Understanding the individual implementation process of eHealth technologies

Exploring factors influencing the sustained use of smartwatches for self-monitoring purposes by healthy individuals

David Calandra

Bachelor Thesis

Faculty of Behavioural, Management, and Social Sciences

Department of Psychology

University of Twente

First supervisor Drs. Marileen Kouijzer

Second supervisor Dr. Tessa Dekkers

18th of July 2024

Abstract

Background

Smart wearable devices, particularly smartwatches, have gained popularity in personal health management. These devices provide real-time data on various health metrics, aiding users in maintaining a healthy lifestyle. Despite their potential to enhance health outcomes through self-monitoring, the long-term use of smartwatches for health behaviour management is not well understood. This study aims to investigate the factors influencing the sustained use of smartwatches for health behaviour management, identifying both facilitators and barriers to their long-term adoption.

Method

This study employed a semi-structured interview approach to collect detailed information from participants. Individuals who had been using smartwatches for at least three months and were over 18 years old were recruited through convenience sampling. Ten participants (all male, aged 22 to 68) took part in the study. Interviews were conducted online via Microsoft Teams, recorded, and transcribed verbatim. Data were analysed using deductive thematic analysis, guided by the Theoretical Domains Framework (TDF), to identify themes related to facilitators and barriers to sustaining smartwatch use.

Results

Analysis revealed several key factors influencing long-term smartwatch use for HBM. Facilitators included personalized health feedback, goal-setting features, and the convenience of real-time health monitoring. Barriers identified were discomfort in wearing the device, data accuracy concerns, and the novelty effect wearing off over time. The importance of evolving

goals to maintain motivation was particularly noted, as static goals often led to diminished engagement.

Conclusion

The findings highlight the critical role of dynamic goal-setting and personalized feedback in promoting the sustained use of smartwatches for health monitoring. Addressing barriers such as device comfort and data accuracy can further enhance user experience and long-term adherence. These insights can inform the design and implementation of future eHealth technologies, ultimately supporting better health outcomes through continuous self-monitoring and behaviour modification.

Introduction

In recent years, there has been a growing interest in smart wearable devices for personal health and fitness among individuals aiming to maintain a healthy lifestyle (Siepmann & Kowalczuk, 2021). Smart wearable devices such as smartwatches are estimated to increase to a market value of 7.66 billion Euros in 2024 (Statista Market Insights, 2024). Healthy individuals use wearable technologies such as smartwatches to monitor various aspects of their physical activity and sedentary behaviour. For instance, individuals use smartwatches to review their training progression and personalize their fitness routines. On the contrary, healthy individuals who are exposed to sedentary activities use fitness trackers to increase their everyday movement (Attig & Franke, 2022). Sedentary activities such as too much sitting or standing can significantly increase the risk of a chronic disease e.g. cardiovascular disease or diabetes (World Health Organization, 2020). Therefore, preventive measures such as exercising regularly e.g. 150 minutes of moderate activity per week, maintaining a healthy weight, and cutting down on alcohol can significantly lower the risk of illnesses such as CVD (NHS, 2022).

Smart wearable devices are a form of eHealth technology. EHealth technology can be defined as the use of information and communication technology for health services, designed to improve individual health outcomes (Eysenbach, 2001). EHealth devices such as smartwatches can provide immediate health information, which revolutionized individual health management. This was done by enabling healthy individuals to track real-time physical health information such as heart rate, sleep patterns, and physical activity (G. Sucharitha et al., 2021; Nadal et al., 2023). Moreover, instant health measures allow people to track their health behaviour by self-monitoring their fitness levels and daily activities (Thornton et al., 2021). In addition, users receive notifications of abnormal heart rates, leading to more informed health decisions (Shei et

al., 2022). The benefits of these instant health measures include empowerment and education, behaviour change facilitation, and efficient information provision (Volpato et al., 2020). In summary, smartwatches are a convenient tool to assist healthy individuals to stay healthy by providing health-related feedback in the form of physical measurements to improve individual health behaviour management (HBM). Moreover, smartwatches contribute to behaviour change by providing users with constant feedback on their physical activity, stimulating them to be more active throughout the day (Thornton et al., 2021). By collecting physical information, these smartwatches encouraged users to set and achieve fitness goals (Del-Valle-Soto et al., 2024). This continual education and motivation can lead to a more active lifestyle. Finally, constant monitoring of health measurements like heart rate and sleep patterns enables users to identify patterns which help the individual to make informed lifestyle changes (Vijayan et al., 2021). This can help people to avoid health problems before they emerge. Therefore, smartwatches are important for self-health management/prevention for healthy individuals.

Previous studies have shown the potential to enhance health outcomes through behaviour modification with the assistance of smartwatch monitoring. Smartwatch users are more likely to adopt healthier habits because of features that give feedback and encouragement. Continuous activity tracking, for instance, promotes self-awareness and motivates people to increase their daily movement (Shei et al., 2022). In addition, smartwatches empower users to take control of their exercise routine by monitoring progress and setting achievable goals (Yang & Pan, 2020). This results in a change towards a more active lifestyle from this continuous availability of physical user information and inspiration, which may lower the risk of health issues linked to inactivity (Yen & Chiu, 2019). To conclude, smartwatches extend beyond their function as passive sensors and become proactive tools for changing behaviour, enabling users to take

control of their health and well-being. This showed that the application of smartwatches in the context of health is not only effective in theory but has also proven to be a useful intervention in practice.

Despite all the benefits, long-term use of smartwatches remains a significant problem (van Gemert-Pijnen et al., 2018). Studies investigating the discontinued use of wearable activity trackers indicated that between 30% and 70% of users cease tracking their activity within a few months (Attig & Franke, 2022). Over one-third of users quit using their smartwatches after a year because they felt they were less interesting and useful (Kamal Basha et al., 2022). Consequently, people were not able to take full advantage of the health benefits associated with smartwatches for self-monitoring (e.g., keeping a healthy lifestyle). Hence, to understand the factors that facilitate or hinder the long-term use of smartwatches for HBM it is critical to identify the factors that influence individual behaviour change. In this study, behaviour change is discussed from two perspectives: the long-term use of smartwatches for health behaviour management and physical activity behaviour influenced by feedback from these devices. While the emphasis is on studying what motivates users to continue or quit their usage of smartwatches, the device´s significance in motivating users to maintain or enhance physical activity is also highlighted.

The Theoretical Domains Framework (TDF) orders such factors which could influence behaviour change into different categories (Atkins et al., 2017). The framework includes 14 different domains to identify factors which can be barriers or facilitators that influence behaviour. The framework has been widely used across healthcare settings and clinical behaviour and was highlighted in implementation science. The TDF may be especially beneficial for this study in identifying characteristics that either encourage or inhibit long-term usage of

smartwatches, as it provides a structured framework for methodically analysing and interpreting these aspects. One of the domains in the TDF framework is called “goals”. This is relevant in this context since it addresses the use of smartwatch self-monitoring applications to set personal objectives. One of the reasons for non-adherence, therefore, could be a lack of motivation when no goal was set by the user (Yang et al., 2022). Another domain is referred to as "environmental context and resources". Particularly, the accessible resources, such as the displayed information and the materials of the smartwatch are important to this study. Because of discomfort or inaccurate data, users may not adhere to self-monitoring usage (Yang et al., 2022; Canali et al., 2022). To conclude, due to its wide applicability and use in implementation science, this framework will aid in the explanation of results in this study. While these domains serve as key examples, the focus of this thesis is not limited to them exclusively. Instead, they are highlighted due to their relevance to smartwatch usage and behavior change. Other domains from the TDF framework will also be considered where applicable to provide a comprehensive analysis.

Despite individual empowerment and motivations to live a healthy lifestyle, promoted by smartwatch self-monitoring use, some users do not change their behaviour accordingly. According to Cristescu et al. (2022), people stop using smartwatches due to the discrepancy between the intention to become healthier and the actual behaviour over time, this concept refers to the intention-behaviour gap. With the intention-behaviour gap, research was done in the past to investigate how intention leads to behaviour. However, the existing body of literature insufficiently addressed how this discrepancy between intention and actual behaviour influences the sustained use of smartwatches for HBM. Therefore, employing the TDF with its multiple domains will set a solid foundation to identify behavioural factors which might explain this gap in intention and behaviour.

