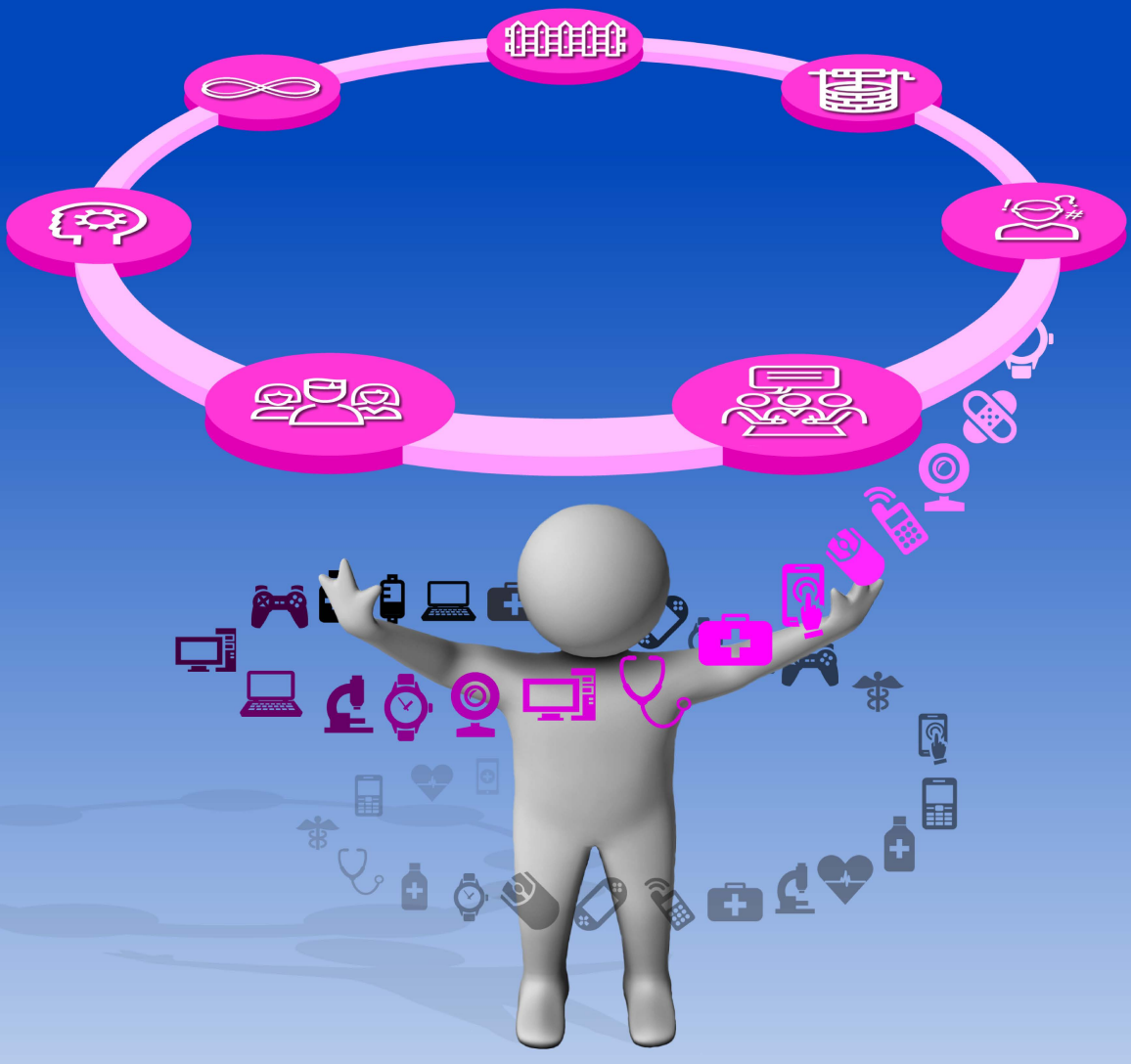
eHealth
In or out of our daily lives?

Measuring the (non-)use of eHealth in summative evaluations



Marian Hurmuz

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EHEALTH - IN OR OUT OF OUR DAILY LIVES?

MEASURING THE (NON-)USE OF EHEALTH IN SUMMATIVE EVALUATIONS

DISSERTATION

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by

Marian Zuhair Mikho Hurmuz

born on the 13th of August, 1994

in Almelo, the Netherlands

This dissertation has been approved by:

Supervisor
prof. dr. ir. H.J. Hermens

Co-supervisor
dr. S.M. Jansen-Kosterink

GRADUATION COMMITTEE:

Chair / secretary:
prof. dr. J.N. Kok, University of Twente

Supervisor:
prof. dr. ir. H.J. Hermens, University of Twente, Roessingh Research and Development

Co-supervisor:
dr. S.M. Jansen-Kosterink, University of Twente, Roessingh Research and Development

Committee members:
prof. dr. C.J.M. Doggen, University of Twente
prof. dr. H.E. Vonkeman, University of Twente
prof. dr. S. Ben Allouch, University of Amsterdam, Amsterdam University of Applied Sciences
prof. dr. ir. M.S. Kleinsmann, Delft University of Technology

Contents

“The game, the physical exercises,
and the platform were very enjoyable. I found it fun
and challenging to perform the minigames. […]
This eHealth service saves on physical therapy and is much more
effective than that! Now that I have tried it out, I have noticed how
beneficial some exercises are, and I will definitely continue performing
them. I also noticed that when I am on the road, in the car for example,
I am tempted to perform some exercises. Besides, I also noticed that it
encourages me to think about other exercises to train my muscles.
My neck and shoulder complaints have not disappeared in
these four weeks, but because of this [eHealth service],
I can deal better with them.”

1

General introduction

Nowadays, many innovative eHealth services are being developed and are available to use for a variety of purposes such as monitoring health, promoting healthy living, assisting activities of daily living, or providing a communication tool between patients and healthcare professionals. Many health applications can now be downloaded on smartphones and used for personal needs due to the extensive day-to-day use of smartphones. Studies show that there is a large quantity of applications to choose from, focusing on a variety of different health topics (e.g. (Alejandro et al., 2020; Machado et al., 2016)). However, long-term use of eHealth services is still limited, despite being widely available and easily accessible.

What is eHealth? The World Health Organization (WHO) defines eHealth as: *"The use of information and communication technologies (ICT) for health"* (World Health Organization, n.d.). This is a short, not comprehensive definition. Eysenbach (2001) defines eHealth as: *"An emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterises not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology"* (Eysenbach, 2001).

The definition of Eysenbach encompasses more than only ICT and health, which is the case in the definition of the WHO. As Eysenbach (2001) states, eHealth is not just a technology which can be used for someone's health or in the healthcare setting, but it is a whole concept, consisting of 10 e's: efficiency, enhancing quality, evidence based, empowerment, encouragement, education, enabling, extending, ethics and equity. These e's together is what eHealth stands for, and what eHealth should create (Eysenbach, 2001). There is not one universal definition of eHealth, but most of these include more than ICT and health (Oh et al., 2005). This shows us that eHealth is a broad concept which encompasses a variety of themes.

During the outbreak of the COVID-19 pandemic, eHealth services became more prominent in care delivery because of the need to continue treatment when face-to-face care was not a viable option (Feijt et al., 2020; Guitton, 2021; Keesara et al., 2020; Stanimirović & Matetić, 2020). For example, consultations between patient and healthcare professional were held remotely (video or telephone) instead of face-to-face (Guitton, 2021), health monitoring was done at home through a patient portal (Stanimirović & Matetić, 2020), or mental health treatment was done online (Feijt et al.,

2020). Due to the pandemic, there was a rapid transition to online care. This was possible because many eHealth services already existed. However, when the pandemic was less critical, sustainable implementation of eHealth in daily care was not apparent (e.g. (Amorim et al., 2021; Garattini et al., 2020)), even though the positive experiences gained regarding eHealth (e.g. (Feijt et al., 2020; Nakshbandi et al., 2021; Wang et al., 2021)).

eHealth services can contribute to solutions for many (health) problems. For example, the problem of the aging population can be conquered by eHealth as it can support older adults to live longer at home, to become more active in their health care process, and enable them to manage their own health (Alvarez, 2002; Sanyal et al., 2018; Ware et al., 2017). Furthermore, it also has considerable potential to improve the accessibility and quality of the whole health care process, to reduce health care costs (Bergmo, 2015; Hill & Powell, 2009)' and to tackle the limited capacity of healthcare (Ahern et al., 2006). Additionally, eHealth is also helpful at promoting a healthy lifestyle, which can prevent chronic diseases and its related care (Chatterjee et al., 2019; Tse et al., 2008; Visser, 2000). Finally, eHealth can be personalised and adjusted (Farahani et al., 2018; Wyatt & Sullivan, 2005), which gives the possibility to use it in multiple settings. eHealth can be implemented preventively for users' own wellbeing, and can be implemented in the healthcare setting as a replacement of, or addition to, regular care (Dedding et al., 2011). In a review study, this concept was called the service configuration of an eHealth application (Jansen-Kosterink et al., 2016). Previous studies have shown that patients prefer eHealth to be an addition to their regular treatment, which is called blended care, instead of replacing their treatment (Huygens et al., 2016; Postel et al., 2013). It is therefore apparent, eHealth has the ability to address many of the challenges currently experienced in healthcare.

One of the disadvantages of using eHealth in the care process, is that there are higher drop-out rates in eHealth services in comparison to face-to-face interventions. This was shown in previous studies investigating the use of eHealth (Alfonsson et al., 2017; Arean et al., 2016; Kannisto et al., 2017). This poses a threat on the effectiveness of eHealth services (Willmott et al., 2019). Buhrman and colleagues (2016) reviewed literature focusing on evaluations of internet-based interventions for persons with chronic pain. They identified drop-out rates ranging from 4% to 56% (Buhrman et al., 2016). Another review explored the extent of drop-out from internet-based treatment for persons with psychological disorders, and showed a range in drop-out rate from 2% to 83% (Melville et al., 2010). These studies show that drop-out in eHealth use has a substantial range, with a high upper value. In eHealth studies, this drop-out in eHealth use is called the law of attrition (Eysenbach, 2005). As Eysenbach (2005) states, this law consists of two phenomena: people who do not use the eHealth service, but for example do complete questionnaires or take part in interviews, and people who are completely loss-to-follow-

up, who do not use the service and do not complete questionnaires. But altogether, if eHealth services are not being used regularly in day-to-day life, are the potential benefits of eHealth materialising? And can these benefits be used as justification when introducing eHealth services, for example, in a hospital?

To optimise the use of new eHealth services, attention needs to be given to use in the evaluation of the services before implementing it in the care process. This will ensure having a high quality, accessible, affordable, and effective eHealth service (Eng, 2002). Currently, most eHealth evaluations focus especially on clinical efficacy (Kairy et al., 2009), and most review studies assess the effectiveness of different types of eHealth services. Overall, these studies show eHealth can have a significant and/or clinical relevant effect on users' health state (e.g. (Diana et al., 2017; Elbert et al., 2014; Stratton et al., 2017)), but, for eHealth to work effectively in target population's health state, patients have to use the service (Lewis et al., 2008; Marcus et al., 2007). This use of eHealth in daily lives is often a significant challenge to overcome. To take a step in this direction, a broader view on eHealth evaluation is necessary, which takes eHealth use/drop-out into account in quantitative and qualitative analyses. When evaluating eHealth services, many researchers conduct Randomised Controlled Trials (RCTs). However, controlled studies are not always suitable when assessing eHealth. First of all, the Technology Readiness Level (TRL) of eHealth services is often not high enough, so these eHealth services are not ready yet to be used in an RCT (Jansen-Kosterink et al., n.d.). Furthermore, within RCTs, researchers prioritise clinical outcomes and they give no or little attention to the question of eHealth use or drop-out (Kairy et al., 2009). Observational studies conducted in a real-world setting among the target population are important in many stages of the process from eHealth development to implementation. Within these observational studies, we can consider the factors which are important for sustainable implementation. For example, you can follow participants in real-time to see how they use an eHealth service in their daily lives without interference as is the case within RCTs (due to the strict controlment) (Saturni et al., 2014). So, even when an eHealth service has a high TRL, we do not have to focus only on clinical effectiveness. We have to focus also on the peripheral issues which lead to eHealth use among the target population by conducting studies in real-world settings.

General aim and thesis outline

In this thesis, use will be broadly defined as every use of the eHealth service among the target population. I focus my research to address the question: why are eHealth services (not) being used by the target population in quantitative and qualitative analyses? The potential of eHealth is not fully employed yet and I wanted to investigate why. **The aim of this thesis is to increase our understanding about the (non-)use of eHealth services among the target population in a real-world setting.** Lessons learned from this thesis will

enable readers to support sustainable implementation of existing and newly developed eHealth services.

The first step taken is to identify demographics and personality traits of eHealth users who stop using eHealth services. By knowing these, we can anticipate and prevent potential drop-outs in eHealth use. So, in Chapter 2, an observational cohort study will be presented, with a focus on determining which demographics and personality traits can predict dropping out of an eHealth service among older adults. At the beginning of the study, demographics and personality traits were measured based on literature. After using the eHealth service for 4 weeks, survival and Cox-regression analyses showed the factors predicting drop-out.

Besides knowing users' characteristics that can predict eHealth drop-out, it is also important to investigate other factors which explain (continued) use of an eHealth service. The study presented within Chapter 3 focuses on the use of the Technology Acceptance Model. Within this study, the influence of these determinants on older adults' use and intention to continue use a gamified eHealth service are investigated. The developed model was assessed with Partial Least Squares Structural Equation Modelling.

Before implementing an eHealth service, the service need to be evaluated. In Chapter 4, a case study will be presented which shows how you can evaluate eHealth in an observational study. It focuses on a summative evaluation of a virtual coaching system, in which user experience, use and potential health effects were assessed by means of mixed methods study (quantitative and qualitative data). This chapter consists of two sub-chapters. Chapter 4a the protocol of the study will be shown, and Chapter 4b the results of that study will be shown.

When using an eHealth service, users may experience different barriers and facilitators for using the service. It is important to know these barriers and facilitators in order to understand the reasoning behind the question why eHealth services are not being used over time by the target population. Within Chapter 5, a fully qualitative study will be presented which investigates these barriers and facilitators when using this eHealth service in a real-world setting. This chapter also aimed to give practical implications on how to tackle the barriers and how to reinforce the presence of facilitators.

In the previous chapters, different aspects related to the use of eHealth services will be studied to better understand why potential end-users drop out in using eHealth services. However, the final important step is to examine the end-users' motivation and expectations for participating in these studies. Their reasons could influence whether they drop-out early, or continue using the eHealth service. For example, if one has some specific reason to improve his/her health, and the eHealth service does not contribute to

this, it is more likely to discontinue the use. So, Chapter 6 focuses on these reasons and expectations, and the influence of their reasons on the use of an eHealth service. During the studies conducted in Chapter 2, 4 and 5, participants were asked to complete a short online questionnaire. With this questionnaire, participants indicated why they participated in that study, what their expectations were, and whether their participation in the study met their expectations.

Finally, Chapter 7 concludes this thesis with a general discussion. Within this chapter the following topics will be discussed: the different eHealth services which will be used within the previous chapters, the lessons learned about measuring (non-)use of eHealth, the recommendations for future summative eHealth evaluations, and the considerations for future research.

"For me, I have experienced that doing physical exercises on the computer works and I enjoy performing them at home at times that suit me. I do think that the use of games leads to more computer use, because you always play them longer than you really want to. I don't think this is always good for my health. I think, for me, this is a suitable eHealth service for the winter period. In the summer, I prefer to be outside (walking, cycling, working in the garden)."

2

Older adults' attrition to a web-based health intervention

Based on:
Hurmuz, M.Z.M., Jansen-Kosterink, S.M., Hermens, H.J., van Velsen, L. Older adults' attrition to web-based health interventions: Survival analysis within an observational cohort study. *(submitted for publication).*

Abstract

Objective: The goal of this study is to identify demographics and personal motivation types that predict dropping out of eHealth interventions among older adults.

Participants: The study population consisted of older adults, aging 55 years or older living in the Netherlands.

Methods: We conducted an observational cohort study. Participants completed a pre-test questionnaire and got access to an eHealth intervention, called Stranded, for four weeks. With survival and Cox-regression analyses, demographics and types of personal motivation were identified that affect drop-out.

Results: Ninety older adults started using Stranded. 45.6% of these participants continued their use for four weeks. 32.2% dropped out in the first week (N=29) and 22.2% dropped out in the second or third week of this study (N=13 in week 2, N= 7 in week 3). The final multivariate Cox-regression model which predicts drop-out, consisted of the following variables: perceived computer skills (HR=0.69, BI=0.49-0.99, P=.04) and level of external regulation (HR=1.19, BI=1.03-1.37, P=.02).

Conclusions: Predicting the chance of dropping out of an eHealth intervention is possible by using their level of self-perceived computer skills and their level of external regulation (externally controlled rewards or punishments direct behaviour). Anticipating to these factors can improve eHealth adoption.

Introduction

eHealth generally suffers from the 'law of attrition' meaning that patients are lost to follow-up and/or drop out from using eHealth (Eysenbach, 2005). Various review studies have inventoried and tried to explain drop-out rates (Buhrman et al., 2016; Melville et al., 2010; Richards & Richardson, 2012). High drop-out rates pose a threat for the success of eHealth: the potential effect of eHealth interventions will be difficult to assess (Willmott et al., 2019), which hinders the implementation of eHealth. A wealth of research has already been conducted, focusing on factors associated with dropping out from an eHealth intervention. These factors differ from technological aspects of eHealth, for example content of messages in an SMS message program (Grutzmacher et al., 2019), to personal characteristics, for example gender and age (Carpenter et al., 2012). Nowadays, a lot of studies focus on demographics' influence on eHealth attrition (Carpenter et al., 2012; Kannisto et al., 2017; Karyotaki et al., 2015; Pedersen et al., 2019; Perski et al., 2017; Van der Mispel et al., 2017). From these studies we learned that mainly gender, age and educational level are important demographics when looking at eHealth attrition. However, regarding gender and age, contradictory results were found (Carpenter et al., 2012; Kannisto et al., 2017; Karyotaki et al., 2015; Pedersen et al., 2019; Perski et al., 2017; Van der Mispel et al., 2017).

Furthermore, motivation is seen as an important personality trait that influences eHealth attrition (Alfonsson et al., 2016, 2017; Perski et al., 2017). Ryan and Deci (2000) define motivation as the trigger to do something and made a distinction between intrinsic and extrinsic motivation. Van Velsen and colleagues (2019) used the Sport Motivation Scale II (Pelletier et al., 2013) to show that for older adults, three types of motivation exist with respect to live healthy: intrinsic motivation ("where one acts because one derives satisfaction from the behavior itself" (van Velsen et al., 2019, p2)), external regulation ("where externally controlled rewards or punishments direct behavior" (van Velsen et al., 2019, p2)) and a-motivation ("a situation where there is a lack of intention to act"(van Velsen et al., 2019, p2)).

However, previous studies about eHealth attrition included drop-out only as a yes/no variable instead of an additional continuous variable, i.e. the time until drop-out. According to Eysenbach (2005), an appropriate method to assess factors influencing drop-out in eHealth use and their predictive values, is by using survival and Cox-regression analyses. These analyses include this 'time-to-event' variable. To the best of our knowledge, no study investigated, as a primary aim, which demographics can predict dropping out of an eHealth intervention with this approach. Therefore, the aim of this study is to identify the demographics and personal motivation types that predict dropping out of eHealth. Additionally we will assess when the predictors have the most influence:

at early drop-out, late drop-out, or when finishing the study. We will focus on older adults as the main target group; the aging population and their demand for eHealth interventions make analysis for this group especially relevant and crucial for society (Recio-Rodríguez et al., 2019). By knowing the personal factors that can predict drop-out in eHealth, we will have a better understanding of the high drop-out rates, which helps to improve the adoption of new eHealth interventions among older adults (Kidholm et al., 2017).

Methods

We conducted an observational cohort study. Participants first completed a questionnaire, then they received their credentials to access the eHealth intervention for four weeks. According to the Dutch Medical Research Involving Human Subjects Act, this study does not require formal medical ethical approval (checked by CMO Arnhem-Nijmegen (file number: 2019-5296)). Each participant gave their informed consent, and data were analysed anonymously.

Participants

The study population was a cohort of older adults from the Netherlands, recruited through mass mailing, snowball sampling, advertisements in newspapers and via physical therapists. The inclusion criteria used in this evaluation were: 55 years or older, owning a computer/laptop/tablet, having Wi-Fi at home, ability to read and speak Dutch, and not living in a nursing home.

eHealth intervention

A web-based, gamified fall prevention training named Stranded was used (see Figure 2.1) (Noorman-de Vette, 2019). Stranded consists of two components. First a fall prevention training, based on the OTAGO Excise Programme (Campbell & Robertson, 2003) with exercises aiming to improve muscle strength and balance (see Figure 2.2) (Dekker-van Weering et al., 2017). Secondly, five different minigames are spread across the island to promote users to conduct the physical exercises (see Figure 2.3). If a user complies to the therapeutic schedule, a new minigame is unlocked. By complying with the schedule of the fall prevention training and by playing minigames, users can fulfil the goal of the game, which is to build a boat to get off the uninhabited island (see Figure 2.4).

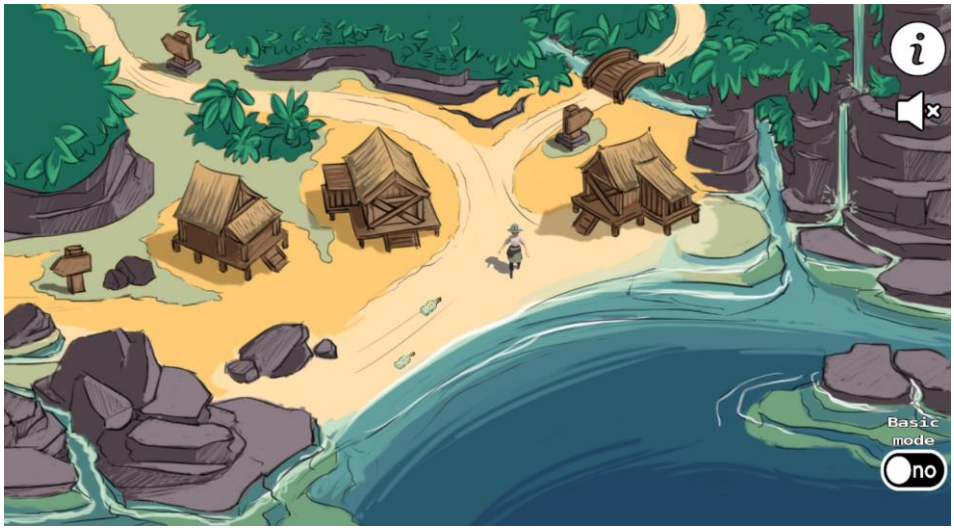

Figure 2.1. Screenshot of the homepage of Stranded used in this study.

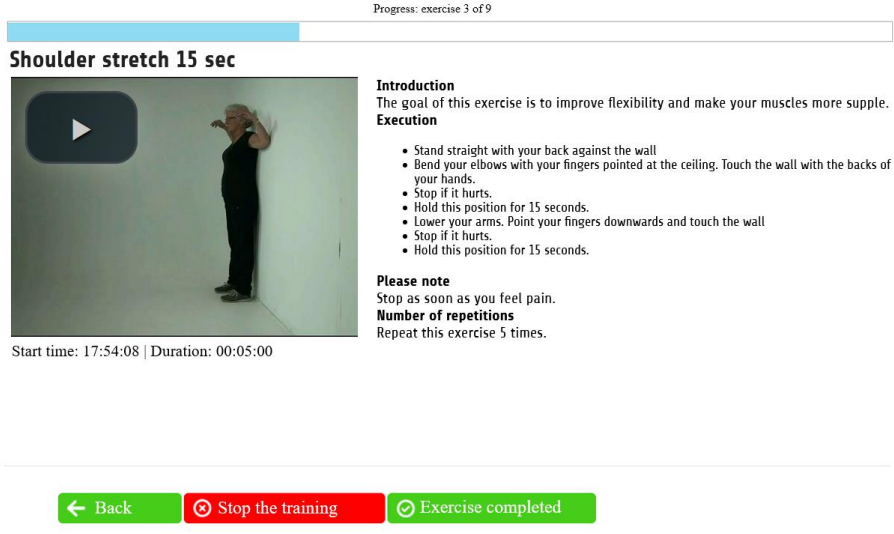

Figure 2.2 Screenshot of a physical exercise.

Figure 2.3. Screenshot of level 14 of the first minigame.

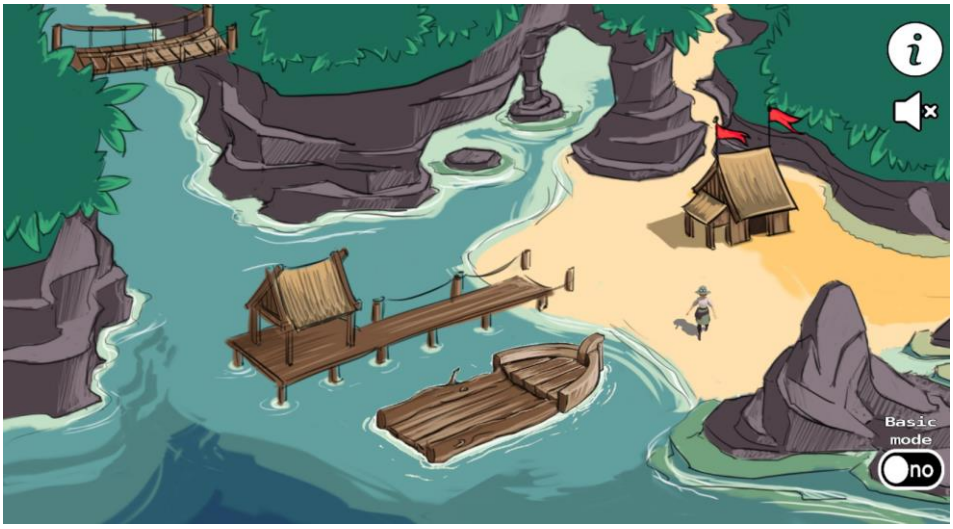

Figure 2.4. Screenshot of boat building progress.

Outcomes

The primary aim of this study was to determine demographics and motivation types that predict dropping out of using Stranded among older adults. A priori, we defined that if participants did not use Stranded for 7 days or if participants contacted the researcher to indicate that (s)he is not willing to continue using Stranded, they were seen as a drop-

out. The primary study outcomes were the number of drop-outs and the use of the technology. Data logs (Sieverink et al., 2017) were used to assess the use (frequency of logins and duration of use per week) and a questionnaire was designed to assess the participants' demographics and personal motivation types. This questionnaire (see Appendix 2.1) consisted of general demographics (age, gender, living/work situation) and a set of validated surveys (see Table 2.1).

Table 2.1. Overview used surveys.

Survey	Aim	Scale	Ref
Short Computer Proficiency Questionnaire	To determine the perceived computer skills.	6 (poor computer skills) – 30 (good computer skills)	(Boot et al., 2015)
Personal motivation type	To measure three motivation types to live healthy: intrinsic motivation, external regulation and a-motivation.	1 (e.g. not being motivated intrinsically) – 7 (e.g. highly motivated intrinsically)	(van Velsen et al., 2019)
Technology Acceptance Model	To assess participants' expectations about Stranded on perceived usefulness, perceived ease of use, attitude towards using technology, intention to use technology.	1 (negative) – 7 (positive)	(Agarwal & Prasad, 1998; Davis, 1989; Davis et al., 1989)
EQ-5D-5L	To measure participants' self-reported quality of life. This survey consists of two parts: a descriptive system and a Visual Analogue Scale (EQ VAS).	Descriptive system: 0 (dead) – 1 (full health) EQ VAS: 0 (the worst health you can imagine) – 1 (the best health you can imagine)	(Van Reenen & Janssen, 2015)
Positive Health	To measure participants' perceived health on six domains. In this study, these domains were measured as done previously in the study of van Velsen and colleagues (2019).	1 (e.g. bad quality of life) – 10 (e.g. good quality of life)	(Huber et al., 2016; van Velsen et al., 2019)

Statistical Analyses

Statistical analyses were performed using SPSS (v.19). Descriptive statistics were used to describe the demographics and the use of Stranded. A survival analysis was performed, using the Kaplan-Meier, and univariate and multivariate Cox-regression analyses. In this study, the event was drop-out and the time-to-event was the last day they used Stranded. The Kaplan-Meier showed the drop-out curve, the univariate Cox-regression showed which variables had influence on the event ($P<0.10$), and these variables were the covariates in the multivariate Cox-regression analysis ($P<0.05$), for which the forward model selection was used. This analysis showed which variables influence the outcome of dropping out and it showed the strength of the influence on the relative hazard of dropping out. To test the predictive ability of the final multivariate Cox-regression model, the Harrell's C was used. The interpretation of this C-statistic is "… the proportion of all usable patient pairs in which the predictions and outcomes are concordant" (Harrell et al., 1996, p370). This means that the C-statistic shows the proportion of people whose prediction will be confirmed by true results.

