MASTER THESIS

Understanding older adults' perceptions towards use of remote health monitoring through smart health devices

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Date: June 1, 2022

Abstract

Aim. Remote health monitoring (RHM) presents a new application field of IoT technologies to the health care and consumer sector. It is a promising solution to address challenges faced by current care models due to an aging population and to support the general wish for independent and healthy living with age. However, use of RHM is not yet well established in Germany, facing low user awareness and acceptance. This suggests that an extension of existing knowledge about user acceptance specific to this application field is needed. Hence, this study aims to contribute to a deeper understanding of perceptions of older adults concerning personal use of RHM.

Methods. A qualitative study was carried out by conducting semi-structured personal interviews, giving the opportunity to gain more in-depth insights into perceptions of a personal topic like RHM. The sample studied consisted of older adults aged 55 and older living independently in their own homes, as they represent the main target group for RHM. A total of 20 interviews was performed and analyzed. Participants were given an explanation of RHM followed by a discussion about future use intentions and related perceptions. Additionally, questionnaires were used to collect information about basic demographic information.

Results. Recognition of personal added value emerged to be crucial for openness towards use of RHM. Health awareness and deteriorations supported positive perceptions, as did personal experiences with caregiving. Further, trust appeared as a central theme within perceptions of RHM. Participants highly considered privacy aspects, while control over use and involved people also contributed to related thoughts. Possible impacts on personal relations by using RHM emerged as an important social aspect regarded by users, in addition to consideration of opinions of others. Additionally, participants required affordability of RHM and assumed high usability and levels of automation for acceptance. Based on the results a conceptual model was developed to illustrate the identified values shaping perceptions of RHM and possible relations with user characteristics.

Conclusion. This study has highlighted the distinctive features of user perceptions concerning acceptance of IoT-based and health-focused technologies. Context-specific aspects like privacy, trust, human touch norms and health beliefs, which are not included in traditional acceptance models, appeared to be most important in affecting perceptions of RHM. The results show that adoption of smart health technologies presents a field that needs to be considered separately and contribute to the required extension of existing knowledge. Additionally, it emerged as essential to heighten awareness and understanding of the aim of RHM in order to facilitate wider adoption in Germany.

Keywords: *Remote health monitoring, smart healthcare, technology adoption, user perceptions, older adults*

Table of Contents

1 Introduction 5
2 Theoretical framework 7
2.1 Status Review: German Healthcare 7
2.2 Introduction to Smart Healthcare 9
2.3 Review of Potential Influences on Perceptions 11
3 Methods 16
3.1 Study Design 16
3.2 Sampling 16
3.3 Participants 17
3.4 Materials 18
3.5 Procedure 19
3.6 Analysis 20
4 Results 21
4.1 General Attitude 21
4.2 Main Influential Values 22
4.3 User Diversity 39
4.4 Conceptual Model 42
5 Discussion 44
5.1 Discussion of Results 44
5.2 Implications 47
5.3 Future Research 49
5.4 Limitations 50
5.5 Conclusion 50
References 51
Appendix 57

1 Introduction

Global healthcare systems, including Germany's, are facing increasing challenges predominantly brought by an aging population (Ahmed et al., 2015; PwC, 2018). This draws attention to the need for innovation in order to remain proficient in providing sustainable and effective care (Möller & Popa, 2019; Philip et al., 2021). Accordingly, conventional healthcare is on the verge of being reformed. New focal points like prevention, personalized care and well-being are emerging and a transition towards a more decentralized approach to healthcare by leveraging digital technologies is evolving to support this change (Allen, 2021; Lymberis, 2003).

Remote health monitoring (RHM) is a central element of this smart healthcare movement (Philip et al., 2021). By utilizing the medical Internet of Things (IoT) RHM enables monitoring of an individual's health status within their home to prevent and monitor health deteriorations (Huang, 2010; Linkous et al., 2019). A collection of wearable and mountable devices, like fall-detectors, is used to collect and evaluate health-related and behavioral information of an individual, while insights like recommendations or warnings can be viewed by caring persons and users themselves (Cicibas & Yildirim, 2019; Doyle et al., 2015). Correspondingly, RHM exhibits a variety of benefits that help reshape health support and accommodate challenges imposed on the healthcare system by an aging population (Schomakers & Ziefle, 2019). Among others, it can reduce strains on caretakers, while also increasing independency and autonomy of elderly or those with chronic conditions (Linkous et al., 2019; Taiwo & Ezugwu, 2020), and supports more personalized treatment (Pantelopoulos & Bourbakis, 2010; Papa et al., 2020). That way, RHM serves the already ongoing shift of healthcare towards more personalized and patient-centered health service, with an increased focus on overall well-being and risk prevention.

It has become evident that the rising value chain around health data will continue to transform the healthcare industry and remote health monitoring will become an essential part of healthcare services and healthy living (Allen, 2021; Lymberis, 2003). The availability and maturity of related technologies offered by the industry is constantly increasing and remote treatment of patients facilitated through use of smart technologies has already gained the attention of various global health policy makers including the German Federal Ministry of Health (Philip et al., 2021; PwC, 2018).

Notably, despite this development and the promising benefits, the implementation and adoption of remote health monitoring systems is not yet as prominent as expected (Jaschinski, 2014; Walker et al., 2019). Especially in Germany, which is widely known as a frontrunner in healthcare provision, the transition towards digital health and utilization of smart health innovations is comparatively slow and lagging in reaching its full potential (Girvan, 2020; PwC, 2018). Wider dissemination is facing several challenges, whereas user awareness and acceptance has been identified to be one of the main factors in this context (Lymberis, 2003; Maeder & Williams, 2017). This is surprising, as RHM is aimed to support people's general wish for independent and convenient healthy living with age (Taiwo & Ezugwu, 2020), and considering other convenience-focused smart technologies are already widely accepted (Ahmed et al., 2015). Despite its relevance for successful adoption, this aspect of user acceptance is found to be often underrated within the introduction of technical innovations (Ziefle et al., 2011). It appears that there is a peculiarity in perceptions towards use of smart devices for personal use in the health sector, which makes it relevant to study user perspectives, such as usage motives and barriers, in this special context as a way to approach this recognized challenge and facilitate wider acceptance of RHM.

However, thus far the majority of existing research focuses on technical aspects of remote health monitoring applications, such as system architectures or data processing (Cicibas & Yildirim, 2019; Nagapuri et al., 2019). Comparatively few studies have focused on perceptions of the technology and attitudes that influence user acceptance (Doyle et al., 2015; Huang, 2010). This stresses the need for user-focused research to comprehend the underlying complexities of acceptance of RHM (Halbach et al., 2018; Nagapuri et al., 2019). Additionally, most related studies have been conducted in a variety of countries, wherein Germany is underrepresented. As cultural differences have proven to be a substantial influencing factor on user perceptions (Balta-Ozkan et al., 2014; Park et al., 2018), it is important to extend country-specific knowledge by exploring this topic further on a national level.

This research therefore aims at contributing to closing the illustrated research gap, by exploring user's perceptions regarding acceptance of RHM in Germany to gain insights into influencing attitudes, their possible connections and roles. Results of this study can support the development of the still needed unified understanding and modelling of user acceptance specified to the new area of IoT-based health technologies (Jaschinski et al., 2021). Additionally, findings from this study can provide practical implications for the development, design and distribution of RHM technologies, which can support accelerating broad diffusion of the services (Park et al., 2018; Yang et al., 2017). Based on this objective, the following main research question was formulated:

> *"What are older adults' perceptions concerning the use of remote health monitoring?"*

A qualitative approach was chosen to examine this question by conducting semi-structured interviews with potential users, as it allows deeper insights into perceptions regarding sensitive topics like health. Theoretical models of technology acceptance and health behavior were used as support and guidance for structuring the interviews and analyzing results.

The following chapter will give a short status review of healthcare in Germany and relevant key concepts concerning smart health technologies and user acceptance will be further explained based on a literature review. Afterwards, the methodologies of the study will be introduced, by outlining research design, procedure and analysis. Consequently, the findings from analysis of the interviews will be presented and afterwards discussed to result in answering the research question. Finally, implications and limitations of this research will be outlined, and a final conclusion will be drawn.

2 Theoretical framework

In order to provide a theoretical background for the research, this part will first give insight into the current status of German healthcare provision, including related challenges and opportunities, followed by an introduction to smart healthcare and remote health monitoring. This will be followed by a review of possible influencing factors concerning remote health monitoring (RHM) acceptance, and finally the introduction of the inferred research question.

2.1 Status Review: German Healthcare

This status review will demonstrate the relevance of acceptance of remote health monitoring in Germany by reviewing the challenges faced by the current healthcare system and how digital innovations, like RHM, can help in overcoming those.

2.1.1 Challenges

The German healthcare system has a reputation of being one of the best worldwide (Girvan, 2020). However, it is currently facing several challenges, which can be traced back to cross-sectional megatrends including demographic change, urbanization, individualization and digitalization (Möller & Popa, 2019; PwC, 2018).

For one, society in Germany is increasingly aging. As aging is demonstrably associated with an increase of chronic diseases and overall deterioration of health (Heidemann et al., 2021; Robert Koch-Institut, 2015), this development consequently leads to a rising need for healthcare (Destatis, 2021; Rothgang et al., 2020). Research has shown that especially the numbers of people requiring low levels of geriatric care is growing (Rothgang et al., 2020). It was found that most people are cared for from within their homes, either by family members or ambulatory care takers, representing a share of 80% of total care provision in 2019 (Destatis, 2021).

This overall development has the consequence that an imbalance in demand and supply of care services has arisen in Germany (Rothgang et al., 2020). The resulting shortage in health professionals entails the risk of resulting in lower quality of services and lower patient safety (PwC, 2018; Robert Koch-Institut, 2015).

Urbanization further contributes to this challenge, as the population shift towards urban areas also affects healthcare. It has been observed that the shortage of health professionals is even more pronounced in rural areas, which results in barriers to accessibility to healthcare in remote regions (PwC, 2018; Robert Koch-Institut, 2015).

The trend towards individualization in society additionally impacts healthcare. German citizens value personalized care, which is reflected in expectations of receiving individualized treatment and wanting health professionals to take more time for patient care (PwC, 2018). These increased demands present further challenges to the already overburdened healthcare system in its current structure.

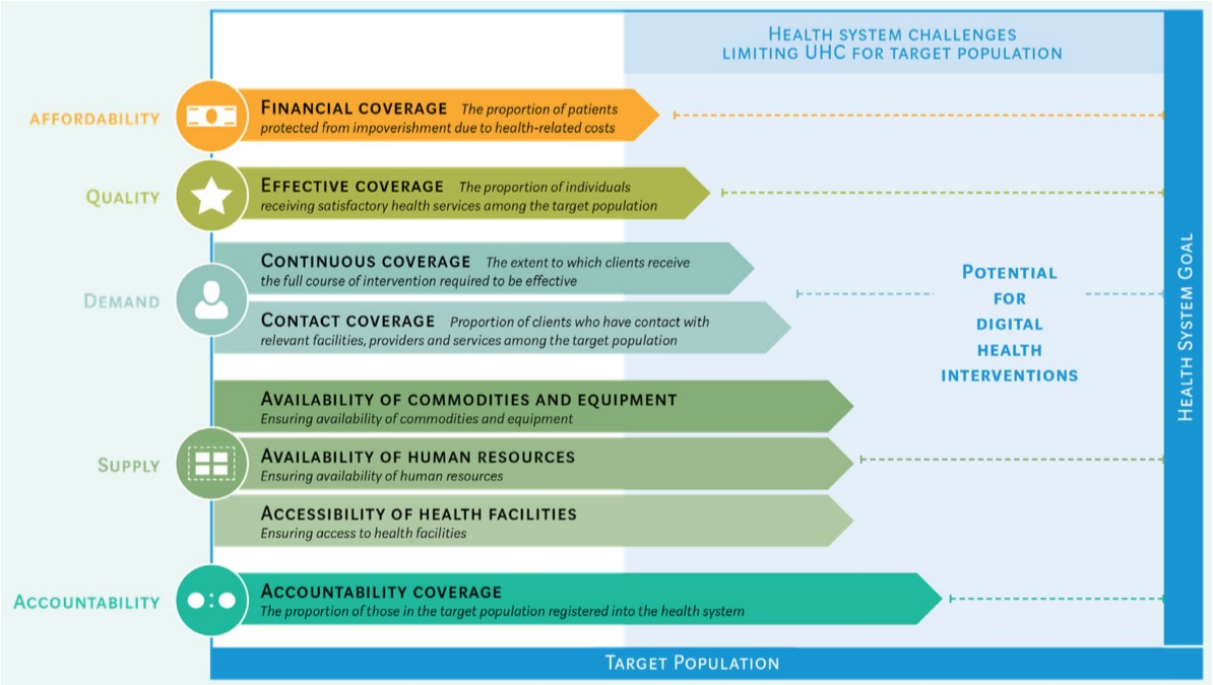
Lastly, digitalization presents a large challenge to healthcare provision in Germany. Digitalization is changing several aspects of life, as society is becoming more connected and moving towards an information-intensive, digital society (Ahmed et al., 2015; Möller & Popa, 2019). This development also requires health care to adjust as a means to be able to provide sustainable supply structures and business models (Möller & Popa, 2019).

2.1.2 The Potential of Digital Health Interventions

It is to be noted that digitalization does not only present a challenge to be faced, it also offers the opportunity to overcome several of the previously mentioned hurdles and revolutionize healthcare (BMWI, 2021). The World Health Organization (WHO; 2019) has provided an overview of the areas in which digital health interventions can support achieving the ultimate goal of universal health coverage (UHC), which is illustrated in Figure 1. It highlights the opportunities to enhance affordability, quality, supply as well as accessibility of health services, which all relate to the challenges faced by German healthcare.

Figure 1

Potential to overcome health system challenges with digital health interventions (WHO, 2019)



The potential of digitalized healthcare has gained significant attention in Germany, as Dr. Baas, CEO of a major German statutory health insurance, stresses in an interview (Postelnicu, 2020). The market for digital innovations in the healthcare sector is growing rapidly (Möller & Popa, 2019; Zeeb et al., 2020). Additionally, first regulatory steps towards creating facilitating conditions to support a digital transformation are being made (PwC, 2018). The digital healthcare act (DVC), passed in 2019 and meant to improve healthcare provision through digitalization and innovation is just one example. It includes regulations concerning the subsidization of healthcare apps, investments in innovation funds, introduction of electronic patient records, relaxations of regulation for remote treatment, support of health services research and the introduction of binding IT security standards (German Federal Ministry of Health, 2019).

However, reflections show that those steps are not yet enough to efficiently face future challenges of healthcare, considering the slow progress in the uptake of digital healthcare solutions (BMWI, 2021; PwC, 2018). It suggests that focusing exclusively on regulatory facilitations is not sufficient to assist this progress, and supports the notion that a user-focused approach concerned with understanding

possible usage motives and barriers is an important complementary means to aid prevalence of new solutions like RHM.

2.2 Introduction to Smart Healthcare

Smart healthcare is a movement within the shift towards digitalized healthcare, where advanced technologies and IoT are utilized to ensure personalized, high quality healthcare with a focus on prevention, well-being and quality of life (Allen, 2021; Burrows et al., 2018). It consists of several innovations, with remote health monitoring as a service presenting a central element (Philip et al., 2021). The following will therefore provide more detailed descriptions of RHM and related technologies.

2.2.1 Internet of Things and Smart Technologies

Principally, smart systems can be characterized as a collection of objects that form a network of information exchange (Romero et al., 2020). The Internet of Things (IoT), also referred to as sensor networks or ubiquitous computing, is the main concept enabling smart technologies (Ahmed et al., 2015; Hsu & Lin, 2016). It relies on the interconnection of items that are used for sensing, processing and storing information over the internet, and communicating it to either human users or other devices in or outside of the network (Balta-Ozkan et al., 2014; Papa et al., 2020). In that manner IoT creates a continuous source of big data that allows the development and application of predictive models, which in turn can be used to support informed decision-making based on the available data (Ahmed et al., 2015; Woodside & Sood, 2017).

Overall, smart systems based on IoT are fundamentally aimed at serving users by offering the opportunity to increase efficiency and convenience of daily life (Hsu & Lin, 2016; Romero et al., 2020). The possible application field of IoT driven smart systems is highly multifaceted and ranges among others from industry, city management, environmental matters to entertainment and fitness and includes a wide range of different devices (Cannizzaro et al., 2020). However, recently the healthcare industry has become a new emerging field of interest for the utilization of IoT, presenting promising application opportunities that can assist in revolutionizing conventional healthcare provision (Burrows et al., 2018; Taiwo & Ezugwu, 2020).