This study aims to explore factors regarding the long-term use of smartwatches for HBM. The following research question was created to investigate this aim: *"What factors impact the sustained use of smartwatches for self-monitoring purposes by healthy individuals?"* The following sub-research questions were designed to help answer the main research question.

1. *What factors facilitate the long-term use of smartwatches for health behaviour management?*
2. *What are the barriers that can hinder the long-term adoption of smartwatches for health behaviour management?*

Methods

Design

This study used a semi-structured interview to collect information to answer the research questions. Semi-structured interviews are appropriate for this type of research because they allow for in-depth exploration of participants' emotions, experiences, underlying motives, and behaviours (Horton et al., 2004). This method enables the investigation of multiple aspects of participants' experiences, resulting in a full understanding of the factors that encourage or impede the long-term use of smartwatches for HBM. This study was approved by The University of Twente's Ethical Committee (Domain Humanities and Social Sciences) under permission number 240278.

Participants

The intended target group were individuals who used smartwatches to monitor their health management over time. The following inclusion criteria were established. (1) Participants

must be above the age of 18 to offer legal consent, (2) are owning and using a smartwatch for at least three months to guarantee enough device experience, and (3) be willing to engage in an English or German language interview to ensure clear communication. There were no specific exclusion criteria. Participants were recruited using convenience sampling (Golzar et al., 2022). Interviewees were chosen based on their availability to the researcher. Recruitment messages outlining the study's background, objectives, and participation course were distributed through WhatsApp (Version 2.24.11.79). The message included the contact information of the researcher, such as a phone number and an email address, so that prospects could express their interest in joining. In the message, participants were invited to engage in an interview, which takes place via Microsoft Teams, based on their availability. A total of 12 people were asked to participate. Of these, 10 accepted the invitation, with 10 completing the interview procedure. Participants were aged 22 to 68 years (M = 31.80, SD = 12.91). The demographic characteristics of the participants can be found in Table 1.

Table 1

Demographic characteristics of the ten participants.

Baseline characteristic	Full sample	
	n	%
Gender		
Female	0	0
Male	10	100
Duration of Smartwatch use		
7 years	1	10

5 years	2	20
3 years	2	20
2 years	3	30
1.5 years	2	20

Materials

In preparation for the study, the researcher developed a semi-structured interview guide to look at several elements of smartwatch use for HBM. The interview guide in Appendix A included 6 closed questions about the demographics e.g. age, gender, occupation, durations of smartwatch ownership, frequency of usage, and type of smartwatch. The 20 open-ended questions were based on the TDF domains; skills, beliefs about consequences, environmental context and resources, and social influences (Cane et al., 2012). For instance, questions like "How often do you use your smartwatch to monitor your health, and what specific health metrics do you track?" were asked, or “Can you describe how you use your smartwatch to monitor your health outcomes?”

The category of the interview guide regarding usage patterns and motivation investigated the reasons for participants' use of smartwatches for HBM. For instance, "What motivates you to use your smartwatch for tracking your health?" was one of the questions. The resource topic addressed facilitators and barriers to the continued usage of smartwatches. Participants were given questions like, "What difficulties do you encounter when using your smartwatch for health monitoring?". The facilitator's topic investigated variables that promote and encourage the continuous usage of smartwatches. For instance, participants were asked "What aspects of your smartwatch help you to continue using it for health monitoring?" The interview guide was pilot

tested with two participants and adjusted according to their feedback to ensure that it was clear and understandable.

Procedure

When participants indicated they were interested in participating in the study, they were sent the informed consent form (see Appendix B) which included detailed information about the study, such as the study's background, inclusion criteria, aim, and the process of participating in it. The consent form also contains contact information for both the researcher and the Ethics Committee. Participants were advised that their participation was voluntary and that the audio will be recorded. If the inclusion criteria were met, and the participant expressed a desire to engage in the study and agreed to audio recording, they were asked to offer their availability to schedule the interview. The interviews took place online using Microsoft Teams. All 10 interviews were conducted online. Each interview began with the researcher describing the study's objectives, interview method, and consent form. The participant got the opportunity to ask questions before signing the informed consent. The interview started only after the participants indicated that they had received sufficient information and were ready to begin.

The researcher then began the audio recording. The participant was asked questions from the interview guide. Moreover, probing questions were used to go further into relevant themes. Participants also had the opportunity to bring up additional information and new experiences or insights that could help answer the research questions. At the end of the interview, participants were allowed to share their opinions on what could be improved in future smartwatches and to add anything that had not been mentioned but was relevant to the research questions. The interview ended when the participant stated that they had no additional questions or remarks to

give. The researcher thanked the participants and informed them that any future questions or concerns may be sent to the contact information listed on the permission form, which was distributed to participants. The average duration of the interviews was 33.73 minutes.

Data analysis

All audio recordings of the interviews were transcribed verbatim by the researcher and manually coded. Transcripts were deductively coded using themes from the research questions and TDF framework domains. The research questions led to the creation of a coding scheme with two primary categories: (1) Facilitators and (2) Barriers towards continued smartwatch use for HBM. Sections of the transcript that contained individuals' experiences on these central topics were marked during the deductive thematic analysis process. The coding system was modified during this process using the Constant Comparison Method, which compares each piece of data with the other pieces of data (Boeije, 2002). Using constant comparison, the responses of participants to a single question were compared. Deductive thematic analysis was used to create the main codes based on the research questions. Similiry, deductive coding was used for the subcodes. The subcodes were based on significant segments related to the TDF domains. The transcriptions were coded and compared until no new themes relating to the research questions were detected, indicating saturation (Constantinou et al., 2017). The subcodes were named and categorised according to the TDF framework. Tables 2-3 of Appendix C include the primary categories code, subcodes, definitions, and associated quotations.

Results

This study aims to explore factors towards long-term use of smartwatches for HBM. The following research question was created to investigate this aim: *"What factors impact the*

sustained use of smartwatches for self-monitoring purposes by healthy individuals?" The following sub-research questions were answered to help answer the main research question.

To answer the first sub-question *"What factors facilitate the long-term use of smartwatches for health behaviour management?", the* **Facilitators** regarding self-monitoring health outcomes with a smartwatch were investigated. This main code relates to anything aimed at encouraging healthy individuals to continue with the smartwatch usage for HBM. The associated codes and their definitions are illustrated in Table 2. The first subcode which is related to the facilitators is **Self-Monitoring Skills.** This code specifies the user´s ability and proficiency acquired through practice tracking and managing their health metrics using the smartwatch. Participants reported various skills to track their daily activities. For instance, one participant stated, *"Whether I'm running on the treadmill or cycling outdoors, doing cross-training, or free training, as soon as I start any of these activities, I track my sports activities." (*Participant 1). Another participant noted, *"I look at things like step count, heart rate, or blood pressure" (*Participant 3). Moreover, interviewees reported tracking their sleep patterns as well, one participant explained: *"I monitor very closely my sleep patterns and the quality of my sleep. It helps me see how well I've slept and adjust my behaviour accordingly, especially during stressful times." (*Participant 4). In addition, participants noted to use the smartwatch to monitor their daily calorie intake. One interviewee noted, *"I watch my diet. I always try to input my diet, and then it helps me monitor my calorie intake for the day."* (Participant 6). In summary, all participants reported various skills in self-monitoring. To specify, tracking the quality of sleep, physical activities e.g. steps and distance, heart rate, pulse tracking and lastly tracking nutrition intake were all beneficial skills to facilitate the use of a smartwatch for health behaviour management.