By using box plots, the ranges and distributions of the scores of the variables in the final multivariate Cox-regression model were visualised. To test whether there are differences in those variables among early drop-outs, late drop-outs and finishers, the one-way ANOVA was used with a post-hoc comparison method (Holm-Bonferroni correction). The cut-off of the drop-out groups are based on a median split of all drop-outs.

Results

Demographics

Ninety participants were included with 65.6% female (N=59) and with an average age of 65.6 years (SD=7.2; range=55-89 years). 44.4% of the participants had attained a higher vocational education or university education. 35.6% of the participants had attained higher general secondary education or pre-university education. The remaining 20.0% had attained preparatory secondary vocational education. 67.8% was married or lived together, and almost half of the population (47.8%) was retired. 28.9% was employed, 10.0% worked as a volunteer or caregiver, and the rest (13.3%) was a job seeker or was in another work situation.

In terms of health, the mean scores on the types of personal motivation to live healthy were: 4.69 (SD=1.08) for intrinsic motivation, 2.66 (SD=1.21) for external regulation, and 2.07 (SD=1.07) for a-motivation. 28.9% of the participants receives care support from family/friends. The mean EQ-5D score was 0.83 (SD=0.15), and the mean EQ VAS score was 76.5 (SD=13.2). Looking at the self-reported health status (see Figure 2.5), the mean score was highest for daily routine (M=8.4, SD=1.2), and lowest for bodily functions

(M=7.1, SD=1.6). The other mean scores were 8.1 (SD=1.3) for meaning, 7.9 (SD=1.3) for quality of life, 7.9 (SD=1.2) for social participation, and 7.8 (SD=1.4) for mental health.

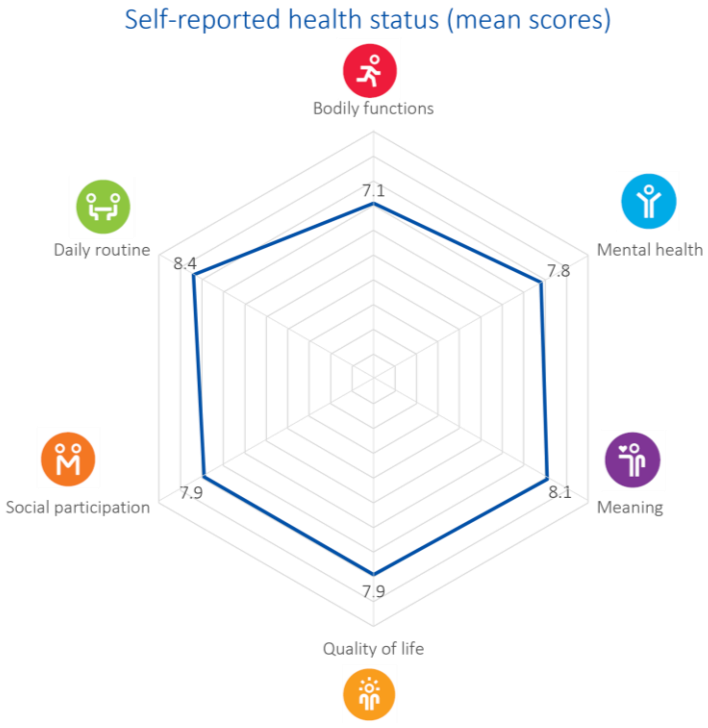

Figure 2.5. Spider plot mean scores on the self-reported health status questions (N=90).

Finally, in terms of technology, the mean score of the participants' attitude towards technology was 4.4 (SD=1.1), a neutral attitude towards technology. The participants perceived their computer skills as high experienced (M=26.8; SD=3.8). 64.4% of the participants was neutral towards the expected usefulness of Stranded, 34.4% was positive, and 1.1% was negative. 90.0% of the participants was neutral towards the expected ease of use of Stranded, 6.7% was positive, and 3.3% was negative. 53.3% of the participants had on beforehand an intention to use Stranded, 45.6% was neutral, and 1.1% had no intention to use it.

Use of Stranded

During the first week, 90 participants used Stranded. In the last week, 41 participants used Stranded (54.4% dropped out). The average number of times users logged in was lowest in the first week; 4.5 times (SD=2.7), and highest in the third week; 5.8 times (SD=5.1). Table 2.2 gives an overview of times and duration of the logins.

Thirty-six participants of the forty-nine drop-outs, gave a reason for dropping out. The main reason they gave was 'I do not have enough time' (N=14) due to several causes of which the most common were: events in the family (N=3), busy with work (N=2), busy with caregiving (N=2). Another reason participants gave multiple times was that they did not like Stranded (N=7).

Table 2.2. Use data of total system: number of participants logged in per week, average (SD), min and max times of use per week, and average (SD), min and max duration in minutes per log in per week.

Week number	Total number of participants that logged in	Average (SD) times of logins per week	Range min-max times of logins	Average (SD) duration in minutes per log in	Range min-max duration in minutes per log in
Week 1	90	4.5 (2.7)	1-13	40.2 (22.9)	3-133
Week 2	61	5.0 (3.7)	1-18	46.7 (23.2)	4-112
Week 3	48	5.8 (5.1)	1-31	44.1 (23.5)	2-125
Week 4	41	5.7 (3.4)	1-20	41.3 (22.8)	7-104

Survival Analysis

The Kaplan-Meier curve (Figure 2.6) shows the participants' time to drop-out. The biggest drop in the curve was after one day. Half of the population was dropped out at 16 days (the median survival time).

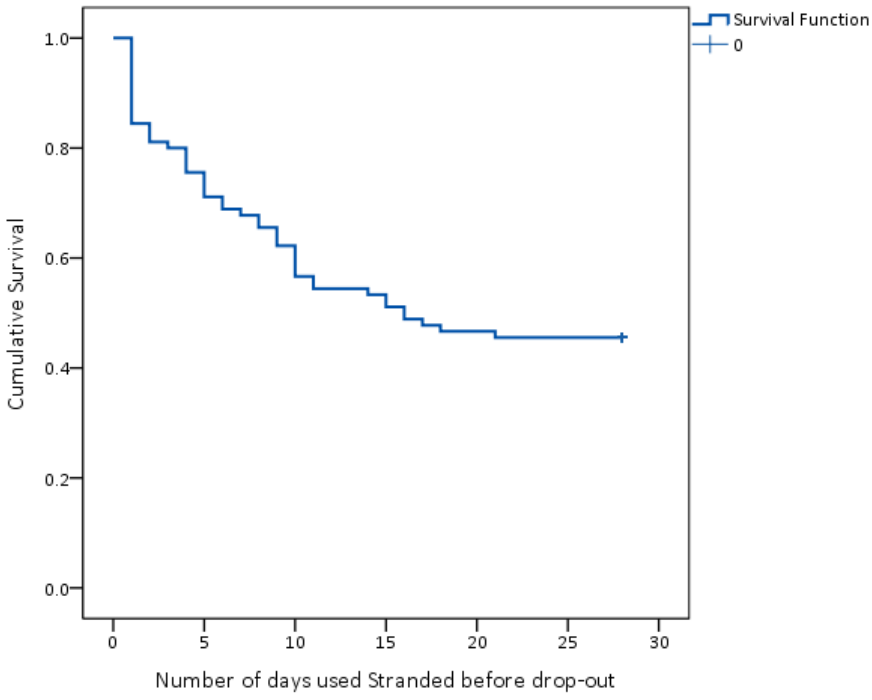

Figure 2.6. Time to drop-out shown in a Kaplan-Meijer curve (N=90).

To have a model to predict drop-out in eHealth evaluations, all demographics were used in univariate Cox-regression analyses. These regression analyses showed four demographics (age, educational level, care involvement, and perceived computer skills) and two personal motivation types (external regulation, and a-motivation) that influenced the event of dropping out. These demographics and personal motivation types were used in the multivariate Cox-regression, which showed that only two variables remained in the predictive model: perceived computer skills and level of external regulation to live healthy. Table 2.3 shows the statistics of both regression analyses.

To explain the hazard ratios (likelihood of dropping out if a model's variable increases by one unit (Zwiener et al., 2011)) in the final model, we will use example values of perceived computer skills and level of external regulation. Firstly, the better someone perceives his/her computer skills, the less likely (s)/he will drop out. A person with a score of 20 is, at each point in time, 31% less likely to drop out than the person with a score of 15 (HR=0.69, CI=0.49-0.99, P=.04, N=90). Secondly, the higher someone's external regulation is, the more likely (s)/he will drop out. A person with a score of 4 is, at each point in time, 28% more likely to drop out than a person that scored 3 on external regulation (HR=1.28, CI=1.04-1.57, P=.02, N=90).

The model fit (assessed by the C-statistic) was 0.62. Given the fact that this C-statistic is derived from a model with two antecedents (perceived computer skills and external regulation), the predictive ability of the multivariate Cox-regression model can be considered high.

Table 2.3. Significant demographics in the univariate Cox-regression and multivariate Cox-regression (N=90).

Demo-graphics	Sub-category	Univariate Cox-regression			Multivariate Cox-regression		
		Hazard Ratio	*95% CI*	*P-value*	*Hazard Ratio*	*95% CI*	*P-value*
Age		1.03	1.00-1.07	.06	-	-	-
Educational level				.04	-	-	-
	Preparatory secondary vocational education	1.89	0.96-3.70		-	-	-
	Higher general secondary education, pre-university education	0.72	0.36-1.43		-	-	-
	Higher vocational education, university	1.00	1.00		-	-	-
Care involvement[a]		1.82	0.91-3.66	.09	-	-	-
Perceived computer skills[b]		0.67	0.47-0.95	.03	0.69	0.48-0.98	.04
External regulation		1.30	1.05-1.60	.02	1.28	1.04-1.57	.02
A-motivation		1.26	0.99-1.59	.06	-	-	-

[a] The reference for care involvement is yes

[b] Perceived computer skills was calculated with units of 5

Influence of predictors on drop-out time

We tested whether level of perceived computer skills and level of external regulation, differed among the early drop-out group, late drop-out group and finished group. The median drop-out split showed that the early drop-out group consisted of participants that dropped out between day 1 and 5, and the late drop-out group between day 6 and 28. Figures 2.7 and 2.8 show the box plots of the score distributions for the two predictors among the three groups. From Figure 2.7, we see that in all three groups most participants perceived themselves as highly experienced with computers. In Figure 2.8 we see, in all groups, a wide range in the distribution of the level of external regulation to live healthy. The late drop-out group had the highest level of external regulation to live healthy.

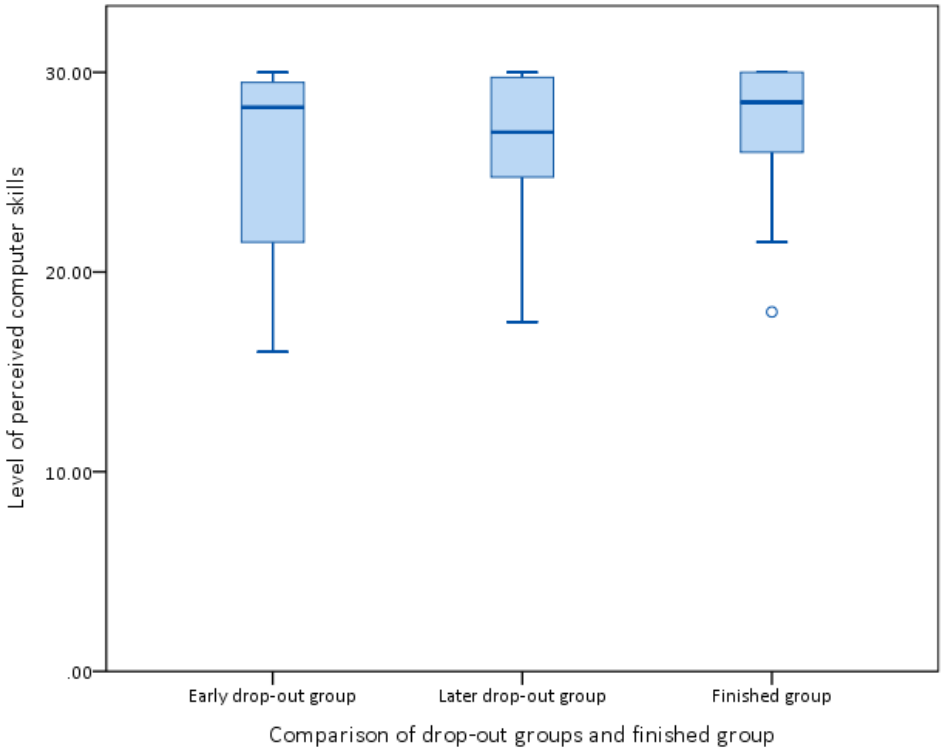

Figure 2.7. Box plots of the scores on perceived computer skills in three groups.

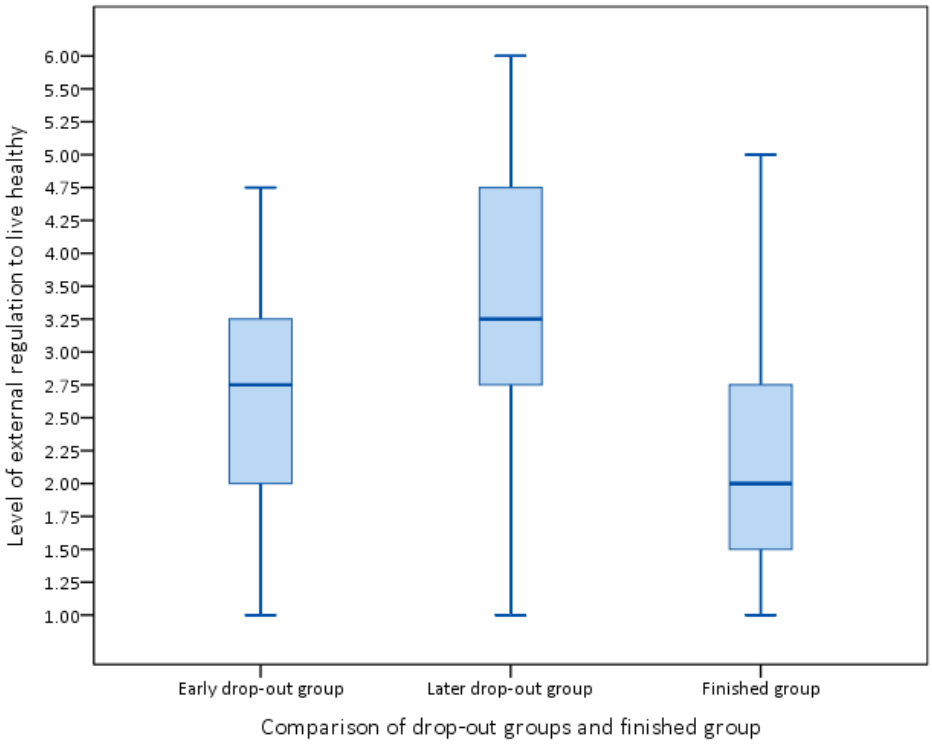

Figure 2.8. Box plots of the scores on level of external regulation in three groups.

The one-way ANOVA shows a significant difference in level of someone's external regulation to live healthy among the early drop-out group (N=26), the late drop-out group (N=23), and the finished group (N=41) (F=7.598, P=.001). Older adults in the late drop-out group had, on average, the highest level of external regulation (M=3.38, SD=1.35), and older adults in the finished group had the lowest level of external regulation (M=2.24, SD=1.08). Older adults in the early drop-out group had a mean level of external regulation of 2.67 (SD=0.98). From the post-hoc comparisons according to the Holm-Bonferroni correction, we see that between two groups there is a significant difference (P=.001): the late drop-out group and finished group. 14.9% of the differences in the level of external regulation to live healthy can be explained by the time of drop-out (η^2=0.149). No significant difference was found in the mean level of perceived computer skills among the three groups.

Discussion

This study aimed to identify demographics and personal motivation types that predict dropping out of an eHealth intervention among community-dwelling older adults. We studied this by observing drop-out when using a web-based, gamified fall prevention training. We found two variables that are part of our predictive model: perceived computer skills and external regulation. The higher an older adult perceives his/her computer skills, the less likely (s)/he will drop out, and when an older adult's motivation to live healthy is externally regulated, it is more likely (s)/he will drop out. Additionally, a high C-statistic was found. This means that by knowing an older adult's perceived computer skills and level of external regulation to live healthy, we will be able to predict with high confidence level whether (s)/he will drop out when using a web-based intervention. Furthermore, we found that participants that dropped out between day 6 and 28 were more externally regulated to live healthy than participants who finished the intervention. Which means that older adults that score moderate/high on level of external regulation, start an eHealth intervention, but after a couple of days they drop out. For perceived computer skills, no differences were found in time of dropping out. Which means that the level of perceived computer skills can predict whether older adults will drop out, but there is no difference in when they will drop out. Finally, we found that a lot of demographics and personality traits were not predictive for dropping out.

To the best of our knowledge, this study is the first study that aimed at creating a predictive model for drop-out in eHealth use consisting of demographics among older adults. When looking at other studies which identified factors that are related to drop-out, we see that a review study (Perski et al., 2017) found both motivation and computer skills to be associated with drop-out. However, motivation was interpreted differently here. The studies included in their review interpreted motivation as how motivated a person is to achieve a goal (e.g. eating more fruit/vegetables, stop smoking) (Perski et al., 2017). Motivation as a factor influencing drop-out has also been found in another study which aimed to explore drop-out in adults with mild to moderate stress and anxiety symptoms (Alfonsson et al., 2016). However, in that study, motivation was purely measured as intrinsic motivation. In our study, intrinsic motivation did not appear to be a predictor for dropping out of an eHealth intervention. Alfonsson and colleagues (2016) found that motivation did not predict drop-out in the first week of a four week web-based intervention. In our study, we also found that motivation, although it was not intrinsic motivation but external regulation had more influence in the late drop-out group.

The predictors for dropping out, in terms of demographics, that we identified contradict the outcomes of previous studies. In our study, gender, age, educational level and employment status were not identified as relevant predictors for dropping out of an

eHealth intervention, while other studies did (Carpenter et al., 2012; Kannisto et al., 2017; Karyotaki et al., 2015; Pedersen et al., 2019; Perski et al., 2017; Van der Mispel et al., 2017). Explanations for the contradictory outcomes could be the different study populations included, different type of eHealth interventions used, lack of power, and differences in data analyses methods. The discrepancy found implicates that in future eHealth research, we should not directly assume that factors like age, gender, and educational level cause drop-out.

Limitations

Due to the relatively small sample size (N=90), fewer variables could be included in the multivariate Cox-regression and no backward deletion method could be used. The antecedents of dropping out that we identified, however, did have a very high explanatory value. Therefore, we do not think this affected the value of our statistical analyses. Second, in this study, selection bias was present. Participants contacted the researcher themselves to participate in this study. So, the participants could be more committed to finish the study, and the participants could be already more motivated to live healthy. Third, in this study, external influences, like seasonal influences or family-related issues, were not included in our analyses, while these could have influenced the drop-out rate.

A question that might arise is whether we investigated drop-out in using an eHealth intervention or drop-out in participating in eHealth research. This question is highly related to people's motivation to participate. In literature, a wide range of motivations are reported why people participate in health research, like participating to improve health care for future patients (Slegers et al., 2015; Soule et al., 2016; Tolmie et al., 2004; Townsend & Cox, 2013), having a personal interest in a research question or being curious about research (Soule et al., 2016; Tolmie et al., 2004; Townsend & Cox, 2013), and getting paid for it or receiving an incentive (Slegers et al., 2015; Soule et al., 2016; Townsend & Cox, 2013). Motivations to participate in eHealth research might overlap, and the same holds for reasons to drop out from research or using an eHealth intervention as an actual patient. To disentangle the two is extremely hard, if possible at all. Future research might address this issue by questioning participants about their reasons to participate in the study and their reasons for using the intervention. However, it is doubtful whether people are able to make this conceptual distinction.

Conclusions

The level of perceived computer skills and level of external regulation to live healthy (a form of personal motivation, triggered by external rewards) can predict whether eHealth users will stop using an eHealth intervention. The influence of external regulation on drop-out is highest in a later stage of an intervention. With our results, we can conclude that in order to maximise adherence to eHealth in practice, first one has to either make sure that an older adult has sufficient digital skills and is aware about this, or has to improve these skills and self-efficacy. Second, to maximise adherence, the functional design of the eHealth intervention can be attuned following the principles of persuasive design. Adherence to the eHealth intervention for older adults with high level of external regulation can be improved by offering users the option to set personal goals, giving users compliments, and educating users about personal health (van Velsen et al., 2019).

Acknowledgements

This work was supported by the FRAIL project funded by Eurostars-2 Programme (Grant no. 10824). The authors would like to thank Boris van Schooten and Silke ter Stal for their valuable help of developing the Stranded application, and Job van der Palen and Marjolein Brusse-Keizer for their help with the statistics.


"I probably do not belong to
the target group yet. However, I do think that this
eHealth service could be helpful when I get older and my
mental and physical condition deteriorate. With that in mind,
I think it is a good initiative and I would recommend it.
I appreciate the programme, but I do not feel physically
challenged enough yet with the island and the
minigames, but that may change in
10 years or so."

3

Explaining older adults' use and intention to continue using a gamified eHealth service

Based on:
Hurmuz, M.Z.M., Jansen-Kosterink, S.M., Hermens, H.J., van Velsen, L. Game not over: Explaining older adults' use and intention to continue using a gamified eHealth service. *(accepted with revisions).*

Abstract

Background: Gamification within eHealth services can increase eHealth adoption. However, little is known about factors affecting adoption of gamified eHealth among older adults. In this study, we sought to explain the (continued) use of a gamified eHealth service among older adults (55+).

Methods: Participants used a gamified eHealth service, focusing on falls prevention, for four weeks and completed a post-test questionnaire based on the Technology Acceptance Model. We used Partial Least Squares Structural Equation Modelling to analyse our data.

Results: Seventy-two older adults participated with a mean age of 65.1 years (SD=7.0). Our results show that first, perceived ease of use affected use of the service (use duration: β=0.303, R2=0.130, and use frequency: β=0.304, R2=0.107). Second, perceived usefulness affected the intention to continue using the service (β=0.754, R2=0.640). Third, use of the service did not predict the intention to continue using it. Furthermore, enjoyment affected perceived usefulness (β=0.783, R2=0.563) and aesthetics affected perceived ease of use (β=0.634, R2=0.652).

Conclusions: This study refutes the expected relation between use and intention to continue use a gamified eHealth service. Additionally, we learned that using theoretical approaches focusing on technology acceptance, are not suitable for explaining (continued) use of gamified eHealth services.

Introduction

Gamified eHealth services can be a means to improve users' engagement with eHealth services (Christie et al., 2019; Lee et al., 2017; Sardi et al., 2017). Since 2010, gamification (defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011)) started to emerge in eHealth services (Sardi et al., 2017). Randomised Controlled Trials (RCTs) have shown that the target population used eHealth services more and dropped out less often when the eHealth service included gamified elements compared to non-gamified counterparts (e.g. (Allam et al., 2015; Litvin et al., 2020)). Furthermore, a recent meta-analysis showed that gamified eHealth services focusing on physical activity were more effective in improving one's physical activity compared to non-gamified eHealth services (Mazeas et al., 2022). These studies suggest that gamified eHealth services might be a solution to tackling the high drop-out rates among eHealth users, which could, in turn, could improve the effectiveness of the service.

For older adults, eHealth has great potential. It can be part of ensuring older adults to live longer at home, to manage their own health, and to increase their health literacy (Alvarez, 2002; Bujnowska-Fedak & Grata-Borkowska, 2015; Jaana et al., 2019; Jacobs et al., 2016; Sanyal et al., 2018; Ware et al., 2017). Looking at gamified eHealth services for older adults, these are mostly used in their home environment, and most of these type of eHealth services focus on users' physical health (Martinho et al., 2020). In rehabilitation care, it is very common to use gamified eHealth services (Tuah et al., 2021). A review study by Skjæret and colleagues (2016) investigated the use of gamified eHealth in rehabilitation care for older adults. They found contrasting evidence towards the adherence to the therapy. In some studies, participants in the gamified group adhered better to the therapy compared to the control group (offline therapy), and in others they did not find a difference.

Looking more closely at literature focussing on gamified eHealth services, lots of studies report the design process of the service or explain the service itself (e.g. (Christie et al., 2019; Davaris et al., 2021; Tolks et al., 2019)). The amount of literature available about gamified eHealth service shows us that gamification within eHealth is an acceptable concept. However, to the best of our knowledge, no study is conducted to uncover antecedents of the intention to continue use a gamified eHealth service among older adults. Most of the studies involving older adults exploratively assess users' opinions towards these services. For example, Minge and colleagues (2014) conducted focus groups and concluded that older adults are positive towards gamified eHealth services. In other studies that looked at the feasibility of gamified eHealth, older adults were also positive towards the gamified eHealth service: they enjoyed using it (Nakai et al., 2013; Pyae et al., 2016). However, if such a service loses its seriousness (e.g. because of too

many fun, useless elements), older adults consider these services as less helpful (Minge et al., 2014). Investigating studies involving younger adults, we can hypothesise that ease of use, enjoyment, attitude (Hamari & Koivisto, 2015a) and social influence (Hamari & Koivisto, 2015b) positively affect the continued use of a gamified exercise service, and usefulness and playfulness indirectly affect the continued use (via attitude).

Knowing the antecedents of older adults' intention to continue use a gamified eHealth service provides developers and researchers guidance when developing, evaluating and implementing gamified eHealth services. This allows for a better fit between the gamified eHealth service and older adults, which, in turn, leads to increased engagement with the service (Kayser et al., 2015). Building forth on the Technology Acceptance Model (Davis, 1986; Davis et al., 1989) we conducted a study to identify these antecedents and to explain the use and the intention for continued use of a gamified eHealth service among older adults.

Method

Participants and Study Procedure

The study population consisted of older adults aging 55 years or older speaking Dutch, with access to a computer, laptop or tablet. We recruited participants through mass mailing, advertisements in local newspapers, physical therapists and snowball sampling. Older adults who wanted to participate, contacted the researcher, after which the researcher checked the inclusion criteria. After inclusion, participants completed a pre-test questionnaire consisting of demographics. Then, they received access to the gamified eHealth service from the researcher, and they used it for four weeks. The participants received a manual from the researcher with instructions how to use the service. Finally, they completed a post-test questionnaire consisting of the antecedents for adoption.

Intervention: a Gamified eHealth Service

The gamified eHealth service that the older adults used was called Stranded (see Figure 3.1). Stranded is an online environment in the form of a deserted island and consists of two parts: a falls prevention program and minigames. Older adults were involved during the development of this eHealth service (Noorman-de Vette, 2019). When logging in into the eHealth service, the service shows the user how the protagonist ended up on a deserted island. The user plays with the protagonist and can help her to leave the island by performing physical exercises and completing minigames. When a user opens his/her training programme, a secondary window is opened in which the program is provided in the form of exercises shown via video, instructed via sound, and explained by text. The physical exercises are part of the OTAGO falls prevention Programme (Campbell &

Robertson, 2003). The program consists of three weekly sessions with a warming-up, training exercises, and a cooling-down. Previous studies evaluated the OTAGO programme positively (Benavent-Caballer et al., 2016; Thomas et al., 2010), also in an online setting (Dekker-van Weering et al., 2017). The minigames within this eHealth service are cognitive minigames (i.e., mind games to activate the brain) and were unlocked after participants completed their exercises, as a reward. The first minigame unlocked after completing the first training session, and from the remaining minigames, each minigame unlocked after completing 3 training sessions. In this eHealth service, the following four motivational affordances (Hamari et al., 2014) from the gamification movement are incorporated: A story (there is a story on how the protagonist ended up on a deserted island, and how the user can build a boat to leave the island), rewards (by completing the physical exercises, users can unlock minigames as a reward), levels (the minigames have difficulty levels), and progress (when completing minigames the user earns boat parts to leave the island).