2.2.2 Smart Medical Devices

IoT based smart devices for medical purposes play a key role in the aforementioned promising application opportunities. So called smart medical devices are specifically designed to perform automatic measurement, processing and communication of health-related parameters, which is also referred to as medical IoT (Ahmed et al., 2015; Linkous et al., 2019; Philip et al., 2021). Based on the available data, predictive models and analytics allow the generation of meaningful insights into the current health status of an individual (Allen, 2021).

Smart medical devices used for sensing can be either wearable or mountable. Wearable technologies, referred to as smart wearable health devices (SWH), can sense parameters such as heart rate, blood oxygen, blood glucose, body temperature or sleeping patterns (Linkous et al., 2019; Pantelopoulos & Bourbakis, 2010). Mountable devices on the other hand are integrated in an in-home environment and complement biomedical data of SWHs with behavioral information, such as movement within the home (Nagapuri et al., 2019).

2.2.3 Remote Health Monitoring

In existing academic literature the concept of remote health monitoring (RHM) also surfaces under comparable terms, such as in-home health monitoring (Philip et al., 2021) or remote patient monitoring (Giger et al., 2015; Taiwo & Ezugwu, 2020) or as a partial element of broader concepts such as ambient assisted living (AAL; Jaschinski, 2014; Schomakers & Ziefle, 2019) and home telehealth services (Cimpeman et al., 2013), with slight variation in the used definitions. For clarification the following presents a definition formulated within the telehealth taxonomy by the American Telemedicine Association (2020), which will be used for the purpose of this research. It characterizes RHM as follows:

> *"The collection, transmission, evaluation, and communication of individual health data from a patient to their healthcare provider or extended care team from outside a hospital or clinical office (i.e., the patient's home) using personal health technologies including wireless devices, wearable sensors, implanted health monitors, smartphones, and mobile apps. Remote patient monitoring supports ongoing condition monitoring and chronic disease management and can be synchronous or asynchronous, depending upon the patient's needs. The application of emerging technologies, including artificial intelligence (AI) and machine learning, can enable better disease surveillance and early detection, allow for improved diagnosis, and support personalized medicine."*

Accordingly, RHM can be categorized as a digital health innovation within the highest level of interaction with consumers based on a framework introduced by the English National Institute for Health and Care Excellence (NICE) (Zeeb et al., 2020).

As the given definition already indicates, RHM systems' ability to allow continuous and mostly unobtrusive monitoring of a person's health status from within their home can provide several benefits to the involved stakeholders of healthcare, including patients, caregivers, healthcare professionals and health institutions (Nagapuri et al., 2019; Philip et al., 2021). Within its focus on personalized and preventive care, RHM can reduce avoidable hospitalizations, reduce strains on caretakers and lower health-related costs (Lymberis, 2003; Philip et al., 2021). Furthermore, it offers opportunities for self-monitoring, enhancing health consciousness and providing accessible care (Schomakers & Ziefle, 2019; Walker et al., 2019). Foremost, RHM can enable independent living and autonomy to elderly people or those with chronical conditions that require constant monitoring and can conveniently foster a healthy lifestyle (Allen, 2021; Giger et al., 2015). Hence, these vulnerable groups also present the main target population for RHM systems (Huang, 2010; Katsivelis et al., 2017). Resultingly, the presented focal points stress the aptitude of RHM to address challenges associated with an aging population.

However, it appears that although RHM is aimed to be unobtrusive and present an alleviation for users, it can also be perceived as being a means for patronization and insinuating fragility (Jaschinski & Ben Allouch, 2015). This implies that users' general comprehension and awareness of the system's purpose and functioning, which is necessary for consent to install RHM, is likely to be affected by emotional aspects (Volkamer & Renaud, 2013). Thus, it is essential to understand how potential users' perceptions towards acceptance are formed.

2.3 Review of Potential Influences on Perceptions

To gain a first understanding of what aspects are potentially of significance concerning perceptions related to use of RHM and establish a foundation for structure and analysis of the interviews, related research has been reviewed. The following will present insights ranging from general technology acceptance, health behavior and context-related studies.

2.3.1 Technology Acceptance Perspective

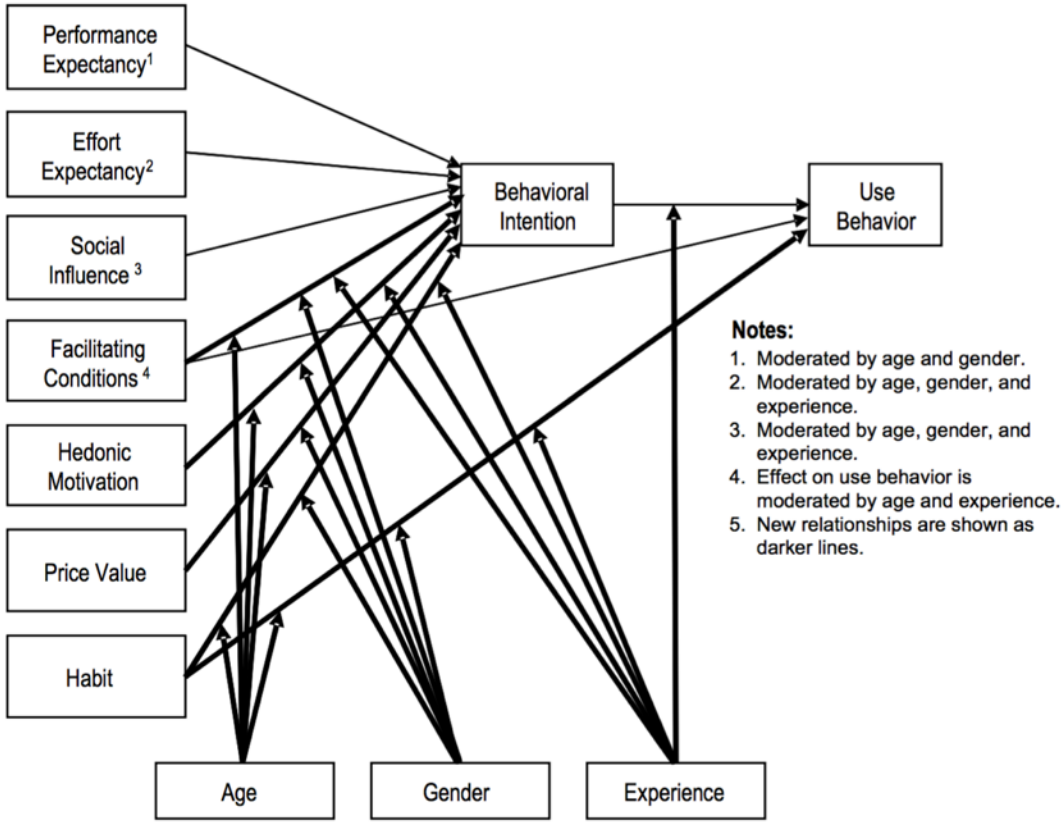
In relying on IoT-based smart devices, remote health monitoring services are categorically technological solutions. As acceptance of technologies presents a well-researched field, a number of different theories have been developed throughout the years with the aim to illustrate users' perceptions in relation to acceptance of technological products or services (Jaschinski, 2014).

In this context, the unified theory of acceptance and use of technology (UTAUT) was developed by Venkatesh et al. (2003) to merge the variety of existing theories. In doing so, insights from eight different established models were considered, including the Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), and Technology Acceptance Model (TAM) (Venkatesh et al., 2003). As UTAUT was primarily developed for organizational contexts, the model was refined by Venkatesh et al. (2012) and progressed to UTAUT2 to extend its generalizability by adapting it to a consumer use context. This perspective of UTAUT2 aligns with RHM as consumer centered service and thus makes it appropriate as reference for exploring relevant influences on perceptions.

UTAUT2 defines behavioral intention (BI) as the main antecedent to actual use behavior, which is congruent with other central theories (Venkatesh et al., 2003). This established causal relationship between BI to use a technology and actual behavior is an important aspect when studying perceptions of RHM, as it enables drawing insights about acceptance and adoption derived from the expressed attitudes of participants in the hypothetical setting of interviews (Huang, 2010).
As illustrated in Figure 2, UTAUT2 defines seven constructs as determinants of BI. Stemming from the original UTAUT model, those include performance expectancy, effort expectancy, social influence and facilitating conditions, as well as hedonic motivation, price value, and habit, which were added in UTAUT2 in course of the adaptation to a consumer use context (Venkatesh et al., 2003, 2012). Age, gender, and experience are illustrated as moderators of BI, while experience is additionally proposed to moderate the relation between BI and actual use behavior in UTAUT2 (Venkatesh et al., 2012). Facilitating conditions and habit are further defined as supplementary influences on use behavior next to BI.

Figure 2

UTAUT2 model by Venkatesh et al. (2012)



UTAUT(2) is a highly influential theory that has been widely tested and validated in the broader field of technology acceptance. More recently, it has also been applied to the field of smart systems and health technologies (Cimpeman et al., 2013). Findings have demonstrated that existing models can be partly applicable when exploring the acceptance of health information technology (Halbach et al., 2018). Therefore, insights derived from UTAUT2 will be used in building a theoretical foundation for this research's context, to explore which aspects are of relevance regarding perceptions in relation to use of RHM services.

However, UTAUT2 has also limitations that need to be considered. The model was found to generate inconsistent results and cannot be used statically, but requires adaption or omission of factors for different contexts (Tamilmani et al., 2021). Consequently, other perspectives that can give insight into possible necessary adaptations are reviewed as well in the following.

2.3.2 Health Behavior Perspective

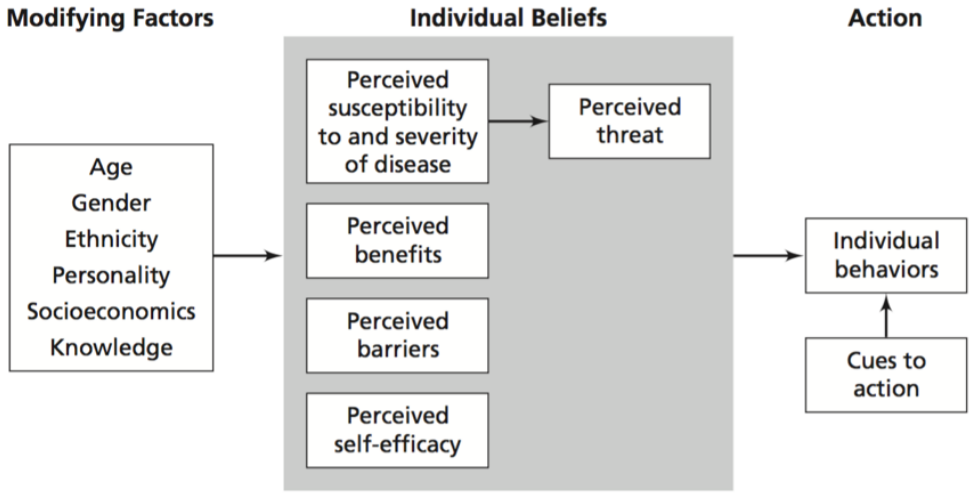
Use of RHM services does not only require acceptance of the technology itself, but also implies the willingness to move towards a more health-conscious behavior. Thus, the health belief model (HBM; see Figure 3), which is determined to predict health-related behavior, is considered as well as a reference for exploring relevant influences for RHM perceptions.

HBM is aimed at understanding why people are willing to take action related to health improvement or prevention (Champion & Skinner, 2008; Cheung et al., 2019). The model defines individual belief constructs that are considered to influence behavior, namely perceived susceptibility and perceived severity of disease, which are consolidated under the construct of perceived threat, perceived

benefits, perceived barriers, and perceived self-efficacy (Champion & Skinner, 2008). These individual beliefs are affected by modifying factors of age, gender, ethnicity, personality, socioeconomics, and knowledge. Next to individual health beliefs, cues to action are also described to influence health-related behavior. Cues can be either internal, such as noticed deterioration of one's condition, or external, such as technological reminders or personal invitations to pursue a certain behavior (Huang, 2010).

Figure 3

Health belief model (Champion & Skinner, 2008)



The framework is widely established in health behavior research, especially in studying health-related interventions and behaviors (Champion & Skinner, 2008). Previous research has demonstrated that it can be effective to include concepts of HBM when studying user acceptance of health-related technologies (Cheung et al., 2019). In certain respects it has common ground to technology acceptance models like UTAUT2. For one, it includes similar moderating factors, such as age, gender and knowledge, which can be related to experience. Further, HBM includes social influences in considering external cues to action, as well as hedonic motivation, which can be related to internal cues to action. Additionally, both models incorporate constructs related to benefits associated with a technology or intervention (Huang, 2010). HBM also complements the technology acceptance view by adding new factors that are specifically related to health behavior, by illustrating that perceived health risk and health consciousness are important factors that influence an individuals' decision to engage in preventive health-related behavior, such as using RHM services (Ahadzadeh et al., 2015).

These complementary effects demonstrate why notions of HBM are considered as well in this research's aim of exploring acceptance of remote health monitoring, as such factors can add value and lead to a more nuanced and complete understanding of users' behavioral intentions.

2.3.3 Context-Specific Perspective

Utilization of IoT-based technologies in the context of healthcare requires the handling of particularly sensitive health-related data, which adds new dimensions to the already existing complexity of technology acceptance and requires a reassessment of the prevailing knowledge in this new field (Balta-Ozkan et al., 2014). For this reason, research in related areas, such as AAL, smart health

homes, home telemedicine services and smart wearables has been reviewed, since findings from these areas may provide more profound insights into possible aspects that influence perceptions towards acceptance of RHM services.

Results from previous studies indicate generally positive user perceptions of health-related sensor technologies, with recognition of their potential for supporting health management and aging in place (Ghorayeb et al., 2021; Papa et al., 2020). Further, it is suggested that the global Covid-19 pandemic has had a positive influence on people's willingness to make use of health monitoring services and share personal data to manage their well-being actively (Allen, 2021; Koonin et al., 2020). However, it was found that consumer attitudes are contradictory, as expressed attitudes towards future use intentions of smart homes are high, while trust in the technologies appears to be rather low (Cannizzaro et al., 2020). This finding suggests trust as a new factor that is not included in the previously illustrated theoretical models, which seems to play a significant role in the observed slow adoption of smart health technologies like RHM.

Hence, trust presents a prominent theme in related research on IoT technologies and appears to be a highly complex construct. It is described as mainly relating to perceptions about technology and service provision, in which perceptions of reliability, security and privacy have found to contribute to shaping trust (Adebesin & Mwalugha, 2020). It is suggested that trust in competence and benevolence of service providers may influence reliability perceptions (Cannizzaro et al., 2020). Security perceptions are described as relating to users' concerns regarding risks of leakage or misuse of personal data, presenting a possible barrier for acceptance (Katsivelis et al., 2017). Concerning privacy, a possible trade-off has been observed, whereas a loss in privacy due to health monitoring may be accepted in exchange for greater autonomy and safety (Jaschinski, 2014; Townsend et al., 2011). Further, privacy was identified to be affected by users' levels of control and perceptions of intrusiveness of sensors (Doyle et al., 2015; Ghorayeb et al., 2021). This illustration of the variety of components that were found to possibly contribute to trust demonstrates the importance of taking it into consideration in exploring users' perceptions towards adoption of RHM.

Further, the review of context-related research suggest that social influences as introduced by UTAUT and HBM might be extended in their effects within the context of smart health technologies. In addition to the influence of social surroundings, such as reference groups, on individual opinions and decision making processes, it was also found that perceptions about the influence of technologies on social relations, such as concerns about replacement of personal care, can affect use intentions (Ghorayeb et al., 2021; Walker et al., 2019).

Moreover, a number of user diversity factors appear repeatedly in research focusing on user acceptance of smart technologies, which concur with those introduced in the examined theoretical models. For one, age presents a prevalent factor that occurs in both theoretical models as well as context-related studies. However, studies demonstrate varying results concerning the impact of age on different user perceptions and prioritizations of regarded factors (Halbach et al., 2018; Lee & Rho, 2013). Additionally, experience is suggested to either concern experience and familiarity with a technology (Giger et al., 2015; Lee & Rho, 2013), or caregiving experience (Halbach et al., 2018) and is proposed to have a generally positive effect on user's acceptance of smart (health) technologies (Walker et al., 2019). Lastly, results imply that health perceptions have a strong influence on acceptance of health technologies (Doyle et al., 2015; Ghorayeb et al., 2021), but presents an aspect that has been considered less frequently in previous research.

This review of contextual research demonstrates that modelling technology acceptance in new contexts, such as the Internet of Things and healthcare, requires adaption of existing knowledge, which underscores the need to understand underlying perceptions when studying acceptance of RHM.

2.3.4 Overview and Research Question

The insights presented earlier point towards the complexities underlying the actual adoption of RHM technologies, indicating the importance of various factors that are considered in shaping users' attitudes. Table 1 provides a consolidated overview of the factors that will be considered as reference for exploring the acceptance by German users of RHM in order to answer the main research question of this study:

> *"What are older adults' perceptions concerning the use of remote health monitoring?"*

In addition, the analysis has prompted user diversity factors to be explored in their effects on perceptions.

