which entails independently supervising a chronic illness through regularly tracking one's physical activity. One participant explained: “*Yes, so I use a step tracker.*” (Participant D). Activity monitoring and medication intake were both mentioned only by one participant. Most participants reported using a device alongside the application for their disease management, such as a blood pressure meter or glucose meter. One participant explained: “*The app works in combination with sensors, which measure the glucose in the body every 5 minutes and the sensor sends this to the phone every time. The app calculates the amount of insulin required for this.*” (Participant F).

Table 2

Coding scheme related to behavior regulation around chronic diseases, including main codes, subcodes, definitions of codes, the number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Nint	Ntot
Behavioral regulation	Monitoring blood pressure	Independently supervising a chronic illness through regularly observing the blood pressure.	2	5
	Monitoring sugar levels	Independently supervising a chronic illness through regularly observing the blood sugar level.	4	7
	Tracking nutrition	Independently supervising a chronic illness through regularly keeping a	3	3

	trace of one's food intake and making healthier choices in food		
Medication intake	Independently supervising a chronic illness through regular prescription intake	1	1
Activity monitoring	Independently supervising a chronic illness through regularly tracking one's physical activity.	1	1

To answer the second sub-research question; “*What motivates people with a chronic disease to use mHealth application(s) to manage their disease?*”, the **motivations** were explored. This main code refers to the psychological pressure that encourages action, in this case; using mHealth applications. The related codes mentioned by participants are reported and defined in Table 3. As can be seen, the subcode **Beliefs about negative consequences** was created, which entails the stimulation to use the mHealth application through negative outcome expectancies if ignoring the application. One participant explained: “*Wanting to prevent these annoying side effects is what keeps motivating me to check it out.*” (Participant C). Six out of seven participants mentioned that wanting to prevent negative side effects is what motivates them to keep using mHealth applications. Most participants mentioned the side effects being physical symptoms, as one participant explained: “*And if I don't use reminders, eh, and forget to take my puff, I feel very short of breath*” (Participant G).

Furthermore, the subcode **Beliefs about capabilities** was created, which entails the stimulation to use the mHealth application through feeling in control over one's chronic disease.

One participant explained: *“It gives me the feeling that I am keeping my high blood pressure lower and under control. That's the feeling I have.”* (Participant D). Other participants also mentioned improved management of their chronic disease through using mHealth applications, as one participant explained: *“Back then, cycling 15 kilometers was enough. Nowadays I put away 40. Yes. I have now been able to halve my medication. So you feel the results.”* (Participant A). Four out of seven participants have mentioned that wanting to be in control of their disease is what motivates them to keep using mHealth applications.

Lastly, one can see that motivations to use the application diverge between participants, as a comparison between the answers showed that a part of the participants get motivated by experiencing positive aspects, while others by experiencing negative aspects. Participants who often mentioned wanting to prevent negative aspects had experienced severe side effects of their chronic disease, such as a brain hemorrhage.

Table 3

Coding scheme related to motivations for mHealth usage, including main codes, subcodes, definitions of codes, the number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Nint	Ntot
Motivation	Beliefs about negative consequences	Stimulation to use the mHealth application through negative outcome expectancies of ignoring application.	6	14

Beliefs about capabilities	Stimulation to use the mHealth application through feelings of being in control over one's chronic disease.	4	16
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To answer the third sub-research question; “*What are the barriers to the sustained use of mHealth self-management application(s) in daily life according to people with a chronic disease?*”, the **Barriers** were explored. This main code refers to factors blocking a specific action, in this case; using mHealth applications. The related codes mentioned by participants are reported and defined in Table 4. As can be seen, the subcode **Skills** was created, which entails obstacles to using mHealth applications because of a lack of knowledge or ability achieved through practice. Most participants (six out of seven) mentioned this being an obstacle, as one participant explained: “*The technology of the telephone makes it a little more difficult.*” (Participant D). Another participant explained: “*If you always have to do that manually, that becomes difficult. Yes, and I can set up things like that, but I can imagine that for some people that is rocket science.*” (Participant A). Comparison between the answers showed that a part of the participants experienced difficulty in using the application and its features while others experienced difficulty understanding the portrayed results (e.g. values) and responding to these regarding their behavior.

Besides, the subcode **Emotions** was created, which explains obstacles to using mHealth applications because of a complicated response routine, concerning behavioral, physiological, and experiential elements, such as frustration when the individual tries to deal with the application. Comparison between the answers showed that a part of the participants mentioned

getting frustrated from having to check the application regularly, while others mentioned experiencing negative feelings when seeing the values of such applications. One participant explained: *“I get frustrated by having to think about it all the time.”* (Participant G). Another participant explained: *“Yes, I often skip measuring when I expect or notice high blood sugars. I don't dare to look because I sometimes experience negative feelings”* (Participant C). Four out of seven participants mentioned sometimes experiencing negative feelings because of the application.