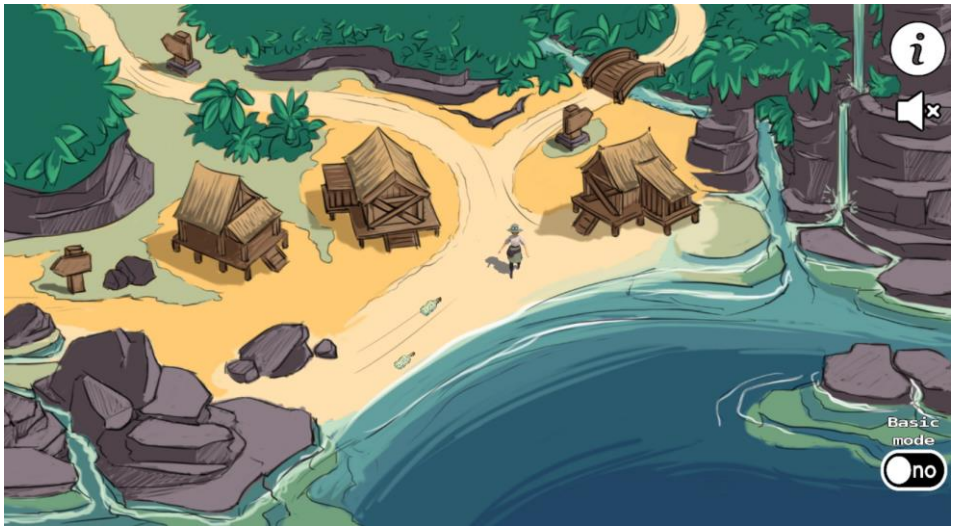

Figure 3.1. Screenshot of the homepage of Stranded.

Research Model and Questionnaire

The gamified elements included within Stranded, are subordinate to the physical exercise module. Therefore, we used the Technology Acceptance Model (TAM) (Davis, 1986; Davis et al., 1989) to investigate the use and intention to continue use, rather than a model focusing on assessing the gaming experience (like the theory of Core Elements of the Gaming Experience (CEGE) (Calvillo-Gámez et al., 2010)). Furthermore, previous literature on the use of digital games with an educational meaning among older adults

also showed that these applications need to be easy to use and useful (Sauvé et al., 2015), which are included in the TAM as well. From the existing theoretical approaches which are being used in explaining eHealth acceptance, we decided to use the TAM due to pragmatic reasons: only three constructs and no sample size power issues. We did expand the TAM with some additional variables that predict the core variables ease of use and perceived usefulness, in order to increase the model's explanatory power.

The additional variables we included were enjoyment, aesthetics and control. It has been found that enjoyment of a digital game was a strong predictor for older adults to play a game (again) (Kaufman et al., 2014; Khalili-Mahani et al., 2020; Schutter & Malliet, 2014). Multiple studies found that aesthetics of a serious game or gamified eHealth service influence older adults' use of the technology (Khalili-Mahani, De Schutter, et al., 2020; Vaziri et al., 2016). Khalili-Mahani and colleagues (2020) found that aesthetics are important; too intense aesthetics (i.e. a confusing and distracting appearance) of a serious game, led to more frustrations among older adults during use of the game. Finally, control increases older adults belief to acquire the habit to play the serious game, which affects the adoption of the eHealth service (Brauner et al., 2015). All together, we think that enjoyment of a gamified eHealth positively influences its perceived usefulness, and aesthetics and control influence its perceived ease of use.

The factors mentioned above are all included in the research model defined (see Figure 3.2). Additionally, we included use of the gamified eHealth service in our causal model. A lot of studies using the TAM, assess the intention to use as proxy for use. As in our study older adults used the service for four weeks, we had access to use data and had the opportunity to include it in our model. There are two use constructs in our model, one measures the total duration in minutes older adults used Stranded, and the second one measures the frequency participants used Stranded, during the 4-week period. These use constructs are measured with system log data.

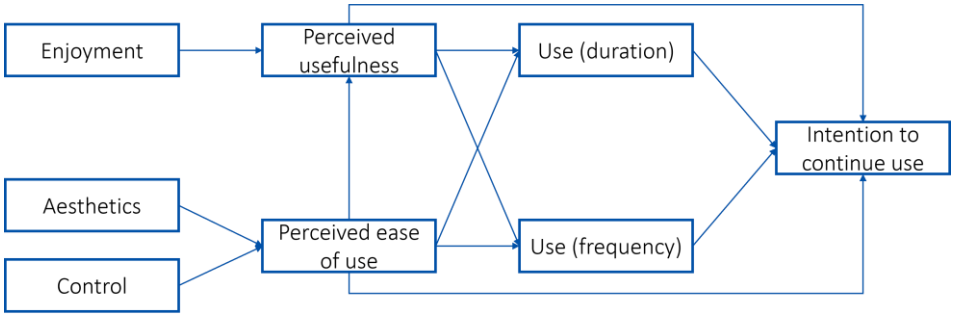

Figure 3.2. The causal model defined.

After using Stranded for four weeks, or after dropping out, participants completed the post-test questionnaire, consisting of the constructs of our research model. All constructs used within this post-test questionnaire and their corresponding items are shown in Table 3.1.

Table 3.1. Constructs and items used in our post-test questionnaire.

Construct	Item	Statement	Scale	Reference
Enjoyment	enjoy_1	Stranded was [disgusting – enjoyable]	1 – 7	(Van der Heijden, 2004)
	enjoy_2	Stranded was [dull – exciting]	1 – 7	
	enjoy_3	Stranded was [unpleasant – pleasant]	1 – 7	
	enjoy_4	Stranded was [boring – interesting]	1 – 7	
Aesthetics	aesth_1	Stranded looks clean	1 – 7	(Lavie & Tractinsky, 2004)
	aesth_2	Stranded looks clear	1 – 7	
	aesth_3	Stranded looks pleasant	1 – 7	
	aesth_4	Stranded looks original	1 – 7	
	aesth_5	Stranded looks creative	1 – 7	
Control	control_1	I have a lot of control over what I can do on Stranded	1 – 7	(Liu, 2003; van Velsen et al., 2015)
	control_2	On Stranded, I can choose freely what I want to see	1 – 7	
	control_3	I can determine for myself what happens on Stranded	1 – 7	
Perceived usefulness	useful_1	Using Stranded helps me understand my physical condition	1 – 7	(Davis, 1989)
	useful_2	Using Stranded improves my physical condition	1 – 7	
	useful_3	Using Stranded improves my health	1 – 7	
	useful_4	Using Stranded gives me insight in my health	1 – 7	

Table 3.1. Constructs and items used in our post-test questionnaire. (continued)

Construct	Item	Statement	Scale	Reference
Perceived ease of use	ease_1	It is clear and understandable how I can work with Stranded	1 – 7	(Davis, 1989)
	ease_2	I do not have to think hard when working with Stranded	1 – 7	
	ease_3	I find Stranded easy to use	1 – 7	
	ease_4	I find it easy to get Stranded to do what I want it to do	1 – 7	
Intention to continue use	intent_1	If Stranded would be available for me, I would definitely use it	1 – 7	(Davis et al., 1989; Gefen et al., 2003; van Velsen et al., 2015)
	intent_2	I would recommend Stranded to others	1 – 7	
	intent_3	I hope Stranded becomes available to me.	1 – 7	

Data Analyses

Descriptives were calculated for participant demographics, use of Stranded, and questionnaire constructs (means, standard deviations) in SPSS (version 19). We used Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS 3.0 (Ringle et al., 2015) to test the research model. The maximum number of constructs influencing another construct is 4. So, the minimum sample size needed for analysing our model is 41 participants, based on a statistical power of 80%, significance level of 5% and a minimum R^2 of 0.25 (Hair et al., 2014). For the model validation we used reflective and formative measurement models to optimise and assess the quality of our model. We started with the reflective measurement model. With this we assessed the indicator reliability (outer loadings) and discriminant validity (cross loadings) of the items, the internal consistency reliability of the constructs (Cronbach's alpha and composite reliability), and the convergent validity (Average Variance Extracted (AVE)). Then we continued with the formative measurement model to assess the level of collinearity between items (Variance Inflation Factor (VIF) values), relative importance of indicators (outer weights), and absolute importance of indicators (outer loadings). After these steps, we determined our formative causal model, with which we determined the path coefficients (β), the model's predictive power (R^2), and effect sizes (f^2). For all bootstrapping procedures we used 5,000 subsamples.

Ethical Considerations

We conducted this study according to the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013). For this study, we did not require formal medical ethical approval according to the Medical Ethical Committee Arnhem-Nijmegen (file number: 2019-5296). Each participant signed an informed consent form beforehand.

Results

Demographics

In total, 72 older adults participated in this study, of which the majority was female (65.3%). The mean age of the study population was 65.1 years of age (SD=7.0). The youngest adult was 55 years of age, and the oldest adult was 89 years of age. Table 3.2 shows all the demographics of the population.

Table 3.2. Demographics of study population (N=72).

Demographics		% or M (SD)
Gender (%)	Male	34.7%
	Female	65.3%
Age (M (SD))		65.1 (7.0)
Level of education (%)	Preparatory secondary vocational education	13.9%
	Higher general secondary education, pre-university education	38.9%
	Higher vocational education, university	47.2%
Living situation (%)	Alone	31.9%
	Married/living together	65.3%
	Other situation	2.8%
Employment status (%)	Employed	31.9%
	Volunteer/caregiver	9.7%
	Retired	43.1%
	Job seeker	2.8%
	Other	12.5%

User Experience

Regarding the post-test questionnaire, all constructs scored above the average. Participants were most positive about Stranded's aesthetics (M=4.7, SD=1.3, N=72). In the box plot of Figure 3.3 we see that in all constructs there is a wide range in the

distribution of participants' user experience with Stranded, and the medians of the constructs lie between 4.0 and 5.0.

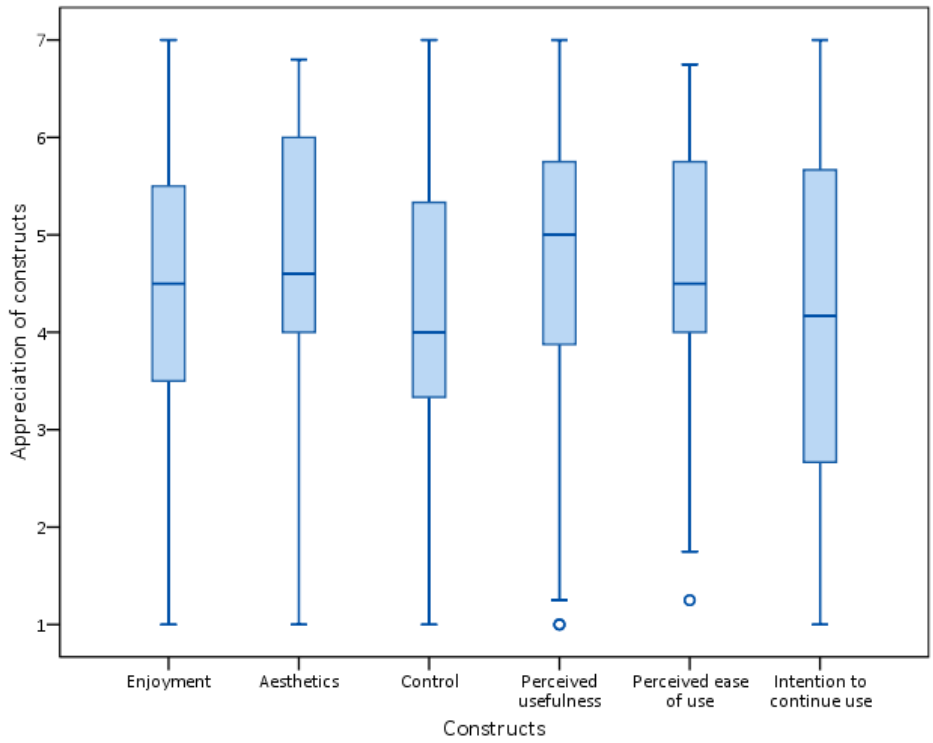

Figure 3.3. Box plot user experience domains measured on a scale from 1 (negative) to 7 (positive) (N=72).

Use Data

During the first week of the study, 72 older adults used Stranded, and in the last week 51. On average, participants used Stranded 17.1 times (SD=12.9) during the study period, with a range from 1 time to 74 times. The mean duration participants spent on the Stranded platform was 764 minutes and 52 seconds (SD=678 minutes and 47 seconds). The minimum duration spent on the platform was 5 minutes, and the maximum was 3463 minutes (57 hours, 43 minutes). On average, one session lasted 42 minutes and 22 seconds (SD=20 minutes and 43 seconds).

Model Validation

First, we checked the outer loading of each item. All outer loadings were above the threshold of 0.7, so we did not remove items from our model at this stage. The next step in assessing the quality of the items was determining the items' cross loadings. These

values determine the discriminant validity of the items. The loading of an item belonging to the corresponding latent variable, needs to be higher than the loading of that item with other latent variables. Table 3.3 shows the cross loadings. We see that all bold values are higher than the values in the same row, so this provides evidence for the latent variables' discriminant validity.

Table 3.3. Cross loadings of each item measured in a reflective measurement model.

Items	Enjoyment	Aesthetics	Control	Perceived usefulness	Perceived ease of use	Use duration	Use frequency	Intention to continue use
enjoy_1	**0.896**	0.709	0.441	0.661	0.427	0.311	0.229	0.721
enjoy_2	**0.895**	0.569	0.303	0.589	0.222	0.228	0.116	0.565
enjoy_3	**0.916**	0.675	0.418	0.508	0.507	0.283	0.257	0.649
enjoy_4	**0.903**	0.586	0.344	0.612	0.216	0.281	0.201	0.613
aesth_1	0.620	**0.886**	0.392	0.483	0.365	0.110	0.036	0.598
aesth_2	0.560	**0.844**	0.520	0.245	0.729	0.239	0.194	0.475
aesth_3	0.722	**0.924**	0.526	0.465	0.593	0.208	0.149	0.626
aesth_4	0.564	**0.827**	0.400	0.549	0.387	0.073	0.018	0.608
aesth_5	0.611	**0.868**	0.466	0.511	0.339	0.136	0.052	0.558
control_1	0.311	0.480	**0.892**	0.041	0.574	0.047	0.020	0.129
control_2	0.390	0.523	**0.879**	0.043	0.522	0.211	0.135	0.167
control_3	0.422	0.400	**0.863**	0.192	0.479	0.084	0.002	0.132
useful_1	0.517	0.350	0.089	**0.891**	0.060	0.194	0.087	0.620
useful_2	0.697	0.559	0.105	**0.925**	0.114	0.216	0.151	0.739
useful_3	0.631	0.549	0.065	**0.930**	0.094	0.130	0.037	0.736
useful_4	0.518	0.361	0.115	**0.888**	0.108	0.124	0.041	0.626
ease_1	0.338	0.528	0.490	0.057	**0.895**	0.297	0.292	0.263
ease_2	0.166	0.329	0.316	0.005	**0.813**	0.015	0.038	0.211
ease_3	0.420	0.578	0.501	0.101	**0.906**	0.169	0.180	0.305
ease_4	0.333	0.434	0.670	0.163	**0.785**	0.028	0.001	0.198
intent_1	0.678	0.594	0.101	0.777	0.233	0.247	0.161	**0.970**
intent_2	0.699	0.691	0.202	0.675	0.352	0.121	0.084	**0.938**
intent_3	0.679	0.620	0.169	0.718	0.265	0.303	0.240	**0.975**

Finally, we assessed the internal consistency reliability of the constructs in our reflective measurement model with the Cronbach's alpha and composite reliability, and the convergent validity of the constructs with the AVE score. The threshold for the Cronbach's alpha and composite reliability is 0.70, and the threshold for the AVE score is 0.50. All constructs scored above those thresholds (see Table 3.4). Regarding the Cronbach's alpha and composite reliability, the constructs have a good or excellent

internal consistency. Regarding the AVE scores, the constructs have high levels of convergent validity.

Table 3.4. Internal consistency reliability of the constructs (Cronbach's alpha and composite reliability), and convergent validity (AVE).

Multi-item constructs	Cronbach's alpha	Composite reliability	AVE
Enjoyment	0.924	0.946	0.814
Aesthetics	0.920	0.940	0.758
Control	0.852	0.910	0.771
Perceived usefulness	0.930	0.950	0.826
Perceived ease of use	0.874	0.913	0.725
Intention to continue use	0.959	0.973	0.924

We then switched from a reflective measurement model to a formative measurement model to further assess and optimise the model. By assessing the Variance Inflation Factor (VIF) values, we checked for multicollinearity. A VIF value of 5.00 or higher, indicates multicollinearity. Five items had an outer VIF value higher than 5.00. First of all, item 3 of the aesthetics construct had an outer VIF value of 5.147. The question belonging to this item ("*Stranded looks pleasant*"), is equivalent to item 3 of the enjoyment construct ("*Stranded was [unpleasant – pleasant]*"), so we deleted item 3 of the aesthetics construct. Two items (item 2 and 3) belonging to the perceived usefulness construct had an outer VIF value of 5.907 and 6.22 resp. The questions of these items are "*Using Stranded improves my physical condition*" (item 2), and "*Using Stranded improves my health*" (item 3). These questions resemble each other, but because the VIF values are still beneath 10.00, so still acceptable (Benitez-Amado et al., 2017), we did not delete these. The same applies for item 1 ("If Stranded would be available for me, I would definitely use it") and item 3 ("I hope Stranded becomes available to me") of the intention to continue use construct, that had outer VIF values of 8.794 and 9.847 resp. Looking at the inner VIF values, no values were above 5.00.

The last step in assessing our model and before determining the causal model, is assessing the significance and relevance of the formative items, with outer weights and outer loadings. To assess this, we ran a complete bootstrap procedure with 5,000 subsamples. Four outer weights were significant ($p<0.05$) and stayed in the model. All other items did not have a significant outer weight, but looking at the outer loadings, all items, except for one (item 2 of perceived ease of use), had a loading of 0.5 or higher. So these items were absolutely important, even though they were not relatively important, and could stay in the model. Item 2 of perceived ease of use had an outer loading of

0.472, but the p-value showed that it was significant (p=0.015). So we also retained this item in the model.

Causal Model

Figure 3.4 shows our causal model. Five path coefficients were significant. Of these significant relations, we determined the effect sizes (f^2). The effect size of the relation between perceived usefulness and intention to continue use was 1.498 (large effect size), between enjoyment and perceived usefulness was 1.25 (large effect size), between aesthetics and perceived ease of use was 0.794 (large effect size), between perceived ease of use and use in duration was 0.104 (small effect size), and between perceived ease of use and use in frequency was 0.102 (small effect size).

Despite those five significant path coefficients, our model also shows six insignificant path coefficients, which were not expected. Especially the following findings: perceived usefulness did not affect use, perceived ease of use did not affect intention to continue use, and use did not affect intention to continue use. These path coefficients and effect sizes were really small (β from -0.075 until 0.176, and f^2 from 0.004 until 0.076), so even if they were significant, the effects of these factors would be low.

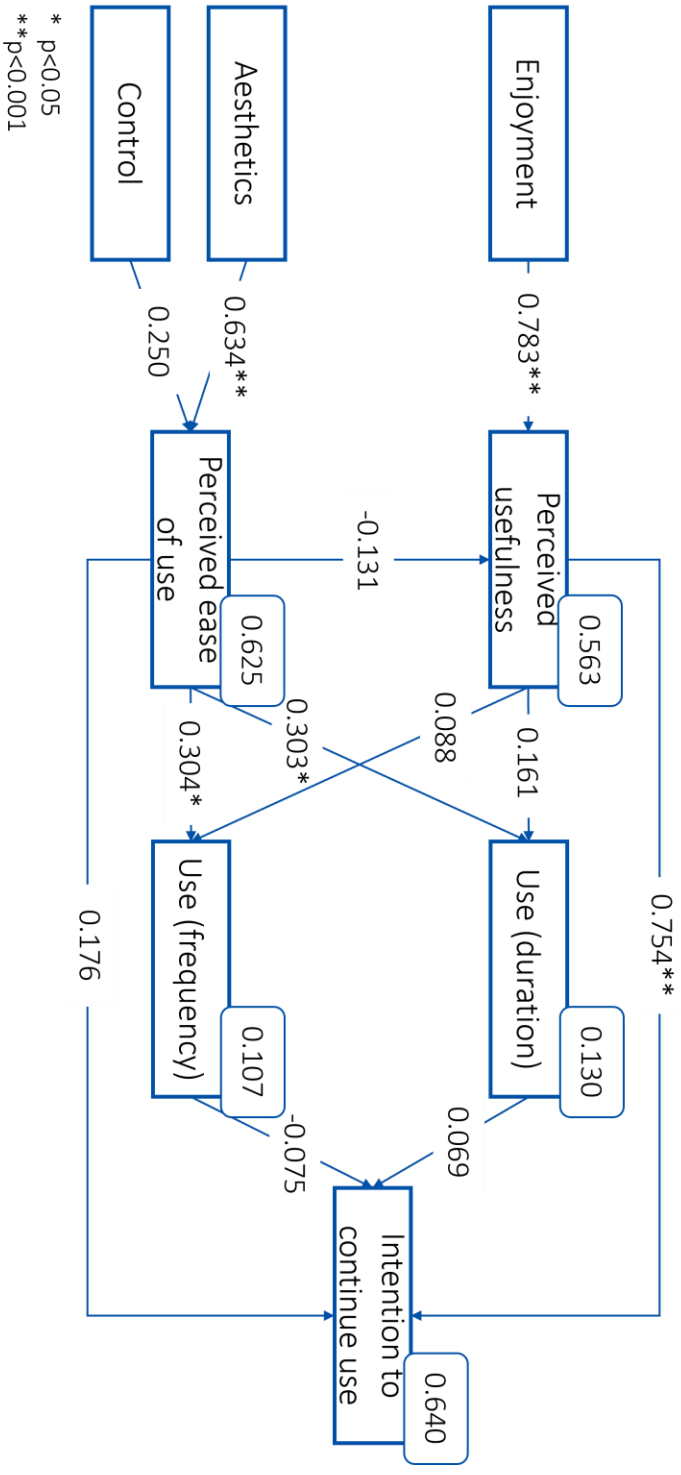

Figure 3.4. Causal model.

Discussion

With this study we aimed to explain the use of and intention to continue using a gamified eHealth service for older adults (in this study, a gamified falls prevention program, supplemented by cognitive minigames: Stranded). The majority of the older adults used the eHealth service for a period of four weeks and multiple times per week. A striking finding is that how often and how long older adults used Stranded did not affect their intention to continue using it. For this type of eHealth, aesthetics affect the perceived ease of use, while control does not. Enjoyment affects the perceived usefulness. Use, in terms of duration and the number of log ins, is predicted only by perceived ease of use. Our model has a high explanatory power for the intention to continue using the service.

We did not expect the lack of a relation between the use parameters and the intention to continue using the gamified eHealth service. On the contrary, given the literature on this topic (Forquer et al., 2014; Li et al., 2020), we expected that short-term use of a gamified eHealth service would be the main predictor for the intention to continue use. Upon reflecting on this issue, we think there are several possible explanations for this lack. First, a methodological explanation. In this study, we looked at two realities. One being the study context in which participants were asked to use the eHealth service and answer questions about its characteristics (e.g., aesthetics, perceived usefulness, etc.), and one being the hypothetical situation in which they would use the technology for their own good beyond the study (i.e., intention to continue use). We think that there is a possibility that a part of the participants were using the eHealth service to, among other reasons, also please the evaluators .The second explanation could be that participants indicated they did not want to continue using the service, because of a lack of novelty, or boredom. The gamified eHealth service does have difficulty levels in the falls prevention programme, and different minigames that can be unlocked. However, eventually, users will not have new content anymore, as the storytelling comes to an end: Building all boat parts, and being able to leave the island. In our study, we merged the use data from the 4-week period in two parameters: the frequency they used it in total, and the minutes they spend interacting with the eHealth service. A previous meta-analysis showed that eHealth apps focusing on improving physical activity is more effective in short-term use. In this meta-analysis, the authors are talking about a period shorter than 3 months (Romeo et al., 2019). However, it could also be the case that in our study the novelty and excitement were mostly present in the first two weeks. Mazeas and colleagues (2022) also suggest that users benefit more from short-term use, compared to long-term use. When assessing the influence of previous use on intention to continue use, we propose future research to focus on the evolution of eHealth use over the different weeks, instead of including use parameters which only show the total duration/frequency over all weeks together.

Furthermore, we found that the use of a gamified eHealth service among older adults was only affected by perceived ease of use and not by perceived usefulness. This is in contrast with previous studies on eHealth in general (e.g. (D'Haeseleer et al., 2019; D'Haeseleer et al., 2019; Hardiker & Grant, 2011; Hoogenbosch et al., 2018; Sampa et al., 2020)), and studies on the use of technology and games among older adults in general (e.g. (Kaufman et al., 2020; Roberts et al., 2019; Sauvé et al., 2015; Schutter & Malliet, 2014; Wagner et al., 2010)). Khalili-Mahani and colleagues (2020) found that if the cognitive game is being perceived as enjoyable and useful, older adults are more willing to play the game again, independent of the difficulty. As a result of these studies, we expected that both perceived ease of use and perceived usefulness would influence the use of the eHealth service. An explanation for this could be that the use of a gamified eHealth service among older adults is being influenced by other antecedents than those we expected and included in our model. Looking at our causal model, we see that the influence of perceived ease of use on use is weak, and the predictive powers of use in our model confirm this, which are both weak. As said previously, we think that use in our study was influenced by the fact the older adults were participants of a study. D'haeseleer and colleagues (2020) found that older adults perceive a self-management eHealth service useful, but not for themselves. Perhaps this was also the case in our study, which explains why we found no relation between perceived usefulness and the use parameters, and a weak relation between perceived ease of use and the use parameters. To confirm this, we recommend that future research should focus on reasons why older adults use gamified eHealth services within a study setting, and why they use it beyond the study.

Based on our results, we would like to raise the question whether theoretical approaches, such as TAM (Davis, 1986; Davis et al., 1989), are suitable for measuring gamified eHealth use and intention to continue use gamified eHealth. The TAM is frequently being used in studies focusing on this topic (e.g.(Cho et al., 2015; Hoque, 2016; Hoque et al., 2017; Hoque & Sorwar, 2017; Nawaz et al., 2016; Tavares & Oliveira, 2016)), even though this approach is developed outside the healthcare setting to measure acceptance of general technology. However, as we found multiple relationships lacking (e.g., between perceived usefulness and use, between perceived ease of use and intention to continue use), we place a critical note on the use of this approach. In our opinion, this approach is too simple to address the complexity of eHealth use and intention to continue use eHealth. This shortcoming is also discussed in other papers (Bagozzi, 2008; Shachak et al., 2019). Therefore, we recommend researchers to be cautious when drawing conclusions upon use of and intention to continue use eHealth based on the TAM. This model can be used as a first starting point in studying the use of and intention to continue use the eHealth

service that is in development, but should not be used to reach a final conclusion on these topics.

Strengths and Limitations

Our study is, to the best of our knowledge, the first in explaining antecedents for use and for intention to continue use a gamified eHealth service among older adults. By uncovering these antecedents, researchers and gamified eHealth developers can increase the fit of the service to the users to increase eHealth use and adoption. Furthermore, the predictive power of our research model to identify the antecedents of intention to continue use was substantial. Besides these strengths, this study also has some limitations. First of all, we used self-enrolment to recruit participants; if one was interested in using Stranded, (s)he contacted the researcher. This could have resulted in selection bias and as a result, participants might have been more committed to using the gamified eHealth service. Another limitation of this study is the use of only one gamified eHealth service, which can affect the generalisability of our results. The findings of this study can be generalised to older adults aging 55 years or older using a gamified eHealth service focusing on falls prevention. However, for being able to generalise our results to gamified eHealth services among older adults in general, more research is needed in which the study population uses different gamified eHealth services focusing on other aspects of health (e.g., mental health, nutritional habits). Finally, a sensible and interesting addition to the research model would be the inclusion of end-user motivation, as for example explained by the Self Determination Theory (Deci & Ryan, 2004). Previous research has shown that motivation can be linked to persuasive features in eHealth technology (van Velsen et al., 2019), and thus, it would be a valuable direction for future research.

Concluding remarks

Our intention of this study was to get a better understanding about participants' use of and intention to continue using a gamified eHealth service, and therefore enriching the TAM as a tool to for assessing gamified eHealth acceptance. Instead, we learned that TAM is not the perfect fit for explaining gamified eHealth use and intention to continue use, as the relation between use and intention to continue use is more complex than envisioned beforehand. This disagreement with literature might be caused by our inclusion of system use data. Based on our results, we recommend researchers in the field of gamified eHealth use to focus on 'perceived ease of use' to explain short-term use of a gamified eHealth service, and to focus on 'perceived usefulness' to explain long-term use of a gamified eHealth service.

Acknowledgements

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"The eHealth service
is very simple. You enter the living room,
and you see all kinds of virtual characters
which introduce themselves. I think that this
is especially interesting for people with low
literacy. Just click on the characters and see
how they talk to you: how they gather
information about you, but also
how they make you do things.
It is very suitable."

4

Protocol and results of a case study of a summative eHealth evaluation

4A

Protocol for a summative evaluation of a virtual coaching system eHealth intervention

Based on:
Hurmuz, M.Z.M., Jansen-Kosterink, S.M., op den Akker, H. & Hermens, H. J. (2020). User Experience and Potential Health Effects of a Conversational Agent-Based Electronic Health Intervention: Protocol for an Observational Cohort Study. *JMIR Research Protocols, 9*(4), e16641. doi:10.2196/16641.