Table 1

Overview and definition of possible factors retrieved from literature review

Construct	Definition
Perceived benefits	relates to perceived usefulness, such as outcome expectations: degree to which the technology will help in attaining gains (Venkatesh et al., 2003)
Perceived ease of use	relates to perceived ease or complexity of use of a technology and one's belief of being capable of using it (Venkatesh et al., 2003)
Social Influences	relates to value and consideration of opinions from reference groups (Venkatesh et al., 2003) and perceived effects of the technology on social relations (Ghorayeb et al., 2021)
Facilitating conditions	relates to the available infrastructure and support to use a technology (Venkatesh et al., 2003)
Hedonic motivation	relates to perceived enjoyment or pleasure derived from using a technology (Venkatesh et al., 2012)
Perceived costs	related to price value: balancing of perceived benefits and monetary cost (Venkatesh et al., 2012)
Perceived health status	relates to perceived threat opposed by health status, which can include susceptibility and severity of a disease (Champion & Skinner, 2008)
Trust	relates to trust in the provision of the service and includes perceptions of service providers, possible violations of one's privacy, and security of personal data (Adebesin & Mwalugha, 2020)

The next chapter will illustrate the methods of how these research questions have been approached.

3 Methods

This chapter will discuss the chosen approach for this research. First the study design and sampling procedure will be introduced, followed by an overview of the sample, the data collection procedure and the analysis of the data.

3.1 Study Design

To achieve the goal of this study of gaining better understandings of user perceptions related to RHM systems and acceptance, a qualitative study design using semi-structured, individual interviews was chosen based on a number of factors.

Semi-structured interviews (SSI) are proven as an effective means for qualitative research, especially when it is of interest to learn more about thoughts and opinions of individuals (Babbie, 2016). RHM systems present a very personal topic, as it is related to one's personal health by collecting and sharing health data and enters one's privacy, as sensors are placed in personal home environments. Consequently, it is essential to gain deeper insights into individual perceptions.

Furthermore, SSI's give the opportunity to provide an introduction of RHM that clarifies the structure and functioning of the solution on an individual level to ensure that participants have a sufficient understanding of the concept in order to discuss their perceptions effectively. This is necessary as participants are most likely unaware of RHM, due to its low diffusion, and knowledge may vary between participants. Additionally, RHM presents a rather complex technical service that requires clear distinction from other, related technologies, and especially the older target population may lack a general comprehension of information technology (Cimpeman et al., 2013).

Moreover, SSI's allow the use of insights gained from scientific literature as a guideline to create a general set of topics to be discussed, while the open and dynamic nature offers the opportunity to dive deeper into specific topics by probing and possibly generate insights into topics that might not have been anticipated in advance (Adams, 2015).

In total, a number of 21 interviews were conducted with an average duration of 37 minutes (SD = 14), whereby the first interview was used as a pre-test to verify the intended procedure and materials and was therefore not included for analysis.

3.2 Sampling

As this study aims to gain a user-centered perspective, subjects were selected based on relevance to the topic under study. The sample was set out to cover possible modifying factors of age, gender and experience, which are suggested by previous literature and models. Hence, participants recruited for interviews were sought to cover a wider age range, including both men and women, with no requirements of certain levels of technology experience with other IoT technologies.

Participants aged 55 years and older were included to cover both the main target group of interest, which are elderly people who represent the biggest direct consumer population of RHM (Ghorayeb et al., 2021), and people of a younger generation personifying a potential future user population.

To serve these previously mentioned requirements and achieve a fairly equal distribution within them, participants were recruited via convenience sampling. Participants were contacted directly based on the authors' social contacts and via snowball sampling methods. Additionally, participants were recruited by means of a short presentation in a local social club (Rotary Club). It was clarified

that participation is on a voluntary basis and withdrawal was possible at any time. Data saturation was used to define the sample size.

3.3 Participants

Recruitment resulted in a total of 20 participants within the sample for analysis, ranging between 57 and 89 years of age. The average age represented in the sample was 68 years and it included an equal amount of men and women. All respondents were living in their own homes at the time of data collection, so the population does not include individuals in palliative care or residential homes. The majority of participants lived with family members and partners and in an urban area. Further, the sample exhibited an overall relatively high level of educational. An overview of the described general demographic factors of all participants is presented in Table 2.

Within the sample, half of the participants reported to have a chronic medical condition, which mainly concerned high blood pressure, and showed higher frequencies with older age. Participants predominantly indicated to perceive their health status as being good, while evaluations appeared to be slightly more positive with younger age and self-perceptions of health were partly also good despite having a chronic condition. Self-perceptions of affinity towards technologies was also rated to be relatively high among participants. All subjects indicated to use some type of smart devices, mostly smart phones, whereas a higher use was presented among younger participants, indicating a generally high familiarity with technologies of the sample. The described context-specific information about participants is displayed in Table 3.

Table 2

Demographic profile of respondents

Measure	Item	Frequency	Percent
Gender	Male	10	*50*
	Female	10	*50*
Educational Level	High school graduation	3	*15*
	Study without degree	1	*5*
	Bachelor's Degree	6	*30*
	Graduate Degree	10	*50*
Living Situation	With partner or family members	17	*85*
	Alone	3	*15*
Living Area	Urban	19	*95*
	Rural	1	*5*

Note. Items that have a frequency of 0 are not displayed in the overview.

Table 3

Further personal characteristics of respondents

Measure	Item	Frequency	Percent
Perceived health status	Very good	8	*40*
	Good	8	*40*
	Satisfactory	4	*20*
Chronic medical condition	Yes	10	*50*
	No	10	*50*
Perceived technological affinity	Very strong	4	*20*
	Strong	9	*45*
	Moderate	7	*35*
Use of smart devices	Smart phone	20	*100*
	Smart watch	6	*30*
	Smart assistant	4	*20*
	Smart home	2	*10*

Note. "Perceived health status" and "Perceived technology affinity" were measured on a 5-point Liker-scale. Items that have a frequency of 0 are not displayed in the overview.

3.4 Materials

The execution of the interviews included preparation and integration of some additional materials. For one, supporting materials were included for illustration and explanation purposes of RHM, as reviewed literature suggests that awareness about the technology is likely to be generally low and it can be beneficial to incorporate practical steps especially for elderly people for inclusion aspects (Ghorayeb et al., 2021). Therefore, a fact-sheet was created, presenting a simplified overview of the technical functionality of RHM including an illustration of processes and short explanations (Appendix F). Additionally, example devices of an RHM system (MySense.ai) were organized to be used as a presentation of how hardware may look like, which are shown in Figure 4. It should be noted, that this study was not linked to MySense.ai and participants were made aware that the devices were intended only as exemplary demonstration devices.

Figure 4

RHM example devices (left: gateway device; right: sensor devices)

Furthermore, a topic guide was created based on insights from previous literature, stating topics that may be of interest, to be used as guidance for the moderator during the interviews (Appendix D).

Supporting materials that were prepared for the interviews were verified with a pre-test interview to confirm comprehensibility of documents provided to participants and usability of materials used for structuring the interview course.

3.5 Procedure

Participants who expressed interest in taking part in the study, were provided with an information sheet regarding the study (Appendix A) and the informed consent form (Appendix B) to familiarize themselves with participation terms in advance.

The interview was started with an introduction, in which participants were welcomed and a brief explanation of the purpose and context of the study was given. Participants were given the chance to ask any remaining questions regarding participation. After being informed about the general approach and the recording of the interview, participants were asked to sign the informed consent form to proceed with the study.

In a first step, a short questionnaire about demographics and other relevant data, such as health conditions, was given to the individuals to fill in (Appendix E). RHM systems were then explained to the participants based on their purpose and operation to ensure that participants had a common understanding of the subject matter, using the demonstration materials mentioned in the previous section. Prepared notes from the factsheet were used to ensure that the scope of explanations was kept constant between interviews. At the same time, explanations were adjusted to the knowledge levels of participants where necessary to ensure comprehensibility, for example by using less technical words (e.g.: “technological solution to support healthcare at home” vs. “IoT-based remote care solution”). Participants were made aware that this part was only aimed at providing a general understanding of RHM systems and opinions will be asked for in the following. Any remaining questions concerning the technology were answered before continuing with the interview. If reactions were nonetheless already expressed during the introduction, those were prevented and noted to be returned back to during the recorded interview.

In the next step, the audio recording was started and the conversation about the topic was initiated, covering themes such as opinions about RHM, benefits and drawbacks, intention to use, or experience with similar technologies. After the discussion opened, the conversation was guided by using the topic guide. When topics that appear frequently in literature were not directly considered by participants in the course of the conversation, a discussion about such topics was provoked by the moderator. In case participants had further questions regarding technological functions during the interviews or appeared to have misconceptions, those were shortly clarified to obtain relevant statements. It is to be noted that within the setting of the interview statements were based on forecasting, as participants had no prior experiences with use of RHM.

The protocol used for the structure of the interviews as described above can be found in Appendix C. To preserve consistent circumstances between interviews the interviewer was kept constant and interviews were held in participants’ native language (German). The study has been approved by Ethics Committee of the University of Twente prior to participant recruitment and data collection.

3.6 Analysis

After data collection, the audio recordings of the interviews were transcribed verbatim with use of a speech to text software (Amberscript). The automatically generated transcripts were subsequently reviewed manually to detect and edit mistakes and remove possible identifying information, such as names.

The reviewed transcripts were analyzed by using a qualitative data analysis software (Atlas.ti) for the coding process. Analysis followed an iterative approach, using open and axial coding principles as described in Boeije (2010), considering only relevant and meaningful fragments for research.

First, open coding was used to analyze a set of five interview transcripts. The interviews were read thoroughly, highlighting relevant text fragments and assigning codes that were close to intent and meaning of the statement by often using words used in the segment. This process resulted in a first base of codes, which were in a next step reviewed to rename and merge similar codes and retrieve common themes. Categories based on insights from previous literature were used to structure related codes into groups. Next, a group of three more interviews was analyzed following the same process, using either existing codes from the previous steps where possible or creating new codes. This process was repeated until all interviews were coded.

After the initial coding, the interviews were re-examined in a second iteration to ensure each fragment was assigned to the most appropriate code. Subsequently, the codes and assigned fragments were assessed again following the principle of axial coding to merge and rename related codes as well as adjust categories based on emerging insights. In this step, broader labels were also added to organize categories that showed relations to broader groups, creating a hierarchy for analysis.

After first feedback from possible second coders on the codebook, a third iteration was used to further compress the number of codes by merging codes that were perceived to be contextually similar, resulting in the final codebook (Appendix H) with 89 codes.

To ensure reliability of the analysis, a second independent coder was asked to code an excerpt of the data. For that purpose, two interviews (interviews 9 and 11) were selected by random principle for analysis. The second coder was provided with the codebook and complete transcripts of the interviews to provide context, while text fragments to be coded were highlighted in color. Fragments that were to be assigned with two codes were marked accordingly and counted separately for each code for reliability analysis. Results of the coding were analyzed using Cohen's Kappa as a measure to verify intercoder reliability and resulted in a Kappa of .8 (see Table 4), which presents a substantial strength of agreement according to interpretation by Landis and Koch (1977) and suggests validity of the analysis. Differences in coding by second and first coder were discussed and addressed, which however did not result in necessary adjustments of the final codebook. The results of the reliability analysis can be found in Appendix G.

Table 4

Intercoder relationship with Cohen's Kappa

	Value
Measure of Agreement: Kappa	.8
N of valid cases	92

4 Results

This chapter will present and discuss the results of the analysis of the interviews. It is sectioned using groups of categories and ordered according to relationships between categories and associated codes. Selected quotes are used to support the findings.

4.1 General Attitude

This first section will review participants' general reactions towards RHM. Related statements were mostly expressed at the beginning of the interview presenting a first impression or at the end of the interview summarizing the participants general impression. The corresponding codes for this category and their frequencies are shown in Table 5.

Table 5

Codes in category "general attitude"

Code	Number of quotes	Number of interviews
Open for usage at later stage	21	14
General positive and openminded	12	11
RHM has future and demand	8	6
Open for further technologies	6	5
Current generation not ready	2	2
Open for usage at current stage	2	2

Overall, participants' general impression of RHM appeared to be mostly positive, showing many affirmative reactions. Related statements were often supported by personal reasonings, like seeing a benefit for oneself. A number of participants also highlighted the general need for RHM in relation to current demographic changes and challenges faced by the health care system, as shown by the following exemplary quote:

> *[1] "It's simply, we are getting older and older, a lot of people are getting old. I think that (RHM) is a part of it. That's a development, it is going to come, because you can't take care of everyone properly otherwise." (Participant 4, female, 58)*

However, although the general attitude towards RHM appeared to be rather positive, the majority of participants stated that they would want to use RHM only at a later stage in life. It indicates that participants see the general benefit of RHM, but do not see the personal need for it in their current situations, which appeared to be mainly dependent on two factors. For one, willingness to use RHM was tied to one's living situation, highlighting that one would be open to use RHM if living alone, as the following statement demonstrates:

> *[2] "So if I were alone or living alone, I would certainly use these things, because I think they are useful and a person living alone can't help themselves otherwise." (Participant 2, male, 85)*

The other most common reason to only use RHM at a later point was one's health condition. Participants stated to be open to use RHM, if their health condition was worse and there was reason to believe that monitoring would be relevant. An example is illustrated below:

[3] "If I see the need, I would use it. If I were in an unstable state of health, I would personally use it." (Participant 8, male, 75)

It is notable that only two participants stated to be willing to use RHM in their current situation. Those expressed recognition that at a certain age health risks are more prevalent and it is important to act with foresight considering one's own health, as shown by the following quote:

[4] "Yes, although from a certain age these changes can come very quickly. That's why I think I would use it already in my current situation. Because things happen unexpectedly. When you are over 70 it happens more likely than when you are 30/40. So, I would already want to use it now. If I were to decide to do so, then it needs to be timely." (Participant 16, female, 73)

The fact that only two participants expressed this statement demonstrates an interesting discrepancy between the overall positive attitude and willingness to use RHM, especially considering that mainly elderly people were included in this study. It suggests that there are more factors that play into the decision to use RHM and that the attitude towards use is a complex construct. It could also explain why the dissemination of RHM is still generally low in Germany, as not many people might be ready to use it.

4.2 Main Influential Values

This section will therefore introduce the main values that were found to drive participants' perceptions of RHM in more detail.

4.2.2 Utility Values

As already indicated by findings from the previous section, the general attitude is related to utility values one sees in RHM, considering that perceived benefits were often also directly mentioned in the beginning of interviews as justification for participants' general impression. It appeared that there are clear benefits to RHM that are easily identifiable, as every participant mentioned several benefits and there were clear repetitions of aspects. Table 6 provides an overview of corresponding codes and their frequencies.

Table 6

Codes in category "perceived benefits"

Code	Number of quotes	Number of interviews
Providing safety and reassurance	28	13
Help in emergency situations (automatic warning)	21	12
Better health awareness and self-control	20	13
Unburdening and support for medical personnel	20	12
Prophylactic function	18	9
Relief and unburdening of relatives	15	11
Prolongation of independence	11	5
Automated systems with little self-effort	10	7
Stimuli for behavioral improvement	10	7
Possible communication medium	6	6
Reduce doctor visits	5	3

Generally, as can also be derived from the codes displayed in the table, benefits perceived by participants can be categorized into two different underlying motivations, namely safety and health related aspects and socially driven aspects.

Safety and health

It was clearly recognized that RHM can provide a feeling of safety and comfort, which respectively presented the most commonly named aspect. Participants mentioned the safeguarding facet of RHM to detect critical situations, often highlighting that automatic functions for triggering alarms were seen as an additional safety feature, given that people are often not able to help themselves in case of emergencies. This point was highlighted slightly more frequently by higher aged participants within the sample, which may be explained due to the fact that incidents like falls are more likely with older age. The value of reassurance brought by RHM is illustrated in the following exemplary reaction:

> *[5] "Secondly, there is a security that if I can no longer help myself, someone will be notified without me having to do it myself." (Participant 2, male, 85)*

Another value that was recognized related to the automated function of RHM was that the system requires little user-effort to function. It was for one seen as a way to simplify taking care of one's health through use of RHM and seen as a positive that the low level of interaction required would make the monitoring less noticeable. A statement highlighting this view was as follows:

> *[6] "Yes, I would also put that in the foreground. That it's simple and thus naturally constantly present and offers security without a big self-effort." (Participant 6, female, 65)*

It was also appreciated by participants that RHM in general provides the opportunity for self-monitoring one's health. The objective information provided by RHM about one's own health status was seen as an aid to develop better health awareness, often supported by statements highlighting that such awareness is often lacking. An exemplary quote is shown as follows:

> *[7] "I think it's good and I think it gives each of us the opportunity to do something for ourselves and take care of our health." (Participant 9, female, 78)*

In this context, it was often further argued that RHM could act as a stimulus to improve one's behavior towards healthier habits by providing advice for actions to be taken, while overall also expressing willingness to comply with according impulses. The following quote presents an example for this view:

> *[8] "So of course I also see advantages in the fact that one's own behavior is reflected by technology and that technology can perhaps also influence my behavior." (Participant 13, male, 69)*

Apart from the already illustrated aspect of feeling safer in acute situations, participants also expressed valuing the prophylactic function of RHM in terms of supporting health. It was seen as a precautionary measure that could support detecting health deteriorations and reducing health risk factors in a timely manner.