Furthermore, the subcode **Social influences** was created, which explains obstacles to using mHealth applications because of interpersonal processes, such as social pressure, that can alter someone's feelings, ideas, or actions. One participant explained: *“Those negative thoughts of, oh, what will people think of me, things like that”* (Participant B). Another participant explained: *“Sometimes I feel ashamed about this... The calorie counter app is sometimes uncomfortable to use in the presence of others.”* (Participant G). Three out of seven participants mentioned that social influences sometimes prevent them from using the mHealth application.

In addition, the subcode **Resources of user-friendliness** was created, which explains obstacles to the adaptation to the usage of mHealth applications because of the lack of important functions or being less sophisticated compared to different devices, as it discourages the usage of these applications over the devices. One participant explained: *“Unfortunately, the app on the phone has no alarm or notification to remind me to measure. The app can only scan.”* (Participant C). Two out of seven participants mentioned the application lacking important features or being less developed compared to a device, such as a glucose meter. One participant explains: *“It doesn't scan quickly until it's not exactly on it, then it doesn't scan it. You also*

cannot measure the sugar several times in a row. You can use this once every half hour. Sometimes you need it to see if your high blood has already gone down, but I can't use it again after that. The device is faster in this.” (Participant C).

Furthermore, the subcode **Behavior regulation (habits)** was created, which explains obstacles to using mHealth applications because of difficulties in handling or adjusting objectively watched or measured actions, such as implementing the use of mHealth applications in the daily routine. One participant explains: *“Getting used to having a chronic illness is more difficult than getting used to using something for it. Mentally you have to get used to a chronic illness and if this is difficult and you do not feel mentally ready for it, then you can have complications with the use of these types of apps.” (Participant C).* Two out of seven participants mentioned this obstacle.

Table 4

Coding scheme related to barriers for mHealth usage, including main codes, subcodes, definitions of codes, the number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Nint	Ntot
Barriers	Social influences	Obstacles to using mHealth applications because of interpersonal processes, such as social pressure, that can alter someone's feelings, ideas, or actions.	3	8

Skills	Obstacles to using mHealth applications because of one lacking knowledge or ability achieved through practice.	6	11
Resources of user-friendliness	Obstacles to the adaptation to the usage of mHealth applications because of the lack of important functions or being less sophisticated compared to different devices, as it discourages the usage of these applications over the devices.	2	7
Emotions	Obstacles to using mHealth applications because of a complicated response routine, concerning behavioral, physiological, and experiential elements, such as frustration when the individual tries to deal with the application.	4	7
Behavior regulation (habits)	Obstacles to using mHealth applications because of difficulties in handling or adjusting objectively watched or measured actions, such as implementing the use of mHealth applications in the daily routine.	2	2

To answer the fourth sub-research question “*What are facilitators or supportive strategies for the sustained use of mHealth self-management application(s) in daily life according to people with a chronic disease?*”, the **facilitators** were explored. This main code

refers to factors enabling a specific action, in this case; using mHealth applications. The related codes mentioned by participants are reported and defined in Table 5. As can be seen, the subcode **Beliefs about positive consequences** was created, which explains enabling the use of mHealth applications through positive outcome expectancies by using the application. One participant explained: *“Well, when I use it constantly, I notice positive consequences. Such as being less short of breath, having a balanced weight. And that motivates me to pick up the apps.”* (Participant G). Participants also mentioned wanting to stay healthy in the long term as a facilitator to keep using the application. One participant explained: *“In the longer term, I am trying to ensure myself of a reasonably healthy old age.”* (Participant E). Other participants stated that the application made their lives easier and facilitated the use of the application. One participant explained: *“Because the tools are there and it's getting easier, Making use of them ultimately makes your life ten times easier.”* (Participant B).

In addition, the subcode **Resources of convenience** was created, which entails easing the adaptation to the usage of mHealth applications through understanding how easier independent supervision gets with the use of applications, therefore encouraging the usage of these applications. Comparison between the answers showed different experiences regarding the perceived convenience. Participants mentioned that the application eases the tracking of values. One participant mentioned: *“It also offers the opportunity to keep track of these kinds of things very well. That's actually the convenience of digital. That everything is simply recorded.”* (Participant A). Other participants mentioned that applications on the phone are easier to carry than the devices used for measuring glucose. One participant mentioned: *“I thought it would be useful because wherever you are, your phone is always in your pocket. You rarely go outside*

without a phone. So the nice thing is that you can take this with you everywhere without having to carry extra stuff." (Participant C).