Next, the subcode **Goals** was developed, this code describes the starting incentive of healthy individuals to use a smartwatch as a self-monitoring device, as well as the changing objectives over time that drive continued use and engagement with the smartwatch. For instance, Participant One stated a quote representing a starting incentive for HBM: *"Initially, I aimed to continue monitoring my health to participate in the selection process for the judiciary.* However, when the participant reached the aim of joining the judiciary, he reported: *"Afterwards, the motivation for that decreased".* On the contrary, other participants reported a shift in goal setting when reaching their initial objective. An interviewee responded, *"the initial goal was just to improve my endurance […] Over the years, it has become more about staying fit, just to maintain a healthy lifestyle, to have a healthy body that I can control myself"* (Participant 2). Similarly, another participant explained, *"I started looking at my lifestyle, and like, I was very overweight okay, I need to lose weight." (Participant 6).* Following, when the interviewee achieved the aim of losing weight the goal shifted: "*But after you have achieved that it's more like a lifestyle, and a lifestyle is continuous […] So, it's more like my goal changed from losing weight to sustaining this healthy lifestyle that I have achieved."* (Participant 6). Likewise, Participant 9 stated, *"The goal shifts from muscle building to overall fitness and health".* To conclude, five out of ten participants reported goals to be an important driver to continued use, in addition to that, participants reported a shift of goal from a former goal e.g. losing weight or muscle building to a later goal of overall fitness and adopting a healthy lifestyle.

Following, the subcode **Beliefs about health consequences** was created to highlight the user's acceptance of the validity and reliability of the health data insights. For instance, one participant stated that reviewing unsatisfactory outcomes encouraged him to change his behaviour accordingly. This interviewee reported: *"Yes, because for me when I see poor results,*

I naturally try to change something about the cause […] And when you see all the results on the Apple Watch, it leads to investigating the causes or doing something to lower the heart rate." (Participant 1). Another participant reported: *"Counting my steps, being able to do breathing exercises through the watch, and so on. I believe it's already become a solid part of my daily routine."* (Participant 4). Moreover, participants trusted in the validity of the provided data which motivated the continuous use of HBM. For instance, participant nine said: *"Yes, I firmly believe that using the Smartwatch has improved my health outcomes I mean, if you look at it from a statistical perspective, you have motivation as a predictor variable, then health and activity as outcome variables, and then the Smartwatch acts as a moderator in that direction*." In addition, another participant stated: *"Yes, I noticed that I feel better when I move more, which motivates me […] It spurs me to extend my walks. Initially, a kilometre was challenging, but last weekend we walked six kilometres[…] Yes, I am sure of it. I used to feel weak, and walking was getting harder. The plans with the smartwatch to track distances have motivated me."* (Participant 10). To conclude, six out of ten participants reported that positive beliefs about the health consequences are a supportive facilitator for the continuous use of smartwatches for HBM. When participants reviewed their monitoring results e.g. heart rate it led them to investigate the causes, and consequently take action to lower the heart rate.

The next subcode created is **social influences**, this includes the individual impact of family, friends or healthcare providers on the user's thoughts, feelings, and behaviour regarding the use of a smartwatch for HBM. Participants reported being encouraged by family, friends and social media. For instance, one reported*: "My sister has an elevated heart rate, which seems to be some sort of genetic predisposition in the family. She also got herself a smartwatch and monitors it permanently. But since I don't want the same thing to happen to me, I try to act*

preventively in advance." (Participant 1). In this case, the disposition in the family for an increased heart rate motivated the participant to use one for himself to self-monitor to act preventively against a heart condition. Another interviewee described how social media encouraged him to use a smartwatch for HBM. He stated*: "Not directly my immediate social circle, but now through YouTube and all the fitness influencers, they make a lot of videos about running, tutorials, how to get faster, how to get better."* (Participant 2). Another participant reported influence from his mother: *"I got that simple device first from my mother because I borrowed it from her, and I watched how she used it. In the end, she always said, "Oh, I've taken so many steps. So, I was interested in finding out about myself"* (Participant 3). In addition, participant 6 started to be encouraged by his interaction at the gym. He reported: *"And then my fitness coach at the gym gave me these great tips. I also started doing some research myself, like, hey, what kind of useful app can I use for monitoring my health in different kinds of aspects?".* Furthermore, one participant said to be encouraged by the function to share the achievement with the social environment e.g. steps per day. This interview explained: *"So, you involve people with it, and likewise, when you share your achievements and say, "Hey, I've already walked 10,000 steps and it's only noon."* (Participant 7). In conclusion, eight out of ten participants reported that social influences were beneficial facilitators for the use of smartwatches for HBM. Namely, the condition of siblings. In addition, social media such as YouTube and its influencers making videos and tutorials also seemed to be a facilitator for prolonged use as well as tips from gym trainers. Interestingly, one participant reported the function of sharing experience e.g. steps per day and sharing this information with his social environment to be beneficial.

The subcode **beliefs about capabilities** entail the individual's confidence in their ability to use a smartwatch effectively for HBM and incorporate it into their daily routines. For instance,

one favoured the capability to measure physical activities by himself without always going to a doctor for health checkups. This interviewee explained: *"I can control myself, instead of always going to the doctor or getting check-ups have it in my hands now, and that's my motivation, to be a better person physically."* (Participant 2). In addition, the ability to control their physical measurement with the help of an overview and being able to organize them was also seen as beneficial. One participant stated: *"It was enough for me, given the features they have, that you can sort and organize them properly"* (Participant 3). Moreover, another participant was pleased by the ability to measure his heart rate while being in the gym. This interviewee reported: *"For example, when I do bench presses, I like to see my heart rate. It's just cool to be able to see that and get a sense of how much my training is helping my body."* In addition, the same participant stated: *"Counting my steps, being able to do breathing exercises through the watch, and so on. "I believe it's already become a solid part of my daily routine. "(*Participant 4). To summarize, five out of ten participants considered their beliefs about their capabilities due to the provided health data to be beneficial in the continued use of the smartwatch for HBM.

The final subcode created regarding the facilitator is **resources**, which refers to the tools that support behaviour change in users. These include the smartwatch's various features, such as health monitoring programs, notifications, data visualizations, and reminders, all of which help users maintain consistent engagement with Health Behavior Management (HBM). These tools provide easy access to essential information, such as activity levels, heart rate monitoring, and other health measures, which play an important role in encouraging long-term usage.". Three participants reported favouring emergency functions which encouraged them to further use. For instance, one stated: "*They can also detect, for example, an impending heart attack or atrial fibrillation very well. That would motivate me to buy and use another one."* (Participant 1).

Similarly, one participant said*: "Some kind of alarm function, so that if you have a car accident or something, it calls emergency services.* (Participant 9). Moreover, one stated: *"If I have a fall, for example, while cycling, so increased acceleration values that are then detected by the watch*." (Participant 7). In addition, a participant reported that a function which starts measurements by itself when starting a physical activity could be of advantage for continued use. The interviewee explained *"Workout tracking so that if it detects that I'm starting to run, it starts the workout itself without me having to actively start it on the display. So, I start running, it detects that I'm running, and it starts automatically.* (Participant2). To conclude, four out of ten participants reported that advances in resources would be beneficial for the continuous use of HBM. For instance, emergency notifications e.g. impending heart attack, or when having a car or bike accident. In addition, if the smartwatch could detect the start of activity e.g. recording the start when running without the user starting it over the display also seemed to be a facilitating factor to continue self-monitoring.

Table 2

Coding scheme related to facilitators for using smartwatches for health monitoring, including main codes, subcodes, definitions of codes,

Main codes	**Subcodes**	**Definitions of codes**	**N*int***	**N*tot***
Facilitators	Self-monitoring skills	User's ability and proficiency acquired through practice in effectively tracking	10	10

	and managing their health metrics using the smartwatch.		
Goals	The starting aims to use a smartwatch as a self-monitoring device as well as changing individuals' objectives over time that drive continued use and engagement with the smartwatch.	5	9
Beliefs about health consequences	Users' acceptance of the validity and reliability of the health data insights provided by the smartwatch.	6	11
Social influences	The impact of family, friends, or health care providers on an individual's thoughts, feelings, or behaviour regarding the use of a smartwatch for self-monitoring.	8	13
Beliefs about capabilities	Individuals' confidence in their ability to use a smartwatch effectively for	5	11

	health self-monitoring and seamlessly incorporate it into their daily routines.		
Resources	Sources that may encourage the sustained use of smartwatches for self-monitoring e.g. improvements of the smartwatches that can positively impact the behaviour of self-monitoring.	4	9

Note: Number of interviews the code was mentioned in (Nint), and total number of times the code was mentioned in all interviews (Ntot).