By providing reassurance of safety and health to oneself and to others, RHM was further positively valued as an assisting technology that could support prolonging one's independency and maintaining personal living standards, which was highlighted to be connected with comfort and privacy. An example is illustrated below:

[9]"Also, the consideration of maintaining independence for one personally as long as possible, independent of external help, that's a very big aspect for me." (Participant 11, female, 64)

Interestingly, this view was held more frequently with lower age. It is possible that this is caused by a perception bias, whereas older people misjudge their independence and need for assistance to attain it.

Social

Aside from benefits that mainly focus on supporting health, it seems that some socially related benefits are seen in RHM as well. One commonly mentioned associated aspect was the possibility to achieve peace-of-mind for family members. This statement showed a slight age trend, as it was represented more commonly by participants of younger age. A possible explanation may be that those take the perspective of a relative caring about older family members, instead of being in the situation of being monitored themselves. It was highlighted that it would be a relief knowing the concerned person was safe and healthy as a result from RHM, as shown in the following quote:

[10] "This monitoring would also be a great help for us as being caregivers for our parents." (Participant 4, female, 58)

Another aspect valued positively in this context was that RHM provides caregivers with objective information. Participants portrayed recognition of RHM as support to gain reliable insights into the health status of the person cared for. This was for one related to the perspective of caring relatives, but also seen as a benefit that could support medical personnel in their work. It was argued that additional information retrieved by constant monitoring and analysis of RHM could be helpful for doctors and care personnel, for example by assisting in decision making on treatment or prioritization, as shown by the following example:

[11] "It would make the work of many people easier. And it would be an objective representation, because I cannot influence it. […]. The doctor would have a clear, objective picture of the state of health and movements." (Participant 9, female, 78)

RHM was also recognized as a solution that could reduce people's needs for doctor visits, which was seen as beneficiary for medical personnel in terms of reducing workload, and also as a benefit for patients by reducing efforts related to doctor's visits. This perception of unburdening medical personnel showed overlap with the recognition of unburdening relatives, which indicates that there is an underlying connection between these social factors, possibly caused by a higher social orientation of thinking of others.

Another possible benefit driven by social values mentioned by participants considered the opportunity to include communication functions with RHM systems to connect people with each other. It was argued that RHM could present a way to not only monitor the physical condition of a person, but also integrate and possibly mitigate mental strains like loneliness. However, loneliness and personal contacts in context with RHM presented an important and controversial topic during interviews, which is therefore discussed in more detail in section 4.5 about social values.

Overall, the high number and recurrence of perceived benefits mentioned by participants shows that the value of RHM is generally recognized by possible users. The illustrated benefits concerning safety and health lead to the inference that RHM is recognized as a possible option to support active aging and independent living, which is further supported by social values seen in RHM. It emerged that

utility values based on perceived benefits clearly contribute to people's attitudes towards RHM. However, there appears to be a difference in rationally recognizing benefits of RHM and the perception of benefits for one personally, considering the discrepancy between overall impression and recognition of benefits to the actual expressed willingness to use RHM. This indicates that, although benefits do play a role in shaping people's opinions, other factors also have an influence on the decision of using RHM. The next sections will introduce and explain such factors that were retrieved from the interviews in more detail.

4.2.3 Reliability Values

One aspect that was found to influence personal perceptions appeared to be trust in the reliability of RHM. Reliability values that were derived from the interviews can be distinguished between system reliability and security aspects.

System reliability

Statements concerning system reliability related to thoughts about trust in the functionality of the technology and its data reliability. Most expressions of participants on this topic were related to possible aspects of concern about RHM, which can already be derived from the associated codes presented in Table 7.

Table 7

Codes in category "system reliability"

Code	Number of quotes	Number of interviews
Data recording of visitors	9	5
Reliability of data and system functionality	8	6
Risk of technological dependency	5	2
Risk of false alarms	4	2
Dependency on networks	3	3
Durability of devices	2	2

Principally, reliability of data presented a point that evoked concerns. In this context, the most commonly aspect that participants gave thought was how a RHM system handles data collection in situations where other, additional people are present in the monitoring area. An exemplary statement was as follows:

> *[12] "Those sensors are primarily configured for people who live alone. What happens, if the grandkid comes visit for the weekend? The frequencies would then be completely different. Is it then possible to turn it off or to personalize the data logging?" (Participant 6, female, 65)*

Participants expressed concerns whether such situations would impact overall reliability of data and evaluations and some also considered possible privacy concerns for others, if the monitoring was not able to only log relevant data.

Another aspect related to reliability of RHM were concerns about false alarms. Participants highlighted the importance of reliable data to avoid false alarms, as those would reduce trust in the technology and could lead to overturning acceptance, which is illustrated by the following quote:

[13] "But when I think about how many false alarms there may be and how many redundant calls relatives or nurses then would have to make, I'm not sure how well it would be accepted. Because automation necessarily includes false alarms. And that would maybe reduce the system to absurdity." (Participant 8, male, 75)

However, this aspect was only mentioned by two participants overall, which indicates that false alarms are not a widely shared concern.

A slightly more represented concern was that RHM relies on a stable internet connection. Participants partly noted that not everyone has access to stable WIFI as criticism, which could impact reliability of RHM. In relation to that participants partly also mentioned concerns of a possible risk of becoming too dependent on RHM as a technology. It was highlighted that it is important to still be able to cope without the system, because there is always a possible risk that technology might fail, as shown by this exemplary quote:

[14] "But you do have a certain dependency. Electricity and network-wise. That's why you always have to learn to also get along without it." (Participant 4, female, 58)

Generally, statements indicated that it is important to users that RHM is reliable and can be trusted. However, it must be emphasized that although the aspects of system reliability were of concern, those were not very frequently reflected statements, indicating that this presents a relatively less important aspect influencing overall perceptions.

Data Security

Reliability concerning data security was a more frequently mentioned topic. Related statements regarded perceptions of possible security risks of personal data gathered and transmitted by RHM. Table 8 provides an overview of corresponding codes and their frequencies.

Table 8

Codes in category "data security"

Code	Number of quotes	Number of interviews
Access by third parties unwanted	16	11
Trust in provider benevolence	11	7
Health data not highly sensitive	11	10
Trade-off data disclosure vs. benefits	7	5
Hacking-risk aware	6	5

One of the main opinions that were expressed considering data security concerned the importance that data will only be used for the intended purposes and access is not possible for unwanted third parties. Participants expressed concerns about negative consequences, for example that data could be used for commercial purposes. Therefore, the need for assurance that personal data handled by RHM is adequately secured was highlighted as a way to reduce uncertainty factors of security risks. An example is provided in the following quote:

[15] "And I think I would also check what security systems are in place. How secure the data is on the server or where it is." (Participant 5, female, 62)

In this context, it was indicated that certifications of credibility and security of RHM systems by third parties could contribute to increase trust in data security.

Related perceptions were often mentioned to also be dependent on trust in the provider of an RHM system and their benevolence. Participants stated that it is important to feel like a provider has the right intentions, which was described as having no commercial ulterior motives and using data only for intended health purposes. A statement highlighting this was as follows:

> *[16] "You don't know who is behind it and how it is operated. So, the question nowadays is, whether this trust is enough and to what extent one wants to trust certain people or companies." (Participant 20, male, 71)*

Concerning possible security risks there were further mainly three different perceptions represented among participants. Most commonly, health related data processed by RHM was not perceived to be highly sensitive. On the other hand, participants partly recognized possible risks of hacking. However, it was not seen as highly decisive, as this risk was perceived to be ubiquitous, which is illustrated by the statement below:

> *[17] "When you consider all the things that are hacked these days, I can imagine that nothing is really safe." (Participant 13, male, 69)*

The third apparent perception in relation to security risks concerned a trade-off principle. That is, there may be a risk seen in disclosure or breach of sensitive data, but it is weighed against considerations of the benefits of the monitoring by RHM. In a majority of cases participants tended to hold the opinion that with RHM the benefits prevail, and it is necessary to disclose data to support one's health. It may be that because of this health and safety aspect, RHM is partly seen less critically than other technologies that transmit personal data via the internet, as the quote below shows:

> *[18] "But in the case of health data it is of course very important individually considering the consequence, which is why I view this as a separate area." (Participant 8, male, 75)*

Overall, it appeared that possible security risks were not perceived as overly critical. Regulation of access emerged as the main demand, whereas there was general trust that data privacy would be given in a system such as RHM. System reliability was considered less frequently, while both aspects occurred to be partly bound to trust in service providers.

4.2.4 Comfort Values

Other than trust in reliability of the technology and its security, personal perceptions of comfort that relate to assessments of intrusiveness of RHM appeared to have an essential impact on participants attitudes. For one, this included perceptions concerning general comfort with being monitored, involving perceptions of privacy, control and level of use of RHM. On another dimension it also included aspects concerning design and integration of the technology itself. The concept of comfort as an overarching value in this relation has been adopted by (Park et al., 2018).

Privacy Perceptions

Among comfort values, personal privacy perceptions appeared to be the most frequently considered aspect by participants and related to perceptions of being monitored and RHM intruding on one's private sphere. Opinions expressed by participants were very diverse, as it can already be derived by the overview of respective codes in Table 9.

Table 9

Codes in category "privacy perceptions"

Code	Number of quotes	Number of interviews
Trade-off monitoring vs. benefits	31	14
Critical towards monitoring	24	12
Wanting to maintain privacy	15	11
Open towards monitoring	14	9
Surrendering privacy is seen as necessary	11	8
Human is nowadays transparent anyways	11	7

For one, participants represented the point of view of being open towards monitoring via RHM. This was justified by perceiving it as a conscious choice to support one's personal health, wherefore monitoring was not seen as an intrusion into privacy, but as valuable. A respective statement was as follows:

> *[19] "Yes, I am very open towards it. I mean, I know that many people are very secretive or against it. But when it comes to my health, I choose for myself, I want it that way and I won't make a secret about it." (Participant 14, female, 57)*

Further, it was also argued that it is simply necessary to surrender one's privacy at a certain point. Mostly participants holding this point of view assumed a situation where one is truly in need of RHM as a safety measure, indicating that considering monitoring as help and not intruding is also partly dependent on personal health perceptions. The quote below illustrates a related reaction:

> *[20] "No, not at all. On the contrary. It has the purpose to help me. And if I am to be helped, I must also be prepared to create the environment for it and also to accept the whole periphery and to deal with it reasonably. That is self-evident to me." (Participant 12, male, 58)*

In some cases, these opinions were also supported by another aspect, namely acknowledgement that one is already transparent nowadays, wherefore further monitoring is not seen critically anymore. Interestingly, there was no clear correlation found between participants' use of IoT-based technologies and holding this opinion.

A contrary standpoint that was represented slightly more often by participants was being rather critical of monitoring and perceiving it as an invasion of privacy. In this context, it was argued that it would give a feeling of being controlled and one would possibly be uncomfortable with others getting insights into one's behavior and health. An exemplary statement was as follows:

> *[21] "You always have in the back of your mind that you are being controlled. It's not the intention in that case, but nevertheless you somehow have, or I have it in the back of my mind, that this is a kind of control." (Participant 19, male, 59)*

Participants highlighted that RHM was regarded as touching upon an intimate sphere, as sensors are placed in one's home. It was often expressed that it was seen as important to maintain a certain level of privacy, which included personal boundaries of whom should be involved, where sensors were placed or what was measured. Especially intimate areas like bedrooms or bathrooms were frequently considered critical and somewhere that should be excluded from monitoring. Participants stated to

want to maintain their privacy for as long as possible, while on the other hand acknowledging that once the relevance is seen, this opinion might change.

As these findings already imply, it emerged that there is a trade-off considering privacy perceptions. The emotional perspective of losing privacy due to the monitoring was carefully weighed against the rational perspective of the value it bares for one's own safety and health, suggesting it was seen as a fine line between what RHM can offer and how it at the same time can constrain. Below is a statement concerning the described trade-off:

> *[22] "So it's really a weighing, is it positive for me? Does it help me? Do I perhaps need it? Then you are more open towards it." (Participant 16, female, 73)*

In relation to this trade-off rationale it seemed to be important for participants to understand the necessity or relevance of sensors and gathered data, which further stressed how one's personal circumstances like health perceptions define how the value of RHM is perceived and consequently either viewed as helpful monitoring or unwanted controlling.

Perceived Control

Another aspect that appeared to be highly influential concerning privacy perceptions and comfort values was perceived control of the technology itself and its use. Corresponding codes and their frequencies are displayed in Table 10.

Table 10

Codes in category "perceived control"

Code	Number of quotes	Number of interviews
Self-determination in use	20	9
Configurability to one's needs	18	13
Transparency of functionality	16	11
Concerns of paternalism by others	13	4
Loss of autonomy	8	7

A frequently and often repeatedly mentioned aspect reflected the general importance of self-determination in the use of RHM. That included the desire of personally having control about who is involved and given access to evaluations. Further, it also concerned what data was used and how it was transmitted. The following quote illustrates this need for control:

> *[23] "Here I agree that these things are allowed. That means I am actively involved. But if it comes to a point, where I am not actively involved anymore, meaning others manage my profile, then I would perceive it as intrusive." (Participant 20, male, 71)*

Transparency emerged as a contributing facet to perceptions of control. It appeared that having a clear overview of the functionality of RHM provides a feeling of control, which in turn reduces uncertainty factors for users and increases trust values. Further, configurability opportunities of RHM to one's personal needs presented another frequently recurring aspect. It appeared to be valued to be able to exclude areas based on personal boundaries and be able to get used to the system gradually using a modular structure of functionalities, as the following quote shows:

[24] "That's why it would be important that such a thing is freely programmable or configurable […]. So, that I would really only monitor what is actually necessary." (Participant 7, male, 60)

Using RHM was partly viewed as losing autonomy, especially when not feeling in control. Participants stressed the importance of being independent and how it can present a difficult step to give that up and accept assistance, in particular if it is personally perceived one is self-sufficient. An example in this respect is given by the expression below:

[25] "You can of course say that if you ask someone else in the family to be involved and see whether everything is ok, it is a loss of independence. You would do it, but it would only be an option, if you were no longer able to do it yourself." (Participant 8, male, 75)

In that context, some participants also expressed concerns of paternalism by involved persons. This aspect regarded not wanting to be dictated to by others, as this would mean a further loss of control.

Level of Use

The wish for control over whom to involve was further related to considerations of level of use of RHM. The choice of data recipients involved in the use of RHM was found to have a strong influence on participants' perceptions of comfort with monitoring and sharing of personal information. The different levels that were reflected on and the corresponding codes are presented in Table 11.

Table 11

Codes in category "level of use"

Code	Number of quotes	Number of interviews
Involvement of doctors	21	14
Involvement of care personnel	19	15
Involvement of relatives	18	14
Connection to health insurance critical	15	9
Provision for research	5	4
Connection to health insurance possible	3	3

The majority of participants stated to be comfortable with involving doctors as well as care personnel in personal use of RHM. It was argued that medical personnel were seen as trusted data recipients due to the respective competence to interpret data appropriately and utilize it for treatment. Expressed openness to include medical personnel was supported by the perceived benefit that RHM presents opportunities to unburden professionals. On the contrary, more critical views were driven by concerns that automatic transmissions of data could lead to an information overload for medical personnel.

An equivalently prominent view represented was openness towards involvement of family members or other close people. The main underlying reason was that those are trusted and further should be included in personal health matters, as indicated by the following quote:

[26] "So I think, if one has a close family, this should also be a topic that includes the whole family" (Participant 6, female, 65)

However, there were also some risks recognized concerning involvement of family members that were based on underlying social values, such as concerns of involvement presenting a burden or others becoming overly involved due to personal factors. The example below presents a related consideration:

> *[27] "I would be very comfortable, if medical personnel observed it, because they are more competent. Privately, if I gave it to my daughter, she should worry right away and doesn't know what to do at first, she has to get medical help anyways." (Participant 2, male, 85)*

Few participants also mentioned willingness to provide their monitoring data for research, motivated by the opportunity to contribute to research developments and help others. Again, an underlying reason for this openness was indicated to be trust into chosen research institutions, as indicated by the following quote:

> *[28] "I would also say that I would be open for my data to be evaluated in a study by certain institutes or universities. For that I would be willing to make my data available." (Participant 20, male, 71)*

On the contrary, the majority of participants perceived a further integration of RHM into the health care system, for example by including health insurances, as questionable. It appeared that involvement of institutions like health insurances is perceived as a different level than family or selected medical professionals, because they are not as trusted to act in one's personal interest. One might also lose oversight of what happens with personal data, which stresses the importance of trust in consideration towards comfort with level of use.