Abstract

Background: While the average human life expectancy has increased remarkably, the length of life with chronic conditions has also increased. To limit the occurrence of chronic conditions and comorbidities, it is important to adopt a healthy lifestyle. Within the European project "Council of Coaches," a personalised coaching platform was developed that supports developing and maintaining a healthy lifestyle.

Objective: The primary aim of this study is to assess the user experience with and the use and potential health effects of a fully working Council of Coaches system implemented in a real-world setting among the target population, specifically older adults or adults with type 2 diabetes mellitus or chronic pain.

Methods: An observational cohort study with a pre-test – post-test design will be conducted. The study population will be a dynamic cohort consisting of older adults, aged ≥55 years, as well as adults aged ≥18 years with type 2 diabetes mellitus or chronic pain. Each participant will interact in a fully automated manner with Council of Coaches for 5 to 9 weeks. The primary outcomes are user experience, use of the program, and potential effects (health-related factors). Secondary outcomes include demographics, applicability of the virtual coaches, and user interaction with the virtual coaches.

Results: Recruitment started in December 2019 and is conducted through mass mailing, snowball sampling, and advertisements in newspapers and social media. This study is expected to conclude in August 2020.

Conclusions: The results of this study will either confirm or reject the hypothesis that a group of virtual embodied conversational coaches can keep users engaged over several weeks of interaction and contribute to positive health outcomes.

Introduction

As a result of socioeconomic development and progression in medicine and education, the average human life expectancy has increased significantly (Gulland, 2014; Suzman et al., 2015). However, the aging population has also led to more older adults living with chronic diseases (Suzman et al., 2015; van Oostrom et al., 2016). Although these diseases cannot be cured, their burden on patients can be reduced by adopting a healthy lifestyle (Suzman et al., 2015; Willett et al., 2017; World Health Organization, 2005). To enable adoption of a healthy lifestyle, a deep understanding of personal motivation and the person's economic and social pressures is needed (Bundy, 2004; Kelly & Barker, 2016). Based on these insights, personalised virtual coaching systems have been developed to support lifestyle changes (Kulyk et al., 2014). For these systems, using multiple coaches is more effective than using a single coach because of the potential positive impact of vicarious persuasion as compared with direct persuasion (persuasion of the crowd instead of directly persuading the person) (Kantharaju et al., 2018). This insight has led to the introduction of the Council of Coaches (COUCH), a new concept for virtual coaching (op den Akker et al., 2018).

COUCH comprises a council of 5-6 virtual coaches. These coaches inform and motivate the user and discuss different topics about healthy living (op den Akker et al., 2018). COUCH was developed in collaboration with end users, and the feasibility and usability of some parts of COUCH have already been tested in a lab setting (formative evaluations). The next step is to gain, through a summative evaluation, knowledge on the possible working mechanism and potential added value of this coaching system in a real-world setting among the target population (Jansen-Kosterink et al., 2016). As we do not want to interfere with the ongoing development of COUCH, we decided to develop a mature and simplified version of COUCH ready for testing in a real-world setting. This paper outlines the study protocol for this first test in the real world, which aims to evaluate the user experience with and the use and potential health effects of a fully working COUCH system implemented in a real-world setting among the target population.

Methods

Trial Design

This study protocol strictly follows the CONSORT-eHEALTH checklist (Eysenbach & CONSORT-EHEALTH Group, 2011) for the introduction and methods sections. This study is an observational cohort study with a pre-test – post-test design. It is explorative and evaluative. The participants will be included for at least 5 weeks and up to a maximum of 9 weeks. The first week will consist of the preparation phase. In this phase, baseline measurements will be collected (T0). The following 4 weeks will consist of the

implementation phase (T1). The participants will interact with COUCH during this phase. The last 4 weeks will consist of the facultative follow-up phase (T2). Participants can choose whether they want to interact with COUCH for these additional 4 weeks.

This study will be conducted in 2 countries (the Netherlands and Scotland) and consist of 2 rounds. Each round will include 25 participants per country. During the development phase, the technology and content were tested extensively. Therefore, during this study, we do not expect technical problems. However, if participants encounter minor technical problems during the first round, these problems will be fixed. During both rounds, content will be added to various coaches.

To properly evaluate the effectiveness of technology-supported health services, such as COUCH, in the real world is challenging (Ekeland et al., 2012; Kairy et al., 2009; LaPlante & Peng, 2011), and it is currently increasingly acknowledged among experts that there is an urgent need for more pragmatic study designs to adequately evaluate technology-supported health services (Ekeland et al., 2010, 2012; Kairy et al., 2009; LaPlante & Peng, 2011). Micro-randomisation could be an appropriate alternative study design. The micro-randomised trial was introduced by Klasnja and colleagues (2015) to overcome the limitations of current experimental methods, for instance randomised controlled trials, and to supplement the use of behavioural theory to guide the development of just-in-time adaptive interventions. As we are also interested in the effectiveness of the interaction between the user and the virtual coaches, we want to assess the applicability of the virtual coaches and the users' duration of interaction with the virtual coaches of a fully working COUCH system implemented in a real-world setting among the target population. To assess the users' interaction with the virtual coaches of COUCH, the interaction with one of the primary coaches (physical activity coach) will be micro-randomised: Every time the user starts a conversation with this coach, the initiative of starting the conversation will be based on micro-randomisation. This micro-randomisation consists of the following two conditions: (1) The user takes the initiative and chooses the topic of the conversation, or (2) the system takes the initiative and automatically suggests the topic of conversation. The predefined topics include gathering information about the user, goal setting, strategy selection, learning skills, and feedback and support.

Participants

The study population will consist of older adults and adults with type 2 diabetes mellitus or chronic pain. For this study, the term older adult is defined as ≥55 years of age, and adult is defined as ≥18 years of age. A potential participant who meets any of the following criteria will be excluded from participating in this study: not able to read and

speak Dutch or English, not having a Wi-Fi connection at home, not able to provide informed consent, or not able to see the smartphone or tablet screen clearly.

Eligible older adults will be recruited for the first round from December 2019 through January 2020. Participants will be recruited for the second round from March through April 2020. The first round will start in February 2020. The preparation phase (1 week) will start with an initial visit to the participant's home or an intake at the researcher's lab. During this phase, the participants do not interact with COUCH yet, but they will wear sensors for the baseline measurements, and they can keep track of their eating patterns using a food diary. The needed equipment (e.g., tablet, smartphone, sensors) will be provided to the participants during this first visit, and they will receive an explanation about the operation of any equipment. Finally, participants will complete the T0 questionnaire. After this first week, the implementation phase will start. The participants will start using the COUCH system for 4 weeks. Thereafter, the second visit will take place at home or at the research location. During this visit, an exit interview will be conducted. The participants will complete the T1 questionnaire, and they will choose whether they want to continue using COUCH for another 4 weeks (the facultative follow-up phase). If they do not want to keep using COUCH, they will return the borrowed equipment to the research staff. After the follow-up phase, all participants will complete the T2 questionnaire. The questionnaires (online or on paper) will be filled in at T0, T1, and T2 (see Figure 4A.1).

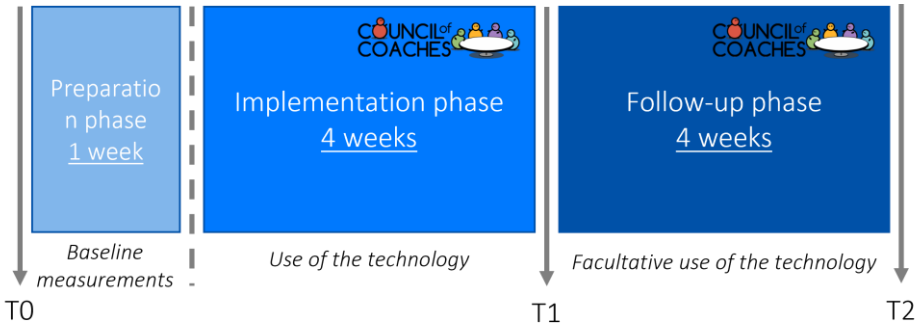

Figure 4A.1. Study procedures for the first and second rounds of this 9-week observational study with a pre-test – post-test design.

Intervention

The application is a web application, designed and built to run on tablets or computers. This technology is currently under development within the COUCH project (European Union's Horizon 2020 research and innovation program under grant agreement No. 769553). The application's main functionality is to provide a friendly and easy-to-use

interface that allows users to have natural language dialogues with a group of (5-6) virtual coaches (see Figures 4A.2 and 4A.3). The final COUCH demonstrator will support the following virtual coaches: physical activity, nutrition, social, cognition, peer/support, chronic pain, and diabetes. Depending on the user's needs and interests, a subset of these coaches can be selected by the user (e.g., in the absence of the specific conditions, the chronic pain and diabetes coaches will not be presented to the user).

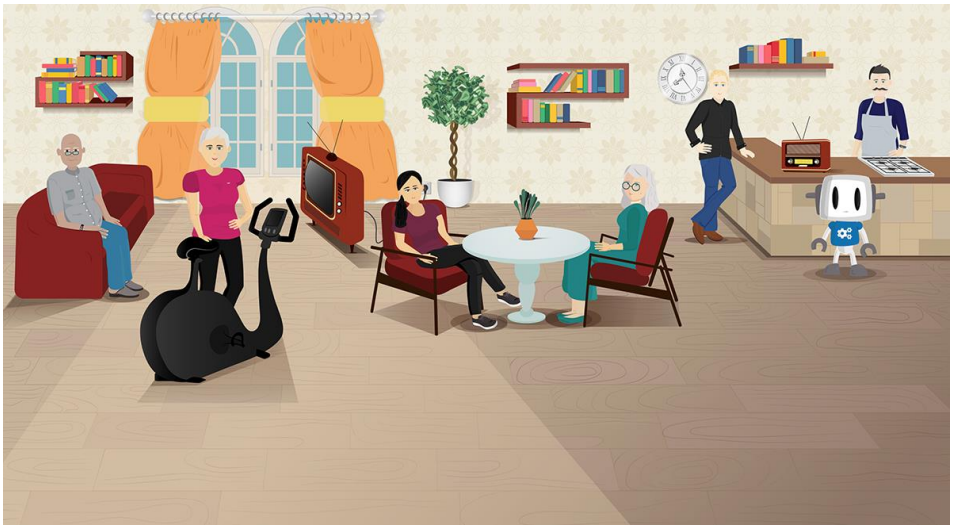

Figure 4A.2. Screenshot of the current test version of the Council of Coaches web application with the chronic pain coach, without a dialogue box (https://www.council-of-coaches.eu/beta/).

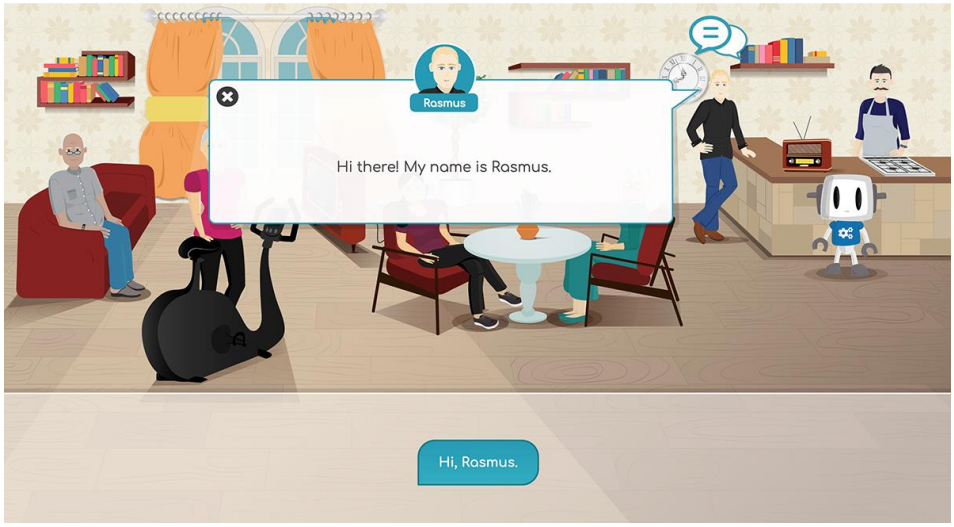

Figure 4A.3. Screenshot of the current test version of the Council of Coaches web application with the chronic pain coach, with a dialogue box (https://www.council-of-coaches.eu/beta/).

The content provided by the virtual coaches focuses on physical fitness and nutrition to improve the users' wellbeing, and the content is based on (Dutch) health guidelines. Both the physical activity and nutrition coaches, which are the primary coaches, can assist the user in their domain in the following ways: providing information on health benefits, setting personalised goals, providing feedback and advice, reflecting on different coaching styles, and assisting with relevant sensor technology.

The secondary coaches (social, cognition, peer/support, chronic pain, and diabetes) interact with the user by providing their points of view on the main topics of activity and nutrition. For example, the social coach may suggest doing group activities outside the house when the user is discussing physical activity with his physical activity coach, while the cognitive coach can provide a memory game to do while grocery shopping for a recipe that the nutrition coach recommended. The peer/support coach is included to be "on the side of the user" and provides encouragement for the user to achieve his/her goals. The secondary coaches, except for the chronic pain and diabetes coaches, can be removed from the council by the user. The interaction with the physical activity coach will be micro-randomised (Klasnja et al., 2015). Every time the user starts a conversation with a primary coach, the initiative of the conversation will be taken by the system or given to the user.

The application optionally supports the use of sensor technology, in order to allow personalised feedback and coaching to the users. The physical activity coach will suggest the user wears a Fitbit watch, which is provided by the researchers to all participants, so

that she may provide feedback on the user's actual activity. Similarly, the nutrition coach will ask the user to track dietary consumption through a provided smartphone app and ask the user to enter their weight information either manually or through a connected (smart) scale. Users can talk with their virtual coaches about the use of these devices, and the coaches will explain which data is collected and for what purpose and offer the ability to stop tracking data when the user feels uncomfortable about this.

All of the interactions take place in the comfort of the coaches' living room (see Figure 4A.2) that includes elements like a radio (playing the coaches' favourite classical songs), recipe books (that Francois, the nutrition coach, can guide the user through), and a television on which to watch physical exercise examples.

During the first visit (T0), the participants will be trained by the researcher to learn how to interact with COUCH on their tablet, and they will receive a paper manual about COUCH. During the entire evaluation period, there will be a helpdesk available for the participants on working days from 9 am to 5 pm, and the participants will receive a non-personalised informative newsletter three times by email to inform them about the project and running evaluation.

Outcomes

In this study, we will focus mainly on user experience, potential effects on health-related factors, and the use of COUCH during the implementation and follow-up phases. Furthermore, we will examine the demographics, applicability of the virtual coaches, and user's interaction with the virtual coaches. Table 4A.1 gives an overview of all the questionnaires that will be used during this study. All survey questions in the 3 questionnaires are listed in Appendix 4A.1.

Table 4A.1. Overview of the questionnaires and when they will be used.

Outcome	Questionnaire	T0[a]	T1[b]	T2[c]
User experience	Technology Acceptance Model		X	
	System Usability Scale		X	
	Willingness-to-Pay		X	
Potential health effect	EQ-5D-5L	X	X	X
	Positive Health dimensions	X	X	X
	Self-Management Ability Scale - short	X	X	X
Demographics	Self-devised	X		
Applicability of the virtual coaches	Rating scale	X	X	
	Working Alliance Inventory		X	

[a] Baseline
[b] After the 4-week implementation phase
[c] After the 4-week facultative follow-up phase

User experience

To determine the user experience, the Technology Acceptance Model (Davis, 1989; Davis et al., 1989) and System Usability Scale (SUS) (Brooke, 1996) will be used. Furthermore, an exit interview will be conducted, and the willingness to pay will be measured. In this study, user experience domains will be used as external variables. In the literature, 4 constructs are found for the user experience of electronic health (eHealth) services. The first is enjoyment. Van der Heijden (2004) defined perceived enjoyment of a technology as the extent to which fun can be derived from using the system as such. He used 4 questions on a 7-point semantic differentials scale to measure the following 4 items: enjoyable – disgusting, exciting – dull, pleasant – unpleasant, and interesting – boring. The second construct is aesthetics. Lavie and Tractinsky (2004) developed and validated a questionnaire to measure perceived website aesthetics. In this study, only classical aesthetics will be used. The third construct is control. In their study, van Velsen and colleagues (2015) used 3 control questions from Liu (2003) that measure how users perceive the controllability of websites. The fourth construct is trust in technology. This domain is also a predictor for someone's intention to use technology (van Velsen et al., 2015). van Velsen and colleagues (2015) used 4 statements about trust in technology based on the study of Harrison McKnight and colleagues (2002) about the impact of consumer trust on intentions to transact with a website.

Perceived usefulness, perceived ease of use, and intention to use will also be used as constructs in this study's questionnaire. The attitude towards the technology domain will be used as a demographic variable for the secondary outcomes. Both the perceived usefulness and perceived ease of use constructs are derived from Davis (1989). In his study, a new measurement scale for perceived usefulness and perceived ease of use was developed and validated. Both constructs are important when determining the intention to use: the less effort involved in a technology, the more it will be used, and the greater someone's belief that using the technology would enhance his/her performance, the more it will be used (Davis, 1989; Venkatesh & Davis, 2000). Regarding the intention to use construct, van Velsen and colleagues (2015) based this construct on those of Davis and colleagues (1989) and Gefen and colleagues (2003), and expanded it with one item of their own. Based on the study by van Velsen and colleagues (2015), 3 statements were used in this study. Those 3 items were deemed the best to assess the intention to use.

The aesthetics, control, trust in technology, perceived usefulness, perceived ease of use, and intention to use constructs all use statements rated using a 7-point Likert scale, ranging from total disagreement to total agreement.

The SUS will be used to measure the usability of COUCH. Broekhuis and colleagues (2019) showed that the SUS is insufficient as a standalone tool for assessing the usability of

eHealth technologies. However, another eHealth usability tool is not yet available (Broekhuis et al., 2019). The SUS consists of 10 statements with 5 response options that are rated using a 5-point Likert scale ranging from strongly disagree to strongly agree. The SUS score ranges from 0 (worst imaginable) to 100 (best imaginable) points (Brooke, 1996).

Qualitative feedback from the participants will be obtained through a short semi-structured exit interview at T1 (after interacting with COUCH for 4 weeks). During this interview, participants will be asked to share their ideas about COUCH. We will discuss the advantages, points for improvement, and problems experienced.

Willingness to pay will be measured by asking whether the participants are willing to pay for COUCH, and, if so, how many Euros they are willing to pay.

Potential effect on health-related factors

Health effects will be measured through differences in scores within the EQ-5D-5L questionnaire, 6 domains of Positive Health, and Self-Management Ability Scale – short version (SMAS-S). The EQ-5D-5L questionnaire measures quality of life and consists of a descriptive system that includes 5 dimensions (mobility, self-care, usual activities, pain/discomfort, anxiety/depression) and a visual analogue scale. Each dimension has 5 levels, ranging from no problems to extreme problems. With the visual analogue scale, the participants rate their health on a vertical scale, labelled from the worst health you can imagine (0) to the best health you can imagine (100) (Van Reenen & Janssen, 2015).

Huber and colleagues (2016) studied how people think about health. They concluded that the concept of health no longer fits within the definition of the World Health Organization (health as complete wellbeing and absence of disease). The Institute for Positive Health created a tool to gain insight into the positive health of a person. This tool consists of 6 dimensions: bodily functions, mental wellbeing, meaningfulness, quality of life, participation, and daily functioning. Participants complete the questionnaire, resulting in a score between 0 and 10 for each dimension (Huber et al., 2016). In our study, an adapted version will be used. Instead of completing a questionnaire consisting of 42 questions, the participants score each dimension from 0 to 10, as reported by van Velsen and colleagues (2019).

The SMAS-S is a questionnaire that measures 6 self-management abilities in older adults: taking initiative, investment behaviour, variety, multifunctionality, self-efficacy, and positive frame of mind. It determines whether older adults need self-management courses (Schuurmans et al., 2005).

Use of COUCH

The actual use will be determined using the platform's log history. This outcome measure is defined as the frequency and duration of use overall, per week, and per session.

Demographics

Demographic data collected in the pre-test questionnaire include gender, age, educational level, living situation, working status, attitude towards technology, self-reported level of physical activity, health literacy (Chew et al., 2004), and motivation level to live healthy. Attitude towards using technology and motivation level to live healthy will be explained in the following paragraphs.

To determine the participant's attitude towards using technology, 4 items from Agarwal and Prasad (1998) are included in the questionnaire. They developed and validated a new instrument consisting of 4 statements rated using a 7-point Likert scale, ranging from total disagreement to total agreement.

To get participants engaged in working on their health, it is important to determine their motivation to live healthy. With this information, the best suitable persuasive feature can be used in COUCH for each participant (van Velsen et al., 2019). The motivation of an older adult to live healthy can be measured by a tool developed by van Velsen and colleagues (2019) based on the revised Sport Motivation Scale (SMS-II). The SMS-II was created and validated by Pelletier and colleagues (2013). This questionnaire measures sport motivation using the Self-Determination Theory. The Self-Determination Theory distinguishes between 6 types of motivation: intrinsic motivation, extrinsic external regulation, extrinsic introjected regulation, extrinsic identified regulation, extrinsic integrated regulation, and a-motivation (Deci & Ryan, 2004). Those 6 types are included in the SMS-II tool. According to van Velsen and colleagues (2019), there are only 3 types of motivation in older adults to live healthy: intrinsic motivation, extrinsic external regulated, and a-motivation. They provided a set of 11 statements that will be used in our study. In our study, a fourth motivation type, dual motivation, will be included because some participants are not obviously intrinsically motivated nor externally motivated.

Applicability of the virtual coaches

The applicability of the virtual coaches will be measured using a rating scale and an adapted version of the Working Alliance Inventory Dutch version for use in the rehabilitation setting. This questionnaire will be completed for the 2 primary virtual coaches. This questionnaire measures how the patient feels about the therapeutic alliance: the better the therapeutic alliance, the more likely the patient will follow the treatment faithfully. Each participant will provide a score between 12 and 60: the higher

the score, the more satisfied the participant is with the physical activity or nutrition coach and the more she/he trusts the coach (Paap et al., 2018).

Sample size

Because of the explorative character of this study, no sample size calculation was conducted beforehand. To answer the objectives of this study, the goal is to include 50 participants per country. So, in each round, 25 participants will be included per country. In our experience, participants are very enthusiastic to participate in this kind of evaluation with new technology before starting the study, but we expect that around 50% of the participants will drop out before the end of the implementation phase.

Statistical analysis

Statistical analyses will be performed using SPSS, version 19 for Windows (IBM Corp, Armonk, NY). For all analyses, the CIs will be set at 95%. Descriptive statistics, such as frequency, mean, SD, and percentages, will be used to describe demographics, user experience, actual use, and the applicability of the coaches.

The outcomes from the EQ-5D-5L, Positive Health questionnaire, and SMAS-S will be investigated using a mixed-model analysis for repeated measures to obtain the effect of using COUCH on the different measurements. The fixed factor will be the measurement time point (T0, T1, or T2). Post hoc comparisons will be conducted when required, and Sidak adjustments will be used to correct for multiple tests.

To assess the users' interaction with the virtual coaches, the duration of the interaction (in seconds) and the number of dialogue steps with the coach will be used. With this analysis, we want to assess the effect of the conversation with the virtual coaches. To discover changes and possible trends, the duration of the interaction and number of dialogue steps will be analysed for the two conditions. When the data follow a normal distribution, the outcome will be investigated using a paired t test; when the data are not normally distributed, a Wilcoxon signed-rank test will be performed.

Ethics and informed consent

This study will be conducted according to the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and in accordance with the Medical Research Involving Human Subjects Act (Dutch law: Wet medisch-wetenschappelijk onderzoek met mensen). According to this law, this study does not require formal medical ethical approval in the Netherlands. This has been checked by the CMO Arnhem-Nijmegen (file number: 2019-5555). Each participant will give his/her informed consent on paper. See Appendix 4A.2 for the informed consent form.

Results

Recruitment of participants will take place twice. The first round of recruitment occurred from December 1, 2019 to January 30, 2020 in the Netherlands, during which time we recruited 26 participants. The first round of recruitment is still ongoing in Scotland. The second round of recruitment will occur from March 1, 2020 to April 30, 2020. For each round, we will recruit 25 participants per country. Participants are recruited through a mass mailing to older adults, snowball sampling, and advertisements in local newspapers and social media. Participants contact the principal investigator to sign up for participation. The principal investigator sends interested individuals an information letter via email and checks the inclusion and exclusion criteria. If a participant is eligible and still wants to be enrolled in the study, the first visit is planned by the principal investigator, and the study starts.

The first round of evaluation started on January 31, 2020. This round will last until April 15, 2020. The second round of evaluation will start in May 2020 and will last until July 2020. Figure 4A.4 shows the planning of the evaluation. In August 2020, we plan to have the first results of this study.

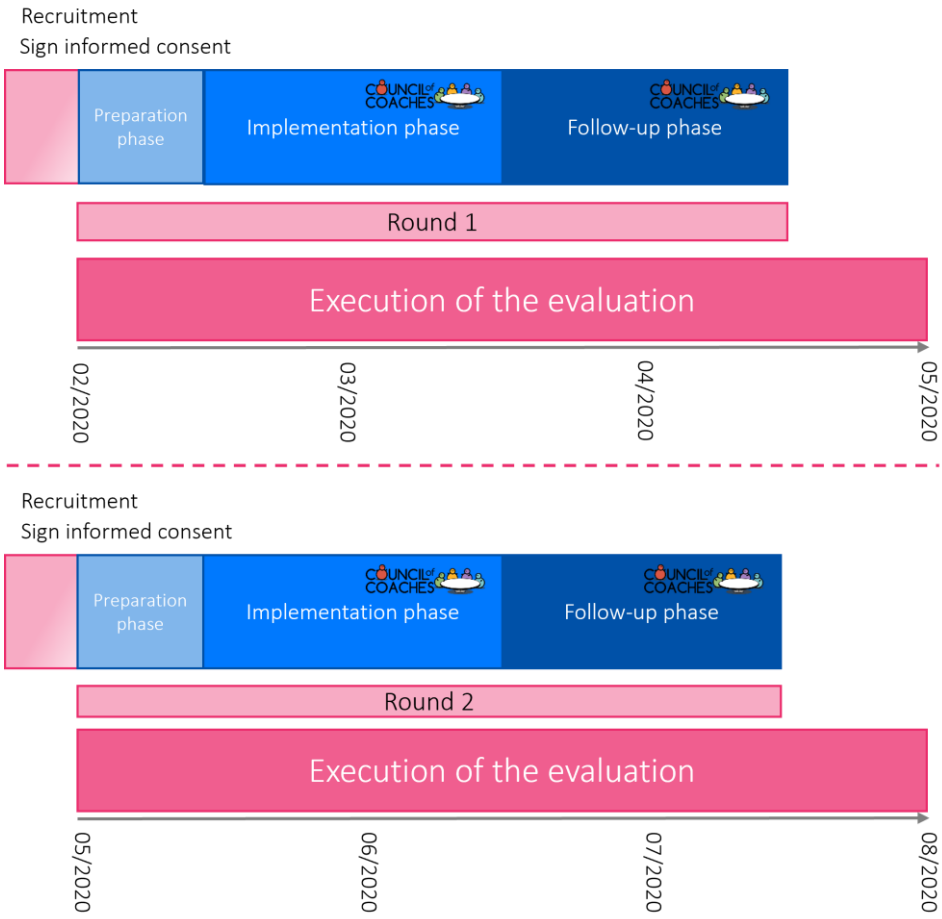

Figure 4A.4. Timeline of the study evaluation period.

Discussion

Overview

This protocol describes the final evaluation of the COUCH system. This study has the following strengths. First, the COUCH system was developed in collaboration with end users. Our expectation is that this will lead to fewer usability issues and better insight into the study's primary outcome measures. McCurdie and colleagues (2012) reported that users identify key requirements that otherwise would entirely be neglected. Second, this evaluation will take place in the participants' residence, a real-world setting, over a long period (5-9 weeks). This will provide a lot of information about how long the target group is willing to interact with a virtual coaching system and whether a virtual coaching system

can lead to behaviour change. Finally, the intervention will be personalised to the participants. We will start the evaluation with a 1-week baseline measurement, in which we will measure the participants' activity level and eating patterns. With this information, we can personalise the physical activity and nutrition coaches for each participant, which will improve the effectiveness of COUCH. Lentferink and colleagues (2017) showed in their scoping review that personalised content improves adherence to eHealth technologies, which subsequently will lead to a more effective eHealth service.