To answer the second sub-question *"What are the barriers that can hinder the long-term adoption of smartwatches for monitoring health outcomes?", the* **Barriers** regarding self-monitoring were investigated. This main code relates to anything that might hinder healthy individuals from continuing with the smartwatch usage for HBM. The associated code and the definition are illustrated in Table 3.

The created subcode **Resources** is related to the barriers, this subcode refers to resources that may discourage sustained use of smartwatches for HBM. These obstacles hinder the individual in self-monitoring activities, due to the perceived lack of essential features or because of less sophisticated functions compared to alternative devices. For instance, one participant

reported a negative experience when going for a swim. He reported: *"The band promises that you can use it in the water too. But the display detects the water as touches, and then it starts some training in the water, and then 5 minutes later, you find yourself in the menu and adjust the language or something because the water mimics the touch of the finger, and then the device is off".* (Participant 2). Moreover, three out of ten participants complained about the battery which demotivated them. One of them explains: *"Annoying that you must charge the device, naturally. Because that was something I had to get used to at the beginning, because a normal watch, when you buy one with a mechanical link, doesn't need to be charged.".* Similarly, another interviewee reported: *"Yes, so the first thing that comes to mind is the battery because when you have 24-hour monitoring enabled, you have to remember to charge the watch daily."* (Participant 7). Finally, participant 8 reported likewise: *"Yes, the battery. The battery is still not great even after several years.".* In addition, the small display size was challenging for one participant, who explained: *"The screen is small. So sometimes you can misclick on some things."* (Participant 6). Lastly, another interviewee saw a hindering aspect when recording sleep patterns, due to the unpleasant feeling overnight when wearing the smartwatch. The participant reported: *"I used the watch to track my sleep, but I don't do that anymore because it's annoying to have a watch around your wrist when you want to sleep."* (Participant 9). In summary, six out of ten participants encountered challenges when self-monitoring their activities. The barriers to smartwatch usage for HBM were only related to the device's resources, such as discomfort or inaccurate data, with no other TDF domains being mentioned concerning these barriers. Specifically, water can be detected as touches during swimming activities, as well as the inconvenience of charging the battery regularly. Further challenges in continued use were seen in the small display size and uncomfortableness of wearing the watch during the night.

Table 3

Coding scheme related to barriers for using smartwatches for health monitoring, including main codes, subcodes, definitions of codes.

Main codes	**Subcodes**	**Definitions of codes**	**N*int***	**N*tot***
Barriers	Resources	Materials and functionalities that potentially discourage sustained use of smartwatches for self-monitoring.	6	9

Note: Number of interviews the code was mentioned in (Nint), and total number of times the code was mentioned in all interviews (Ntot).

Discussion

Main findings

This study aimed to explore factors that influence the sustained use of smartwatches for health behaviour self-monitoring (HBM) among healthy individuals. This study investigated individuals' perceptions regarding facilitators and barriers regarding long-term smartwatch use for HBM. The findings of this study can help to shape the development and implementation of smartwatches, eventually increasing the continued use of HBM.

Skills regarding effective tracking and management of health information were identified as the main facilitators. As a result, the proficiency of the participants in these activities

encouraged continuous use of the smartwatch for HBM. Furthermore, initial goals and evolving objectives were crucial for sustained use too. This shift highlights the importance of the establishment of new goals over time for long-term use. In addition, beliefs about the health consequences were also important factors for sustained use. Participants were motivated to change behaviours based on health data, such as adjusting activities to lower heart rates or decrease weight, indicating trust in the smartwatch data's accuracy. Besides, social influence was to be found an important facilitator for HBM. Encouragement from family, friends, and social media impacted sustained use. Examples include monitoring heart rate due to family health history, modelling from the mother, and motivation from fitness influencers on platforms like YouTube as well as tips from gym trainers. Beliefs about capabilities in using the smartwatch effectively was another facilitator. Participants appreciated their ability to organize health data and track physical activity progress. Resources were also noted as beneficial factors for long-term use. Users favoured emergency functions like detecting impending heart attacks or falls and automatic workout-tracking, enhancing the smartwatch's perceived value. On the contrary, barriers hindered long-term use, which were only related to the smartwatch's resources. Participants reported issues such as battery life, water usability, small display size, and discomfort during sleep. Water detection issues during swimming, frequent charging needs, navigation difficulties on a small screen, and discomfort wearing the smartwatch overnight were common complaints. In summary, the study found that self-monitoring skills, evolving goals, trust in health data, social influences, confidence in capabilities, and advanced resources are key facilitators for sustained smartwatch use for HBM. However, technical limitations, such as battery life and usability issues, posed challenges for the user. Addressing both motivational and

technical aspects is essential to enhance the long-term adoption of smartwatches for health monitoring.

Comparison to prior work

The study's main findings demonstrated that important factors of smartwatch usage such as facilitators and barriers could be additionally separated into specific subcodes e.g. goals, beliefs about consequences and capability. Hence, the TDF appeared to be beneficial for studying personal factors regarding the sustained use of smartwatches for HBM and its implementation process as well as long-term behaviour change aiming to live a healthy lifestyle in long-term. Finding specific research that explicitly compares the application of the Theoretical Domains Framework (TDF) in smartwatch usage for health behaviour self-monitoring (HBM) was quite challenging. Previous research applied the TDF in designing interventions to support healthcare practitioner behaviour change (Bele et al., 2021). Similarly, the TDF was used to identify barriers and enablers to implementing virtual healthcare for children (Bele et al., 2021). While the TDF has been used in various health behaviour change studies, its specific application to smartwatch usage and HBM might be a relatively new area of research.

This study found that self-monitoring skills were crucial for the sustained use of smartwatches for HBM. These skills, coupled with their beliefs about the health consequences and beliefs in the provided health data were important factors for long-term use. These findings align with previous research emphasising the role of self-efficacy in health behaviour change. For instance, bandura´s self-efficacy theory suggests that individuals with higher confidence in their ability to perform a task, are more likely to engage in and maintain behaviour (Bandura, 1977). In the context of smartwatches, Merver et al. (2016) found that people with higher self-

efficacy regarding their ability to use fitness trackers were more likely to sustain their usage over time. However, the present study extends this by highlighting specific self-monitoring skills, such as tracking sleep patterns and calorie intake, as important components of sustained use.

The evolution of user´s goals from initial health improvements to maintaining a healthy lifestyle was another relevant finding. This shift in goals suggested that long-term engagement with smartwatches may depend on the user's motivation and willingness to set new goals. Previous studies have shown that goal setting is a powerful motivator for health behaviour change (Yang & Pan, 2020). In addition, the present study indicates that maintaining long-term engagement requires not just establishing initial objectives but also evolving and refining these goals over time, such as transitioning from an initial goal of decreasing weight to a more continuous aim of maintaining a healthy body weight. This changing aspect of goal setting aligns with the Transtheoretical Model of Behaviour change (TTM), which considers that individuals move through different stages of change and require different types of support for each stage (LaMorte, 2022). As a result, if the user's action is to lose weight, subsequently, the individual needs to set a new goal after losing weight. In this maintenance stage, people have sustained their behaviour change for a while, and intend to maintain the behaviour change going forward. This is the critical moment in which users need to set a new goal which is the aim of maintaining a healthy lifestyle. Another aspect of goal setting can be analysed with the intention behaviour gap, which refers to the discrepancy between the intention to become healthier and the actual behaviour over time (Cristescu et al., 2022). The existing body of literature did not address how this incongruity between the intention of living a healthy lifestyle and the behaviour evolves. The present study however can fill this gap in knowledge with the finding that goals need to be transformed over time to keep the user motivated. To conclude, goals was an important subcode

for users to sustain the use of smartwatches for HBM. Especially, the evolution from short-term goals to sustained goals of living a healthy lifestyle is important to consider.

Social influences appeared as a beneficial facilitator for the long-term use of HBM. Participants expressed encouragement from family, friends, and social media as motivating factors. This finding is supported by the Social Cognitive Theory, which identifies the role of social influences and observational learning in behaviour adoption (LaMorte, 2022b). Notably, the present study highlighted the impact of social media influencers and fitness communities, which have not been extensively covered in previous literature on wearable technology adoption for sustained use. Hence, family, friends and social media platforms provide a unique opportunity to promote smartwatch usage for HBM through peer modelling and social reinforcement.