Some, also, mentioned that detailed information regarding the usage of such applications facilitates their use. One participant explains: *"It could be, for example, a healthcare provider, something in terms of support or instructions. Or maybe an app developer tells you, technically this and this."* (Participant A). Furthermore, participants mentioned that the applications staying up-to-date and having the function to inform others, such as healthcare providers, would facilitate the use of such applications. One participant explained: *"Suppose there is a function in the app that tells you to contact my diabetes nurse or my internist, or my wife when I'm not home or something. I could imagine that being an advantage."* (Participant E). Most participants (six out of seven) mentioned that the applications made self-managing their disease easier and that beliefs about positive consequences facilitated their use.

Furthermore, the subcode **Reinforcing behavior** was created, which entails easing the use of mHealth applications by increasing the likelihood of using the application by developing a relationship between the response and given stimuli. In this situation, awareness of having the disease and notifications. Comparing the answers showed that some participants mentioned awareness of having the disease given stimuli to open the application. One participant answered the following question: *"The disease gives you a feeling that every day you have to look at the app to keep yourself under control"* (Participant D). Other participants mentioned that getting notifications gives them stimuli to open the application. One participant answered the question related to strategies that help continuously using the app with: *"The beeping and notifications"* (Participant C). Five out of seven participants mentioned these stimuli.

Lastly, the subcode **Social influences** was created, which entails that easing the use of mHealth applications through interpersonal processes, such as social support, can alter someone's feelings, ideas, or actions. Two out of seven participants mentioned that their surroundings recommending the applications facilitated the use of the mHealth application. One participant explained: *"I had not chosen it myself, but it was recommended to me by the diabetes nurse."*(Participant C).

Table 5

Coding scheme related to facilitators for mHealth usage, including main codes, subcodes, definitions of codes, the number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Nint	Ntot
Facilitators	Social influences	Easing the use of mHealth applications through interpersonal processes, such as social support, can alter someone's feelings, ideas, or actions.	2	5
	Reinforcing behavior	Easing the use of mHealth applications by increasing the likelihood of using the application by developing a relationship between the response and given stimuli. In this situation, awareness of having the disease and notifications.	5	9
	Resources of convenience	Easing the adaptation to the usage of mHealth applications through understanding how easier independent supervision gets with the use of	6	17

applications, therefore encouraging the usage of these applications.

Beliefs about positive consequences	Easing the use of mHealth applications through positive outcome expectancies by using the application.	6	12
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Discussion

Main findings

This study explored the possible barriers and facilitators people with chronic diseases face when trying to use mHealth self-management applications for a longer period to track their health and self-manage their chronic diseases. This study gave insight into why patients do or do not adhere to mHealth self-management applications and could guide the development and implementation of these technologies in daily life.

This study showed that people with chronic diseases mostly use self-management applications to track their blood sugar, blood pressure, and nutrition. The most important motivation for people with chronic diseases to use mHealth applications to manage their disease was that they expect negative outcomes if they stop the application. Wanting to prevent negative side effects, such as high blood sugar, motivated them to keep using mHealth applications. In contrast, the most important barriers to the sustained use of mHealth self-management applications in daily life, according to people with chronic diseases, were lack of knowledge or

ability, and frustration when the individual tries to deal with the application. Some participants mentioned getting frustrated from having to check the application regularly, while others mentioned experiencing negative feelings when seeing negative results of measured values (e.g. high blood sugar) on such applications. In contrast, the most important facilitators or supportive strategies were; expecting positive outcomes from using the application and perceiving the conveniences of the use of applications. This showed that acquiring the right knowledge and skills for using mHealth applications and understanding their long-term benefits can increase sustained use.

Comparison with prior work

The study's main findings showed that critical factors of motivation, barriers, and facilitators can be further divided into specific aspects, which show high similarity with the constructs of the TDF framework. Almost all codes found as underlying obstacles or enablers could be placed under the constructs of the TDF framework. This means that the TDF framework seemed to fit for studying individual factors and underlying factors in implementation processes and sustained behavior change, such as the sustained use of mHealth applications.