Limitations

However, this study also has some limitations. First, there will likely be selection bias. Participants contact the researchers to enrol in the study. We expect that these participants are already more motivated to live healthy or already live more healthily than the average older adult population and the average adult population with type 2 diabetes or chronic pain. Second, the content that will be ready at the start of the evaluation only lasts for 4 weeks. During the follow-up phase, no new content will be provided to the participants. This can influence the interaction frequency during the follow-up phase. Finally, this study will possibly have to deal with confounders, for example if users receive advice from their health care professionals or others about a healthy lifestyle. This occurs in real life. To handle this as best as possible, confounders such as these will be discussed with the users during the exit interview.

Conclusions

This study will provide insight spanning many areas to improve the COUCH system, and it will contribute to further development of the system and to a better understanding of the value of virtual coaches for behaviour change. In addition, the summative approach of this study protocol to evaluate an eHealth application in a real-world setting can be used to guide other eHealth evaluations.

Acknowledgements

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4B

Results of a summative evaluation of a virtual coaching system eHealth intervention

Based on:
Hurmuz, M.Z M., Jansen-Kosterink, S.M., Beinema, T., Fischer, K., op den Akker, H., & Hermens, H.J. (2022). Evaluation of a virtual coaching system eHealth intervention: A mixed methods observational cohort study in the Netherlands. *Internet Interventions, 27*, 100501. doi:10.1016/J.INVENT.2022.100501.

Abstract

Background: With the rise in human life expectancy, the prevalence of chronic disease has increased significantly. Adopting a healthy lifestyle can decrease the risk of chronic disease. Virtual coaching systems can help older adults adopt a healthy lifestyle.

Aim: The primary objective of this study was to assess the use, user experience and potential health effects of a conversational agent-based eHealth platform (Council of Coaches) implemented in a real-world setting among older adults.

Methods: An observational cohort study was conducted with older adults aged 55 years or older in the Netherlands. Participants were enrolled for 5–9 weeks during which they had access to Council of Coaches. They completed three questionnaires: pre-test, post-test, and at follow-up. After five weeks, an interview was conducted, and participants chose whether they wanted to use the eHealth intervention for another four weeks during the facultative phase.

Results: The study population consisted of 51 older adults (70.6% female) with a mean age of 65.3 years (SD=7.4). Of these, 94.1% started interacting with Council of Coaches, and most participants interacted once per week. During the facultative phase, 21 participants were still interacting with Council of Coaches. Minimal clinical important differences in quality of life were found among the study population after interacting with Council of Coaches.

Conclusion: Our results demonstrate that eHealth interventions with virtual coaching can be used among older adults. This may increase quality of life for older adults, and decrease their healthcare needs. Future research into such eHealth interventions should take into account the inclusion of sufficient personalised content and the use of a mixed methods study for assessing the eHealth intervention.

Introduction

The average human life expectancy has steadily increased in recent decades (Gulland, 2014; Suzman et al., 2015). Among the aging global population there has been a concomitant increase in the prevalence of chronic diseases (Suzman et al., 2015; van Oostrom et al., 2016), which places additional demands on the health care system (van Oostrom et al., 2016; Van Oostrom et al., 2014). Adopting a healthy lifestyle can reduce a person's risk of chronic disease, and their healthcare burden (Visser, 2000; World Health Organization, 2005). eHealth interventions are one way to help people adopt a healthy lifestyle (Chatterjee et al., 2019; Tse et al., 2008).

Many emerging eHealth interventions have a focus on behaviour change, for example relating to physical activity, addiction, and weight loss (Dallery et al., 2015). Several review studies found that eHealth interventions are effective in achieving behaviour change towards a healthy lifestyle. For example, one found that eHealth interventions targeting behaviour change in young adults can be effective in the short term (Oosterveen et al., 2017). Another found that in the short term, eHealth interventions are effective at promoting physical activity in older adults (Muellmann et al., 2018).

Embodied conversational agents (ECAs) are computer-generated animated characters that facilitate one-on-one personal interactions with users. ECAs can be included in eHealth interventions to increase user engagement and achieve better outcomes. ECAs are (most of the times) not included to have a more fun eHealth intervention, but to create conversations with the users about helping/supporting them. Scholten and colleagues (2017) found in their review that including an ECA in an eHealth intervention improved user motivation and duration of participation. A randomised controlled trial (RCT) of an ECA eHealth intervention for healthy living among older adults (N=263) found that the eHealth intervention was more effective at increasing physical activity in the short term than the use of a pedometer. In the long term, this effect was not visible in this study (Bickmore et al., 2013).

Kantharaju and colleagues (2018) performed a fundamental study within the context of this research, investigating the effect of employing multiple virtual agents to persuade the user who is interacting with the system. The benefit of using multiple virtual agents is that they can discuss a health topic and its benefits with each other, and persuade each other (and any potential bystanders), rather than trying to convince the user directly. Translating this concept to the field of eHealth, in order to convince a user of the importance of a health topic, it may be more effective for two virtual coaches to discuss a health topic, compared to having an individual virtual coach directly persuade the user. This positive effect of vicarious persuasion is one of the core elements of Council of

Coaches (COUCH), a new virtual coaching concept that is the topic of evaluation in this article (op den Akker et al., 2018).

The use of VCSs in older adults has not yet been studied, however this population is at higher risk of chronic disease and in need of effective eHealth interventions. Many VCS studies focus on short-term studies, such as single interaction in a lab setting conducted with a focus group to assess the usability and acceptance of the VCS. However, to better assess the acceptance and user experience, especially in the older adult population, a long-term study of several weeks is needed. A long-term study allows older adults to use the intervention in their homes for a longer period and become comfortable using the technology. Therefore, in this study we focus on the long-term use of a VCS. To apply the renewed framework of evaluating eHealth (Jansen-Kosterink et al., 2016), we address the following objective in our study: to assess the use, user experience and potential health effects of a conversational agent-based eHealth platform in a real-world setting among older adults.

Material and methods

The detailed methods of this study have previously been published (Hurmuz et al., 2020). Participants were included in this observational cohort study for 5–9 weeks. This study was conducted according to the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and in accordance with the Medical Research Involving Human Subjects Act (Dutch law: Wet medisch-wetenschappelijk onderzoek met mensen). According to this law, this study did not require formal medical ethical approval. This was confirmed by the Medical Research Ethics Committee CMO Arnhem-Nijmegen (file number: 2019-5555).

eHealth intervention

Within the COUCH project (European Union's Horizon 2020 research and innovation program under grant agreement No. 769553), a functional demonstrator (Technology Readiness Level 6) of COUCH (Figure 4B.1) was developed for older adults, adults with diabetes mellitus type 2 and adults with chronic pain. This eHealth application was developed in the Netherlands. It allows users to have natural language dialogues with a group of virtual coaches. There are a total of 160 dialogues among all coaches. These virtual coaches have their own expertise in several domains: physical activity, nutrition, social, cognition, peer/support, chronic pain and diabetes. When a user is not diagnosed with diabetes mellitus type 2 or chronic pain, the coaches of these domains are not available. The interaction between users and the coaches happens via a text-based user interface; a speech bubble pops up, and the user has several answer options to choose.

More information about the dialogue content and the implementation of the dialogues is described in a paper by Beinema and colleagues (2022).

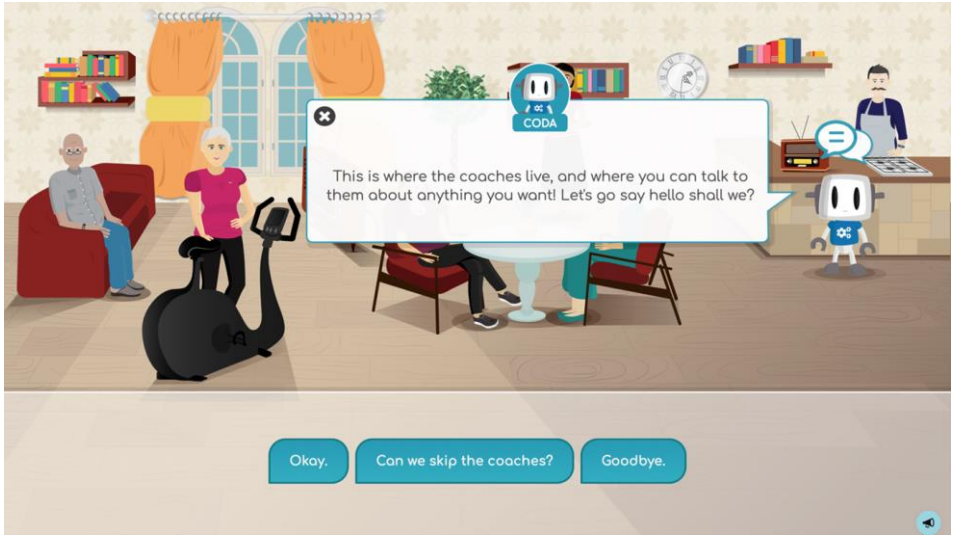

Figure 4B.1. Screenshot of the Council of Coaches' living room. f.l.t.r. Carlos (peer), Olivia (physical activity), Emma (social), Katarzyna (Diabetes), Helen (Cognitive), Coda (helpdesk robot), and François (nutrition) (https://www.council-of-coaches.eu/).

Study procedure and participants

This study was conducted from January 31 to August 9, 2020, in two rounds. Each round started with an intake and consisted of three phases. The preparation phase (week 1) was the baseline week, with use of an activity tracker but no eHealth intervention. The implementation phase (weeks 2–5) involved the activity tracker and the eHealth intervention. The facultative follow-up phase (weeks 6–9) included the activity tracker and the eHealth intervention, if the user elected to continue.

During intake, participants were informed about the study, received a guideline about COUCH, and were informed that they could interact with COUCH however and whenever they wanted. After the implementation phase, participants were interviewed and were asked whether they were willing to finish the facultative follow-up phase. Beforehand participants were informed that they would receive a small gift to thank them for participating, independent from how actively they participated.

The study population was recruited through advertisements in local newspapers, advertisements on social media, and through snowball sampling. Participants were eligible for this study when they were 55 years of age or older, were able to read and

speak Dutch or English, had Wi-Fi connection at home, were willing and able to give informed consent, and were able to clearly see a smartphone or tablet screen.

Outcomes

The primary outcomes of this study were the use of COUCH, user experience with COUCH, and potential health effects. Use was defined as the frequency, duration and interaction (i.e. number of dialogue steps) of use overall, per week, and per session. User experience was measured with questionnaires and semi-structured interviews, both conducted after the implementation phase (T1). These questionnaires consisted of the Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989), the System Usability Scale (SUS) (Brooke, 1996), and the willingness to pay. Finally, the health-related factors were measured with activity tracker data, and with three questionnaires completed at three timepoints: baseline (T0), after the implementation phase (T1) and after the facultative follow-up phase (T2). The three questionnaires were: the EQ-5D-5L (Van Reenen & Janssen, 2015), the six domains of Positive Health (Huber et al., 2016; van Velsen et al., 2019), and the short version of the Self-Management Ability Scale (SMAS-s) (Steverink, 2009). Table 4B.1 gives an overview of all questionnaires used, and an elaborate explanation about the different questionnaires is written down in the protocol (Hurmuz et al., 2020).

Table 4B.1. Questionnaires used in study and the timepoint when they were used.

Outcomes	Questionnaires used	T0[a]	T1[b]	T2[c]
User experience	TAM		X	
	SUS		X	
	Willingness-to-Pay		X	
Health-related factors	EQ-5D-5L	X	X	X
	Six dimensions of Positive Health	X	X	X
	SMAS-s	X	X	X

[a] Baseline
[b] After the 4-week implementation phase
[c] After the 4-week facultative follow-up phase

Data analyses

Quantitative data were analysed with SPSS v.19 Windows (IBM Corp., Armonk, NY). The significance levels were set at 5%. Descriptive statistics, such as frequency, mean, standard deviation and percentages, were used to describe demographics, use and quantitative user experience data (TAM, SUS, willingness-to-pay). Before analysing the log data, some rules were specified:

1. Session duration was defined as number of minutes that the user interacted with coaches without interruption. So, the duration of browsing through the recipe book, or only listening to the radio, were not included in the session duration.
2. Session duration <1 min was not included.
3. Break time within a session was defined as time ≥ 1 min between two interactions. Break times longer than the median were omitted from the duration of the corresponding session.
4. If break time was ≥20 min, the subsequent interaction was considered a new session.

Qualitative user experience data were analysed with ATLAS.ti, v.8 Windows (Berlin, Germany). Interviews were recorded, transcribed, and independently coded by two authors (MH, KF), and discrepancies were discussed until consensus was reached.

Outcomes of the health questionnaires (EQ-5D-5L, the Positive Health tool, and the SMAS-s) were assessed on group and individual levels. On the group level, we assessed normality with histograms. For variables that were normally distributed, we used a linear mixed model analysis with Sidak adjustments. For variables that were not normally distributed, we used the Friedman test. On the individual level, we assessed whether there were minimal clinical important differences (MCIDs) between T0 and T1, T0 and T2, and T1 and T2. In literature we did not find cut-off points for an increase to be clinically relevant for all the health variables we measured. The MCID threshold for EQ-5D-5L was set at 0.074, in accordance with the literature (Jayadevappa et al., 2017). The MCID threshold for the other health variables was set at 25% increase. In literature, we found multiple studies stating that the minimal increase of the baseline value is around 25% to consider it as an MCID (Henderson et al., 2019; Hernandez-Sanchez et al., 2014; Van Hooff et al., 2010).

For activity tracker data, step data below 100 steps per day were removed (this was considered to be non-wear). For each participant, a mean number of steps per day per week was calculated. We divided participants into two groups according to their activity during the baseline week: group A had mean steps per day higher than the median for all participants that week, and group B was lower than the median. Step data was tested for normality with histograms. In group A, there was one week in which the step data was not normally distributed. For this group, so we analysed the data with Friedman test. For the total study population and group B, data was analysed with linear mixed model analysis.

For analysing questionnaires, interviews, and activity tracker data, per protocol analysis was used. If a participant did not interact with COUCH at least once in the implementation phase, their data was omitted. The reason we chose this analysis, was because if someone

did not use the eHealth application, (s)he could not give proper answers on the questionnaires and interview questions.

Results

Participants

The study began with 51 participants. The mean age was 65.3 years old (SD=7.4 years), and the majority was female (N=36, 70.6%) (Table 4B.2). After completing the baseline (T0) questionnaire, three participants did not use COUCH, and were not included in the final analyses.

Table 4B.2. Demographics of study population (N=51).

Demographic	Sub-category	N (%) or M (SD)
Age (M (SD))		65.3 (7.4)
Sex (N (%))	Male	15 (29.4%)
	Female	36 (70.6%)
Level of education (N (%))	Preparatory secondary vocational education	9 (17.6%)
	Higher general secondary education, pre-university education	16 (31.4%)
	Higher vocational education, university	26 (51.0%)
Living situation (N (%))	Married/living together	37 (72.5%)
	Alone	14 (27.5%)
Employment status (N (%))	Employed	14 (27.5%)
	Volunteer/caregiver	7 (13.7%)
	Retired	23 (45.1%)
	Other	7 (13.7%)
Health literacy (M (SD))[a]		4.0 (0.6)
Self-reported level of physical activity (N (%))	Not at all	1 (2.0%)
	Not at all, but thinking about beginning	2 (3.9%)
	< 2.5 hours a week	16 (31.4%)
	> 2.5 hours a week in the last six months	9 (17.6%)
	> 2.5 hours a week for more than six months	23 (45.1%)
Attitude towards technology (M (SD))[b]		4.5 (1.5)
Type of motivation to live healthy (M (SD))[b]	Intrinsic motivation	5.1 (1.0)
	External regulation	2.8 (1.2)
	A-motivation	2.1 (1.3)

[a] Measured on a scale from 1 (low) to 5 (high)

[b] Measured on a scale from 1 (low) to 7 (high)

Use of Council of Coaches

During the implementation phase, 48 participants interacted with COUCH at least once. During these four weeks, participants interacted with COUCH on an average of 5.3 days (SD=3.7). COUCH was used most often during the first week of the implementation phase (week 2, M=3.3 sessions, SD=2.2) (see Table 4B.3). During the facultative phase, 21 participants interacted with COUCH on an average of 3 days (SD=3.0). Reasons given for interacting with COUCH during the facultative phase were: to see whether the coaches had new content (N=10), to receive healthy living advice (N=2), out of curiosity (N=2), because it was fun (N=1), and because of promises made to the researcher (N=1). Reasons for not interacting during this phase were personal (no time, sickness, already very active, no motivation) (N=10), not receiving added value from interaction (N=6), content-related (too little, too general) (N=5), or technology-related (too difficult) (N=5). One participant indicated not interacting with COUCH because of having real-life coaches, and one because of the outbreak of the COVID-19 pandemic. In the third week of the facultative phase (week 8), COUCH was used most often (M=2.0 sessions, SD=1.4) (see Table 4B.3). For every week, except week 2, most participants interacted once with COUCH.

Table 4B.3. COUCH use data.

Week	N	Mean (SD) number of sessions	Range min-max number of sessions	Mean (SD) duration in minutes per session	Range min-max duration in minutes per session	Mean (SD) number of interactions per session	Range min-max number of interactions per session
1	-	-	-	-	-	-	-
2	44	3.3 (2.2)	1 – 11	7.2 (5.1)	1.0 – 23.1	114.1 (82.7)	9 – 471
3	33	2.0 (1.4)	1 – 6	7.4 (5.6)	1.1 – 23.1	114.0 (92.4)	6 – 448
4	25	1.5 (0.8)	1 – 4	7.9 (6.4)	1.1 – 28.8	122.4 (76.5)	19 – 339
5	22	2.0 (1.5)	1 – 7	5.8 (5.9)	1.1 – 26.7	90.7 (75.8)	18 – 388
6	17	1.8 (1.1)	1 – 5	5.2 (4.1)	1.2 – 15.4	91.6 (66.8)	16 – 282
7	10	1.6 (0.8)	1 – 3	5.0 (2.9)	1.8 – 11.2	79.8 (36.4)	36 – 173
8	7	2.0 (1.4)	1 – 4	4.9 (2.4)	1.4 – 8.4	81.0 (51.2)	13 – 232
9	7	1.7 (1.1)	1 – 4	5.0 (4.4)	1.2 – 13.9	80.3 (70.3)	21 - 227

During interviews, participants were asked for reasons to interact with COUCH and to not interact with COUCH. Regarding reasons to interact with COUCH, the most common response was to become more physically active (N=13). Other reasons related to healthy living (N=19) included: to lose weight, and to receive advice related to healthy eating and health conditions. As one participant said:

> *In some areas you do notice that you are getting older and that your body abandons you in those areas.* (P-1)

Other reasons were related to participants' daily routine (N=5), such as getting knowledge about and being aware of their health; social participation (N=3), such as expanding social contacts, mental health (N=3), such as being informed about mental wellbeing; and quality of life (N=2), such as feeling well-balanced. Other reasons (N=9) included: just for fun, helping researchers, and curious about the technology. Six participants did not indicate any reasons to interact with COUCH.

Reasons to not interact with COUCH were mostly related to the technology (N=45), such as the content of the coaches and difficulty logging in. In total, eight participants indicated they had no reasons for not interacting with COUCH:

> *I do not have a reason. I think health is an important subject, and knowledge about this is very important.* (P-25)

Other reasons were not having enough time to interact with COUCH (N=3), starting a new intervention (N=1), or related to participants' bodily functioning (N=5), social participation (N=2), and quality of life (N=1).

User experience

The usability of COUCH was scored with a mean of 51.4 (SD=20.0, N=46). This means that the usability of the system was marginally acceptable according to the participants. During interviews, 15 participants indicated they experienced some problems with COUCH: too slow or technical issues. Most participants found it easy to use COUCH (N=24 vs. N=9 difficult), and two indicated that it was difficult in the beginning, but after a while it was easy to use:

> *In the beginning, I have to be honest with you, my daughter helped me. I am not very into this. She said you have to do it this and this way, and then you master it.* (P-28)

Regarding the user experience measured with the TAM, participants were mostly neutral about COUCH. Participants were most positive about the trust in COUCH (M=4.6, SD=1.0, scale 1–7), and least positive about the intention to use COUCH (M=2.9, SD=1.7, scale 1–7). Table 4B.4 shows the mean of each user experience domain, and the percentages of participants that were positive, neutral and negative towards each domain. Figure 4B.2 shows the box plot of each domain.

Table 4B.4. User experience assessed on seven domains of the TAM (N=46).

User experience domains	M (SD)	% negative	% neutral	% positive
Enjoyment	3.8 (1.2)	17.4%	80.4%	2.2%
Aesthetics	4.3 (1.1)	4.3%	82.6%	13.0%
Control	3.9 (1.6)	21.7%	63.0%	15.2%
Trust in technology	4.6 (1.0)	2.2%	69.6%	28.3%
Perceived usefulness	3.4 (1.6)	34.8%	56.5%	8.7%
Perceived ease of use	4.1 (1.5)	17.4%	67.4%	15.2%
Intention to use	2.9 (1.7)	47.8%	43.5%	8.7%

Note: These user experience domains are measured on a scale from 1 (negative) to 7 (positive)

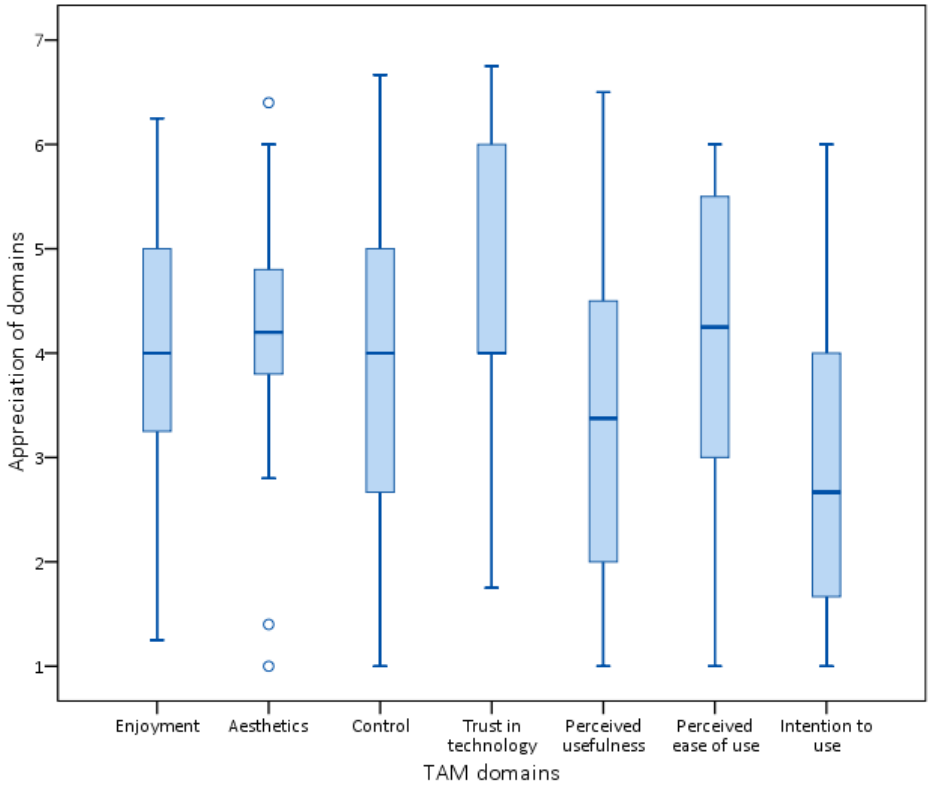

Figure 4B.2. Box plot representation of user experience on seven domains of the TAM (N=46).

Nine participants (19.6%) indicated that they are willing to pay for using COUCH. The average price a participant was willing to pay was €6.15 per month (N=13). Twelve participants indicated they would recommend COUCH to others, mostly for people who, for example, have little knowledge about healthy living, are lonely, or people who have difficulties changing or want to change their lifestyle (N=10):

> *If someone wants to change his lifestyle, I would recommend this. There are good tips about food and drinks, there are recipes, etc., and I heard good tips to prevent dementia.* (P-47)

Other examples for why to recommend COUCH were because it is helpful (N=5), it gives the user discipline to follow advice (N=3), and because with COUCH the user has easy access to health advices (N=2).

However, 30 participants would not recommend COUCH to others, and 5 participants were neutral towards this. The most common reason (N=15) for not recommending COUCH was that the coaches give overly generalised information:

> *The questions are being asked from situations not corresponding to mine.* (P-20)

Other reasons mentioned more than three times were about: limited content (N=9), childish/patronising conversations (N=6), and difficulty logging in (N=4).

Regarding COUCH's user experience, 19 participants had a good experience:

> *That [interaction with system] was absolutely great.* (P-15)

> *The ease of use is fine.* (P-46)

> *That works well, the interaction with the coach, it is funny, it is nicely built.* (P-47)

Six participants likes the appearance of the system:

> *I really like the way it looks; I really like how the system is built.* (P-1)

Participants liked the recipes (N=4) and advices given by the coaches (N=3):

> *I came across a nice recipe book. It was very concrete, and I could retrieve really nice dishes from this book.* (P-10)

> *The tips she [Emma, the social coach] gives are good for being socially active. You get confronted with your own situation.* (P-47).

Two participants said interacting with the coaches was fun. Others responded: friendly coaches, clear conversations, good interaction between the coaches, especially François (nutrition coach) was lovely to interact with, the way the coaches talk to the user is good, the user has the control, fun radio, nice brain quizzes, and good intent of the application, (N=1 each).

However, 24 participants also had some critical points, mostly regarding the content:

- Too limited content and general advices (N=9):
  > *It is good to exercise, yeah I know that too. But help me with my own situation. I tried, but the dialogues are limited.* (P-45)
- The social talks were not liked a lot (N=6):
  > *Just the social talks, I am not very into that. It is not needed for me.* (P-26)
- Too much repetition in the dialogues (N=1)
- No need for knowing François' food preferences (N=1)
- Childish explanations (N=1)
- Not interesting in general (N=1)
- No concrete tips/advices (N=1)
- Too many step-by-step explanations (N=1)
- Unilateral stories (N=1)
- Sometimes wrong answer options (N=1)
- Hard to interact with the coaches because of pre-programmed dialogues (N=1)

Seven participants found it cumbersome that they had to log-in each time they wanted to interact with the coaches. Furthermore, some responded that it was too robotic and it did not stimulate the user (N=3 each). The following comments were mentioned twice: did not like the lay-out, no possibility to ask questions, too simple, childish in general, the coaches ask for information that is too personal, not liking the interaction with the coaches, and annoying that after each log-in the user does not continue where user was left. Finally, some participants had other comments: did not like the radio, no personal connection with François, crappy system, did not like Emma, Emma assumes it is a problem when you have little social contacts, paternalistic coaches, and not interactive.

Potential health effects

For measuring the potential health effects, three questionnaires were used. Table 4B.5 shows the mean scores of all health variables at T0, T1 and T2. Two variables were not normally distributed: perceived health state measured with the EQ-5D-5L and the Positive Health domain mental health. For these variables, the Friedman test did not show any significant effects between the different measurement points. For all other

variables, the mixed model analyses showed that in two SMAS-s domains there was a significant difference: the investment behaviour domain (P=0.013, F=4.588, df=88.184) and the self-efficacy domain (P=0.028, F=3.737, df=88.246). For both variables, the best model fit (measured with the Akaike's Information Criterion) was with the covariance structure Compound Symmetry. The Sidak multiple tests adjustment showed that for the investment behaviour domain, there was a significant effect between T0 and T2. The mean increase was 5.542 (SE=1.912, P=0.014). For self-efficacy there was a significant increase between T1 and T2, with a mean increase of 4.581 (SE=1.725, P=0.028).

Table 4B.5. Mean (SD) of health variables at T0, T1, and T2.

Health variables	Sub-category	M (SD) at T0 (N=48)	M (SD) at T1 (N=47)	M (SD) at T2 (N=42)
Perceived health state		0.83 (0.15)	0.84 (0.15)	0.86 (0.15)
Perceived health state on a VAS		78.1 (15.4)	79.1 (14.3)	81.4 (13.0)[b]
Positive Health domains	Bodily functions	7.0 (1.6)	7.3 (1.5)	7.5 (1.5)[b]
	Mental health	7.5 (1.4)	7.7 (1.4)	7.9 (1.3)[b]
	Meaning	7.7 (1.6)	7.9 (1.6)	8.1 (1.3)[b]
	Quality of life	7.7 (1.5)	7.9 (1.5)	8.0 (1.3)[b]
	Social participation	7.7 (1.4)	7.9 (1.7)	8.1 (1.3)[b]
	Daily routine	8.1 (1.3)	8.3 (1.4)[a]	8.4 (1.3)[b]
SMAS-s domains	Taking initiatives	65.1 (14.6)	67.9 (13.0)	70.5 (16.3)
	Investment behaviour	69.4 (14.5)[c]	70.8 (14.1)	74.9 (14.3)[c]
	Variety	61.5 (19.2)	60.7 (16.3)	64.1 (16.3)
	Multifunctionality	63.2 (14.2)	61.8 (15.4)	62.1 (14.6)
	Self-efficacy	70.3 (14.4)	67.4 (15.4)[c]	71.6 (15.5)[c]
	Positive frame of mind	58.5 (17.0)	62.3 (18.1)	60.6 (15.4)
SMAS-s total score		64.7 (11.3)	65.2 (11.3)	67.3 (11.1)

[a] N=46

[b] N=41

[c] Significant (p<0.05)

On the individual level, 41 of 47 participants (87.2%) experienced an MCID in at least one health variable during the whole study period. From T0 to T1, most MCIDs were found in the SMAS-s domain positive frame of mind (N=11), followed by the Positive Health domains bodily functions (N=10) and meaning (N=8). Looking at the health scores at T0

and T2, most MCIDs were found in both perceived health state measured with the EQ-5D-5L and the SMAS-s domain taking initiatives (N=11), followed by the SMAS-s domain variety (N=10). From T1 to T2, most MCIDs were found in the SMAS-s domain self-efficacy (N=9), followed by the SMAS-s domains investment behaviour and positive frame of mind, and the perceived health state (N=8).