Despite the facilitators, technical limitations such as battery life, water usability, small display size, and discomfort during sleep were expressed barriers towards using smartwatches for HBM. In this study, the barriers to continued smartwatch use for HBM were exclusively related to the device's resources, such as discomfort and data inaccuracy, with no other TDF domains contributing to the identified challenges. This suggests that design improvements in smartwatch features could be a critical factor in overcoming non-adherence. These findings are consistent with previous research highlighting usability issues as a critical factor in the long-term use of wearable technology (Alshamari & Althobaiti, 2024). The present study provides elaborate insights into how specific technical challenges impact user experience and long-term use, for instance, the issue of water detection during swimming and the inconvenience of

frequent charging. Addressing these technical barriers is critical to improving the user experience and maintaining engagement.

Strengths & limitations

This study has several strengths and limitations that impact the reliability and validity of its findings. One of the main strengths of this study was the use of a structured interview scheme designed according to the Theoretical Domains Framework (TDF). This framework provided a comprehensive approach to exploring various facilitators and barriers expressed by participants about the sustained use of smartwatches for HBM. Using this framework ensured that the interview questions covered a broad range of relevant constructs of the TDF, which likely contributed to the depth of data collected. This methodological strategy increased the credibility of the finding, as it provided a structured and theory-based method to understand the facilitator and barriers to sustained smartwatch use for self-monitoring

Despite this strength, the study has several limitations to consider when interpreting the results. The use of convenience sampling means that participants were selected based on their availability and willingness to participate, rather than through a random sampling method. This approach could have introduced selection bias, because the sample may not be representative of the broader population of healthy individuals using smartwatches for HBM. To mitigate this, it was ensured to select a diverse range of ages within the participants to capture a variety of perspectives and experiences. A second considerable limitation was gender representation. The study´s sample consisted entirely of men, which limits the generalisability of the findings to the wider population, particularly women. The lack of female representation may impact the validity of the data, as gender differences could influence the use and perception of smartwatch features

for HBM. According to Escoffery (2018), U.S. adults are using the Internet for health activities; however, females are more likely to engage in different e-health behaviours than males (Escoffery, 2018).

Implications for future research and practice

The findings from this study indicate several opportunities for future research. First, expanding the demographic diversity of participants is crucial. Given that the sample consisted entirely of men, future studies should include women to examine potential gender differences in the sustained use of smartwatches for HBM. Similarly, Escoffery (2018) concluded that additional research is needed to identify the causal factors underlying gender differences in online healthcare use and to explore the implications for public health practice for each group. Second, research should investigate the specific self-monitoring skills that contribute to sustained HBM use. While this study identifies skills such as tracking physical activity during workouts, tracking sleep patterns and calorie intake, further studies could explore how these skills develop over time and which educational or training intervention can enhance them. Third, examining the role of goal setting and evolution is necessary. Future research could examine how user´s goals shift over extended periods. Longitudinal studies over several years could provide better insights into how initial health goals evolve and the impact of continued goal setting on the sustained use of HBM with smartwatches (Beukenhorst et al., 2020). Lastly, addressing technical barriers identified in this study, such as battery life, water usability, and display size, is crucial. Future research could focus on technological advancements and user-centred design improvements to mitigate these issues. For instance, exploring user satisfaction with new models featuring extended battery life or enhanced waterproofing could provide valuable insights.

The results of this study have several practical implications for the further development and implementation of smartwatches for self-monitoring. These implications can help to improve development and implementation and sustain the use of smartwatches for HBM, leading to better health outcomes. Developers, practitioners or sports centres e.g. gyms could implement training sessions or resources to help users develop self-monitoring skills. This could include workshops on effectively tracking various health data and interpreting and organizing the data provided by smartwatches. Next, practitioners or gym trainers should encourage users to set initial health goals and continuously reassess and adjust these goals. Guiding goal tracking and achievement can help to maintain user motivation. For instance, smartwatch developers could integrate features that prompt users to set and update their goals regularly. Lastly, improving the device features such as battery life and waterproofing as well as user comfort e.g. alternative wearable design or materials could enhance the functionality and comfort of the smartwatch for self-monitoring. In summary, addressing both motivational and technical aspects is essential to enhance the long-term use of smartwatches for HBM. By focusing on the areas outlined above, the future and practical application can work collectively to improve the sustained use of HBM, possibly contributing to better health outcomes for users.

Conclusion

This study explored factors influencing the sustained use of smartwatches for health behaviour self-monitoring (HBM) among healthy individuals. While the generalizability of the findings is limited by the all-male sample, the study still offers valuable insights for researchers, designers, and practitioners developing and implementing smartwatches for health purposes. The key takeaway is that both motivational and technical aspects have a perceived impact on

sustained smartwatch use. Users who develop self-monitoring skills, set evolving goals, trust health data, and receive social support are more likely to keep using smartwatches for HBM. However, technical limitations like battery life, display size, waterproofness, and discomfort wearing during the night can hinder the use. To conclude, this study highlights the importance of a combined approach that addresses both motivational and technical aspects to promote sustained use of smartwatches for health behaviour self-monitoring.

References

Alshamari, M. A., & Althobaiti, M. M. (2024). Usability Evaluation of Wearable Smartwatches Using Customized Heuristics and System Usability Scale Score. *Future Internet*, *16*(6), 204. https://doi.org/10.3390/fi16060204

Atkins, L., Francis, J., Islam, R., O'Connor, D., Patey, A., Ivers, N., Foy, R., Duncan, E. M., Colquhoun, H., Grimshaw, J. M., Lawton, R., & Michie, S. (2017). A Guide to Using the Theoretical Domains Framework of Behaviour Change to Investigate Implementation Problems. *Implementation Science*, *12*(1). https://doi.org/10.1186/s13012-017-0605-9

Attig, C., & Franke, T. (2022). Why Do People Abandon Activity Trackers? The Role of User Diversity in Discontinued Use. *International Journal of Human–Computer Interaction*, 1–13. https://doi.org/10.1080/10447318.2022.2067935

Bandura, A. (1977). Self-efficacy: toward a Unifying Theory of Behavioral Change. *Psychological Review*, *84*(2), 191–215. https://educational-innovation.sydney.edu.au/news/pdfs/Bandura%201977.pdf

Bele, S., Cassidy, C., Curan, J., Johnson, D. W., & Bailey, J. A. M. (2021). Using Theoretical Domains Framework to Identify Barriers and Enablers to Implementing a Virtual Tertiary-regional Telemedicine Rounding and Consultation (TRaC-K) Model for Kids: A Qualitative Study (Preprint). *Journal of Medical Internet Research*. https://doi.org/10.2196/28610

Beukenhorst, A. L., Howells, K., Cook, L., McBeth, J., O'Neill, T. W., Parkes, M. J., Sanders, C., Sergeant, J. C., Weihrich, K. S., & Dixon, W. G. (2020). Engagement and Participant Experiences With Consumer Smartwatches for Health Research: Longitudinal,

Observational Feasibility Study. *JMIR MHealth and UHealth*, *8*(1), e14368. https://doi.org/10.2196/14368

Boeije, H. (2002). A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews. *Quality & Quantity*, *36*, 391–409. https://qualquant.org/wp-content/uploads/text/Boeije%202002-1.pdf

Canali, S., Schiaffonati, V., & Aliverti, A. (2022). Challenges and Recommendations for Wearable Devices in Digital health: Data quality, interoperability, Health equity, Fairness. *PLOS Digital Health*, *1*(10). https://doi.org/10.1371/journal.pdig.0000104

Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science*, *7*(1). https://doi.org/10.1186/1748-5908-7-37

Constantinou, C. S., Georgiou, M., & Perdikogianni, M. (2017). A comparative method for themes saturation (CoMeTS) in qualitative interviews. *Qualitative Research*, *17*(5), 571–588. https://doi.org/10.1177/1468794116686650

Cristescu, I., Iordache, D.-D., & Ţîrlea, C. (2022, June 1). *Behavioral intention to use smartwatches: a case study*. IEEE Xplore. https://doi.org/10.1109/ECAI54874.2022.9847469