Overall, it appears that the presented comfort values of privacy perceptions, perceived control and level of use are interrelated. Privacy perceptions presented to be the most prevalent aspect, as a majority of participants addressed related thoughts. The results show that privacy concerns with regard to RHM present a very personal and controversial perception. Generally, different perspectives were taken into consideration concerning RHM's possible influence on one's privacy, by weighing potential downsides against perceived benefits in relation to one's personal circumstances. Additionally, using RHM based on own terms appeared to positively affect feelings of self-determination, as well as willingness to accept monitoring in one's personal space. Hence, control about how RHM is used presents a significant factor, which can support comfort of being monitored. This notion also included levels of use of RHM and whom one is willing to include as data recipients. Results show that trust is a key factor in this context, as it influenced whom one is comfortable to disclose personal information to.

Design and Integration

Design and integration of RHM appeared as another facet, which is related to intrusiveness perceptions and thus comfort with having RHM in one's personal sphere, but did not show a relation to the previously illustrated factors. It involved perceptions about the visual appearance of sensors and their integration into the home. An overview of corresponding codes from the interview analysis can be seen in Table 12.

Table 12

Codes in category "design & integration"

Code	Number of quotes	Number of interviews
Unobtrusive design	20	14
Design is secondary	6	5
Aesthetic requirements for wearables	5	4
Appealing, modern design	5	3
Practicable design	3	3
Not too many devices	2	2

Participants mainly expressed the opinion that sensors should be unobtrusive and not disturb the environment. Related statements included desired characteristics like no blinking lights, no noises, small devices, neutral colors and no exposed cables. Preferences for inconspicuousness of devices seemed to be partly driven by an underlying objective of not wanting it to be easily recognizable that there is a monitoring device. A small number of participants disclosed higher demand for design, highlighting devices should be appealing and comply with personal aesthetic preferences, meaning sensors were desired to not only be unobtrusive, but fit into the environment. Below presents a statement about the wish for unobtrusive design:

> *[29] "So in terms of design, if it's small and graceful, that's perfectly fine, that wouldn't be a problem then. It should not be too conspicuous." (Participant 14, female, 57)*

On the contrary, few participants also represented the view of design aspects being secondary or even trivial. In most cases, such perceptions were reasoned by the opinion that function is more important than design. However, generally it was mostly still acknowledged that an unobtrusive design would be preferred, as the following quote shows:

> *[30] "Concerning optical appearance, whether I find such a sensor beautiful or not, would not matter to me. [..]. I would not care, it depends on the function. But of course, an attractive design is always more beautiful." (Participant 7, male, 60)*

It occurred that for some participants aesthetic requirements for wearable devices were assessed differently than for other sensors. Views appeared to be more critical concerning devices that are worn, as those were seen not only to have to combine design and function, but also comfort of wearing and are generally more visible.

These results imply that an unobtrusive and modern design presents the main expectation concerning appearance of RHM devices. Mostly, it was expressed that the design of example devices that were presented (as illustrated in section 3.4 *Materials*) would comply with personal requirements and would be accepted. This suggests that design and integration does not present a highly crucial influence on users' perceptions of RHM, which is further supported by the fact that this aspect generally did not receive much attention of thoughts by participants and was often probed during interviews.

4.2.5 Social Values

As it has already become apparent in previously illustrated results, social aspects, like inclusion of others into use of RHM and related possible effects, also contributed to shaping participants'

perceptions of RHM. In the following, social values that appeared to be influential are divided into two different levels, namely direct influence of opinions of others and personal human touch norms.

Social Influence

It appeared that participants would be influenced by opinions of others, which included recommendations and their influence on one's decision to use RHM, as well as recognition of sensors by others and related possible perceptions. The corresponding codes from the analysis are illustrated in the table below (Table 13).

Table 13

Codes in category "social influences"

Code	Number of quotes	Number of interviews
No shame about use	19	17
Recommendation family accepting	15	12
Professional recommendation accepting	11	7
Preferably not directly recognized by others	6	5
Recommendation family critical	4	4

Although the previous section has demonstrated that unobtrusive design appeared to be partly important to participants, it seems that such views were not mainly driven by concerns about whether others recognize sensors and how they might perceive one using RHM. Participants' statements highlighted that RHM was principally seen as something positive, wherefore there was no need seen to hide sensors or be ashamed of the use of RHM. In some cases, participants even expressed to be open to tell others about their use of RHM or recommend it, justified as follows:

> *[31] "Yes, I would have no problem with that. I would not hide such a device then. On the contrary, I would rather communicate openly and perhaps encourage others to do the same if it is useful" (Participant 21, male, 60)*

Only few participants stated it would be preferred if devices were discrete to not be directly recognized by others. These views were mainly driven by the desire not to be directly confronted regarding the use of RHM, but having the choice to make it a topic of conversation oneself. It was also highlighted that this would be especially important concerning visitors one does not have a close relationship with. An example is provided by the quote below:

> *[32] "It should not be noticeable, that is right, that one is not directly asked about it. But if it fascinates me and I find it interesting and useful and good, then I would also tell my visitors about it and talk about it […]." (Participant 8, male, 75)*

As results in section 4.1 (general attitude) have shown, participants' personal openness to use RHM in their current situation was rather low. However, it was frequently stated by participants that recommendations of others to use RHM would be considered and influence decisions, as expressed in the quote below:

> *[33] "If one notices, that some impairments are developing, then I think such considerations come into mind, and one should then also acknowledge advice from external people or family and accept it." (Participant 11, female, 64)*

For one, this concerned recommendations by family members. Those were mostly viewed positively and as regarded, because family members were perceived as trusted advisors. Only in a few cases recommendations of family members were seen critically, based on concerns of conflicting or biased views as a point of disagreement. Therefore, it was also often stated that a professional recommendation (e.g. by doctors) would be highly valued, as it presents a neutral and independent assessment. Hence, medical professionals were seen as reliable and trusted advisors concerning realization of the personal need for RHM.

These results highlight that recommendations are more likely to be influential by people that are trusted and believed to be objective. Further, it appears that if provided sensors are unobtrusive users might have fewer concerns about perceptions of others.

Human Touch Norm

Human touch norms present a different angle of social values that showed impact on attitudes towards RHM and includes perceptions of possible influences of RHM on social relations and contacts. In general, it was felt that human contact is considered very important, with a number of participants emphasizing that RHM should not negatively affect human contact, both on a personal and professional level. The relative codes and their frequencies can be viewed in Table 14.

Table 14

Codes in category "human touch norm"

Code	Number of quotes	Number of interviews
Human contact can't be replaced	19	11
Personal relations are unaffected	12	10
Influence on relationship possible	5	5
Risk for loneliness	4	3
Machine preferred over human	4	3

Concerning professional levels, the importance of the human factor was highlighted especially in relation to care. Opinions were stated that RHM should not be used as a tool to reduce personal contact, like reducing personal visits of caring nurses, but rather as a precaution that possibly supports caregivers work. The quote below presents an example:

> *[34] "And that would also have to be made clear here that this does not affect human contact in any way, but rather functions just as a precautionary measure. That is one of the main points for me." (Participant 6, female, 65)*

In this context, participants also expressed mild concerns that RHM might contribute to an increased risk for loneliness, by negatively affecting face-to-face contacts. The emphasis of being concerned about risks for loneliness appeared to be driven by acknowledgement that loneliness is a crucial factor, especially for older people, that can also cause other physical or mental health deteriorations. A related statement was as follows:

> *[35] "I think the human aspect is very important. I mean, loneliness is actually a very, very big problem, and it is important that this [RHM] does not further increase it." (Participant 4, female, 58)*

On the other hand, participants partly also appeared to recognize that RHM and care are separate services with different aims, wherefore it was not seen as a risk to reduce personal contact brought

by care. Participants acknowledged the limitations of RHM as a health and safety precaution, not as a care solution.

Regarding personal levels of social relations there was also some concern expressed that including family in the use of RHM could affect those relations. It was argued that discrepancies in opinions, too much control by others or perceived duty to be involved could negatively affect relationships, as illustrated in the following:

> *[36] "If something like that becomes too intense and they are too challenged with me, then, yes. Then I think one may develop more restraint and withdraw oneself. I think you have to think about how much you can expect of others." (Participant 11, female, 64)*

However, it was mostly perceived that use of RHM would not have negative effects on personal relations. Participants reasoned that personal contacts are based on care for another, wherefore being involved in use of RHM would not be seen as a burden. The belief was expressed that personal relations are strong and trusted and would hence not be affected in any way, as shown below:

> *[37] "I basically have a very, very close and trusted relationship with both family and friends. And I don't see why that should be influenced negatively or positively by use of RHM." (Participant 7, male, 60)*

In this context, similarly to the professional level, personal contact was perceived separate from health monitoring, acknowledging RHM more as an additional safety tool that is not meant to replace human contact.

Overall, the results demonstrate that social values come into play on different levels. Partly contradicting statements of participants regarding whether RHM may have a negative influence on social contacts demonstrated that this aspect leaves room for concerns and is regarded relevant. A common view was presented that human contact is essential and should not be affected by RHM. Perceptions that social contacts, both on personal and professional levels, would not be affected by RHM appeared to be driven by participants' comprehension and recognition of the purpose and limits of RHM. The evaluation also insinuates that social values are affected by trust factors, like trust as a base to accept recommendations, as well as trust in strength of personal relations to maintain unaffected, which highlights that social values appear to be very personal.

4.2.6 Usability values

It further appeared from the interviews that values linked to usability and convenience of using a technology influenced participants' possible use intentions as well. This included perceptions related to general handling of RHM, which were based on perceived ease of use of interaction with the technology itself, as well as external facilitating conditions that influence those perceptions. Further hedonic motivations appeared to have indirect implications for usability expectations.

Ease of Use

Perceived ease of use presents one aspect that was discussed by participants in relation to usability thoughts. Because participants did not have direct contact or experience with RHM or prior to the interviews, related statements concerned thoughts of what users expect of usability in order to be capable of using RHM. Associated codes from the analysis and their frequencies are illustrated in Table 15.

Table 15

Codes in category "perceived ease of use"

Code	Number of quotes	Number of interviews
Easy and self-explaining use	26	15
Low required interaction	12	8
Age-friendly design	11	9
Technological affinity	10	8
Learning required for use	6	6
Usability assumed to be given	4	2

The most frequently mentioned aspect by participants regarded that a technology should be easy to use. Related terms that were used in that context included self-explanatory, clear, simple or intuitive. It was highlighted that learning how to use the system should not require significant effort, as people may develop a reluctance towards a technology if it is perceived to be complicated. A related statement is shown below:

> *[38] "But it has to be easy, because with older age you are simply no longer accessible to complicated processes. It has to be simple as well as logical for one." (Participant 14, female, 57)*

Related to that, participants also expressed a preference that use of RHM should not be demanding, which was described as not requiring effort or much interaction in order for the system to function. Therefore, a high level of automation was valued, as it was considered to be easy to handle, as well as being most likely independent from user operability. Further, it was argued that less required interaction would reduce awareness of monitoring activities.

As seen in the previous quote, participants especially highlighted the importance of easy use and automatic functions in consideration to users with older age. It was partly argued that it may present a higher challenge at an older age to learn new things like handling a technology. Additionally, it was quite frequently stated in this context that usability of RHM was expected to be designed in accordance with requirements of older people, which would include considerations of typical problems that may occur with age, like impaired vision and motor functions.

It appeared that not only age may have an influence on usability perceptions, but also general technology affinity. Participants who mentioned to be confident in using technologies either did not mention requirements for usability or did not regard them as very important. On the other hand, participants who said they were not as confident in using technology valued ease of use and support. A related statement highlighting the role of technology affinity was as follows:

> *[39] "Of course, it's always difficult to admit to yourself that you can't handle it and then put it aside. Of course, this is also a contributing factor, and age also plays a role at some point. The affinity for electronic devices, for new technologies, for sure that becomes increasingly difficult with age." (Participant 13, male, 69)*

However, it emerged that participants did not have direct concerns that usability expectations would not be met. On the contrary, in some cases it was even mentioned that usability would be assumed to be given and does not present a point of attention. Such views were reasoned by observations of a general development towards technology becoming more user-friendly.

Facilitating Conditions

Facilitating conditions are generally related to the availability of supporting infrastructures to use a technology and considering usability of RHM appeared to mainly concern direct support by others. The respective codes can be found in Table 16.

Table 16

Codes in category "facilitating conditions"

Code	Number of quotes	Number of interviews
Support by provider	9	6
Support on private level	8	6

In terms of support for using a technology, participants for one referred to technical support from vendors. It was highlighted that availability of assistance would be perceived as helpful, if one was not confident about own capabilities to handle RHM. Further, it may be perceived as reassuring, if it is known that support is given to help maintaining and assuring functioning of the system. It appeared to also be of importance to participants how support was provided, as in-person support was sometimes mentioned to be preferred. A respective statement concerning technical support was as follows:

> *[40] "But there is good support and there is also bad support. […] Sometimes, when you ask a question, it is clear and helps you. But unfortunately, it's often the case that you then use a help function, quickly spend 15 minutes or 20 minutes on it and the problem is still not solved." (Participant 7, male, 60)*

Additionally, participants mentioned just as frequently that it can be reassuring to also be confident in support from one's immediate environment, for example from children. This may be important, because users might have a lower inhibition threshold when asking someone familiar for help than professional technical support. Moreover, it indicates again that having a human contact person for support is valued and considered easier than automated support functions.

Hedonic Motivation

Hedonic motivation is generally described as perceived enjoyment derived from use of a technology. In the context of RHM it appeared to mainly concern interest in receiving information from the system to better understand one's health and support self-management, as an internal cue, which presented to affect usability perceptions. The related codes are presented in Table 17.

Table 17

Codes in category "hedonic motivation"

Code	Number of quotes	Number of interviews
Interest in health evaluations	15	12
Information overload	5	3
Joy	3	3

Principally, a high proportion of participants stated to have interest in personal health evaluations provided by RHM, in order to develop better health awareness, as shown by the following quote:

[41] "Yes, absolutely. I would have to be able to use it for myself as well. That would be important for me, not that it only goes to my doctor or so. No, I would use it, perhaps also to improve my habits a little, to change something." (Participant 16, female, 73)

It was also highlighted by participants that joy in using a technology could positively contribute to use and acceptance of RHM. It is possible that such feelings of joy could be achieved by perceived ease of use of the system, as easy handling can prevent negative experiences like frustration.

Though, some participants also expressed critical views that being confronted with health information may not always be wanted, due to ignorance or fear of irrelevant worries, shown as follows:

[42] "So it can also lead to an information overload that ultimately makes you crazy about your health." (Participant 17, male, 57)

Hence, it is possible that having the system run more in the background and requiring less interaction may be beneficial concerning motivational aspects of using RHM.

These observations demonstrate that personal motivations may influence requirements for usability. It is to be noted that participants mainly already assumed general use of RHM in their considerations and it appeared that hedonic motivations would rather influence to which extent one would make use of provided information personally, than directly influencing intentions to use RHM.

Overall, this evaluation has shown that RHM is expected to be easy to use and adapted to requirements of older people. It further suggests that self-efficacy in handling a technology is not only dependent on age, but also on general attitude towards technologies. However, most participants expressed confidence they would be capable of handling the technology, either directly or with support from others, demonstrating that usability aspects do not present a dominant reason that negatively affects users' perceptions of RHM.

4.2.7 Price Values

Considerations of costs related to RHM presents a final factor derived from the interviews that appeared to influence use intentions. Associated statements concerning cost perceptions covered reasonability and impact of costs as a factor. The related codes and their frequencies are illustrated in Table 18.

Table 18

Codes in category "perceived costs"

Code	Number of quotes	Number of interviews
Trade-off costs vs. benefits	18	12
Costs play a role	11	8
Exemplary costs ok	8	8
Costs not decisive	7	7
Cost assumption health insurance	4	3

Partly, costs were regarded as a vital factor that needs consideration. Concerns about costs expressed by participants were mainly bound to thoughts about one's financial situation, mentioning

that financial limits may be more restricted with age. This indicates that principally it is considered essential that RHM should be affordable, as shown below:

> *[43] "Yes, if the costs generally and monthly were very high, I would be a little anxious about how to pay for it." (Participant 9, female, 78)*

A related thought that was disclosed in some cases referred to the possibility of costs being carried by health insurance. Although it was not directly mentioned to be preferred personally by participants, these thoughts signify that cost assumption by health insurance could present a possible positive incentive for users, as it would reduce the magnitude of personal investments.