During the baseline week, mean steps per day ranged between 3475 and 18,440 steps, and median steps this week was 8290 steps (IQR=6793 - 10,215). Figure 4B.3 shows the box plots of mean steps per day for each week. Mean steps per week increased each week for the total study population. For group B (participants with mean steps below median during baseline week) this increase was maintained. For group A (above median), in four weeks there is an increase compared to the baseline week. These increases were not significant with linear mixed model analyses and Friedman test. However, during the interviews, some participants mentioned things about being more physically active (N=3). For example:

> *“I think I exercised more, not only because of wearing the Fitbit activity tracker, but also as a result of talking to Olivia, I, yeah, wanted to accomplish my goals, unconsciously.* (P-4) ”

> *“I now live temporarily in an apartment, and I always took the elevator, but now I always take the stairs.* (P-8) ”

(Taking the stairs instead of the elevator was one of the physical activity coach’s daily tips.)

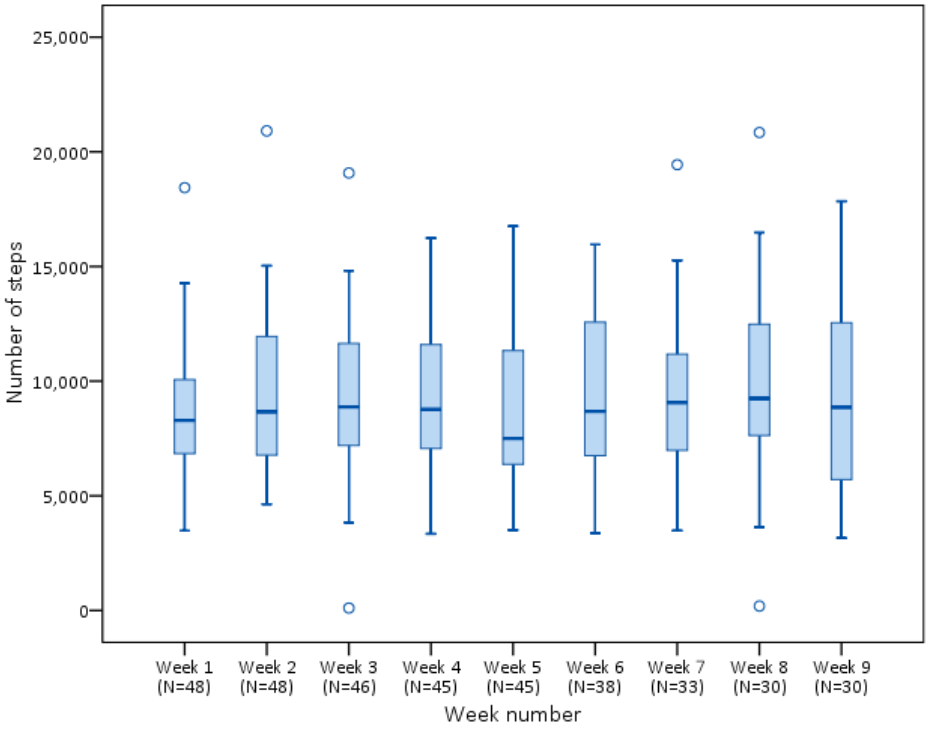

Figure 4B.3. Activity tracker data: Box plot representation of mean steps per day per week the in total study population.

Regarding healthy living in general one participant said:

> *If he [François, the nutrition coach] gave tips, they were good tips. Things I already know, like do not eat too much salt and those kind of things. So, for me no added value. But as a system, I think it is also for people that need to start with the basics. And that is really good.* (P-26)

Two other participants indicated that they are more aware of the importance of being socially active as a result of using COUCH:

> *Yes, that's important for sure. To develop yourself, otherwise if you are lonely, the loneliness becomes even more. … Because of COUCH I understand the importance of this.* (P-47)

Discussion

The aim of this study was to assess the use, user experience, and potential health effects of a conversational agent-based eHealth platform implemented in a real-world setting among older adults. We found three main findings related to our study objective. First, regarding the use of COUCH, in almost all weeks, most older adults that interacted with COUCH did so once per week, and the number of participants declined over time. This confirms the law of attrition in eHealth studies, as described by Eysenbach (2005). The law of attrition has two aspects: the first is about loss to follow-up (i.e. not using the eHealth intervention and not completing questionnaires/interviews), and the second is about non-use (i.e. not using the eHealth intervention, but completing questionnaires/interviews) (Eysenbach, 2005). In our study, both types of attrition were present. A possible explanation for the attrition here can be due to the content of the eHealth application. Because of the mixed methods used in the study, we gathered more qualitative information about the eHealth application, which revealed that the content of the different coaches was a topic of frequent discussion. Most participants thought it was not personalised to their own situation or there was not enough content that warranted continued use of the application. Thus, it is likely that the available content of the coaches influenced the use of the system. This suggestion is supported by two other papers that have analysed the results of this same study from different perspectives. The work of ter Stal and colleagues (2021) described which of the coaches in the COUCH system was preferred most/least often and why. This work shows that most older adults did not have a preference for one specific coach, but the coach that is mentioned most often was Olivia (the physical activity coach). The main reason given for this was the content available for Olivia. Her content was perceived positively, because of the feedback she gave, the realistic goals she gave, and the concrete tips she gave, and in fact Olivia was the coach that has the most content in terms of defined dialogue steps. The coach who was mentioned most often as the least preferred one, was Carlos who is not a real coach but a peer. A lack of content and an absence of his personality were cited as reasons for Carlos being least preferred. This paper also shows that the participants were more positive about the different coaches at first sight compared to after four weeks of using the COUCH system (ter Stal et al., 2021). The second paper, from Beinema and colleagues (2022) looks specifically at the difference in lengths of interaction in situations where the user chooses the topic of discussion versus situations in which the system suggests a topic. This paper provides a more in-depth analysis of the dialogue types which includes the participants from our study and the study conducted in Scotland. It shows among other things that the acceptance rate of coaching dialogues (e.g. dialogues focusing on tips, feedback, goal-setting) was higher than the acceptance rate of social dialogues (e.g. dialogues focusing on small talk, coaches' background stories) (Beinema

et al., 2022). All this demonstrates that for COUCH and other eHealth coaching interventions to be implemented in the real-world situation, the coaches need to focus more on the user's situation to provide personalised content. For example, by gathering information about the user's living situation, hobbies, physical activities, or diet pattern, virtual coaches can give more targeted advice that is relevant to the user.

The COUCH system was easy to use for older adults, and older adults were mostly positive about trust in the technology. An important prerequisite for eHealth technologies to be used by the target group, is that they must be easy to use (Davis, 1989; Huygens et al., 2016; O'Connor et al., 2016).With only the quantitative data (TAM in this case), we could not state that COUCH was easy to use for the participants, as most of them scored perceived ease of use neutral in the questionnaire. However, we asked the participants during interviews whether the use of COUCH was easy, and whether they experienced any problems with its use. These interviews showed us that a total of 72.7% of 33 participants found it easy to use COUCH. This agrees with the published literature, which demonstrates ease of use of VCSs among older adults (Albaina et al., 2009; Jegundo et al., 2020; Mostajeran et al., 2019; Ofli et al., 2016). Our study also demonstrates that older adults have trust in the VCS, which indicates that VCSs may be a solution to achieve behaviour change in older adults, as long as it is easy to use and there is enough personalised content.

Finally, on the group level, no major potential health effects were found after interacting with COUCH. However, looking at the individual level, MCIDs were achieved in health variables. On the group level, participants improved their self-management abilities in investment behaviour and in self-efficacy. This means that after interacting with a VCS, older adults may be better at investing in resources to benefit in the long-term, and better at being conscious about managing these resources to achieve a healthier life (Schuurmans et al., 2005). However, these are potential health effects, as there was no control group in our study. When we look at the average health state of our population, it indicates a quite high quality of life. During interviews, some participants mentioned that they are already very active and living healthy. We could also see this in participants' self-reported physical activity measured in the baseline questionnaire, and the median number of steps during the baseline week. Almost half of the population indicated they are active for more than 2.5 h per week for more than six months. Only three participants indicated not being active at all. This high baseline health status could have influenced our results of the small potential health effects found on group level. However, even though the average health scores at baseline were quite high, almost all participants experienced an improvement in one or more health variable. For future research on potential health effects of an eHealth intervention, we recommend to assess the MCIDs on an individual level. Little was found in the literature towards the health effect of VCSs

on older adults. A recent review of VCS for older adults found that some RCTs showed VCS to be effective, and some showed no significant effects (Bevilacqua et al., 2020). For future research, more studies are needed to assess the effectiveness of VCSs, with a focus on MCIDs to assess the system on an individual level. However, it is also necessary to establish a standardised method to measure MCIDs in health variables, in order to assess the clinical relevance of health interventions.

Strength and limitations

An important strength of our study is the mixed use of methods including quantitative and qualitative measurements. Looking only at the quantitative data, an incorrect conclusion could be derived about COUCH. For example, looking at the SUS, COUCH scored on average low. However, previous research has shown that it is not appropriate to only use the SUS for assessing eHealth usability (Broekhuis et al., 2019). With the data gathered through interviews, we better understood the data measured with questionnaires. When we asked about the usability of and interaction with COUCH during the interviews, most older adults did not experience problems with this. In this stage of the eHealth application, where iterative lab tests are already performed and the product is ready for testing in a real-world setting (Jansen-Kosterink et al., 2016), a mixed methods study has added value compared to only conducting quantitative or only qualitative measurements. For future research with eHealth applications in the same stage, we recommend to use these mixed methods. Furthermore, we noticed that participants were more or less neutral when completing the questionnaires, but when asking about this in interviews, they said that this was because they had other expectations towards COUCH. Some thought they would be coached by a human coach behind the computer, or that COUCH would directly help them to lose weight. For future research, to avoid this mismatch between expectations and reality, we recommend to give attention to expectation management beforehand. In our study we tried to give clear information to the participants about the study and the eHealth intervention itself, however, it appears that more information is needed about what users can expect from the eHealth intervention.

This study had some limitations. As expected (Hurmuz et al., 2020), selection bias was an issue. Possible participants were informed about this study with advertisements. When they were interested in participating, they contacted the first author. This might be the reason for having a study population with older adults who are mainly intrinsically motivated towards healthy living, and have on average a high health literacy. Bickmore and colleagues (2010) found that patients with low health literacy are more positive towards accepting ECAs compared to patients with high health literacy. As our study population had a high health literacy at baseline, it might have influenced our participants' opinions towards accepting COUCH. Another limitation is that participants

felt there was not enough personalised content, which affected their opinion about COUCH. At this moment, COUCH is not a medical device. When the coaches will have more personalised content, this should be reviewed again. Furthermore, it takes a lot of time to write the coaches' dialogues. Within COUCH, there is a considerable amount of content, but, if participants started by exploring all the dialogues on the first day, there was not a lot of new content coming in for the following weeks. Finally, during this study, the COVID-19 outbreak reached the Netherlands. Due to this, the rest of the study was performed remotely: the equipment participants needed were sent via post, and the intake and the interviews were conducted by phone. Nonetheless, we do not think the outbreak and change in study procedure influenced our results. Since the social coach Emma had advice to meet other people, which was no longer applicable for the situation participants were in, a disclaimer was added in the system about this and these dialogues were changed as soon as possible.

Conclusions

To conclude, older adults interacted with COUCH once a week, found it easy to use, and experienced MCIDs on the individual level in one or more health variable. Our results show that a VCS can be implemented among older adults to motivate them to adopt a healthy lifestyle. This may decrease the risk of being affected by chronic diseases and the burden on the health care system. Older adults are willing to use such eHealth interventions for improving their health and lifestyle if there is sufficient personalised content. From this study, we can derive two important implications for future research. First, when designing VCSs for older adults, it is important to include personalised content. Second, when studying eHealth systems that are in the same development stage as COUCH, a mixed methods study is more valuable than either quantitative or qualitative methods alone.

Acknowledgements

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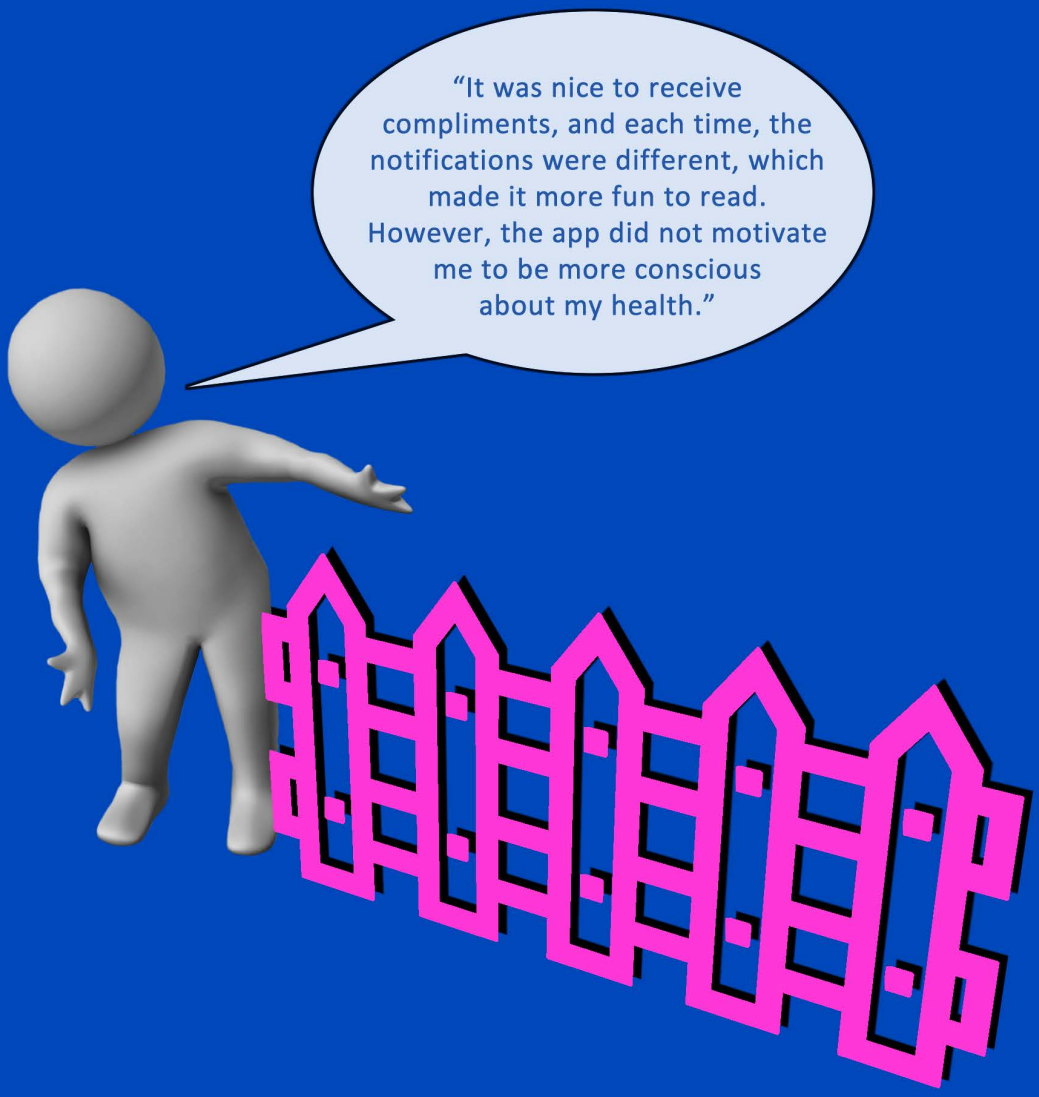
"It was nice to receive compliments, and each time, the notifications were different, which made it more fun to read. However, the app did not motivate me to be more conscious about my health."

5

What influences the use of an mHealth app among adults with neck and/or low back pain?

Based on:

Hurmuz, M.Z.M., Jansen-Kosterink, S.M., Mork, P.J., Bach, K. & Hermens, H. J. Factors influencing the use of an artificial intelligence-based app (SELFBACK) for tailored self-management support among adults with neck and/or low back pain. *(submitted for publication).*

Abstract

Objective: Tailored self-management support is recommended as first-line treatment for neck and low back pain. Using mHealth applications has been put forward as a promising way to provide such support. However, there is limited knowledge about factors influencing the engagement with app-delivered self-management interventions. The aim of this study was to assess barriers and facilitators for engaging with a self-management mHealth app among adults suffering from neck and/or low back pain.

Methods: We carried out an observational cohort study among adults with neck and/or low back pain. The artificial intelligence-based SELFBACK app supports tailored self-management of neck and low back pain and was used by the participants for six weeks. After six weeks of use, participants were interviewed by phone. A deductive approach was used for analysing the barriers and facilitators.

Results: Thirty-two adults (17 males) with neck and/or low back pain participated in this study (mean age=54.9 (SD=15.8)). Our results show that the mode of delivery (i.e. the way the intervention is delivered to the users (via smartphone)) and the novelty of the SELFBACK app were perceived most often as a barrier to use the app, and the action plans (i.e. weekly self-management recommendations) of the app and health-related factors (e.g. pain relief) were perceived most often as facilitating factors to use the app.

Conclusions: This study provides strategies on how to improve an eHealth service, by tackling the barriers and incorporating the facilitators. Furthermore, our study shows that these adults are willing and ready to receive blended treatment.

Introduction

Neck and low back pain (NLBP) among adults are main contributors to years lived with disability worldwide (Deyo et al., 1992; James et al., 2018). Chronic NLBP is associated with reduced quality of life, increased risk of sick-leave, and increased use of healthcare services (Borghouts et al., 1999; Gore et al., 2012; Vogt et al., 2005; Wolff et al., 2011). Tailored self-management is recommended in the treatment of NLBP (Bernstein et al., 2017; Du et al., 2017; Gustavsson et al., 2010). Self-management refers to a person's acts in managing his/her health state, for example adopting a healthy lifestyle or dealing with a chronic condition (Lorig & Holman, 2003). A promising tool to offer self-management strategies is the use of eHealth services (Beatty & Lambert, 2013).

Lots of different eHealth services targeting adults with neck and/or low back pain (N/LBP) are developed (e.g. (Ambrose et al., 2018; Blödt et al., 2014; van Tilburg et al., 2021)). Machado and colleagues (2016) found in their systematic 61 different mHealth apps for supporting people to self-manage their low back pain, of which one focused on a combination of neck and back pain. These apps focus on different things: education and physical exercises, physical exercise only, mind-body exercises only, and others (graded motor imagery, brainwave entrainment). Regarding the efficacy of eHealth services targeting this population, different studies showed a positive effect on in health status in pain patients when using an eHealth service (e.g. (Burke et al., 2019; De Boer et al., 2014; Du et al., 2020)). These examples show us that eHealth could have a great potential in treating NLBP patients.

eHealth services can have a positive impact on users' health status when these users actually use the services at least for a specific amount of time in order to reach for example behaviour change (e.g. (Lewis et al., 2008; Marcus et al., 2007)). However, in general, when implementing eHealth services, a commonly found problem is its non-adoption. Buhrman and colleagues (2016) found a substantial range in drop-out rates of using eHealth services when reviewing literature about these services focusing on chronic pain patients. These drop-out rates ranged from 4% to 56%. Furthermore, previous studies have shown higher drop-out rates in eHealth interventions compared with face-to-face interventions (Alfonsson et al., 2017; Arean et al., 2016; Kannisto et al., 2017). This phenomenon is being referred to as the law of attrition in eHealth (Eysenbach, 2005), and poses a threat to the adoption of eHealth services among the target population. Non-adoption within eHealth implementation processes, negatively affects the effectiveness of the eHealth services (Willmott et al., 2019).

Problem statement

To better understand the reasoning behind why eHealth services are or are not being adopted by users, to our opinion qualitative studies are needed which investigate the barriers and facilitators users perceive when using eHealth. By knowing this, eHealth developers can take these factors into account when developed these services, to increase the adoption of them. Svendsen and colleagues (2020) recently reviewed literature to identify the perceived barriers and facilitators when using an eHealth service to self-manage low back pain. They found limited literature (5 papers) on this topic and concluded that more research is needed. So, with our study we aim to identify which barriers and facilitators are perceived by adults suffering from neck and/or low back pain when using a self-management mHealth service in a real-world setting and their use of this mHealth service.

Methods

Study procedure

A 6-week observational cohort study was carried out in which an mHealth application was used as a self-management tool. In this paper, we report the study based on the COnsolidated criteria for REporting Qualitative research (COREQ) (Tong et al., 2007). Participants started the study by completing an online pre-test questionnaire, consisting of demographics only. Then they received an account for the mHealth application, which they could use for six weeks. Before using the application, they completed the application's baseline questionnaire mainly focusing on their pain, in order to personalise the application toward the needs of the user. After using the application, the participants were asked to participate in a semi-structured interview by phone which was audio-recorded. These interviews were conducted by one female researcher (MH) with background in health sciences (MSc). During this study, she was working as a junior researcher at Roessingh Research and Development (the Netherlands), and she was experienced in conducting interviews. The interviews were conducted between 4.5-6.5 weeks of using the app, and lasted for approximately 15-30 minutes per participant. The participants that had not used the app for 6 weeks, were asked whether they want to continue using it to complete their 6 weeks of use.

Study population

The study population consisted of adults (18 years or older) suffering from N/LBP. The participants were recruited through advertisements in local newspapers and snowball effect. If a participant was not able to read and speak Dutch, or did not have a smartphone (with internet connection), (s)he was excluded from participation in this study. Due to project obligations we targeted to include 30 participants.

The participants of this study, and the interviewer had no relationship. The participants were aware that the interviewer conducted this study to gather data for her PhD thesis.

Intervention: an mHealth application

In this study, participants used the SELFBACK app (see Figure 5.1), a decision support system which has been developed to support tailored self-management among people with N/LBP (Marcuzzi et al., 2021). The SELFBACK app provides weekly tailored self-management recommendations with a main focus on advice on physical activity, on physical exercises, and on educational content. The app also encompasses information about N/LBP and a toolbox with for example a sleep tool, a goal-setting tool, two mindfulness audios and pain-relieving exercises. For the app to give personalised recommendations, the user needs to complete the SELFBACK baseline questionnaire about their N/LBP. To tailor the weekly self-management recommendations, the app uses case-based reasoning, a branch of knowledge driven Artificial Intelligence (Aamodt & Plaza, 1994; Bach et al., 2016). This app does not substitute physical therapy treatment, but it is intended as supplementing usual care. Users can use this app to support their self-management activities, with a particular focus on physical activity, strength and flexibility exercises, and information about how to cope with pain (Marcuzzi et al., 2021; Mork & Bach, 2018; Sandal et al., 2019).

The SELFBACK app was tested in an RCT and is being tested in another RCT to assess the effectiveness of the app in two different health settings: primary healthcare and secondary healthcare (Marcuzzi et al., 2021; Sandal et al., 2019). The first results of one of the two RCTs are recently published. The results show that the intervention group had reduced low-back pain related disability compared to the control group, but the effect was small and of uncertain clinical significance (Sandal et al., 2021).

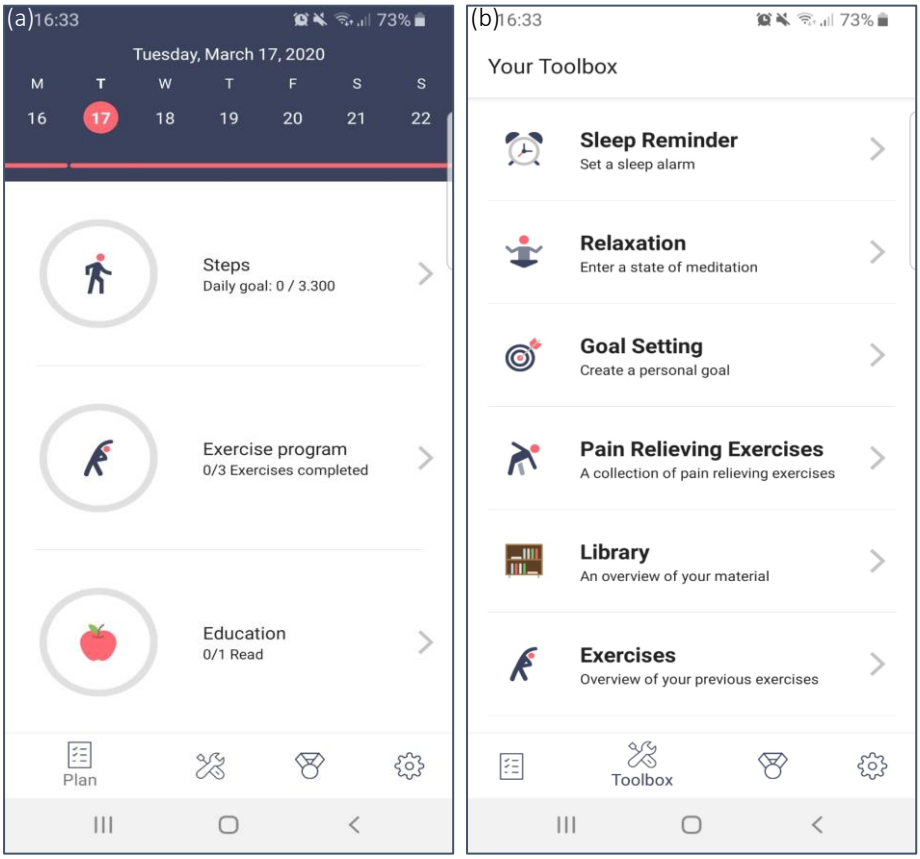

Figure 5.1. Screenshots SELFBACK app. Left picture (a) shows the home screen. Right picture (b) shows the tools within the app.

Study outcomes

The main study outcomes are barriers and facilitators for using the SELFBACK app. These barriers and facilitators were assessed in semi-structured interviews. The complete set of interview questions are shown in Appendix 5.1. To figure out which barriers and facilitators participants perceived when using the SELFBACK app, we asked three different questions for both factors. We chose to ask multiple questions in order to find out as many barriers and facilitators as possible, and we chose to ask open questions. One question (question 9, Appendix 5.1) for identifying the perceived barriers was closed, but we asked a follow-up question to have more in-depth information. An example question we asked to identify barriers is: "*What is the most important reason for you to not use the SELFBACK app?*" An example for identifying facilitators is: "*What is the main motivation for you to start using the SELFBACK app (over other options)?*". After these questions we

also asked for follow-up questions, for example: "*Are there any other reasons?*', or "*Could you explain your answer?*"

The secondary study outcome was the use of the SELFBACK app, evaluated with interviews (see Appendix 5.1). During these interviews, we asked participants how many timed they used the SELFBACK app during the previous 6 weeks, how they used the app, which parts of the app were valued most and what it meant for them to use the app. Furthermore, besides asking about the perceived barriers and facilitators and their use, we also asked participants about, their willingness to use the SELFBACK app in the future, and some more general questions (i.e. kind of help needed to manage their pain, self-management before study, contact with healthcare professional during study, general opinion about using eHealth apps).

Data analyses

Descriptive statistics (frequency, mean, standard deviation and percentages) were used to describe demographics and use of the SELFBACK app. Qualitative interview data were analysed with ATLAS.ti, version 9.0.24 for Windows. Interviews were recorded, transcribed, and simultaneously coded by two researchers. Discrepancies between the researches were discussed and a decision was made upon this discussion. The transcripts of the recordings and findings of the interviews were not given to participants for feedback. A deductive approach was used for coding barriers and facilitators as the coding themes were identified in advance of conducting the interviews and were based on a review study of Perski and colleagues (2017). Perski and colleagues (2017) identified factors that influence engagement with digital behaviour change interventions. These factors are categorised into four categories: content, delivery, population, and setting. Content and delivery factors are related to the intervention. Content factors cover the features within the intervention (e.g. having a goal setting mode, receiving reminders). Delivery factors cover factors related to how the intervention is delivered to the user (e.g. the mode of delivery, whether the intervention delivers new updates to the user on a regular base (i.e. novelty)). Population and setting factors are related to the context of eHealth use. Population includes characteristics of the users: psychological characteristics (e.g. motivation, expectations), demographic characteristics (e.g. age, education), and physical characteristics (e.g. weight, comorbidities). Finally, setting factors include the engagement factors related to the setting in which it is being used: social/physical environment, time, and access to technology. Appendix 5.2 shows the coding tree.