Del-Valle-Soto, C., López-Pimentel, J. C., Vázquez-Castillo, J., Nolazco-Flores, J. A., Velázquez, R., Varela-Aldás, J., & Visconti, P. (2024). A Comprehensive Review of Behavior Change Techniques in Wearables and IoT: Implications for Health and Well-Being. *Sensors*, *24*(8), 2429. https://doi.org/10.3390/s24082429

Escoffery, C. (2018). Gender Similarities and Differences for e-Health Behaviors Among U.S. Adults. *Telemedicine and E-Health*, *24*(5), 335–343. https://doi.org/10.1089/tmj.2017.0136

Eysenbach, G. (2001). What Is e-health? *Journal of Medical Internet Research*, *3*(2). https://doi.org/10.2196/jmir.3.2.e20

G. Sucharitha, Bodepu Tannmayee, & Kanagala Dwarakamai. (2021). Revolution in IoT: Smart Wearable Technology. *Springer Link*, 407–425. https://doi.org/10.1007/978-3-030-77528-5_21

Golzar, J., Noor, S., & Tajik, O. (2022). Convenience Sampling. *International Journal of Education & Language Studies*, *1*(2), 72–77. https://doi.org/10.22034/ijels.2022.162981

Horton, J., Macve, R., & Struyven, G. (2004). Qualitative Research: Experiences in Using Semi-Structured Interviews. *The Real Life Guide to Accounting Research*, 339–357. https://doi.org/10.1016/b978-008043972-3/50022-0

Kamal Basha, N., Aw, E. C.-X., & Chuah, S. H.-W. (2022). Are we so over smartwatches? Or can technology, fashion, and psychographic attributes sustain smartwatch usage? *Technology in Society*, *69*, 101952. https://doi.org/10.1016/j.techsoc.2022.101952

LaMorte, W. (2022a). *The transtheoretical model (stages of change)*. Boston University School of Public Health. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories6.html

LaMorte, W. (2022b, November 3). *The Social Cognitive Theory*. Boston University School of Public Health. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories5.html

Longhini, J., Chiara Marzaro, Bargeri, S., Palese, A., Dell'Isola, A., Turolla, A., Paolo Pillastrini, Battista, S., Castellini, G., Cook, C., Gianola, S., & Giacomo Rossettini. (2024). Wearable Devices to Improve Physical Activity and Reduce Sedentary Behaviour: An Umbrella Review. *Sports Medicine - Open*, *10*(1). https://doi.org/10.1186/s40798-024-00678-9

Mercer, K., Li, M., Giangregorio, L., Burns, C., & Grindrod, K. (2016). Behavior Change Techniques Present in Wearable Activity Trackers: A Critical Analysis. *JMIR MHealth and UHealth*, *4*(2), e40. https://doi.org/10.2196/mhealth.4461

Nadal, C., Earley, C., Enrique, A., Sas, C., Richards, D., & Doherty, G. (2023). Patient Acceptance of Self-Monitoring on Smartwatch in a Routine Digital Therapy: a Mixed-Methods Study. *ACM Transactions on Computer-Human Interaction*. https://doi.org/10.1145/3617361

NHS. (2022, April 22). *Cardiovascular disease*. NHS; NHS. https://www.nhs.uk/conditions/cardiovascular-disease/

Pennington, N., & Dam, L. (2023). Social interaction, support preferences, and the use of wearable health trackers. *Frontiers in Communication*, *8*. https://doi.org/10.3389/fcomm.2023.1256452

Shei, R.-J., Holder, I. G., Oumsang, A. S., Paris, B. A., & Paris, H. L. (2022). Wearable Activity Trackers–advanced Technology or Advanced marketing? *European Journal of Applied Physiology*, *122*(9). https://doi.org/10.1007/s00421-022-04951-1

Siepmann, C., & Kowalczuk, P. (2021). Understanding continued smartwatch usage: the role of emotional as well as health and fitness factors. *Electronic Markets*, *31*(1). https://doi.org/10.1007/s12525-021-00458-3

Statista. (2022). *Europe: per capita e-waste generation by country 2022*. Statista. https://www.statista.com/statistics/1219417/per-capita-ewaste-generation-europe-by-country/

Statista Market Insights. (2024, February). *Smartwatches - Europe | Statista Market Forecast*. Statista. https://www.statista.com/outlook/hmo/digital-health/digital-fitness-well-being/fitness-trackers/smartwatches/europe

Thornton, L., Gardner, L. A., Osman, B., Green, O., Champion, K. E., Bryant, Z., Teesson, M., Kay-Lambkin, F., & Chapman, C. (2021). A Multiple Health Behavior Change, Self-Monitoring Mobile App for Adolescents: Development and Usability Study of the Health4Life App. *JMIR Formative Research*, *5*(4), e25513. https://doi.org/10.2196/25513

van Gemert-Pijnen, L. van, Kelders, S. M., Kip, H., & Sanderman, R. (2018). *EHealth research, theory and development : a multidisciplinary approach*. Routledge.

Vijayan, V., Connolly, J. P., Condell, J., McKelvey, N., & Gardiner, P. (2021). Review of Wearable Devices and Data Collection Considerations for Connected Health. *Sensors (Basel, Switzerland)*, *21*(16), 5589. https://doi.org/10.3390/s21165589

Volpato, L., del Río Carral, M., Senn, N., & Santiago-Delefosse, M. (2020). General practitioners' perceptions towards the use of wearable electronic health monitoring devices: A qualitative analysis on risks and benefits (preprint). *JMIR MHealth and UHealth*, *9*(8). https://doi.org/10.2196/23896

World Health Organization. (2020). *WHO Guidelines on Physical Activity and Sedentary Behaviour*. S.N.

Yang, X., & Pan, D. (2020). In the Face of Negative Data, the Effects of Goal Type and Feedback Type on the Willingness to Continue to Participate Quantified-Self. *American*

Journal of Industrial and Business Management, *10*(02), 327–343. https://doi.org/10.4236/ajibm.2020.102021

Yang, Y., Boulton, E., & Todd, C. (2022). Measurement of Adherence to mHealth Physical Activity Interventions and Exploration of the Factors That Affect the Adherence: Scoping Review and Proposed Framework. *Journal of Medical Internet Research*, *24*(6), e30817. https://doi.org/10.2196/30817

Yen, H., & Chiu, H. (2019). The effectiveness of wearable technologies as physical activity interventions in weight control: A systematic review and meta-analysis of randomized controlled trials. *Obesity Reviews*, *20*(10), 1485–1493. https://doi.org/10.1111/obr.12909

Appendix A

Interview Scheme **Date:**

Exploring factors influencing the sustained use of smartwatches for self-monitoring purposes by healthy individuals

Demographics:

Age:
Gender:
Occupation:
Duration of Smartwatch Ownership:
Frequency of Smartwatch Usage (Multiple times a day, daily, weekly, monthly:
Type of Smartwatch:

Introduction:

Hello, thank you for participating in my research study. My name is David Calandra, and I am conducting this study as part of my bachelor's research at the University of Twente. This study aims to explore the factors influencing the long-term adoption of smartwatches for health behaviour self-monitoring. Your participation in this interview will provide valuable insights into the challenges, difficulties, and motivations related to using smartwatches for health monitoring. Before we begin, I'll need you to sign the informed consent form. Do you have any questions before we proceed?

Note: 1 Let them sign the consent.
2 Ask for questions.
3 start audio recording

Interview Questions:

1. Introduction & usage patterns:

- Can you describe how you use your smartwatch to monitor your health outcomes?
- What specific health metrics or features do you track with your smartwatch?
- Can you describe a typical day or routine where you rely on your smartwatch for health monitoring?
- How long have you been using a smartwatch for health monitoring?

2. Usage Patterns and Motivation:

- What initially motivated you to start using a smartwatch for health monitoring?
- Have these motivations changed over time? If so, how?

- Have you noticed any changes in your health behaviour or outcomes since using the smartwatch? If so, can you elaborate on these changes?
- How do you perceive the role of your smartwatch in maintaining your health and wellness in the long term?

3. Facilitators of Long-Term Adoption:

Intention:

- Do you intend to keep using your smartwatch for health monitoring; why or why not?

Social Influence:

- To what extent has your (social) environment influenced your smartwatch use for health monitoring? Can you give examples?