On the other hand, a similar proportion of participants viewed costs to not present a decisive factor, which was again related to personal financial situations. Further, it was partly highlighted that even if costs are personally not per se decisive, the value and need for RHM still needs to be recognized for costs to be perceived as justified. A quote expressing costs to not be crucial was as follows:

> *[44] "Costs not for me. If I wanted to use that, I would purchase it. But because I can afford it." (Participant 10, male, 71)*

A principally underlying rationale concerning cost perceptions appeared to be a trade-off, in which monetary costs are balanced against personal benefits. Generally, participants expressed to be willing to invest into supporting their health, but mostly only if they realized the specific need for it. In relation to this trade-off, it was further highlighted that costs should be transparent, as it may help to better evaluate costs against benefits. An example is shown below:

> *[45] "Yes, you'd have to see: what would it cost? How important is it? It's always a question of calculating whether it's nice to have or whether it's totally important. If it's really important, then yes, and there are costs, then you have to contribute to the costs if you can." (Participant 19, male, 59)*

In some cases, participants that considered costs as an important aspect were provided with exemplary costs to get a better indication of their valuation. This guideline value was suggested to be around 300 Euros acquisition costs and 30-40 Euros monthly costs for a basic RHM mainly meant for private use, based on actual costs of the example RHM system presented in the interview introduction. Participants expressed to perceive the exemplary costs as reasonable and affordable, suggesting that equivalent costs would be accepted.

Overall, although considerations of costs were probed in around half of the interviews, suggesting that it does not present a highly considered aspect, it still seemed to play a role in influencing participants' behavioral intentions. Results suggest that cost perceptions are highly dependent on two factors, which play into the trade-off between costs and benefits. For one, personal financial situations were indicated to have an important impact, considering it was mentioned by both participants who considered costs as decisive and not decisive. Secondly, personal circumstances, like health and living conditions, may be of influence, as those affect perceptions of personal need for RHM and the benefits it provides for one.

4.3 User Diversity

During analysis of the interviews attention was also paid to identifying possible indirect influences bound to personal characteristics, based on suggestions from the theoretical background and by exploring possible additional factors that may derive from the results. Factors related to user

diversity that were investigated as a result were health status, experience with caregiving and other technologies and age. The outcomes will be presented in the following.

4.3.1 Health Status

Statements concerning one's health status were mentioned very commonly by most of the participants, and almost exclusively in combination with other factors, as an aspect that would influence regarding perceptions. Those included statements referring to one's perceived health condition in reflections of certain aspects, but also remarks of awareness that such self-perceptions may be biased, especially with increasing age. The frequencies of the regarding codes are presented in Table 19.

Table 19

Codes in category "health status"

Code	Number of quotes	Number of interviews
Dependency on health status	37	15
Biased perceptions with older age	8	6

Health status perceptions appeared to impact participants general openness to use RHM. Results suggested that the personal need for RHM was reasoned by distortions in health conditions, demonstrating that related perceptions influenced participants' recognition of personal usefulness of RHM. The previous illustrations have shown that perceived benefits affect trade-offs that take place in consideration of certain values, which demonstrated that perceptions of personal health conditions presented a decisive factor in those trade-off thoughts. This included for one privacy perceptions. It appeared that perceptions of one's health condition affected whether monitoring was viewed as unwanted and intruding or as reassuring observance, indicating that health status assessments have a general impact on comfort to use RHM. Perceived health conditions further affected trade-off considerations concerning costs, as participants expressed to be more willing to pay for RHM, if its need and value was recognized.

These results suggest that perceptions concerning one's health status impact attitudes regarding utility values, comfort values and price values.

4.3.2 Experience

Participants often illustrated personal experiences to support or explain stated opinions. Those generally concerned experiences in relation to caregiving and use of other IoT-based technologies or health-related technologies like emergency call buttons. Table 20 shows an overview of corresponding codes and their frequencies.

Table 20

Codes in category "experience"

Code	Number of quotes	Number of interviews
Experience caregiving	29	13
Experience related technologies positive	16	10
Experience related technologies negative	14	8
Emergency button negative	8	7
Emergency button positive	6	5

Caregiving and Health

In many cases, experiential factors related to experiences regarding health and caregiving within one's personal environment. Those mostly included fall incidents and use of other safety tools like emergency buttons, which highlighted the importance of being helped in emergency situations and emphasized comforting effects safety tools can cause. Thus, related experiences appeared to support perceptions to view RHM as a reassuring safety measure.

In some cases, disclosed experiences also showed that tools that require higher interaction can present barriers to effective use. Therefore, such experiences appeared to result in higher value of automatic functions of RHM. Further influencing perceptions regarding interaction occurred to be experiences that operating new technologies often presents a difficulty for people with older age, which supported statements regarding usability requirements for RHM to be designed age-friendly and simple.

Experiences of caregiving appeared to influence social values. Those demonstrated concerns that can be linked to caring for someone, but also the importance of being involved and knowing about the condition of the person cared for. Related examples were given to highlight that RHM would be seen as a possibility to unburden involved relatives, which was often mentioned as a reason to accept recommendations of relatives to use RHM.

Generally, this shows that personal experiences in the context of caregiving in the first place have a positive effect on perception of benefits of RHM, but also partly affects perceptions related to usability and social values.

Technologies

Another category of experiences mentioned by participants regarded use of other technologies, that are either also IoT based or health-related, such as smart assistants or fitness trackers. Participants often expressed positive reactions towards use of other technologies to support health-behavior. Such statements were mentioned in connection with showing interest in health evaluations, as supportive arguments for recognizing positive aspects of monitoring and being willing to use evaluations for self-management of health.

It further appeared that technological experience has an impact on perceptions related to reliability values of RHM. For one, participants mentioned experiences of false alarms caused by technologies in relation to possible concerns about automation of technologies. This indicated that trust in reliability of technologies might be negatively affected by such experiences, although there was no direct relationship detectable to perceptions that false alarms are a resulting active concern regarding RHM. Additionally, disclosed experiences with technologies showed that perceptions of

trust in reliability of systems and security of data is linked to organizational reputations, as certain companies were highlighted to support related arguments. Further, negative experiences concerning handling of other technologies that resulted in a decline of use were used to highlight the importance of easy use and consequently appeared to influence usability values.

It emerged that experiences with technologies have different effects on attitudes towards RHM, depending on whether those experiences were positive or negative, but generally affect perceptions of usefulness, reliability and usability of RHM.

4.3.3 Age

The possible influence of age on perceptions of RHM was analyzed by examination of possible trends in frequencies of codes dependent on the age of participants. As already illustrated in the analysis of the direct influencing factors, age showed a small trend to relate to differences in perceptions of benefits of RHM, concerning the prioritization of different aspects. Further, it was indicated that circumstances that are partly bound to age, like occupational status, have an influence on data privacy perceptions, whereas one was less critical of sharing personal data with increasing age. On the other hand, there was a slightly imminent trend that social values regarding concerns for loneliness were mentioned more by younger participants within the sample.

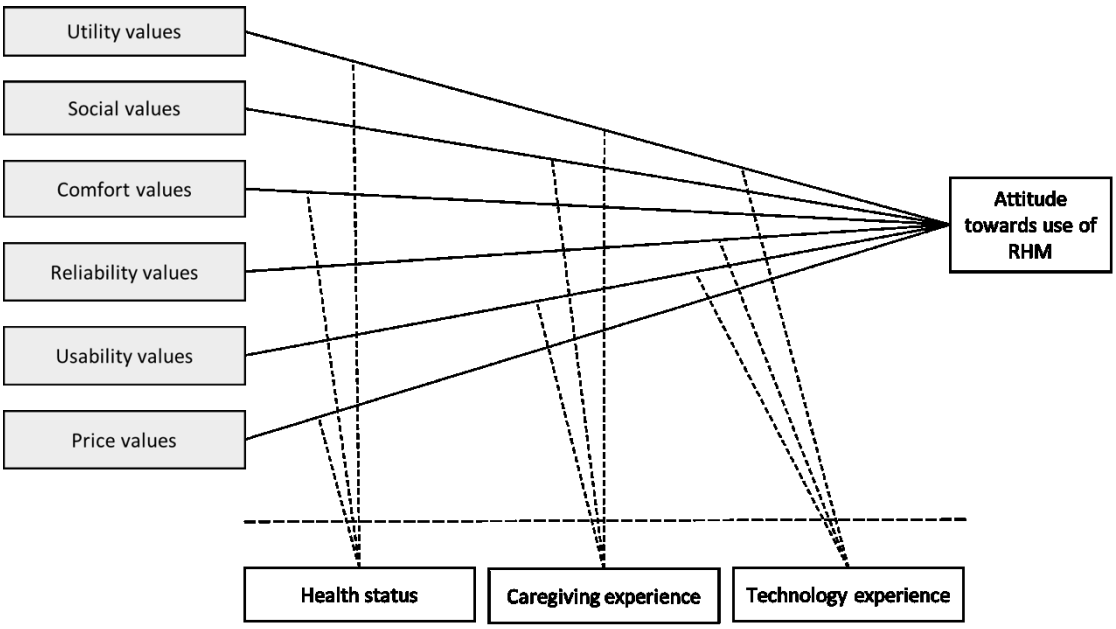
However, overall age did not appear to have an evident coherence with differences in participants' perceptions, as it mainly affected the perspective that was taken in considerations, but not general opinions.

4.4 Conceptual Model

Based on the presented results, an adapted conceptual model based on UTAUT2 has been developed to illustrate the factors that influenced participants perceptions of RHM (Figure 5). It pictures the values that appeared to be main influences in shaping perceptions and attitudes towards use of RHM, as previously described in the respective sections. Further, indirect influences that are bound to user diversity are included according to conclusions from the corresponding analysis, which is why age was not incorporated in the model. The relations between factors are portrayed by the connecting lines.

Figure 5

Conceptual model



5 Discussion

This section discusses the previously presented results to answer the initial research question. Afterwards, resulting implications for theory and practice are presented followed by possible future research directions. Lastly, possible limitations of this research are reflected on and a final conclusion is drawn.

5.1 Discussion of Results

The aim of this study was to investigate perceptions related to acceptance of RHM to answer the following main research question: *"What are older adults' perceptions concerning the use of remote health monitoring?"*

Results of the analysis of interviews indicate six main predicting values for users' perceptions of RHM namely utility, social, comfort, reliability, usability and price values, as illustrated in the introduced conceptual model (Figure 5). This mostly coincides with findings from literature reviewed in the theoretical framework, by including aspects from UTAUT, HBM and contextual research.

Similarly to Papa et al. (2020), participants were found to express generally positive attitudes towards RHM. It was recognized as a valuable technology for active aging, as one of the main advantages that was identified within this study's focus concerned RHM providing safety and supporting healthy aging. Utility values in general emerged to play a key role in shaping perceptions, as the analysis showed the significance of usage being perceived as beneficial in order for potential users to express willingness to use RHM, which is in congruence with other studies in the context of IoT service acceptance and UTAUT (Hsu & Lin, 2016; Park et al., 2018). As represented in the conceptual model in Figure 5, the analysis further showed that caregiving experience can have a positive impact on recognizing the benefits of RHM (Halbach et al., 2018), since reflecting on certain events made people more aware of the direct relevance of RHM.

Interestingly, there was a discrepancy between general recognition of benefits and seeing benefits for one's personal situation. This may relate to the third-person effect (Davison, 1983), as it seems that personal biases caused participants to value the positive effects of RHM for others higher than for themselves. Further, it shows that knowledge alone is not predictive for people's perceptions, but emotions have an inevitable effect on how this knowledge is used and valued (Volkamer & Renaud, 2013).

In contrast to results from Cannizzaro et al. (2020) the described discrepancy did not only result from lacking trust in the technology. Namely, health status perceptions emerged as a main antecedent for acknowledgement of the personal value of RHM, which supports findings by Ghorayeb et al. (2021). Results portrayed a dependency, in which clear deteriorations in health appeared to heighten recognition of value and need of RHM and could in turn override possible concerns. This highlights that possible perception biases can distort benefit perceptions, with possible users not seeing the personal need for an assisting technology. Further, it emphasizes that the health-focused aim of technologies like RHM forms an additional factor that plays a role in acceptance compared to other smart technologies, which is reflected by inclusion of health status perceptions as introduced by HBM to the conceptual model (Figure 5).

Considering trust on the other hand, it was found that concerns related to reliability values, like system reliability and data transmission, were not the most prevalent aspect affecting perceptions of RHM. Participants expressed confidence in general security mechanisms of reliable providers and

showed awareness of risks of possible security incidents (Yang et al., 2017). Nonetheless, general regulation of access to prevent unauthorized access or use of data remained a prevailing request, because information gathered by RHM is seen as sensitive and personal as it contains health related data and can reveal daily routines.

This underscored that concerns about data security are highly related to perceptions of privacy, which emerged as the main aspect of personal judgements about the intrusiveness of a surveillance technology such as RHM and is consistent with related studies (Balta-Ozkan et al., 2014; Cimpeman et al., 2013). In this respect, this study has adopted the construct of comfort values as suggested by Park et al. (2018) and Papa et al. (2020) as an overarching theme for privacy related considerations in the presented conceptual model (Figure 5). Though, in contrast to findings by Papa et al. (2020) who mainly referred to appearance of devices, design of the technology did not emerge as a substantial comfort value in this study. This is in line with findings by Ghorayeb et al. (2021) and Doyle et al. (2015), stating that sensor design is not a substantial factor affecting acceptance and may stem from the fact that RHM includes mountable sensors that are perceived to be generally less prominent than wearables.

Resultingly, comfort values mainly concerned data access regulation and the desire to have control over who is involved in using RHM, as people appear to have inhibitions about disclosing information about their private life (Schomakers & Ziefle, 2019). However, it also included functional aspects, like types of sensors used and what is measured. As found by Katsivelis et al. (2017), a high preference was identified to be able to adjust functionality to personal demands, because monitoring was perceived as intrusive if its necessity was not recognized. Hence, the analysis from this study contributes to the notion presented by Park et al. (2018) that perceived control is a core element in relation to comfort with monitoring technologies, whereas higher self-determination could reduce intrusiveness perceptions. The importance of control is further highlighted by the finding that participants not solely perceived RHM as a solution that can help living independently with age, but also perceived it as giving up autonomy by being monitored and others having access to personal health information. Results provided additional evidence of a trade-off in this context of comfort values, wherein privacy concerns may be overridden by perceived usefulness of RHM (Ghorayeb et al., 2021; Jaschinski et al., 2021), further highlighting the substantial role of utility values and thus also health beliefs in impacting perceptions.

Additionally, this study has shown that perceptions of intrusiveness are not generally critical, but are influenced by personal values. This could support the hypothesis by Adebesin and Mwalugha (2020) that perceived privacy has no direct influence on use intentions, but is mediated by trust. In congruence with related studies, the analysis has demonstrated the overall importance of trust in influencing perceptions of RHM as an underlying rationale for reliability and comfort values (Cannizzaro et al., 2020; Philip et al., 2021), which both present context-resulting additions to the UTAUT-based conceptual model in Figure 5. However, trust appeared to not only be affected by perceptions of provider benevolence or the technology itself, but also largely by trust in other stakeholders included in the use of RHM. It shows that evaluations are not only based on technology-based features and mental models, but that trust adds an emotional layer towards perceptions of RHM (Yang et al., 2017).

This emotional facet becomes even more prominent in social values, which were identified as another important influence on perceptions of RHM (see Figure 5). For one, opinions of others may have an impact on the recognition of the personal value or need of RHM (Cheung et al., 2019). Family

was seen as a trusted source of advice, although it was also sometimes viewed critically, as it could present a potential point of conflict when opinions contradicted with one's own assessment. Thus, a higher valuation of professional opinions like from doctors was found, based on trust in their competence. But a more important aspect in relation to social values that appear to result from the care aspect of RHM were identified to be perceptions about effects of using RHM on others and social relations. People are concerned about being a burden on others (Burrows et al., 2018) by involving them in use of RHM. This on the one hand concerned family members, resulting in wanting limited access to data for close relations (Cimpeman et al., 2013), but partly also included concerns about overloading medical personnel if data was transmitted automatically. Although results imply a slightly higher willingness to share data with professionals as suggested by Ghorayeb et al. (2021), this presents a contradicting aspect. It shows that social concerns are not only limited to personal relations and highlights the connection of social values to perceptions of control and privacy.