However, one code in the coding scheme; resources of convenience (facilitator), did not completely fit with the TDF framework. The code could fit under the overarching construct 'Environmental context and resources' of the TDF framework, as material resources were mentioned as a component construct that refers to the convenience of the application which facilitates the usage of the application. However, this construct did not specifically refer to the beliefs around convenience regarding the application, but rather to the material resources of convenience around the application. For example, the code of 'resources of user-friendliness' referred to mHealth applications lacking important functions or being less sophisticated

compared to different devices, thereby specifically referring to the material resource (the application's functions). The code of 'resources of convenience' referred to a subjective belief of the individual; the belief of how a practice or act could add value in one's life (e.g. using applications) and that the goal (independent supervision) is easier achieved with the specific action. Therefore, the belief about the convenience of a behavior could not be found as a construct mentioned in the TDF framework.

Furthermore, the findings were expected as they can be found in previous research. The code of 'resources of convenience' and 'beliefs about positive consequences' were the most important facilitators as these were indicated by most participants. When one expects that a different behavior is easier to perform than their current behavior and will lead to a better result it could increase their intention to adopt that other behavior. This is also mentioned in the Theory of Planned Behavior (TPB), as it explains that one's beliefs about the consequences and the ease of a specific behavior could influence behavioral intention (Montano & Kasprzyk, 2015). Moreover, Bansah and Darko (2022) explained that perceived convenience, effectiveness, and usefulness are important factors in implementation processes as these factors increase the acceptance of innovation.

In addition, the codes 'skills' and 'emotion' were the most important barriers as most participants indicated these barriers. People may be less likely to adhere to an application when they lack the knowledge or expertise required to use it. The Integrated Behavioral Model explains that even if an individual has high intentions to perform a specific behavior, the individual needs the required knowledge and ability to perform this behavior (Montano & Kasprzyk, 2015). Moreover, Durlak and DuPre (2008), explained that mastery of the necessary skills is a factor that could affect the implementation process as it improves self-efficacy.

Moreover, people may be less likely to adhere to an application when experiencing frustration when trying to deal with the application. This could be frustration due to seeing negative feedback from the application or having to check it constantly. The Integrated Behavioral Model explains that the intention to conduct a recommended behavior is influenced by the person's emotional reaction to (the idea of) executing this behavior (Montano & Kasprzyk, 2015). People who experience bad emotions when using the application are less likely to use it. Moreover, Choi et al. (2011), explains that individuals' emotional responses towards innovation are important for the implementation process as these emotions generate (un)favorable cognitive evaluations around the innovation.

Limitations & Strengths

Despite the interesting findings of this study, it is necessary to acknowledge the study's limitations. Firstly, the method of convenience sampling was used to recruit the study sample. Participants were sought who were easy to find and had to meet specific requirements. The study sample consisted mostly of elderly people and too few (healthcare, technology) professionals, and was therefore probably not representative. As a result, the study's informative usefulness can be minimal. There is not enough perspective on young people's experiences in this study. Besides, the information given could lack certain in-depth insights as professional perspectives were insufficiently included in this study. To produce more general claims about the critical factors that have a perceived impact on the sustained use of mobile health self-management applications in the daily lives of people with chronic diseases additional data must be gathered. Secondly, one individual coder completed all of the coding for this particular study. Therefore, researcher-dependent factors might have affected the transcript coding and which segments or

codes were chosen. For example, the researcher could have no information about what factors might play a role in the implementation process and could overlook important segments during the coding.

These restrictions, however, had little impact on the study's conclusions because all data had equal importance for answering the research questions. Moreover, the wide age range and diversity in the other demographic details in the sample size helped the study receive varied valuable information; hence, the participants mentioned a wide range of facilitators and barriers found in the TDF framework. Also, to minimize the effect of the researcher-dependent factors, a coding scheme was created based on the TDF framework. This framework acted as a guide in identifying key segments as well as a basis for main codes. In addition, there were also certain strengths to this study. Firstly, the study's interview scheme design was structured according to the TDF framework. The inquiries for the interview were guided by this framework, ensuring that as many critical factors as possible were discussed during the interviews. Furthermore, the coding scheme and the coding of the transcriptions were based on the TDF framework. The TDF framework allowed the interview design and data analysis to also consist of facilitators and barriers, rather than only taking up the advantages and disadvantages of using the mHealth self-management applications as crucial elements. The framework, therefore, allowed for a deeper understanding of the critical factors influencing the sustained use of mHealth self-management applications in the daily lives of people with chronic diseases and provided a more comprehensive overview of the outcomes.

Implications for future directions for research and practice

A first implication could be for the TDF framework. The TDF framework could be improved by adding a construct that refers to the ease of use of technology, such as 'beliefs about

convenience', as it is not specifically mentioned in the TDF framework. This construct refers to the individual's perspective on how useful the introduced product or act could be in one's life and if it aids in achieving the individual's goal more easily.