Beliefs about consequences

- Do you believe that using a smartwatch improves your health outcomes? Yes or no, give examples.

Additional probing

To what extent have you encountered any features or functionalities of your smartwatch that have motivated you to continue the smartwatch?

Which features?
Why do you find these features convenient?
What makes them better than other features?

4. Barriers to Long-Term Adoption:

- Have you experienced any challenges or obstacles that have hindered your usage of the smartwatch for health monitoring? Can you give examples?
- Are there any specific features or limitations of the smartwatch that have discouraged you from using it consistently?
- Have you ever considered discontinuing the use of your smartwatch for health monitoring? If so, what were the reasons behind this consideration?

5. Strategies for Overcoming Barriers:

Support and Assistance:

- What would help you to keep using the smartwatch for health monitoring and tackle these barriers? Please provide examples.

Desired Features or Improvements:

- Are there any additional features or improvements you would like to see in future smartwatch models that could enhance your motivation to continue using the device for health monitoring and management?

Closing:

- Thank you for participating and sharing your experiences with me. This was the last question that I wanted to ask you.
- Is there anything else you would like to add or any additional insights you would like to share about your experience with using a smartwatch for health behaviour self-management?
- Thank you for participating in the study.

Appendix B

Research Participant Informed Consent Form

Title of the Study:
Understanding the individual implementation process of eHealth technologies
Exploring factors influencing the sustained use of smartwatches for self-monitoring purposes by healthy individuals

Principal Investigator: David Calandra

Introduction:
You are being invited to participate in a research study conducted by David Calandra from the University of Twente. Before deciding whether to participate, it is important that you understand why the research is being conducted and what will be involved if you agree to take part. Please take your time to read the information provided in this consent form and feel free to ask any questions before making your decision.

Purpose of the Study:
The purpose of this study is to investigate the factors influencing the long-term adoption of eHealth technologies, particularly smartwatches used for self-monitoring purposes. By participating in this research, you will help contribute to our understanding of how individuals integrate and sustain the use of these technologies in their daily lives.

Procedures:
If you agree to participate, you will be asked to take part in a semi-structured interview conducted by the researcher. The interview will be audio/video recorded to ensure accuracy in data collection. During the interview, you will be asked about your experiences, perceptions, and challenges related to using a smartwatch for self-monitoring purposes. The interview will last approximately 30 – 45 minutes.

Risks and Benefits:
Participating in this study involves minimal risks. However, you may experience some discomfort or emotional distress when discussing personal experiences or challenges related to smartwatch usage. The potential benefits of participating include contributing to research that may inform the development of future eHealth interventions and improving our understanding of the factors influencing technology adoption.

Confidentiality:
Your confidentiality and privacy are important to us. All information collected during the study will be kept strictly confidential and will only be accessible to the research team. Your identity will be anonymized in any reports or publications resulting from the study. The transcripts of the audio recordings will be anonymously stored with the participating ID on the secured server of

the UT. The interview recordings will be destroyed after completing the data analysis. The anonymized interview transcripts will be stored for a period of 10 years.

Voluntary Participation and Right to Withdraw:
Your participation in this study is entirely voluntary, and you have the right to withdraw at any time without penalty or consequences. If you choose to withdraw, any data collected up to that point will be excluded from the study.

Contact Information:
If you have any questions or concerns about the study, please do not hesitate to contact David Calandra, at d.calandra@student.utwente.nl. If you have any concerns about the conduct of the research or wish to report a complaint, you may also contact the Ethics Committee at ethicscommittee-hss@utwente.nl.

Consent:
By signing below, you acknowledge that you have read and understood the information provided in this consent form, and you agree to participate in the study.

Signatures

_____	_____
Participants' Signature	Date

David Calandra	_____	_____
Researcher name	Signature	Date

Appendix C

Table 2

Coding scheme related to Facilitators for continuous use of smartwatches for self-monitoring, including main codes, subcodes, definitions of codes, related quotes.

Main codes	**Subcodes**	**Definitions of codes**	**Related quotes**	**N*int***	**N*tot***
Facilitators	Self-monitoring skills	User's ability and proficiency acquired through practice in effectively tracking and managing their health metrics using the smartwatch.	"I use the watch while sleeping to check my average pulse upon waking up. I also monitor how quickly my pulse returns to normal or resting levels. I check if this occurs, especially after physical activities." (participant 1) "I use it for monitoring my sports performance and there are various functions for different workouts. Whether I'm running on the treadmill or cycling outdoors, doing cross-training, or free training, as soon as I start any of these activities, I track my sports activities. It shows me at the end how long it lasted, how long it took me, for example, to run a kilometre and my heart rate in different phases of	10	10

				my training. Additionally, I occasionally check my blood oxygen levels, and at night, it tracks my sleep, which contributes to better sleep tracking." (participant 2)	
				"The ones I focus on the most are how many active calories I've burned throughout the day, how many minutes of activity, or let's say more strenuous activity, I have per day, and how often I stand. So, mostly, it's data about my activity. Occasionally, I look at things like step count, heart rate, or blood pressure, but it depends on how I feel and if I feel healthy." (participant 3)	
				"Track my steps. I also like to monitor my blood pressure and heart rate while running on the treadmill or lifting weights. I wear it to see how I perform during exercise." (participant 4)	
				"I monitor very closely my sleep patterns and the quality of my sleep. Also, my pulse and heart rate are measured continuously. I also monitor my daily	

			activities, like how many steps I've taken today. If I've worked out, I monitor it too. Additionally, I watch my diet. I always try to input my diet, and then it helps me monitor my calorie intake for the day." (participant 6) "Yes, mainly I monitor my pulse throughout the day to keep track of the average. And then also in combination with the activity I do, I monitor the pulse. It also records the oxygen saturation in the blood. It not only counts the steps but also records pretty accurately how far I've moved.". "it helps me see how well I've slept and adjust my behaviour accordingly, especially during stressful times." (Participant 7) "Yes, pulse, blood pressure, and the distance I cover daily." (Participant)		
	Goals	The starting aims to use a smartwatch as a self-monitoring device as well as changing individual objectives over time that drive	"I had previously completed nursing training and had become more familiar with what information can be obtained from the pulse	5	9

		continues use and engagement with the smartwatch	and what it indicates about the body's health and fitness. That's what motivated me to get a smartwatch." (participant 1) "Initially, I aimed to continue monitoring my health to participate in the selection process for the judiciary, as one must also undergo a medical examination by a government doctor for civil service. However, afterwards, the motivation for that decreased." (participant 1) "Well, I wanted to improve my endurance and run more kilometres in a shorter time, while also being fitter at the end of the goal, so that I'm not exhausted after 2 kilometres. That's what motivated me to buy the tracker." (participant 2) "Yes, the initial goal was just to improve my endurance, as mentioned. Over the years, it has become more about staying fit, just to maintain a healthy lifestyle, to have a healthy body that I can control myself, instead of always	

				going to the doctor or getting checkups. I have it in my hands now, and that's my motivation, to be a better person physically." (participant 2)	
				"I started looking at my lifestyle, and like, I was very overweight. For example, like, what can I improve? And then somebody, like my fitness coach at the gym, gave me these great tips. And I also started doing some research myself, like, hey, what kind of useful app can I use for monitoring my health in different kinds of aspects? So yeah, it was because I wanted to improve the quality of my lifestyle and my health that I started looking into these apps. And since two years or something, I think I've started integrating and using them, yeah, to monitor that progress." (participant 6)	
				"But after you have achieved that it's more like a lifestyle, and a lifestyle is continuous. So, it's more like my goal changed from losing weight to sustaining this	

		healthy lifestyle that I have achieved." (participant 6) "The goal shifts from muscle building to overall fitness and health." (participant 9) "Yes, I was motivated because my blood pressure was very high and hard to reduce. I felt weak and lacked endurance, so I wanted to see if increased physical activity would improve my condition." (participant 10)		
Beliefs about health consequences	Users' acceptance of the validity and reliability of the health data insights provided by the smartwatch.	"Yes, because for me, when I see poor results, I naturally try to change something about the cause. And when you see all the results on the Apple Watch, it leads to investigating the causes or doing something to lower the heart rate." (participant 1) "Counting my steps, being able to do breathing exercises through the watch, and so on. I believe it's already become a solid part of my daily routine." (participant 4)	6	13