An interesting result is that, contrary to Allen's (2021) hypothesis, participants did not appear to face shame towards others regarding RHM use, indicating that stigma does not present a factor that negatively influences attitudes towards use of RHM. Additionally, a general premise emerged that RHM should not be intended to replace personal contacts or negatively affect personal relations (Walker et al., 2019), due to concerns about increased loneliness, though it was partly expressed that there is confidence that personal relations would remain unaffected. These results concerning social values have shown that trust, which has in previous research mainly been considered in relation to technological aspects like security, reliability and privacy, also has an impact on perceptions based on social values.

Based on the findings, perceptions about usability on the other hand did not cause direct concerns regarding use of RHM. This result may be related to a relatively high experience with technologies within the sample and high self-evaluations of technological affinity. Participants mainly expected easy use and low required interaction, adapted to abilities of older people. Related perceptions were often influenced by personal experiences with other technologies. The hypothesis that older people may be concerned about abilities to operate new technologies (Cimpeman et al., 2013; Walker et al., 2019) was not directly supported, as participants expressed trust in being able to use RHM due to possibilities to get support and highly automated functionality. However, as shown by the Dunning-Kruger effect, people are likely to overestimate their abilities of handling a technology (Kruger & Dunning, 1999; Mahmood & University of the Punjab, 2016). This could have been exacerbated by the hypothetical nature of considerations and could have affected the results. For these reasons, usability is still regarded to present an important aspect concerning general acceptance and included in the presented conceptual model (Figure 5).

Notably, cost perceptions also emerged to not be an aspect to be considered when initially reflecting on possible use of RHM, which might be influenced by a relatively high socio-economic status of the sample. Results showed that perceived benefits can positively affect price values. Affordability emerged as the most crucial factor in this context and thus can present a barrier for acceptance of RHM (Park et al., 2018). Interestingly, it was found that costs of exemplary RHM services were perceived as reasonable. While results further suggest that perceptions of affordability could be increased by external cost assumptions for example by healthcare providers, it is to be noted that most participants had critical views about involvement of healthcare providers in the use of RHM.

Lastly, other than the already presented user diversity factors, age appeared to not affect perceptions of RHM in the sample if this study, supporting previous findings of Halbach et al. (2018) and Jaschinski et al. (2021), but may also be due to the limited age range included in the study.

In general, the study has shown that while people do appear to have positive attitudes towards RHM and show interest in the topic, overall awareness and familiarity was still very low. Participants mostly did not have prior knowledge about RHM, which made it difficult for them to state clear opinions, as they started deliberating about possible benefits and drawbacks during the interview, which often resulted in vague or contradicting answers. The results showed that awareness and having a mental model of possibilities and limitations of RHM enable being better able to derive the value of RHM for oneself and consequently has a strong influence on people's perceptions in relation to trust and acceptance of RHM (Volkamer & Renaud, 2013). This can present a challenge for general adoption, as technological innovations like RHM are knowledge intensive concerning functional comprehension (Saaksjarvi, 2003) and the target population of RHM often has lower understanding of innovative IoT based technologies (Cimpeman et al., 2013).

5.2 Implications

5.2.1 Theoretical Implications

The results of this study provide theoretical implications by complementing existing research in the wider field of acceptance of healthcare technology. It supports researchers in gaining a deeper understanding of users' perspectives towards RHM adoption in Germany, helping to alleviate the existing gap in user-focused research in order to understand and meet users' needs (Nagapuri et al., 2019).

Firstly, this research has verified that although traditional models for acceptance of technologies, like UTAUT2, do offer an appropriate base for research, they require adaptation to specialties of IoT-based and health-related technologies (Halbach et al., 2018; Park et al., 2018). For one, results demonstrated that the four main factors of UTAUT (performance expectancy, effort expectancy, social influence and facilitating conditions) also apply to other contexts like RHM (Helena Chiu et al., 2010). However, contained constructs were partly weighted differently in their relevance, as for example facilitating conditions and effort expectancy appeared to be conjunctional concerning usability perceptions. Further, other constructs contained in UTAUT2, such as habit or hedonic motivation, appeared to not be applicable to every context, as they showed no direct influence on perceptions towards RHM and were therefore omitted in the derived conceptual model. It is possible that this may result from the fact that RHM is rather a purpose bound than a convenience bound technology.

Secondly, it is especially notable that other, additional aspects emerged to be most impactful in shaping perceptions that result from the context of health and IoT. Such context-related factors have not been focused on frequently in previous studies, but appear to present crucial aspects in relation to adoption of smart health services and have thus been added to the conceptual model. For one, this study has further highlighted privacy values as one of the main influences on users' perceptions in relation to IoT-based technologies and monitoring in the personal environment that present a context-related addition. Additionally, the importance of social values focusing on human touch norms as a consideration resulting from the care aspect of an assisting technology like RHM has been made more prominent and presents an aspect that is not considered in traditional acceptance models (Jaschinski & Ben Allouch, 2015). Moreover, the valuable addition of considering context-

related models has been demonstrated, since the inclusion of health status perceptions derived from HBM emerged as an influential aspect considering attitudes towards RHM (Cheung et al., 2019). The importance of these values emphasizes the differences in perceptions of smart technologies in the health sector towards other sectors and the need to consider them.

Thirdly, previous literature has mostly examined the influence of experience as direct experience with the technology under study, focusing on how perceptions change over time (Ghorayeb et al., 2021; Lee & Rho, 2013). The approach followed in this study of analyzing whether experience with other IoT technologies also has an influence on perceptions, presents a new course and the confirmatory results can be used as new insights for further research. In addition, results of the influence of caregiving experience on perceptions have highlighted that in relation to smart health technologies, experience should be examined separately considering technological and caregiving experience (Halbach et al., 2018).

Fourthly, this research has contributed to understanding the impact of personal characteristics, like experience or health perceptions and individual values like privacy and social concerns, as an addition to technological knowledge. It has shown that these factors related to user diversity add a layer of complexity to attitudes towards smart health technologies that needs to be considered. That way, these results support the suggested approach by Saaksjarvi (2003) of contemplating compatibility with personal values and knowledge a new way to categorize adopters.

5.2.2 Practical Implications

In addition to theoretical implications, this study also provides practical implications that can be drawn from the results as guidance. Those can be used by service providers for development, service design and marketing to make more informed decisions by being mindful of users' perspectives.

Firstly, the analysis has shown that general awareness about RHM needs to be heightened in Germany. It appears to be important how RHM is introduced to people, which can be translated into marketing interventions. RHM should be highlighted as being supportive for health, safety and independence and aiding own abilities, but not as a control mechanism, which could be perceived to be condescending (Jaschinski, 2014). Further, it could be beneficial to not frame it as focused on older or fragile people, as that could reduce the influence of health perceptions of people's openness to use RHM. Further, to counteract social concerns, it should be highlighted that RHM presents an addition, not a substitute for personal care and could further be supported by including functions that promote social contacts (Jaschinski & Ben Allouch, 2015). The general importance of perceived benefits is a valuable insight that can be used by practitioners. The identified significance of being aware of functionalities and aims of RHM to recognize the value of use for oneself, emphasizes how clearly communicating benefits and usefulness could enhance adoption of RHM (Huang, 2010).

Secondly, the influence of trust on users' perceptions presents a notion that should be considered by providers. There should be a focus on alleviating consumers concerns about the technology. Highlighting security aspects and providing transparency of technological functions could heighten trustworthiness, because clarity regarding how personal data is managed can reduce privacy concerns and increase willingness to share personal data (Hsu & Lin, 2016; Philip et al., 2021). Additionally, emphasis should be placed on providing modular structures of systems, as the ability to customize and select functionalities and features can increase positive attitudes towards use of RHM (Ghorayeb et al., 2021; Schomakers & Ziefle, 2019).

Thirdly, the results can provide implications for design of RHM devices. For one, the appearance of devices should be designed carefully, because obtrusive design can negatively affect perceptions of intrusiveness and willingness to place sensors in the home (Jaschinski, 2014). Further, concerning design of user interfaces and interaction, a focus should be set on simplicity and intuitiveness. This could for example be achieved by ensuring a low level of required interaction and considering requirements of older people. The findings that consumers have an interest in actively in taking charge of their health and changing their behavior lead to the conclusion that feedback options for self-monitoring purposes should be included into RHM, as well as advice on how to act on given data (Doyle et al., 2015).

5.3 Future Research

Based on the results and implications of this study, recommendations can be derived for future research into perceptions and acceptance of RHM.

For one, subsequent studies should examine the feasibility of the presented conceptual model of influences on users' perceptions. This could initially be accomplished by expanding the scope of included participants. Further, it should be tested using quantitative methods. This approach would allow gaining deeper insights into the relative influences of the suggested values and possible underlying relations, as the results have indicated that some aspects are valued higher than others and might be interconnected.

In this context, it is especially suggested for subsequent research to investigate further into different privacy values in relation to use of RHM. Results have shown that those present one of the main aspects affecting people's perceptions and that considered facets are highly connected to each other. Thus, it appears relevant to gain a higher understanding of the relations between security, privacy and reliability perceptions, their connection to trust and the role of trade-offs with perceived benefits.

Second, it is recommended to further investigate the influence of user diversity factors on perceptions and acceptance of RHM, as those were partly limited in the sample under study. One suggested approach is to examine the role of experience in more detail, as previous literature has shown that perceptions towards smart home and health technologies change over time (Balta-Ozkan et al., 2014; Halbach et al., 2018). This research has supported the presumption that care experience and technological experience have different effects on perceptions and that the latter is not limited to experience with the studied technology but also concerns related products. Hence, consecutive studies could examine the influence of technological knowledge in relation to acceptance further.

Third, this study has highlighted the role of awareness in shaping perceptions towards RHM, by showing how low awareness and knowledge about usefulness and handling can distort opinions. This effect should be further investigated for example by comparison of perceptions of people with low awareness with people having a clear understanding of RHM. In this context, it would also be interesting to study what types of incentives are effective in increasing awareness and consequently enhance positive perceptions towards use of RHM.

5.4 Limitations

Although this research presents a contribution to the wider field of adoption of smart health technologies, it has some limitations that need to be considered for generalization of the results and for future research.

For one, the sample presents a factor that limits generalizability of results. Due to the exploratory nature of this research the sample size was generally rather small and did not show a big diversity concerning demographic factors. Participants had relatively high levels of education and familiarity with other smart technologies, which could have resulted in more profound thoughts about the topic and building better mental models of RHM. Hence, it is possible that a higher variety within the sample could lead to different results.

Another limitation that should be considered results from the method of relying on voluntary participation. It is possible that only people who are generally more open towards talking about personal matters like health and sharing information participated, as people who face stigma concerning their health and are generally more private might not be willing to discuss a topic like RHM without incentives. Therefore, it is possible that insights are partly biased to the positive.

The low general awareness about RHM presents another aspect that should be taken into consideration, as it required an introduction of RHM prior to the interviews. Depending on varying technological comprehension, explanations could not be uniform, but had to be adjusted individually to be comprehensible to participants. As knowledge has been shown to be an important factor for acceptance, differences in overall understanding of capabilities of RHM could have affected related perceptions.

Additionally, despite the explanation and demonstration of the technology, results showed that it was partly difficult for participants to imagine the usage of RHM without directly having experienced it or being in a situation, where it is needed. The theory of affective forecasting has shown that people tend to have biased predictions of emotional reactions (Wilson & Gilbert, 2003), which can affect opinions and decision-making. Thus, the mostly fictional evaluations of participants could have influenced the results by leading to overestimations or distortions of perceived barriers or personal value of RHM (Halbach et al., 2018).

5.5 Conclusion

This study has investigated German potential users' perceptions of RHM solutions and what considerations shape them. Based on the results, six main values have been found to be important for people's perceptions, namely utility values, social values, comfort values, reliability values, usability values and price values. Additionally, user diversity factors like health status perceptions, caregiving experience and technological experience were identified to relate to differences in perceptions towards RHM.

Findings have highlighted the distinctive characteristics of technology adoption in the health and IoT sector by identifying aspects, which are not included in traditional adoption models, to be of high importance in shaping possible users' perceptions. This shows that adoption of smart health technologies presents a field that needs to be considered separately and requires extension of existing knowledge. The results and developed conceptual model present a contribution to this field, in providing insights for future research as well as design and promotion of RHM, which can be used to increase acceptance and adoption of RHM services.

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Appendix

Appendix A: Research information sheet

Appendix B: Informed consent form

Appendix C: Protocol for interviews

Appendix D: Topic guide for interviews

Appendix E: Survey for demographic information

Appendix F: Fact Sheet for RHM Introduction

Appendix G: Reliability analysis of the codebook

Appendix H: Codebook

Appendix A: Research information sheet

Information Sheet

Research Project: Perceptions of remote health monitoring through smart health devices

Background and Purpose:

- This study is conducted as part of a master's thesis project at the Faculty of Behavioural, Management and Social Sciences at the University of Twente
- The purpose of the study is to gain insights into the views of potential users on technology-based remote health monitoring solutions, that are aimed at supporting aging-in-place

What does participation involve?

- A personal interview will be held of approximately 45-60 minutes
- Interviews will start with a short introduction of the relevant technology
- You are asked to fill in a short survey concerning basic personal information
- The interview will entail questions concerning your personal views and will be audio-recorded

What will happen to the received information?

- All data will be treated confidentially:
    - Data will be stored and processed anonymized, disconnected from any identifying information
    - Interviews will be audio-recorded and transcribed to text. Recordings will be deleted after completion of the research.
    - Access to data is limited to the main researcher and supervisors with whom collaboration is required as part of the research
    - Any summary interview content or direct quotations from the interview that are made available through academic publication will be anonymized to ensure you cannot be identified

Voluntary participation:

- Participation to the study is entirely voluntary and you can withdraw from the research at any time without giving any reason

There are no known risks associated with participation in this research.
The study has been approved by the Ethics Committee from the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

If you have any questions regarding the appointment of the interview or regarding the study, please contact:

Rebecca Feldberg E-mail: r.feldberg@student.utwente.nl

Appendix B: Informed consent form

Informed Consent Form

Research Project: Perceptions of remote health monitoring through smart health devices
Research Investigator: Rebecca Feldberg
Research Participant Name:

This consent form is necessary to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Therefore, you are asked to read the accompanying information sheet and sign this form to certify that you approve to the following:

Taking part in the study

1. I have read and understood the study information sheet. I have been able to ask questions, and understand that I am free to contact the researcher with any questions I may have in the future.
2. 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.
3. I understand that taking part in the study involves filling in a questionnaire concerning personal information and participating in a personal interview, which will be audio-recorded. Recordings will be transcribed as text and original recordings will be deleted after completion of the research project.

Use of the information in the study

4. I understand that all or part of the content of the interview will be used for publication of the concerned master's thesis and related other academic publications
5. I understand that personal information collected about me that can identify me will not be shared beyond the responsible researcher and data will be processed anonymized.
6. I agree that I can be quoted directly in the resulting research output with safeguarding that quotes will be anonymized.
7. I agree to being audio-recorded during the interview.

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I have provided the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name [printed]	Signature	Date

If you have any further questions or concerns about this study, please contact:

Rebecca Feldberg
E-mail: r.feldberg@student.utwente.nl

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 of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

Appendix C: Protocol for interviews

Time	Script	Material	Topic
5	Starting interview session - Welcome by moderator - Explanation of context and purpose of study - Master thesis - Background: *new technological solutions in healthcare* - Topic: *IoT based Remote Health Monitoring* - Aim: *Understanding possible users' perceptions* - Outlining procedure o Information sheet and informed consent o Questionnaire (demographics) o Explanation RHM o Interview (with voice recording, data anonymized) - Informed consent o General conditions & procedure clear? o If no question: signing informed consent & proceed	- Informed Consent form - Information sheet	Introduction
5	Questionnaire for demographics - Handing questionnaire to fill in - Only basic information needed	- Questionnaire	Questionnaire
5	Explaining Remote Health Monitoring - Meant to aid in understanding of technology - Use of fact sheet and example devices for demonstration - Proceed if no further questions *Note: stating focus is on technological understanding, opinions/reactions asked in following interview part*	- fact sheet - demonstration devices	RHM Explanation
45	Beginning Interview: - reminder aim: *personal opinion is important, conversation stays confidential* - opening: *What are your thoughts about this technology?* *Would you use RHM? (why / why not?)* - more detailed if needed:	- Start recording - Topic guide	Interview

	Can you think of factors that would affect your decision to use it (positively or negatively)? *What are next to …. other factors that would affect your decision to use?* *Do you have any concerns about the technology or using it?* Possible Prompts: - *Can you give an example?* - *Can you explain that further?* - *Can you elaborate further / in more detail?* - *What exactly are you thinking about in this regard?* - *Why is that?* Depending on stimulation of thoughts, the interviewer can provide direction using the topic guide		
5	End of interview - acknowledgements	- End recording	Closing

Appendix D: Topic guide for interviews

Topic	Notes
Perceived benefits	- Benefits and value of RHM
Perceived health status	- Value/use in current situation - And in case of deterioration of health status
Social Influences	- Opinions of others (family/close people vs. medical professionals - Possible effects on social contacts - stigma
Usability	- technological confidence - aspects that are important for usability - design
Motivation	- personal motivation to use / how to use RHM
Technological experience/affinity	- personal experience with similar (IoT-based) technologies
Trust/concerns	- data transmission of health data - perception on invasion of privacy - need for control
Costs	- Role of costs - Willingness to pay
Care Experience	- Personal experiences related to care
Possible addition	- *integration into health system or private use*

Appendix E: Survey about demographic characteristics

Questionnaire on Personal Information

Please fill in the following information about yourself. Your answers will be used exclusively for research purposes within the scope of this study and will be treated strictly confidential.