Furthermore, for a future study, a longitudinal study could be done. Ongoing or recurring assessments are used in longitudinal studies to monitor specific individuals over extended periods (Caruana et al.,2015). A group of patients with chronic diseases could be followed for a longer period, during which their mHealth usage would be monitored. Quantitative and qualitative data over a longer period could be collected about the usage patterns and their reasons for (non-)adherence. This type of study is relevant in defining specific exposures in terms of time and chronicity and identifying and connecting events to particular exposures (Caruana et al.,2015). The study could show which difficulties arise and when they occur in the implementation of mHealth applications. Besides, by gathering data prospectively this study design further eliminates participant recollection bias (Caruana et al.,2015). This could provide more accurate answers to questions about why the participant continues or stops using the mHealth application. This is important as it could help to improve the implementation process of mHealth applications for people with chronic diseases.

Furthermore, The TDF framework can be used in practice when applying new practices, for example, eHealth, in patients' lives. Underlying aspects of what is holding back or what is facilitating the use of eHealth can be understood through the TDF framework. By strengthening underlying factors that encourage use (e.g. beliefs about positive consequences) and resolving underlying factors that hold back use (e.g. lack of skill), according to the TDF framework, one can bring change in patients' behavior. These aspects can be applied in practice by providing

additional help or looking for solutions to create a personalized and improved behavior change intervention to increase the constant use of a specific product.

For example, the results showed that patients are motivated to use mHealth self-management applications to avoid possible negative consequences and that the positive consequences and convenience facilitate the use of these applications. These results can be incorporated into healthcare to stimulate mHealth usage by having healthcare professionals, who guide patients with chronic diseases, informed about such innovations. The information should be about what mHealth self-management applications are available for managing one's health and a specific chronic disease. Also, sustained use of this application could help prevent the negative consequences of chronic disease, provide positive outcomes, and ease self-management. The healthcare professionals could then inform the patients and guide them in using the application.

Lastly, the results showed that lacking technological skills or technological knowledge to use the application could prevent the sustained use of mHealth self-management applications. Informing the patients about the use of the application by healthcare professionals may not be enough as the patients may face daily difficulties in understanding the application. The professionals cannot always be there when these complications occur. To stimulate sustained use of mHealth applications, the applications should contain instructions and a step-by-step plan on what they contain and how the application and its features are used. An instruction video or visual examples could also be provided to make sure that people comprehend the instructions optimally.

Conclusion

This study aimed to identify critical factors that have a perceived impact on the sustained use of mobile health self-management applications for health tracking and self-management disease in the daily lives of people with chronic diseases. The results showed that the most important facilitators were positive outcome expectancies by using the application and understanding how easier independent supervision gets with the use of applications while the most important barriers were lacking knowledge or ability, and frustration when the individual tries to deal with the application. These results show high similarity with the constructs identified in the TDF framework. To better comprehend the identified constructs and obtain more accurate data, a future longitudinal study could be conducted that identifies usage patterns, barriers, and facilitators over a longer period. In practice, the sustained use of mHealth applications by people with chronic diseases could be increased by having healthcare professionals inform the patients about mHealth self-management applications and guide them in using the applications. The study results provided data to enhance the implementation process and patient participation in self-management habits.

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Appendix A

Interview Scheme

1. First I would like to ask you some **demographic questions**:
 - 1.1 What's your age?
 - 1.2 What gender are you?
 - 1.3 What is your educational level?
 - 1.4 What is your occupation?
2. What type of chronic disease do you have?

Self-management, usage pattern, and motivation:

3. In what way do you self-manage your disease?
4. Have you used or been using self-management apps to manage your health or chronic disease? If so, which ones?
5. Can you describe how you use self-management applications to manage your health or chronic disease?
6. What specific features or functionalities of the app do you find most helpful in managing your disease? Can you give an example of how you use these features?
7. Do you track any particular health metrics or data points using the app? If so, which ones?
8. How many times would you say you use these features daily or per week (usage pattern)?
9. Have you noticed any improvements in your health or disease management since using the mHealth app? If yes, could you share some examples?
10. What initially motivated you to start using this app for self-managing your disease?
11. Do you still feel motivated to use this app to self-manage your disease? Why or why not?

Thoughts behind the usage

12. Do you feel capable of using self-management apps for health monitoring? Why or why not?
13. Do you have the feeling that you have enough knowledge and skills to use self-management apps for health monitoring? Why or why not?
14. Do you have the intention to keep using self-management apps for health monitoring; why or why not?
15. To what extent has your (social) environment influenced your use of self-management apps for health monitoring? Can you give examples?