"So, sleep is very important to me, and I had long struggled with it, and there's a big difference when you sleep properly, and you feel well-rested." (participant 5)

"Yes, I firmly believe that using the Smartwatch has improved my health outcomes I mean, if you look at it from a statistical perspective, you have motivation as a predictor variable, then health and activity as outcome variables, and then the Smartwatch acts as a moderator in that direction." (participant 9)

"Yes, I am sure of it. I used to feel weak, and walking was getting harder. The plans with the smartwatch to track distances have motivated me. I can see how far I've walked, which I wouldn't have known otherwise. Without it, I might have overestimated the distance." (participant 10)

"Yes, I noticed that I feel better when I move more, which motivates me. It spurs me on to extend my walks. Initially, a

		kilometre was challenging, but last weekend we walked six kilometres." (participant 10)		
Social influences	The impact of family, friends, or health care providers on an individual's thoughts, feelings, or behaviour regarding the use of a smartwatch for self-monitoring.	"Hmm, yes, for example, my sister also has an elevated heart rate, which seems to be some sort of genetic predisposition in the family. She also got herself a smartwatch and monitors it permanently. But since I don't want the same thing to happen to me, I try to act preventively in advance." (participant 1) "Not directly my immediate social circle, but now through YouTube and all the fitness influencers, they make a lot of videos about running, tutorials, how to get faster, how to get better." (participant 2) "I got the idea from my mother at the beginning. I got that simple device first from my mother because I borrowed it from her, and I watched how she used it. In the end, she always said, "Oh, I've taken so many steps." So, I was interested in	8	13

finding out about myself (participant 3)

"My siblings and I got one for my father's birthday. Simply because I was convinced that he could also benefit from it, because he said he wanted to start exercising, so I thought it could motivate him better if he had it too." (participant 4)

"So, you see other people using these things and so I got curious like, hey, what is that? How does it work? So, by asking other people and by seeing it with other people and seeing them use it, I got a bit into it saying, hey man, it looks interesting. I want to see more of that. So, then I and yeah, it's based on that that I saw other people using it and having it that I was like yeah maybe this is something for me too. And then my fitness coach at the gym gave me these great tips. And I also started doing some research myself, like, hey, what kind of useful app can I use for monitoring my health in different kinds of aspects? So yeah, it was because I wanted to

improve the quality of my lifestyle and my health that I started looking into these apps. And for two years or something, I think I've started integrating and using them, yeah, to monitor that progress." (participant 6)

"So, you involve people with it, and likewise, when you share your achievements and say, "Hey, I've already walked 10,000 steps and it's only noon." (participant 7)

"So I came up with the idea because I saw it with my former roommate, he had the same smartwatch, and I started boxing, and I tried out this function with the body scan, and then I was very impressed with what such a small watch can do, and then I thought to myself, "Do you want to ask your roommate if you can try his body scan, do you also want to have your watch?" So, I wished for it for my birthday." (participant 9)

		"Yes, my son he gave it to me as a gift." (participant 10)		
Beliefs about capabilities	Individuals' confidence in their ability to use a smartwatch effectively for health self-monitoring and seamlessly incorporate it into their daily routines.	"I also don't know any other way to track it better in this case. I wouldn't know myself, besides very complex procedures, how I could track my sleep. Of course, I could do it through a doctor or specialist who would conduct some kind of EKG during sleep, but from the outside, I couldn't do it myself. I couldn't think of any other way besides this device, which has various functions; I'd have to. Yeah, yeah, yeah, way too cumbersome, way too expensive, and I wouldn't have the desire for it now, and so I have a kind of live ticker. I can check every day how I slept instead of doing something somehow and going to someone and paying for it, and I wouldn't want to do that." (participant 2) Over the years, it has become more about staying fit, just to	5	11

maintain a healthy lifestyle, to have a healthy body that I can control myself, instead of always going to the doctor or getting checkups. I have it in my hands now, and that's my motivation, to be a better person physically." (participant 2)

"Mhm, so I think I find this interactive design of the Apple Watch better because, as I mentioned, it makes it easier for me to understand what I'm affecting with my behaviour. That wasn't the case with other products I had seen or looked at before the comparison. And the second point would be this help app on my phone, where you can see all the data. I'm not sure how it could be with most others, but it was enough for me, given the features they have, that you can sort and organize them properly." (participant 3)

"I think that's a very special factor, being able to do so much with the watch and other devices from the same brand, all through the watch for

		example, when I do bench presses, I like to see my heart rate. It's just cool to be able to see that and get a sense of how much my training is helping my body." (participant 4) "Yes, just to assess my health status, to analyse it overall that I don't just have a small snapshot when the doctor examines me and says my pulse is high, but I can see for myself throughout the day if that's true or if I was just nervous at the doctor's, you know, the typical thing?" "Counting my steps, being able to do breathing exercises through the watch, and so on. I believe it's already become a solid part of my daily routine." (Participant 7) "I can now manage longer distances, which I couldn't do before." (participant 10)		
Resources	Sources that may encourage the sustained use of smartwatches for self-monitoring e.g. functions or improvements of the smartwatches that can	"Well, the newer models already have a blood pressure monitor built in. As you surely know, blood pressure is always dependent on the pulse, so both values are	6	9

positively impact the behaviour of the helathy individual for HBM	interdependent to detect anything. They can also detect, for example, an impending heart attack or atrial fibrillation very well. That would motivate me to buy and use another one." (participant 1) "Workout tracking, so that if it detects that I'm starting to run, it starts the workout itself without me having to actively start it on the display. So, I start running, it detects that I'm running, and it starts automatically. So, like when you're on the cross trainer, it should immediately detect that I'm on the cross trainer and adjust the parameters accordingly instead of the running parameters. It should be able to differentiate simply." (participant 2) "Well, I'm a big fan of a charging station that I bought separately, which didn't come with the device, and I could imagine that maybe that could be a point that could be added with the device to convince people to avoid this problem with charging completely, which was something I

	had at the beginning. Another thing, as I mentioned, is that the device should be improved, and more features added. So, when I buy this product and invest money in it, it should be an ongoing process." (participant 3)
	"Emergency notification, I mean, for one, if I have a fall, for example, while cycling, so increased acceleration values that are then detected by the watch." (participant 7)
	"Yes, better displays, a better ratio between the case and the display, so you have more screen real estate without increasing the size of the device, essentially maximizing the surface area of the device. participant 8)"
	"Some kind of alarm function, so that if you have a car accident or something, it calls emergency services. participant 9)

Note: *number of interviews the code was mentioned in (Nint) and total number of times the code was mentioned in all interviews (Ntot).*

Table 3

Coding scheme related to barriers for continuous use of smartwatches for self-monitoring, including main codes, subcodes, definitions of codes, related quotes.

Main codes	**Subcodes**	**Definitions of codes**	**Related quotes**	**N*int***	**N*tot***
Barriers	Resources	Materials and functionalities that potentially discourage sustained use of smartwatches for self-monitoring.	"I had negative experiences with connecting once because apparently, I had some outdated software on it or not the current one at least, and the band promises that you can use it in the water too. It's waterproof, but the display detects the water as touches, and then it starts some training in the water, and then 5 minutes later, you find yourself in the menu and adjust the language or something because the water mimics the touch of the finger, and then the device is off. That's why you can't use it in the water." (Participant 2) "Annoying that you must charge the device, naturally. Because that was something I had to get used to at the beginning, because a normal watch, when you	6	9

			buy one with a mechanical link, doesn't need to be charged, but that naturally also doesn't have the same possibilities." (participant 3) "The screen is small. So sometimes you can misclick on some things." (participant 6) "Yes, so the first thing that comes to mind is the battery because when you have 24-hour monitoring enabled, you have to remember to charge the watch daily." (participant 7) "Yes, the battery. The battery is still not great even after several years." (participant 8) "I used the watch to track my sleep, but I don't do that anymore because it's annoying to have a watch around your wrist when you want to sleep." (participant 9)

Note: *number of interviews the code was mentioned in (Nint) and total number of times the code was mentioned in all interviews (Ntot).*