Ethics

We conducted this study according to the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and in accordance with the Medical Research Involving Human Subjects Act (Dutch law). The Medical Research Ethics Committee CMO Oost-Nederland stated that this study did not require formal medical ethical approval (file number: 2020-6501). Each participant signed an informed consent form before participating.

Results

A total of 112 adults with N/LBP were interested to participate in this study. After receiving information about the study, 58 adults indicated they are willing to participate, and the other 54 adults lost their interest (mostly because the SELFBACK app was not suitable for their health situation (i.e. specific N/LBP)). In the end, 32 were included in this study. Twenty-five adults could not participate as they had an iPhone smartphone, and the SELFBACK app was eventually only available on Android smartphones. After completing the pre-test questionnaire, two participants dropped out: one because of owning a smartphone which declined downloading the app, and one was lost-to-follow-up. So, 30 participants used the SELFBACK app, of which 29 were interviewed, one participant was lost-to-follow-up after using the SELFBACK app. During the interviews, most participants mentioned they signed up for this study to relieve their pain (N=16) or to learn new skills to manage their pain (N=8).

The demographics of the study population can be found in Table 5.1. Slightly more than half of the study population was male (53.1%), and the mean age was 54.9 (SD=15.8) years old. Most participants finished a higher vocational education or a university study, were married or lived together, and were employed. Regarding the pain location, most participants experienced low back pain.

Table 5.1. Demographics of study population (N=32).

Characteristics	Sub-category	N (%) or M (SD), range
Gender (N (%))	Male	17 (53.1%)
	Female	15 (46.9%)
Age (M (SD), range)		54.9 (15.8), 23 – 81
Level of education (N (%))	Preparatory secondary vocational education	3 (9.4%)
	Higher general secondary education, pre-university education	7 (21.9%)
	Higher vocational education, university	22 (68.8%)
Living situation (N (%))	Married/living together	26 (81.3%
	Alone	5 (15.6%)
	Other	1 (3.1%)
Employment status (N (%))	Employed	15 (46.9%)
	Volunteer/caregiver	1 (3.1%)
	Retired	10 (31.3%)
	Other	6 (18.8%)
Pain location (N (%))	Low back pain	15 (46.9%)
	Neck pain	5 (15.6%)
	Neck and low back pain	12 (37.5%)

During the interviews, participants were asked how they self-managed their pain before enrolling in this study. Different strategies were mentioned, and some participants mentioned more than one strategy. The most mentioned ones were being treated by a healthcare professional (N=16, 42.1%) and exercising (N=14, 36.8%). Other strategies used to manage their pain were doing nothing (N=3, 7.9%), relaxing (N=3, 7.9%) or avoiding particular movements (N=2, 5.3%). The advices healthcare professionals gave these participants were mostly to exercise (N=13, 65%). Other advices were resting (N=3, 15%), accepting the pain (N=1, 5%), trying out alternative medicine (N=1, 5%), not making extreme movements (N=1, 5%) and paying attention to your posture (N=1, 5%). During our study, only 5 participants had contact with a healthcare professional, of which most of them said that the advices from the healthcare professional were in line with those of the SELFBACK app. The kind of help participants needed from the SELFBACK app was mainly guidance in self-managing their pain (N=8, 40%), and receiving physical exercises to perform at home (N=7, 35%). Furthermore participants indicated they want the SELFBACK

app giving them a positive prompt or nudge (N=4, 20%) or giving them guidance from a healthcare professional through the app (N=1, 5%).

Furthermore, the majority of the participants have a positive attitude towards self-managing N/LBP (N=23, 82.1%), and towards the use of eHealth in general (N=21, 72.4%). One participant even said the following:

> *I think self-management is the greatest remedy for people in pain.* (P-5)

This shows that the acceptance of implementing eHealth focussing on self-managing your own health is high among the adults that used the SELFBACK app. However, not for all users eHealth will be the solution. There was one participant that had a sceptical attitude towards using eHealth in general:

> *Well, I'm very critical regarding eHealth. […] I find it problematic to think that my phone should replace my physical therapist. I find this a strange thought.* (P-12)

Perceived barriers and facilitators

Various barriers were mentioned by the 29 participants that were interviewed. A total of 5 participants mentioned they do not experience any barrier when using the SELFBACK app:

> *I don't see a reason to not use it.* (P-10)

In Table 5.2 we see that most barriers that were mentioned were related to delivery factors (43.1%), and most facilitators that were mentioned were not related to one of the four main categories (47.8%). Looking at only the main categories, most facilitators were related to content factors (36.3%).

Table 5.2. Number of times and percentages each engagement factor is mentioned as a barrier or as a facilitator.

Category	Barriers		Facilitators	
	N	*%*	*N*	*%*
Content factors	12	18.5	41	36.3
Delivery factors	28	43.1	9	8.0
Population factors	7	10.8	1	0.9
Setting factors	5	7.7	8	7.1
Other factors	13	20.0	54	47.8
Totals	65	100	113	100

Perceived barriers

Starting with the perceived barriers, the most mentioned barrier within content factors was related to goal setting (N=6). The algorithm within the SELFBACK app sets each week a new daily step goal for users depending on the reached steps in the week before. There is a flexibility in the app to adjust steps with 10%. However, users indicated that they want to have more self-control over the weekly step goal, especially when participants nearly never reach the minimum of 3,000 steps.

> *"It always says you need to reach 3,000 steps. That would be a reason to say I don't want to use it anymore if they say that every time, and you're not allowed to set it [the step goal] yourself.* (P-24)"

Looking at the delivery factors, the most mentioned barrier within this category, was related to the mode of delivery of the SELFBACK app (N=14). Users indicated that they need to carry their smartphone the whole day, otherwise no step activity will be measured. If one has a smartwatch, they can use their smartwatch for counting steps, however, sometimes another app needed to be downloaded to assure the synchronization with the SELFBACK app. This did not always work perfectly, which was also seen as a barrier. Furthermore, novelty was also mentioned quit often as a barrier (N=9). Users became discouraged to use the SELFBACK app, because there was too much repetition within the physical exercises and the educational messages.

> *"It is totally linked to your mobile phone. Therefore, you are obliged to have it in your pocket the whole day to measure your steps.* (P-2)"

> *"If at a certain point it appears that nothing new is coming in. You have to keep incentives for novelties.* (P-29)"

Within the population factors, the only barriers mentioned were related to psychological characteristics (N=7). Users indicated they are not intrinsically motivated to use the app, or they know their own limits when talking about daily activity and exercises. Which they perceived as a barrier to use the SELFBACK app.

> *"I have the feeling I know my own boundaries. I don't want an app to be hounding me.* (P-12)"

Furthermore, within the last category, setting factors, the least barriers were mentioned. The most mentioned barrier related to setting factors was time (N=4). Users experienced that they have to invest a lot of time to use the app and perform physical exercises, which they did not always want to do, or due to other circumstances they do not have time anymore to use the SELFBACK app.

> *The attention it needs. You need to invest energy into it, and people are often busy. You can do something else during that time.* (P-20)

Finally, other barriers were mentioned not related to one of the four engagement factors. The most mentioned barrier in this case was related to their health. For example when users experience more pain when using the SELFBACK app, it acted as a barrier. But also when users experience less pain, it acted as a barrier to use the app, because then there is no incentive to continue using it. Other health-related reasons to stop using the SELFBACK app were if one does not see any progression or if one does not want to give active attention to the complaints.

> *I experienced less complaints, so then.. Yeah, the stimulus is gone.* (P-9)

Perceived facilitators

Regarding facilitating factors, the most mentioned content factor was action plans (N=29), i.e. the weekly self-management recommendations in the app. Users enjoyed having a weekly plan focusing on daily step activity, physical exercises and educational messages. This plan acted as a facilitator to continue using the SELFBACK app, as it changed each week depending on their feedback (i.e. the responses in the weekly tailoring sessions). Besides, more content factors were mentioned multiple times: rewards and incentives (N=5), and goal setting (N=5).

> *The main motivator for me to use the app is that I hope and expect to learn something, to gain more confidence, to not give up. This is what I received from the SELFBACK app. The education appealed a lot to me.* (P-11)

Subsequently, two delivery factors were mentioned with the same frequency, the aesthetics and design of the SELFBACK app (N=3), and the mode of delivery (N=3). Regarding aesthetics and design users were talking about liking the physical exercise videos, the lay-out of the app which was professional, and the app being very approachable. Mode of delivery was the most frequently mentioned barrier, however, some participants also perceived this as a facilitator. For those, having a self-management app on their own smartphone acted as a facilitator, as they did not had to go to a healthcare professional, or perform exercises explained on paper.

> *The videos are appealing. I think the app looks professional.* (P-6)

> *I have it [the SELFBACK app] with me. It's easy to just follow your programme every day. So I notice that I really like it, and I don't have to leave the house, so that's another advantage.* (P-16)

Only one participant mentioned a population factor, related to psychological characteristics, as facilitator. This user felt obliged to improve his/her health intrinsically. Feeling this way can be a reason to use eHealth services to keep on improving your own health.

> *A sense of duty. We're talking about my health status.* (P-20)

Access to technology is the most mentioned facilitator within setting factors (N=7). Users perceived that having access to this app was acting as a facilitator to use it. Having access to it, motivates and acts as a positive prompt or nudge to use it.

> *I can open it whenever I want, I have my phone close to me, you're looking at your phone quite often. So then I take a look and I see: 'Oh, I've already reached 8,000 steps', and then I see: 'Oh yeah, that exercise needs to be done'.* (P-16)

Finally, regarding other factors which were mentioned as facilitators, most of them were health-related (N=20). So, both for perceived barriers and perceived facilitators, this was mentioned multiple times. Which shows us that it differs for each person; one thing can act as a barrier for person A, but as a facilitator for user B. Some users stop using the app when the pain is relieved, and for others pain relieve gives a boost to continue using the app. Other reasons mentioned in this category were using the app as prevention for N/LBP, using the app to live a healthy lifestyle, or using the app to feel more fit. Furthermore, research-related facilitators were mentioned also quite often (N=9). So, for example because users want to help the researcher.

> *My motivation to use it is to try relieving my back pain.* (P-17)

> *Knowing it's for a research, gives you guidance.* (P-28)

Table 5.3 shows an overview of the most mentioned barriers and facilitators in total. The whole list of barriers and facilitators mentioned during the interviews are shown in Appendix 5.3.

Table 5.3. Most mentioned barriers and facilitators for using SELFBACK app.

	Barrier [engagement category]	Facilitator [engagement category]
Mentioned 15 times or more	-	Action plans [content factors] Health-related factors [other]
Mentioned 10-14 times	Mode of delivery [delivery factors]	-
Mentioned 5-9 times	Novelty [delivery factors] Health-related factors [other] Psychological characteristics [population factors] Goal setting [content factors]	Research-related factors [other] Access to technology [setting factors] Rewards and incentives [content factors] Goal setting [content factors]

Use of selfBACK app

During the interviews, participants were asked to estimate the frequency of their use of the SELFBACK app. Most participants (N=13, 44.8%) indicated they used the app on a daily basis. Others indicated they used it almost daily (N=9, 31.0%) or a couple of times a week (N=6, 20.7%), and one participant first used SELFBACK on a daily basis, but after 4 weeks his/her use declined:

> *I used it for four weeks, and then I felt better, so I did not use it for a while.* (P-9)

When asking participants whether there was a change in their use of the SELFBACK app, most indicated they used it less frequently, or there was no change in use. The majority of the participants indicated they had a regular pattern in using the SELFBACK app, for example:

> *I start the day by reading the educational message. Then I go to my training programme to do the exercises. Then the day starts with measuring my steps. During the whole day I look at my steps. Every now and then I look at the average of the steps over the past time: How am I doing compared to yesterday, last week?* (P-26)

Participants were asked about which part(s) of the app they appreciated the most. The physical exercises in the weekly plan were mentioned most often, followed by the activity data and educational messages. So, all parts of the weekly plan were together the most appreciated parts of the SELFBACK app. Besides those, participants also appreciated the physical exercises in the toolbox, the rewards and the app as a whole. Furthermore, participants were asked what it meant for them to use the SELFBACK app. Most participants said that using the app gave them insights in how to manage their pain and that using it relieved their pain. Other answers given were they have a more positive mindset and they learned new ways in how to manage their pain. Some participants did not experience any meaning from using the app.

> *"Well, using it made me a little happier. […] Because you have a bit less pain, and you are a bit more mobile.* (P-4) "

Future use of SELFBACK app

Using the SELFBACK app had a positive influence on participants in raising awareness concerning their health. For example, one participant told us that (s)he will buy a wearable activity tracker to monitor his/her daily steps more accurately. When asking the participants whether they would recommend the SELFBACK app to others with N/LBP, almost everyone (N=26, 89.7%) indicated they would. The majority of the participants wanted to continue using the SELFBACK app (N=19, 65.5%). Eight participants did not want to continue using the app, and two participants were in doubt. In total, 16 participants provided reasoning why they want to continue using the app. Relieving pain (N=7, 43.8%) and wanting to have this external motivation (N=3, 18.8%) were mentioned multiple times. Regarding willingness to pay for using the SELFBACK app, almost 60% of the participants is willing. The amount of euros differs between 1-2 euros to 17.50 euros per month. The participants were also asked whether they are willing to pay for eHealth in general, now only 31% is willing to pay.

During the interviews, we sometimes discussed the role of physical therapists within treating N/LBP. These participants foreseen a blended treatment: receiving physical therapy, and using the SELFBACK app at home. 14 of the 16 participants with whom this topic was discussed, had a positive attitude towards this blended treatment. The other two participants had no strong opinion. Participants thought that when a healthcare professional recommends you to use an app, the motivation to use it will increase. One participant was very enthusiastic about blended treatment that (s)he already had asked his/her physical therapist about this:

> *"I asked my therapist about it, he said he tried but it didn't work for him.* (P-5) "

One participant also indicated that (s)he thinks maybe physical therapists are reluctant towards eHealth, as they could think that introducing eHealth in practice will reduce the number of patients that need treatment:

> *But maybe the physical therapist is afraid that he will lose his patients.* (P-3)

Finally, within this study, we found that participants experienced the SELFBACK app more useful during the COVID-19 pandemic, according to them the added value of eHealth increased due to this pandemic:

> *Especially in this time of corona this is a fantastic tool.* (P-7)

The COVID-19 pandemic showed us that mHealth, and eHealth in general are wanted by potential users. These users are ready to implement eHealth in their treatment and daily lives.

Discussion

This study aimed at identifying which barriers and facilitators adults suffering from N/LBP perceive when using a self-management mHealth application and identifying their use of such an mHealth application. Before implementing an eHealth service focusing on self-managing N/LBP, the eHealth service needs to be assessed on clinical efficacy. For the SELFBACK app the clinical efficacy is (being) tested in two RCTs (Marcuzzi et al., 2021; Sandal et al., 2019), from which the first results have been published (Sandal et al., 2021). However, besides the clinical efficacy, it is also important to study the factors influencing the use of the eHealth service before implementing it, this provides insight into factors that should be considered in further development. Without doing so, the eHealth service can be effective, but that does not automatically imply that it will be used among the target population's daily lives. Knowing the barriers and facilitators for use, the eHealth service can be adapted towards these, and use of the eHealth service among the target population could increase.

In the current study, the weekly program for strength/flexibility exercises was the module in the SELFBACK app that was most appreciated. Regarding the factors that were perceived as a barrier or facilitator to use the SELFBACK app, nine factors were perceived both as a barrier and as a facilitator (examples are: mode of delivery, action plans, health-related factors, goal setting). In total, the main barriers were mode of delivery, novelty, health-related factors, psychological characteristics, and goal setting. Regarding mode of delivery, participants mostly criticised the way the app measures their steps. This barrier can be overcome by using a wearable activity tracker which is directly linked to the mHealth app. To tackle the barrier novelty, more difference in content is needed within

the weekly self-management recommendations. Users did not want to have the same exercises each week in a row. More variation in content is also recommended in a previous review (Lyzwinski et al., 2017). The health-related factors which act as barriers for some users, are more difficult to overcome. Woo and Dowding (Woo & Dowding, 2018) found that the acceptance of eHealth increases if users have knowledge about its benefits. So, by educating the users about the importance of self-managing, we can try to prevent drop-out. Furthermore, the psychological characteristics which act as barriers are also hard to overcome. The effect of lack of intrinsic motivation on interacting with the SELFBACK app can be decreased by increasing external stimuli (Notenbomer et al., 2018). However, the SELFBACK app already has external stimuli (e.g. rewards). Another strategy is to increase their intrinsic motivation. A method to do so is if the mHealth service helps the user by identifying personal intentions and benefits from using it (Seifert et al., 2012). When taking in mind the SELFBACK app, increasing intrinsic motivation can be achieved by educating users about the importance of self-managing. Finally, to tackle the barrier goal setting, the SELFBACK app needs to give users more influence on the different goals that can be set within the app. Especially regarding the minimum step count per day. Having control over the mHealth service, influences how the service will be used. There should be an appropriate mix between what the user can control and what not (Hawkins et al., 2010).

Our study showed multiple factors which facilitated the use of the SELFBACK app. First of all, the availability of action plans (i.e. the self-management recommendations). Participants indicated that the inclusion of plans telling them what to do ensured them to use the app. Secondly, health-related factors were acting as a facilitator to use the SELFBACK app. When participants felt the app is working effectively (e.g. they experience pain relief, feel more fit), they were more willing to continue using it. Effectiveness of eHealth services is mentioned in multiple reviews as a facilitator for using the eHealth service (e.g. (Harvey et al., 2015; Kruse et al., 2018)). Thirdly, another frequently mentioned facilitator was access to technology. Because the app was available on their own smartphone, participants indicated that facilitated the use of it for them. They could always open the app whenever they wanted and wherever they were. Looking at previous literature, we can confirm this finding. Svendsen and colleagues (Svendsen et al., 2020) also found in their review about eHealth for low back pain that easy accessible eHealth services facilitate their use. Additionally, multiple other studies involving other types of eHealth services also stated if the technology is easy accessible, the use of it will be promoted (e.g. (Koivunen & Saranto, 2018; Lyzwinski et al., 2017; Montagni et al., 2020)). Furthermore, setting goals in the app acts as a facilitating factor. Participants were pleased by setting weekly personal goals about the weekly action plan, but also by having the option to set own personal goals not related to this plan. Previously, Lyzwinski and

colleagues (Lyzwinski et al., 2017) also found that with weight loss mHealth services, setting goals encourages users to interact with the service. Finally, participants mentioned the inclusion of rewards and incentives within the SELFBACK app as a facilitator. They indicated that they want to win the possible badges and the daily stars. Including rewards within mHealth services can motivates users (van Dooren et al., 2019). However, Peng and colleagues (Peng et al., 2016) found in their study that users rather have tangible rewards, instead of points within the mHealth service. Within our interviews, we noticed that it is very person-dependent whether these external motivators actually act as a facilitator for use. In our study, we also found that multiple participants indicated they used the mHealth service because the context was a research setting, i.e. they wanted to help the researchers. So, for researchers it is important to know that participating in a study facilitates the use of eHealth. Altogether, when developing an eHealth service, the service needs to include plans telling users what to do, needs to be effective, needs to be easy accessible (at each time and place), needs to have an option to set personal goals, and needs to give users rewards and incentives. Incorporating these things could increase the use of eHealth services among the target population.

This study showed us that these neck and/or low back patients have a positive attitude towards receiving blended treatment. The COVID-19 pandemic gave a boost to their acceptance of eHealth. However, only few physical therapists implement this in their practice, as the following quote also shows:

> “ *He [the physical therapist] gave me a sheet of paper with exercises. Performing these exercises became less and less. I was not motivated to perform those exercises, as it was on paper, and then you have to figure it out yourself.* (P-16) ”

So, unfortunately, a lot of physical therapists still hand-out physical exercises on paper to patients to perform at home, even though patients may feel less committed to perform the exercises in this way. Future research should focus on the attitude of physical therapists towards adopting eHealth services within their treatment. By knowing this, developers and researchers can anticipate on this, by for example fitting eHealth services to their needs, or educating them to remove their incorrect expectations. When physical therapists have a more positive attitude towards implementing eHealth in their practice, the needs of patients can be better fulfilled, i.e. receiving blended care.

Study limitations

One of the limitations of this study is selection bias, due to the used recruitment method (i.e. self-enrolment). This method can attract a study population that is more positive towards eHealth than the general population. Additionally, some participants suffer from specific N/LBP, whilst the SELFBACK app aims at self-managing non-specific pain. We still included these participants, because even though they knew the app focused on non-specific NLBP, they still thought that participating would help them. This might lead to a less positive attitude towards the app. However, considering our results we do not think this had a significant influence. Furthermore, we wanted to include quantitative use data in this paper. However, due to a 10-days downtime of the server which measures log history of the app, the quantitative use data was not reliable during these 10 days, so we presented only quantitative use data. Finally, we did not differentiate between participants. For example, some only used the SELFBACK app, and others used the app together with treatment from a therapist or chiropractor. It could be possible that the perceived barriers and facilitators differ between these groups. So, we suggest that future research should focus on difference in use and barriers and facilitators of a self-management app implemented as a standalone tool and as a supplement to face-to-face treatment among patients with N/LBP.

Conclusions

In conclusion, this study gave us two important insights. First of all, by eliminating the perceived main barriers and reinforcing the perceived main facilitators, we can make a first step in increasing the adoption of an eHealth service among N/LBP patients. To do so, the eHealth service needs to comply at least with the following four factors: (1) if the service collects activity data, this needs to be done with a wearable, (2) the service needs to have variation in content, (3) the service needs to have a daily/weekly plan for the user, and (4) the service needs to have a positive effect on relieving users' pain. We believe that by addressing these within the development of eHealth services, their adoption can be maximised. Second, this study adds to the body of literature that at least a part of the N/LBP patients are willing to receive blended care, but not all physical therapists are. With our study we hope to convey a message to the healthcare professionals that it is important to go along with these patients, as they are ready to use eHealth.

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"I enjoyed participating and it is good to hear that this may contribute to other people's well-being, happiness and health."
"Thank you for allowing me to participate for six weeks. I will continue performing the various exercises I have learned."
"It was very nice to participate, good luck with everything!"

6

Why do adults participate in summative eHealth evaluations?

Based on:

Hurmuz, M.Z.M., Jansen-Kosterink, S.M. & van Velsen, L. How to prevent the drop-out: Understanding why adults participate in summative eHealth evaluations. *(submitted for publication).*

Abstract

Background: eHealth studies experience high drop-out rates, which negatively impacts their results. In order to tackle this problem, we need to understand the coming about of these drop-out rates. In this study, we investigated why adults participate in summative eHealth evaluations, and whether their reasons for participating affect their (non-)use of eHealth.

Methods: A questionnaire was distributed among adults (aged ≥ 18 years) who participated in a summative eHealth evaluation. This questionnaire focused on participants' reason to enrol, their expectations, and on whether the study met their expectations. Answers to open-ended questions were coded by two researchers independently. With the generalised estimating equations method we tested whether there is a difference between the type of reasons in use of the eHealth service.

Results: One hundred and thirty-one adults participated (64.9% female; mean age 62.5 years (SD=10.5)). Their reasons for participating were mainly health-related (e.g., being more active). Between two types of motivations there was a difference in the use of the eHealth service: Participants with an intellectual motivation were more likely to drop out, compared to participants with an altruistic motivation. The most prevalent expectations when joining a summative eHealth evaluation were health-related (like expecting to improve one's health). 38.6% of the participants said their expectation was fulfilled by the study.

Conclusions: We encourage eHealth evaluators to learn about adults' motivation to participate in their summative evaluation, as this motivation is very likely to affect their results. Including altruistically motivated participants biases the results by their tendency to drop out of a study.

Introduction

High drop-out among participants in eHealth studies, is a common problem (e.g. (Alfonsson et al., 2017; Buhrman et al., 2016; Melville et al., 2010)) which impacts study results. For example, a study loses statistical power (Blankers et al., 2010), and it becomes difficult to determine the effectiveness of eHealth services (Eysenbach, 2005; Willmott et al., 2019). When experiencing drop-out, it is important to investigate why this occurs. Maybe it can be prevented by adapting a study, adapting the eHealth service, or by giving better explanations to participants. When looking at summative eHealth evaluation reports, they do not disclose reasons for drop-out rates (e.g. (Bhatia et al., 2021; Klausen et al., 2016; Kuipers et al., 2019; Van Dyck et al., 2016; Young et al., 2014)), or provide short explanations, like a loss of contact (Burke et al., 2019), participants moving house (Kerr et al., 2016; Schiaffini et al., n.d.), personal/family reasons (Burke et al., 2019; Jansen-Kosterink et al., 2015; Sönnerfors et al., 2020), studies being too time consuming (Broers et al., 2020), participants being too busy or with a lack of time (Burke et al., 2019; Kerr et al., 2016), being reluctant towards using technology (Broers et al., 2020), technical problems (Jansen-Kosterink et al., 2015), not wanting to be confronted with a medical condition (Broers et al., 2020), or medical problems (Burke et al., 2019; Jansen-Kosterink et al., 2015; Kerr et al., 2016). However, these are all merely short explanations and reasons for dropping-out are often not being investigated in-depth. A first step in reducing the number of drop-outs in summative eHealth evaluations is to examine participants' reasons for participating.

A lot of research focusing on motivations of different groups to participate in health studies has been conducted. Soule and colleagues (2016) studied, among 164 patients suffering from heart diseases, the importance of four different motivations (intellectual motivation, altruistic motivation, health motivation, and financial motivation) to participate in observational health research. They found that the most important reason to participate was altruistic: Participants wanted to help future patients in the same situation, or to help the researchers. The least important motivation, they found, was financial. In another study conducted in Canada, 39 adults were interviewed about reasons for participating in different kinds of health studies. These adults, it turned out, primarily participated for their own health gain: to have access to drugs, to have access to healthcare, and to have access to technologies for monitoring their health. Also in this study, receiving a financial incentive was not a pre-dominant motivation (Townsend & Cox, 2013). Both studies suggest that, in healthcare, adults primarily participate in studies to either help themselves or others.

For the context of eHealth, studies that uncover reasons for participating in summative evaluations among adults are scarce and only one study is available. Coley and colleagues

(2019) studied reasons for participating in a randomised controlled trial (RCT) involving an eHealth service focusing on prevention of cardiovascular diseases among older adults. The top three main motivations for participants to take part were contributing to science, improving one's lifestyle to improve health, and obtaining additional medical monitoring. More studies with a diverse range of eHealth services are needed, to better explain the high drop-out rates in these evaluations. By gaining knowledge on participants' motivation to participate in a summative eHealth evaluation, we can tune their setup towards the participants' needs and try to reduce the number of drop-outs. In this article, we report on a study in which we investigated adults' motivations to participate in different summative eHealth evaluations, conducted in real-world settings, and tested whether their reasons affect the (non-)use of eHealth.

Materials and Methods

Within three studies in which different eHealth services were evaluated, participants were asked to complete an online questionnaire about their reasons to participate and their expectations of the study, after they finished the study or when they dropped out. All three studies were conducted in the Netherlands.

eHealth services

Motivations to participate in the evaluation of three different eHealth services were inventoried. The first service, Stranded (see Figure 6.1), is a web-based, gamified eHealth service for (pre-)frail older adults. Stranded (Hurmuz et al., 2021) consists of two parts: a falls prevention programme based on the OTAGO Programme (Campbell & Robertson, 2003), and cognitive minigames. The falls prevention programme consists of physical exercise videos that older adults can perform at home. These exercises focus on improving muscle strength, balance, and flexibility. The minigames are different kinds of puzzle games. The second eHealth service, Council of Coaches (COUCH) (op den Akker et al., 2018) (see Figure 6.2), is a web-based service designed for adults with Diabetes Mellitus Type 2 or Chronic Pain, and older adults who are dealing with age-related impairments. The goal of COUCH is to encourage a healthy lifestyle via conversations with virtual coaches. Within COUCH six different coaches are available: a physical activity coach, a nutrition coach, a social coach, a cognitive coach, a chronic pain coach (only available for users with chronic pain), and a diabetes coach (only available for users with diabetes). The last eHealth service, the SELFBACK app (Marcuzzi et al., 2021; Mork & Bach, 2018; Sandal et al., 2019) (see Figure 6.3), is a mobile self-management application for adults with neck and/or low back pain. The SELFBACK app provides users with a weekly tailored plan to self-manage this pain. The weekly plain focusses on three aspects: Physical activity (i.e., daily step data), physical exercises to strengthen the muscles and increase flexibility, and educational messages to motivate users and to give them advice.