Barriers:

16. What demotivates you or makes it difficult for you to continuously use these apps/features daily? (e.g. features missing on the application or feelings of frustration)
17. Are there times when you find it challenging to use these apps/features regularly? If yes, could you give examples of these challenges?
18. What aspects of these features or app usage have made it difficult to adhere to?
19. Have you noticed any negative outcomes from using these applications?

Facilitators:

20. What factors or strategies help you to keep using these apps in daily life? (e.g. easy to use interface or reminders to use the app)
21. What makes it easier for you to keep adhering to these features/apps
22. In your opinion, how can healthcare providers or app developers better assist you in using mHealth apps daily? (e.g. What support do you need to keep using the app?)

CLOSING:

- Thank you for sharing your experiences with me, this was my last question.
 - Is there anything else you would like to add or share that we did not discuss yet?
- Furthermore, if any questions arise or if you are interested in the results of this study feel free to contact me as contact information is provided below on the consent form as well. I would like to thank you for participating in his study, and for your time and valuable insights!

Appendix B

Hi, I am Wannie Mizouri from the University of Twente and I am seeking participants who would like to be part of my research study

Title of the study:

Understanding the individual implementation process of eHealth technologies

Exploring critical factors influencing the sustained use of mHealth self-management applications by people with chronic diseases

Objective of this study:

This study aims to explore comprehensively the possible challenges, difficulties, and barriers people with chronic diseases stumble upon when trying to use mHealth self-management applications on mobile devices to track their health and self-manage their chronic disease. The study focuses on people with chronic diseases; Chronic lung disease, Diabetes Mellitus, and Cardiovascular Diseases, who use or have used features to track and remind themselves regarding nutrition, physical activity, medication, and wellness, and to communicate with healthcare workers. The results of this study could give insight into why patients do or do not adhere to mHealth self-management applications and could guide the development and implementation of these technologies in daily life.

The procedure of this study:

If approval is granted by the participant, this person will be interviewed by the researcher. If approved by the participant, this interview will be audio recorded to analyze the answers thoroughly and obtain accurate data. The participants will be asked about their adherence to the features of the self-management applications, reasons for adherence/non-adherence, and possible challenges/barriers or motivations to use them. The interview will take approximately 30-45 minutes to complete.

If you are interested in participating in the study or have any questions, Please leave your contact details

Appendix C

Consent Form for participation in this research

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Title of the study:

Understanding the individual implementation process of eHealth technologies

Exploring critical factors that have a perceived impact on the sustained use of mHealth self-management applications by people with chronic diseases

Researcher:

Wannie Mizouri

You are being invited to participate in the research study performed by Wannie Mizouri from the University of Twente. To get a complete understanding of the aim of this study and the procedure that will follow it is essential to read this consent form carefully. Please feel free to ask any questions, indicate when feeling uncomfortable during the study, and withdraw at any time.

Objective of this study:

This study aims to explore comprehensively the possible challenges, difficulties, and barriers people with chronic diseases stumble upon when trying to use mHealth self-management applications on mobile devices to track their health and self-manage their chronic disease. The study focuses on people with chronic diseases; Chronic lung disease, Diabetes Mellitus, and Cardiovascular Diseases, who use or have used features to track and remind themselves regarding nutrition, physical activity, medication, and wellness, and to communicate with healthcare workers. The results of this study could give insight into why patients do or do not adhere to mHealth self-management applications and could guide the development and implementation of these technologies in daily life.

The procedure of this study:

If approval is granted by the participant, this person will be interviewed by the researcher. If approved by the participant, this interview will be audio recorded to analyze the answers thoroughly and obtain accurate data. The participants will be asked about their adherence to the features of the self-management applications, reasons for adherence/non-adherence, and possible challenges/barriers or motivations to use them. The interview will take approximately 30-45 minutes to complete.

Please tick the appropriate boxes

Yes No

Taking part in the study

I have read and understood the study information or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

I understand that taking part in the study involves an audio-recorded interview regarding the usage of self-management applications that will be transcribed as text and that the recording will be destroyed after the study ends.

Risks associated with participating in the study

I understand that taking part in the study involves the following risks: possible feelings of discomfort or mental distress when discussing challenges/barriers or experiences regarding the usage of self-management applications.

Use of the information in the study

I understand that the information I provide will be used to obtain information about the possible challenges, difficulties, and barriers people with chronic diseases stumble upon when trying to use mHealth self-management applications, which will be used in the report and publications resulting from the study.