1. Please state your age in years:

   _____

2. What gender do you identify with?
   - ☐ Male
   - ☐ Female
   - ☐ Other

3. What is your nationality?
   - ☐ German
   - ☐ Other

4. What is your highest level of education?
   - ☐ Lower secondary school graduate
   - ☐ High school graduate
   - ☐ Study without degree
   - ☐ Prediploma
   - ☐ Bachelor's Degree
   - ☐ Graduate Degree

5. What is your (former) main occupation? Please specify below:

   _____

6. What is your marital status? Please select the answer that applies.
   - ☐ Married
   - ☐ Widowed
   - ☐ Divorced
   - ☐ Unmarried

7. Which of the following answers describes your current living situation?
   - ☐ Living alone
   - ☐ Living together with spouse or family members
   - ☐ Other (if applicable, please specify below):

     _____

8. In what environment do you live?
   - ☐ Urban
   - ☐ Rural

9. How would you describe your state of health in general?
   - ☐ Very good
   - ☐ Good
   - ☐ Satisfactory
   - ☐ Less good
   - ☐ Bad

10. Do you have one or more chronic diseases (e.g. diabetes, asthma, high blood pressure, etc.)? If yes, please list them below.

_____

11. How would you classify your affinity to technology in general? This refers to your interest in technologies and openness to use them.
    - ☐ Very strong
    - ☐ Strong
    - ☐ Moderate
    - ☐ Low
    - ☐ Very low

12. Do you use smart devices in your everyday life? Please specify them below. Multiple selections are possible. If your answer is not listed, please add it in the intended placeholder.
    - ☐ Smartphone
    - ☐ Fitness watch (e.g. Fitbit or Apple Watch)
    - ☐ Smart Assistant (e.g. Alexa or Google Home)
    - ☐ Others:

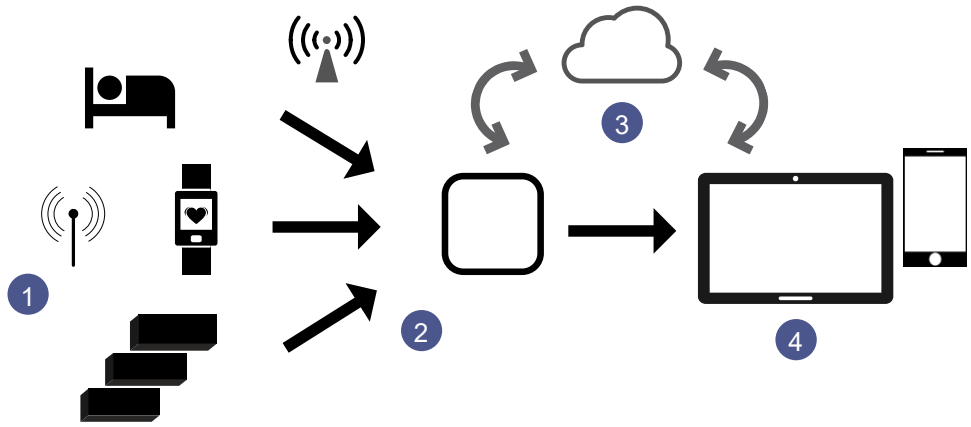
_____

Appendix F: Fact Sheet for RHM Introduction

Technology-based remote monitoring of health and well-being

Overview: structure and function

Measurement of health and behavioral data through a combination of networked sensors, for general monitoring of one's health status



Sensors
for measurement of data related to the health status

Gateway Device
for consolidation of data and exchange with the cloud for data evaluation

Mobile Applications
for access to data evaluations and notifications by users

Further Information:

1 **Data measurement:**
- Mounted sensors within the home (e.g. sleep sensor or door sensor) & wearable sensors (similar to fitness wristbands or smart watches) sense information about common vital signs, mobility and sleep

2 **Data exchange:**
- Sensors are wirelessly connected with a central gateway device for consolidation of collected data

3 **Data analysis:**
- Data is automatically analyzed and checked for anomalies. Insights into the health status are available in overviews on smartphone or tablet applications

4 **Notifications/Warnings:**
- In the event of changes of the health status, notifications or warnings are triggered, which are sent to users and specified caregivers to signal need for action

Appendix G: Reliability analysis of the codebook

Reliability analysis of interview sessions

Sessions: 9 and 11
Date: 10/03/2022

Citation	Encoder 1	Encoder 2	After Consultation
9.1	GA6	GA6	
9.2	B4	B4	
9.3	B5	B5	
9.4	E3	M2	E3
9.5	B4	B4	
9.6	EOU3	EOU3	
9.7	E2	E2	
9.8	EOU5	EOU5	
9.9	EOU6	EOU6	
9.10	FC3	FC3	
9.11	EOU5	EOU5	
9.12	FC4	EOU6	EOU6
9.13.1	H1	H1	
9.13.2	GA4	GA4	
9.14	B7	B7	
9.15.1	H1	H1	
9.15.2	GA4	GA4	
9.16.1	B3	B3	
9.16.2	SI2	SI2	
9.17	B11	B11	
9.18	M1	SR6	M1
9.19	B11	B11	
9.20	P2	P2	
9.21	P4	P4	
9.22	C3	C3	
9.23	C1	C1	
9.24	C3	C1	C3
9.25	P6	P6	
9.26	DP3	DP3	
9.27	D4	D4	
9.28	D4	D4	
9.29	SI5	SI5	
9.30	HT5	HT5	
9.31	E3	E1	E3
9.32	B2	B2	
9.33	PC4	PC4	
9.34	PC4	PC4	
9.35	PC1	PC2	PC2
9.36	B5	B5	
9.37.1	B5	B5	
9.37.2	L4	L4	

Citation	Encoder 1	Encoder 2	After Consultation
11.1	GA6	GA6	
11.2	B10	B10	
11.3	B3	B3	
11.4.1	GA4	GA4	
11.4.2	H1	H1	
11.5	SI2	SI2	
11.6	H2	H2	
11.7	SI3	SI3	
11.8	H2	H2	
11.9	SI2	SI4	SI2 & SI4
11.10	B11	B11	
11.11	B10	B10	
11.12	M2	M2	
11.13	EOU3	EOU1	EOU3
11.14	EOU1	EOU1	
11.15	EOU5	M1	EOU5
11.16	P5	P5	
11.17	H1	H1	
11.18	P1	P1	
11.19	DP4	DP4	
11.20	DP3	DP3	
11.21	L5	L5	
11.22	P5	DP5	P5
11.23.1	FC1	FC1	
11.23.2	H1	H1	
11.24	L2	C3	L2
11.25	C4	L5	C4
11.26	L5	L5	
11.27	C2	C2	
11.28	C3	B11	C3
11.29	P3	P3	
11.30	H1	P1	H1 & P1
11.31	D3	D3	
11.32	D2	D3	D3
11.33	SR2	SR2	
11.34	SI6	SI6	
11.35	SR2	SR2	
11.36	M1	M1	
11.37	FC1	-	deleted
11.38	FC4	FC4	
11.39	FC4	FC4	
11.40.1	L4	L4	
11.40.2	H1	H1	
11.41	HT4	HT5	HT4
11.42	SI1	SI1	
11.43	HT1	HT1	
11.44	PC1	PC1	
11.45	PC2	PC2	
11.46	PC1	PC1	
11.47.1	C5	SR4	C5
11.47.2	H1	H1	

Appendix H: Codebook

Category	Code ID	Code Name	Description	Frequency
General attitude				
General attitude	GA1	RHM has future and demand	There is generally a need and future for RHM	8
	GA2	current generation not ready	Younger generations may be more willing and able to use RHM	2
	GA3	open for usage at current stage	Willing to use RHM in current situation	2
	GA4	open for usage at later stage	Willing to use RHM at a later stage in life (e.g. when older or living alone)	21
	GA5	open for further technologies	Also willing to use other similar technologies, such as care robots or implanted chips	6
	GA6	general positive and openminded	Generally positive and open towards RHM as first reaction	12
Utility values				
Perceived benefits	B1	Reduce doctor visits	Certain things might be possible to be resolved by RHM, so possible doctor visits may be reduced	5
	B2	Automated systems with little self-effort	Seen as benefit that system is automated and requires little self-effort	10
	B3	Relief and unburdening of relatives	Use of RHM can be soothing and relieving for family members	15
	B4	Better health awareness and self-control	Having the possibility to engange with own health condition and have a better self-perception	20
	B5	Unburdening and support for medical personnel	RHM can help medical personnel like doctors (e.g. by having additional data)	20
	B6	Help in emergency situations (automatic warning)	Emergency situations (e.g. a fall) are recognized automatically and no self-action required for triggering	21
	B7	Stimuli for behavioral improvement	Sugggestions and reminders are given, which can help to improve one's own health-related behavior	10
	B8	Possible communication medium	RHM could be used to mitigate loneliness, e.g. by integration of social features	6
	B9	Prophylactic function	Prevention and early detection of health risks	18
	B10	Prolongation of independence	RHM helps to prolong independence and living longer in own environment	11
	B11	Providing safety and reassurance	RHM provides feeling of safety	28
Reliability values				
System reliability	SR1	Dependency on networks	Functionality of RHM is dependent on reliable internet connection	3
	SR2	Data recording of visitors	Thoughts on how RHM handles and distinguishes data from other people in the home, like visitors	9
	SR3	Risk of false alarms	sees a risk of false alarms with RHM	4
	SR4	Risk of technological dependency	Critical to rely too much on technology, and possibly loose own body feeling	5
	SR5	Durability of devices	Sustainability and durability of function (e.g. batteries) important	2
	SR6	Reliability of data and system functionality	Accuracy of collected data and ensured function of the system	8
Data security	DP1	Trade-off data disclosure vs. benefits	Possible risks from transfer of data are weighed against benefits	7
	DP2	Trust in provider benevolence	Trust in provider's good intentions as an independent, not commercialized company	11
	DP3	Health data not highly sensitive	No risk seen of how health data could be misused	11
	DP4	Hacking-risk aware	Awareness that hacking risk theoretically always exists	6
	DP5	Access by third parties unwanted	Seen as important that third (unwanted) parties can't access data	16

Comfort values				
Privacy perceptions	P1	Tradeoff monitoring vs. benefits	Surrending privacy due to monitoring is weighed against benefits	31
	P2	Open towards monitoring	Data can be viewed by others, no invasion of privacy seen	14
	P3	Wanting to maintain privacy	Personally important to not disclosse too detailed information, certain areas too intimate (e.g. bathroom)	15
	P4	Surrendering privacy is seen as necessary	view that to have a benefit, it is necessary to dispense privacy and also willing to do so	11
	P5	Critical towards monitoring	Thinks critical about monitoring, because data is collected about you Everywhere, without control and transparency	24
	P6	Human is nowadays transparent anyways	one is transparent anyways nowadays, there is so much data available that there are no big concerns anymore	11
Perceived control	C1	Concerns of paternalism by others	Concern that involved people might take too much influence or neutrality of monitoring is not given	13
	C2	Configurability to one's needs	Important to be able to select functions to own personal needs	18
	C3	Self-determination in use	Wanting to have control over own use of RHM and who is involved	20
	C4	Transparency of functionality	Important to have an overview of what happens with one's data (like what data is recorded, how it is handled and who can access it	16
	C5	Loss of autonomy	Use of RHM seen as loss of autonomy	8
Level of use	L1	Provision for research	Willing to provide own data for research	5
	L2	Involvement relatives	Willing to involve relatives/dependants in RHM use (data access/monitoring)	18
	L3	Involvement doctors	Willing to involve doctors in RHM use (data access/monitoring)	21
	L4	Involvement care personnel	Willing to involve care personnel in RHM use (data access/monitoring)	19
	L5	Connection to health insurance critical	Concerns about possible negative consequences resulting from data access	15
	L6	Connection to health insurance possible	Ppen towards connection to health care system	3
Design & integration	D1	Aesthetic requirements for wearables	Appearance of wearables mentioned extra, more important	5
	D2	Design is secondary	Function is more important than design	6
	D3	Appealing, modern design	Higher demands with regard to design, to be not just unobtrusive but appealing	5
	D4	Unobtrusive design	Devices should be blending into the environment, not be too prominent	20
	D5	Practicable design	Few devices for better integration to environment	2
	D6	Not too many devices	Devices should be resistant concerning external influences and practicable in handling (like mounting)	3
Social values				
Social influence	SI1	Burden on family members	Possibe that it may present an additional burden on families	10
	SI2	Recommendation family accepting	If family would advise to use RHM, their recommendation would be taken into account	15
	SI3	Recommendation family critical	Controversial opinions from familiy that are not congruent with own perception may be seen critical	4
	SI4	Professional recommendation accepting	Advice from medical professionals (e.g. doctors) to use RHM would be taken into account	11
	SI5	No shame about use	Does not matter personally, if others notice RHM sensors in the home, willing to talk about it openly	19
	SI6	Preferably not directly recognized by others	Preferred, if sensors are not directly noticed by others (but still willing to talk about it)	6
	SI7	Overload for medical personnel	Lack of capacity seen for additional monitoring effort for medical personnel	3

Human touch norm	HT1	Influence on relationship possible	Involvement of family can potentially have an influence on the relationship	5
	HT2	Risk for loneliness	RHM poses risk to contributing to loneliness	4
	HT3	Machine preferred over human	Technoligical monitoring and control preferred over human monitoring	4
	HT4	Human contact can't be replaced	Human contact (e.g. through care) must not be replaced, because it is important or cannot be replaced, because it requires physical tasks	19
	HT5	Personal relations are unaffected	No concerns that use of RHM would affect personal contacts (of people involved)	12
Usability values				
Perceived ease of use	EOU1	Age-friendly design	Usability in accordance with requirements of older people	11
	EOU2	Usability assumed to be given	Usability is assumed to be automatically given	4
	EOU3	Easy and self-explaining use	Important that handling is easy and uncomplicated	26
	EOU4	Learning required for use	Thinking that handling requires learning and memory performance	6
	EOU5	Low required interaction	Handling should not require many interactions for functioning	12
	EOU6	Technological affinity	Influence of open-mindedness and self-confidence in dealing with new technologies on attitude towards operation	10
Facilitating conditions	FC1	Dependency on occupationsal status	It matters/makes a difference, if one is still employed or retired	5
	FC2	Awareness about RHM	Awareness of the technology itself and its possibilities is important to form an opinion about it	14
	FC3	Support on private level	Helpful if one can get support in own environment	8
	FC4	Support by provider	Helpful if there is support offered by the provider	9
	FC5	Marketing	It matters, how RHM is presented to people and marketed	4
Hedonic motivation	M1	Information overload	Too much information can be intimidating / not wanting to be confronted	5
	M2	Interest in health evaluations	Interest to view personal data and self-check, perceiving it to be motivating and possibly used to change own behavior	15
	M3	Joy	Joy in usage may have influence on usage	3
Price values				
Perceived costs	PC1	Tradeoff costs vs. Benefits	Cost perception is depending on personal benefits, costs should be reasonable	18
	PC2	Exemplary costs ok	Mentioned example price for a RHM system would be acceptable	8
	PC3	Costs not decisive	Costs personally not a crucial factor	7
	PC4	Costs play a role	Costs seen as a vital factor that needs consideration	11
	PC5	Cost assumption health insurance	Seen as a positive incentive as it reduces personal investments	4
User diversity				
Perceived health status	H1	Dependency on health status	Views are painted to be dependent on health status	37
	H2	Biased perceptions with older age	Possible perception distortion of need for help with older age	8
Experience	E1	Experience Caregiving	Personal experience with regard to health and care (e.g. caring for family members)	29
	E2	Experience related technologies negative	Use of related (smart) technologies experienced negatively (e.g. smart home)	14
	E3	Experience related technologies positive	Use of related (smart) technologies experienced positively (e.g. smart home)	16
	E4	Emergency button negative	Experience with or attitude towards emergency button negative	8
	E5	Emergency button positive	Experience with or attitude towards emergency button positive	6