I understand that personal information collected about me will not be shared beyond the study team.

I agree that my information can be quoted in research outputs.

I agree to be audio-recorded

Signatures

Participants' Signature

Date

____Wannie Mizouri_____ _____

Researcher name Signature Date

Study contact details for further information: Wannie Mizouri

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl

UNIVERSITY OF TWENTE.

Appendix D

Tables with the codes

Table D1

Coding scheme related to behavior regulation around chronic diseases, including main codes, subcodes, definitions of codes, related quotes, and number of interviews the code was mentioned in (Nint) and total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Related quotes	Nint	Ntot
Behavioral regulation	Monitoring blood pressure	Independently supervising a chronic illness through regularly observing the blood pressure.	“I measure my blood pressure. Yes. And yes when he starts showing outliers, that is the reason to call the doctor.”(Participant A)	2	5
	Monitoring sugar levels	Independently supervising a chronic illness through regularly observing the blood sugar level.	“An app has been created that you can set up on your phone. You can open this app and then hold it on your sticker, when it scans it you will receive your current blood sugar.”(participant C)	4	7
	Tracking nutrition	Independently supervising a chronic illness through regularly keeping a trace of one’s	“Eat less salt and sugar, and eat healthier.” (Participant D)	3	3

	food intake and making healthier choices in food	“I have a calorie counter app.”(Participant G)		
Medication intake	Independently supervising a chronic illness through regular prescription intake	“I use reminders that remind me to take medication.”(Participant G)	1	1
Activity monitoring	Independently supervising a chronic illness through regularly tracking one's physical activity.	“Yes, so I use a step tracker.”(Participant D)	1	1

Table D2

Coding scheme related to motivations for mHealth usage, including main codes, subcodes, definitions of codes, related quotes, number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Related quotes	Nint	Ntot
Motivation	beliefs about negative consequences	Stimulation to use the mHealth application through negative outcome expectancies of ignoring application.	“that brain hemorrhage was also the reason for the need to monitor more closely.”(Participant A) “Because as those blood numbers fluctuate considerably, that is to say from high to low in the	6	14

glucose, which follows with other complications, for example with your eyes, and that really bothers me. So with rapidly falling blood sugar, if you don't know, that's not good.”(Participant F)

“Wanting to prevent these annoying side effects is what keeps motivating me to check it out.”(Participant C)

“And if I don't use reminders, eh, and forget to take my puff, I feel very short of breath” (Participant G)

beliefs about capabilities

Stimulation to use the mHealth application through feelings of being in control over one’s chronic disease.

“ It gives me the feeling that I am keeping my high blood pressure lower and under control. That's the feeling I have.”(Participant D)

4

16

“You want to have insight into what is happening and that you are very shocked that your body does things while you are sick. Yes. Then that's a moment when you think, how can I get that under control a little better?” (Participant A)

“It motivates me to exercise. To say well, this is a problem. I can solve that” (Participant A)

“Back then, cycling 15 kilometers was enough. Nowadays I put away 40. Yes. I have now been able to halve my medication. So you feel results.” (Participant A)

Table D3

Coding scheme related to barriers for mHealth usage, including main codes, subcodes, definitions of codes, related quotes, number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Related quotes	Nint	Ntot
Barriers	Social influences	Obstacles to using mHealth applications because of interpersonal processes, such as social pressure, that can alter someone's feelings, ideas, or actions.	<p>“Those negative thoughts of, oh, what will people think of me, things like that”(Participant B)</p> <p>“Sometimes I feel ashamed about this. Yes, it is already known about the medication, so I am no longer ashamed of that. However, the Calorie counter app is sometimes uncomfortable to use in the presence of others.”(Participant G)</p>	3	8

Skills	Obstacles to using mHealth applications because of one lacking knowledge or ability achieved through practice.	<p>“If you always have to do that manually, that becomes difficult. Yes, and I can set up things like that, but I can imagine that for some people that is rocket science.” (Participant A).</p> <p>“These types of instructions are often complicated, young people understand this more quickly. I wouldn't understand it easily myself, my nurse explained to me how to apply this to my life and my children installed it for me. I wouldn't have figured it out myself, my nurse recommended this to me.”(Participant C)</p> <p>“The technology of the telephone makes it a little more difficult.”(Participant D)</p> <p>“Yes, about the telephone, every time there is a new system, a new telephone. It is not easy to operate, not easy to get the app, so to speak, not easy.”(Participant D)</p>	6	11
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Resources of user-friendliness	Obstacles to the adaptation to the usage of mHealth applications because of the lack of important functions or being less sophisticated compared to different devices, as it discourages the usage of these applications over the devices.	<p>“The phone does not quickly establish a connection with my sticker, this takes a while. You cannot measure your blood sugar multiple times in a row and it does not report if blood sugar is too high.”(Participant C)</p> <p>“Unfortunately, the app on the phone has no alarm or notification to remind me to measure. The app can only scan.” (Participant C)</p> <p>“Well, what I still find annoying is that the app asks all the time if I would like to use a premium program for 9.99 euros per month.”(Participant A)</p> <p>“But then you get a message like this every time. Push notifications. That's quite annoying.”(Participant A)</p>	2	7
Emotions	Obstacles to using mHealth applications because of a complicated response routine, concerning	<p>“You sometimes get frustrated by having to check it constantly, so I just leave it alone and look at the graph later</p>	4	7

behavioral, physiological, and experiential elements, such as frustration when the individual tries to deal with the application.

to see how something went.”(Participant C)

“Yes, I often skip measuring when I expect or notice high blood sugars. I don't dare to look because I sometimes experience negative feelings” (Participant C).

“I get frustrated by having to think about it all the time.”(Participant G)

“When I'm in a meeting and my pump starts giving alarms every time, then it is noticed. I don't like that.” (Participant E)

Behavior regulation (habits)

Obstacles to using mHealth applications because of difficulties in handling or adjusting objectively watched or measured actions, such as implementing the use of mHealth applications in the daily routine.

“Yes, you have to do it every day. But yes, that is a matter of developing a routine.”(Participant A)

“Getting used to having a chronic illness is more difficult than getting used to using something for it. Mentally you have to get used to a chronic illness and if this is difficult and you do not feel mentally ready for

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it, then you can have complications with the use of these types of apps.”(Participant C)

Table D4

Coding scheme related to facilitators for mHealth usage, including main codes, subcodes, definitions of codes, related quotes, number of interviews the code was mentioned in (Nint), and the total number of times the code was mentioned in all interviews (Ntot).

Main codes	Subcodes	Definitions of codes	Related quotes	Nint	Ntot
Facilitators	Social influences	Easing the use of mHealth applications through interpersonal processes, such as social support, can alter someone's feelings, ideas, or actions.	<p>“My mother really encouraged me to use it.”(Participant B)</p> <p>“I had not chosen it myself, but it was recommended to me by the diabetes nurse.”(Participant C)</p>	2	5
	Reinforcing behavior	Easing the use of mHealth applications by increasing the likelihood of using the application by developing a relationship between the response and given stimuli. In this situation, awareness	“Is there anything that reminds you to look at this app? Yes, the disease. The disease gives you a feeling that every day you have to look at the app to keep yourself under control” (Participant D)	5	9

of having the disease and notifications.

“People who have diabetes constantly think about their body because the body sends out these signals. For example, if you don't pay attention, you might get dizzy or get a headache. I can sense that my blood sugar is too high, so I automatically look at how much sugar is in my blood.” (Participant C)

“I usually set reminders to use the app”(Participant G)

“What strategies help you to continuously use the app? The beeping and notifications” (Participant C)

Resources of convenience

Easing the adaptation to the usage of mHealth applications through understanding how easier independent supervision gets with the use of applications, therefore encouraging the usage of these applications.

“And it also offers the opportunity to keep track of these kinds of things very well. So. That's actually the convenience of digital. That everything is simply recorded.”(Participant A)

“I thought it would be useful because wherever you are, your phone is always in your pocket. You rarely go outside without a phone. So the nice thing is that you can

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take this with you everywhere without having to carry extra stuff.”(Participant C)

“It could be, for example, a healthcare provider, something in terms of support or instructions. Or maybe an app developer tells you, technically this and this.”(Participant A)

“Because I'm wearing a dress, I often tuck it around my leg. And then it's a bit awkward to suddenly raise your skirt or something. So then your phone is nice”(Participant B)

Beliefs about positive consequences	Easing the use of mHealth applications through positive outcomes expectancies by using the application.	“Because the tools are there and it's getting easier, Making use of it ultimately makes your life ten times easier.”(Participant B)	6	12
		“Is there something that motivates you to keep using it? Yes. Those are the features of that app. It saves you a lot of extra attention to make sure everything is going well		

in the evening.”(Participant F)

“In the longer term, I am trying to ensure myself of a reasonably healthy old age.”(Participant E)

“Well, when I use it constantly, I notice positive consequences. Such as being less short of breath, having a balanced weight. And that motivates me to pick up the apps.”(Participant G)