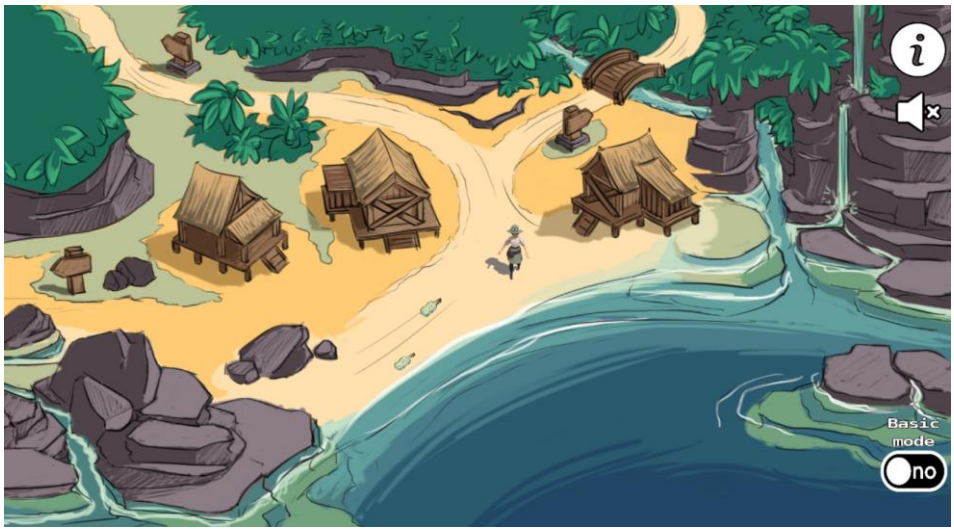


Figure 6.1. Screenshot homepage Stranded (Hut on the left is the physical exercises hut, arrow on the right brings user to minigames).

Figure 6.2. Screenshot homepage Council of Coaches. F.l.t.r. Carlos (peer), Olivia (physical activity coach), Emma (social coach), Katarzyna (diabetes coach), Helen (cognitive coach), Coda (helpdesk robot), François (nutrition coach).

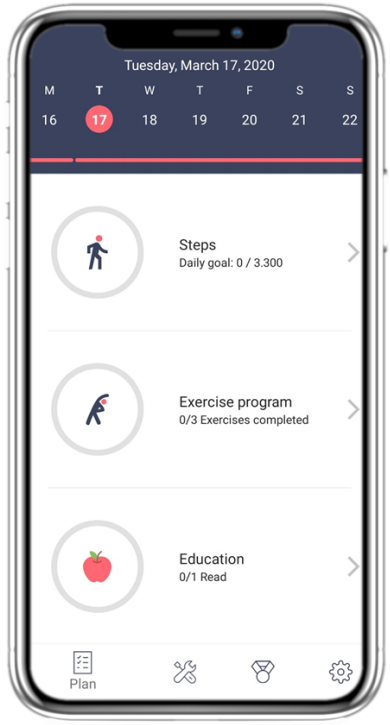


Figure 6.3. Screenshot homepage SELFBACK app (showing weekly self-management plan).

Data collection

An online questionnaire was distributed, consisting of seven questions (see Appendix 6.1 for full questionnaire). First, two questions on demographics (age and gender), and one multiple choice question, inventorying how participants came across the study (e.g., advertisement in local newspaper, social media, friend/family/colleague). Then, there was one open question, asking why participants wanted to participate in the study. Finally, to have more in-depth information about expectations towards summative eHealth studies that participants have, we posed three more questions. These questions elicited participants' initial expectations of the study (open question), asked whether the study met these expectations (closed question yes/no), and questioned why the study did (not) meet their expectations (open question).

Data analyses

We calculated descriptive statistics (frequency, mean, standard deviation, percentages) within SPSS v.19 to describe the demographics, to describe how participants came across the summative evaluation, and to inventory whether the evaluation met their expectations. We coded all open-ended questions thematically. Here, we used a

deductive approach to code the reasons for participating in a study. The themes by Soule and colleagues (2016) were used as the initial codebook: Intellectual motivation (i.e., being interested in the study), altruistic motivation (i.e., helping researchers and/or future patients), health motivation (i.e., wanting to improve one's health), financial motivation (i.e., receiving compensation (which does not need to be necessarily a monetary compensation)), and other motivations (e.g., fun, gaining knowledge). We used an inductive approach to code the other two open-ended questions (what were the expectations, why the study did (not) meet these expectations). The first and second authors coded all answers separately, and then discussed them together until there were no disagreements left.

To test for differences between the different motivation types, we conducted logistic regression analyses according to the generalised estimating equations (GEE) method within SPSS. The dependent variable was whether or not the participants used the eHealth service during the length of the study; predictors were the types of motivations. We opted for the GEE method, as some participants mentioned multiple reasons for participating. To be able to compare all three motivations (altruistic motivation versus intellectual motivation, altruistic motivation versus health motivation, and intellectual motivation versus health motivation), we performed the GEE analysis twice with different reference categories. After these analyses, we corrected the p-values according to the Holm-Bonferroni method. We excluded the category 'other motivation' from these analyses, as this was a relatively small, heterogeneous group of reasons that did not make for a sensible collection.

Ethics

All studies were all conducted according to the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and in accordance with the Medical Research Involving Human Subjects Act (Dutch law). The Medical Research Ethics Committee CMO Oost-Nederland stated that these studies do not require formal medical ethical approval (file numbers: 2019-5296, 2019-5555, 2020-6501). All participants signed an informed consent form before participating.

Results

A total of 131 adults completed the questionnaire. Their mean age was 62.5 years (SD=10.5); 64.9% was female. Fifty-three participants took part in the Stranded evaluation, 49 evaluated COUCH, and 29 evaluated the SELFBACK app. Most participants came across the studies via advertisements in local newspapers (66.4%). From 101 adults of the total study population, we have data whether they continued using the eHealth service during the full length of the study. Of these participants, just over half of the study

population used the eHealth service during the full length of the study: 55 out of 101 adults (54.5%). Table 6.1 shows the distribution of the demographics, data regarding how participants were recruited and data regarding use of the eHealth service of the different groups.

Table 6.1. Demographics and descriptive statistics for completed study of the total study population, and divided into the three eHealth groups.

		Total group (N=131)	Stranded group (N=53)	COUCH group (N=49)	SELFBACK app group (N=29)
Age (Range		23 – 87	55 – 84	55 – 87	23 – 77
M (SD))		62.5 (10.5)	64.4 (6.3)	65.4 (7.5)	53.9 (15.7)
Gender (%)	Male	35.1%	32.1%	28.6%	51.7%
	Female	64.9%	67.9%	71.4%	48.3%
Recruited via … (%)	Advertisement newspaper	66.4%	52.8%	71.4%	82.8%
	Advertisement social media	6.9%	7.5%	8.2%	3.4%
	Friend/ family/ colleague	19.1%	20.8%	20.4%	13.8%
	E-mail research panel	6.1%	15.1%	-	-
	Other	1.5%	3.8%	-	-
Continued using eHealth service for length of study (%)	Yes	42.0%	37.7%	22.4%	82.8%
	No	35.1%	11.3%	77.6%	6.9%
	Missing	22.9%	50.9%	-	10.3%

Reasons to participate

In total, 129 participants gave one or more reason(s) for participating in an evaluation, with a total of 157 reasons. Most of these reasons were related to health motivation (N=81). Examples of these reasons are that they want to improve/maintain their health, to live a healthy life, to have more energy, to relieve their pain, or to be more physically active.

> *“Because of an often found disease in the family, Type 2 Diabetes, I find it important to take my responsibility regarding my lifestyle.* (P-100, female, 62 years, COUCH study) ”

> *The older you get, the more attention you need to pay to your physical health. This requires discipline and at the same time the ability to keep it together. I saw the exercises you provided as an opportunity to strengthen this.* (P-32, male, 76 years, Stranded study)

The second most mentioned motivation was intellectual motivation (N=41), followed by altruistic motivation (N=22), and other motivations (N=13). No participant gave a financial motivation to participate in these studies. Reasons related to intellectual motivation were, for example, being interested in the study or being curious about the eHealth service under investigation.

> *Out of curiosity. I wanted to know what kind of exercises such a programme offers. Whether it is useful for me. Whether it is fun. Why exercises and games are implemented in one programme?* (P-39, female, 79 years, Stranded study)

Regarding their altruistic motivation, participants said they wanted to help the research(er) or wanted to help improve healthcare for future older adults/patients.

> *Because I think that if you want to develop new tools, technologies or drugs, you also need people who are willing to act as 'guinea pigs'.* (P-27, female, 59 years, Stranded study)

Other motivations participants mentioned for participating in these studies were: just for fun (N=5), wanting to be introduced to eHealth (N=5), because peers motivated them to participate (N=2), and because of the reputation of the research centre (N=1).

Table 6.2 shows the number of participants who used the eHealth service during the full length of the study and those that abandoned using the service, per motivation type. The statistical analyses show a clear difference in the degree of eHealth service use between participants with an altruistic motivation and participants with an intellectual motivation (see Table 6.3). The risk that participants drop out is 12.2 times higher among those with an intellectual motivation compared to those with an altruistic motivation (P=0.042, 95%-CI=1.648 – 90.827).

Table 6.2. Cross table showing number of times (not) continued use of eHealth service per motivation type.

Type of motivation	Number of participants who used eHealth service during length of study	Number of participants who abandoned use of the eHealth service	Totals
Intellectual motivation	N=17	N=16	N=33
Altruistic motivation	N=13	N=1	N=14
Health motivation	N=37	N=29	N=66
Totals	N=67	N=46	N=113

Table 6.3. Results logistic regression according to GEE method.

Comparison	Odds ratio	95% Confidence Interval	P-value	Corrected P-value
Altruistic[a] x Intellectual	12.2	1.65 – 90.8	0.014	0.042
Altruistic[a] x Health	10.2	1.28 – 80.9	0.028	0.056
Intellectual[a] x Health	0.83	0.40 – 1.73	0.624	0.624

[a] Motivation category used as reference value

Expectations for the eHealth evaluation

When asking the participants about their initial expectations for the eHealth evaluation, 70 participants mentioned at least one expectation (with a total of 79 expectations), 39 participants indicated they had no expectations, 16 participants did not answer this question properly (i.e., not providing an expectation, but mentioning something else), and the remaining 6 participants only indicated that their expectations were (too) high. Most expectations were health-related (N=41), followed by content-related (N=34), and technology-related expectations (N=4).

The health-related expectations can be divided into four kinds: Expecting to improve one's health (N=28), expecting to perform physical exercises (N=6), expecting to become aware of one's lifestyle (N=5), and expecting to maintain one's health (N=2).

> *"I expected to receive some exercises that might relieve my neck pain in some cases.* (P-110, female, 33 years, SELFBACK study) "

Content-related expectations were divided into six kinds: Expecting to receive help/tips (N=15), expecting to receive a positive prompt or nudge (N=7), expecting to receive personalised content (N=6), expecting to receive a combination of exercises and games

(N=3), expecting to receive a lot of content (N=2), and expecting to be talking to real coaches (N=1).

> *My expectation was that I would receive a personalised exercise programme […].* (P-109, male, 34 years, SELFBACK study)

Finally, technology-related expectations were either that participants thought the eHealth service was easy to use (N=2), or that the eHealth service had a high maturity level (N=2).

> *Beforehand, I thought it would be a simple programme, easy to start and fun to use as a variation.* (P-48, female, 62 years, Stranded study)

Of the 70 participants who mentioned a specific expectation, 27 indicated that participating within the study fulfilled their expectation(s) (38.6%). Twenty-two participants gave a reason why their expectation(s) was/were fulfilled. This was either content-related (N=13) (e.g., the eHealth service had suitable content, users received a positive prompt/nudge from the eHealth service), health-related (N=8) (e.g., improved health state), or personal (N=1) (enjoyed the eHealth service). The 43 participants whose expectations were not fulfilled, all explained their answer. The most mentioned reason was content-related (N=29) (e.g., lack of specific or personalised content), followed by personal reasons (N=9) (e.g., no fit with technology, lack of time), health-related (N=7) (no improvement in health state), or technology-related (N=7) (e.g., experienced problems while using the technology).

Discussion

In this paper, we investigated the reasons of adults to participate in summative eHealth evaluations in real-world settings, and tested whether their reasons affect the degree to which they used the eHealth service during the study. Finally, we elicited participants' expectations when joining these evaluations and assessed whether these expectations were met.

With regard to reasons for participating in summative eHealth evaluations, our findings show that most adults participate in order to actively do something for their own health state (e.g., improving their fitness levels, relieving pain). Townsend and Cox (2013) also found that health-related reasons to participate in health studies are dominant. However, based on other prior literature (e.g., (Bouida et al., 2016; Coley et al., 2019; Soule et al., 2016)), we expected that altruism would be (one of) the most prevalent reason to participate in summative eHealth evaluations. In our study, this reason was only a minor driver for participation. Furthermore, in our study, financial motivation was not mentioned by any participant as a reason to participate in a summative eHealth

evaluation. It should be noted though, that in none of the studies there was a substantial financial compensation; the participants knew they would receive a small gift to thank them for their participation. Apparently this did not influence their reason to participate in a study. The literature shows a different picture. Here, financial incentives *are* one of the reasons to participate (James et al., 2016; Liu et al., 2014; Moller et al., 2012). Explanations for the differences in the reasons for participating that we identified and those found in other studies, could be attributed to the use of the term 'small gift' in our information letters, or the different healthcare systems in the countries in which the studies were performed. After all, whether or not to participate in a health study when being in a healthcare system where every citizen is fully insured for a low fee (like in the Netherlands) might lead to a different incentive than when one lives in a country where being insured is less self-evident (like in the United States). In all, these results imply that during the recruitment process, potential participants should be primarily informed about the role the evaluation or the intervention can play with regard to their own health.

When analysing whether the reason to participate affected use of the eHealth service, we saw a difference in use between altruistically and intellectually motivated participants, with intellectually motivated adults being more likely to stop using an eHealth service before the end of a study: they became a drop-out. In a time where optimizing adherence is a hot topic (some people even talk about an 'engagement crisis'), we think this is an important finding. In order to further our understanding of adherence, studying the role of motivation is not new. Other researchers have, for example, studied the role of personal motivation types for complying with persuasive eHealth functionality (van Velsen et al., 2019). We propose that in future evaluations focusing on eHealth use, researchers identify participants' motivations at the beginning of the study. Later, they can then use this motivational profile to explain drop-outs and eHealth service use. The usefulness of this data would be enhanced by knowing the motivational profile of the addressable market for an eHealth service, so that the generalizability of the evaluation results can be made insightful.

Finally, our findings show that the expectations adults have about summative eHealth evaluations are mostly health-related or content-related. They expect that by participating in these studies, they will improve their health state, and receive helpful, personalised advice. Other studies also found that participants expect to receive this type of personalised content and these health benefits (e.g. (Cranen et al., 2012; Kuijpers et al., 2015, 2016)), and when developing eHealth services with involvement of end-users, end-users often mention personalised content as an important factor (e.g. (Morton et al., 2015; Vermeulen et al., 2014)). In order to increase the success of a recruitment strategy, evaluators should therefore stress the health potential of taking part in the study and the

eHealth service, and, if applicable, should stress the personalised features of the technology.

Study limitations

Our study has some limitations. First of all, in the three included studies, participants were recruited via self-enrolment. As a result, participants may have been motivated to participate in eHealth evaluations more than if we could have picked participants from the population at random. Possible, this has biased our results somewhat. Second, we chose to ask the participants after their participation why they chose to participate and which expectations they had before starting the study. There is a possibility that participants were not sure about their initial reasons anymore, or their answers might have been affected by the study and by the eHealth service used. However, we do not think this had a major impact on the results, because of the comprehensive answers participants gave, and because there was no participant that mentioned (s)he was unable to recall his or her reasons. To confirm our findings, we propose that future summative eHealth evaluations identify participants' reasons and expectations before starting. Finally, our study was conducted in the Netherlands. We think that the healthcare system of the country participants live, influences the findings. In the Netherlands, residents have relatively good access to healthcare, as everyone has an healthcare insurance, and the general practitioner acts as a gatekeeper (Schäfer et al., 2010). As it is easy to access healthcare for free in the Netherlands, we think that reasons such as 'participating in study to gain access to healthcare' do not play a role among our participants, or only marginally. So, the conclusions we can draw with our findings, do not directly apply to other countries with other healthcare systems.

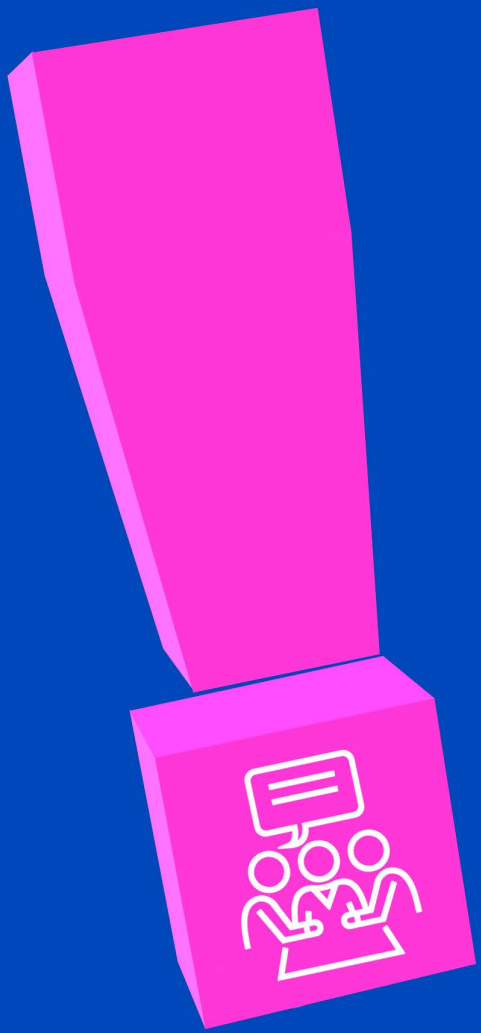
Conclusions

Drop-outs are a concern in science, in medical studies, and in summative eHealth evaluations, and it is in the researchers' interests to minimise the number of drop-outs in a study and to understand the reasons of the persons who decide to stop in an evaluation. For the case of summative eHealth evaluations, recruitment strategies should be focused on stressing the potential health benefits of participating in an evaluation and using the eHealth service. Offering monetary compensation will have no benefits. Additionally, if the eHealth intervention offers personalised information or advice, this should be stressed in recruitment strategies, as participants appreciate such a feature. Using this strategy will result in both, a higher number of participants and a lower number of drop-outs.

Acknowledgements

We want to thank Job van der Palen for his help with the statistical analyses. This work was supported by the FRAIL project funded by Eurostars-2 Programme [grant number 10824], the Council of Coaches project funded by the European Union's Horizon 2020 research and innovation programme [grant number 769553], and the Back-UP project funded from the European Union's Horizon 2020 research and innovation programme [grant number 777090].

"I think using eHealth stimulates people to first try to solve a problem yourself, to become healthier. Especially with the economy we live in nowadays. There is a lot of information available. However, you want to find the right and reliable information. Yes, you can start Googling all over the place, and you will read all sorts of strange things. But with an eHealth app like this, I have the impression that, due to the scientific story behind it, you are supported as a user, that you are not messing around with your body. I think that is very important, because of course it is about your health."



7

General discussion

Overview

The aim of this thesis was to increase our understanding about the (non-)use of eHealth services among the target population in a real-world setting. The first study of this thesis (**Chapter 2**) focused on predicting drop-out in eHealth use with users' demographics and personality traits. In **Chapter 3**, the described study sought to explain eHealth use and intention to continue using eHealth by means of the Technology Acceptance Model. Then, in **Chapter 4** the protocol (**Chapter 4a**) and results (**Chapter 4b**) of a case study of evaluating eHealth in a real-world setting with mixed methods (quantitative and qualitative) were presented. The study documented in **Chapter 5** qualitatively identified perceived barriers and facilitators when using eHealth. The last study (**Chapter 6**) described the reasoning of adults regarding why they participate in eHealth studies, whether this influenced their continued use of the eHealth service during the length of the studies, and it described their expectations about these studies. Finally, in this last chapter (**Chapter 7**) the findings of this thesis will be discussed in a broader perspective. This chapter starts with discussing the different eHealth services that are used within the studies of this thesis. Then, it continues with the learned lessons about the (non-)use of eHealth, it gives recommendations for future summative eHealth evaluations and it gives considerations for future research, ending with concluding thoughts.

This thesis focused on the use of eHealth services among their target populations. Within this thesis, I had the possibility to study the research aim in three major European projects: FRAIL (Eurostars-2 Programme, grant no. 10824), Council of Coaches (EU's Horizon 2020, grant no. 769553), and Back-UP (EU's Horizon 2020, grant no. 777090). So, three different eHealth services have been used: Stranded, Council of Coaches (COUCH), and SELFBACK. **Stranded** is a gamified falls prevention programme developed for older adults (Noorman-de Vette, 2019), which was used in Chapters 2, 3 and 6. **COUCH** is a virtual coaching application focusing on healthy living developed for older adults and adults with chronic pain or type 2 diabetes mellitus (op den Akker et al., 2018), which was used in Chapters 4 and 6. **SELFBACK** is a self-management mobile health application developed for adults with neck and/or low back pain (Marcuzzi et al., 2021; Sandal et al., 2019), which was used in Chapters 5 and 6. All studies conducted with these eHealth services were summative evaluations, as the Technology Readiness Levels (TRLs) were high enough (at least 6).

The (intensity of) use of the different eHealth services

Studying our research aim in different projects and eHealth services was a huge advantage because similarities and differences between the use of multiple eHealth services can be discussed. Within the studies using only Stranded or COUCH (**Chapters 2,**

3 and 4), the study populations targeted the same group: older adults aging 55 years or older. In both Chapter 2 and Chapter 4b, results of use data of the eHealth service under study were shown. In both these studies, there was a decline in the number of users over the weeks, which is in line with the law of attrition for eHealth (Eysenbach, 2005). This tells us that when older adults use eHealth services, it is likely that users will gradually decline over time. Similar trends were demonstrated in previously completed PhD dissertations of Roessingh Research and Development colleagues among other target populations (Cranen, 2018; Jansen-Kosterink, 2014; Tabak, 2014; van Weering, 2011). However, an obvious distinction between the use of Stranded and COUCH, is the difference in intensity of use. The average use of Stranded among the remaining users increased over the weeks, and the average use of COUCH among the remaining users declined over the weeks. So, within Stranded, the remaining users were using the eHealth service more intensively. A possible explanation for this variation in intensity could be the different content of both eHealth services. Within Stranded, users could increase every week in the level of the training programme, and users could gain new cognitive minigames by completing the weekly training programme. This could have motivated those who continued using Stranded to maintain or increase intensity of their use. Those who dropped out, did not use Stranded that frequent during a week. Within COUCH, new content every week was less of a prominent feature. Two coaches (a social coach and a cognitive coach) had a new weekly coaching session, but for the other coaches the users did not notice a major difference in new content between the different weeks. A likely reason for this is because they did not have such weekly coaching sessions and their new content was relatively small (e.g. small talk). Also, during the interviews participants mentioned multiple times that they would like to have more variation in content. Altogether, this shows us that regarding the use of eHealth services among older adults, a proportion of the users will stop using the eHealth service, but if the eHealth service has diversity in content, the remaining users will maybe use the eHealth service more intensively.

Looking at the use of the SELFBACK app in Chapter 5, there was no apparent decline of users. In Chapter 5, the study included only qualitative interview data regarding use. In the interviews, participants mentioned they used the app less frequently over time, but participants did not mention they stopped using the app in total. Of course, as there was no quantitative data to support this feedback, it is not possible to rule out self-reported bias. However, it is still plausible that this difference in use of the three eHealth services exists despite the bias. An explanation for this difference could be the different target populations of these studies. The SELFBACK app focuses on adults with neck and/or low back pain, and the study population in Chapter 5 also consisted of this group. This study population had an apparent physical complaint, i.e. pain. The other two study populations

consisted of a general group of older adults, who did not always have an obvious health complaint. To the best of my knowledge, in literature, it is not yet proven whether such a difference in study population leads to a difference in use of eHealth. The differences in use shown in this thesis, could show us that the law of attrition is more present in eHealth services focusing more on health prevention or promotion compared to eHealth services focusing on care or cure. Thus, for preventive eHealth services, it is important that users are adequately and clearly informed about the benefits of using the service, to try to prevent them from dropping out.

Explaining eHealth use

When talking about measuring eHealth use, different aspects can be studied. The studies within this thesis show that demographics and personality traits influence use (**Chapter 2**), perceived ease of use influences use (**Chapter 3**), perceived usefulness influences intention to continue use (**Chapter 3**), the content of technology influences use (**Chapters 4** and **5**), different perceived barriers and facilitators influence use (**Chapter 5**), and motivations to participate in eHealth studies influence use (**Chapter 6**). Figure 7.1 summarises these aspects derived from the different chapters of this thesis. These aspects are related to three main categories: user (demographics/personality traits), technology (the eHealth service itself) and interaction (interaction between user and technology).

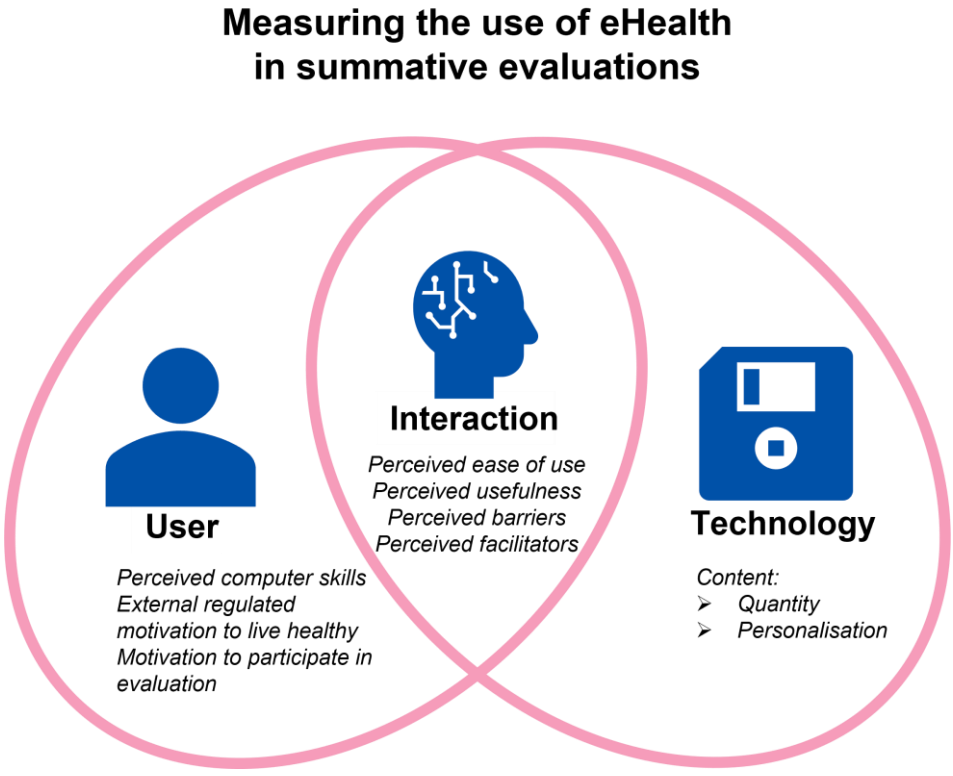


Figure 7.1. Aspects involved with measuring the use of eHealth in summative evaluations.

Evaluation of previous literature shows that researchers focus on the use of theoretical models (Hoque et al., 2017; Kim et al., 2016; Kutia et al., 2019; Ladan et al., 2018), on identifying technological factors (Grutzmacher et al., 2019; Van der Mispel et al., 2017), or on identifying personal characteristics (Alfonsson et al., 2016; Pedersen et al., 2019; Perski et al., 2017; Van der Mispel et al., 2017) to study eHealth (non-)use. Especially theoretical models, like the Technology Acceptance Model (TAM) (Davis, 1986; Davis et al., 1989), and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) are commonly used aspects when studying eHealth use. However, this thesis shows that using only these models will not give an accurate overview of the use of the service. There are a lot of aspects that influence the use of eHealth among the target population (see Figure 7.1), and theoretical models can of course be used as starting points in assessing this, but it cannot be the only aspect under investigation. A focus group study of Jansen-Kosterink and colleagues (2019) demonstrated that patients with a chronic disease do not focus on the constructs included in theoretical models when they think about aspects that reinforce or hinder their acceptance of eHealth. In literature, there are several papers which discuss some

shortcomings of the TAM. For example Bagozzi (2008) discusses the lack of social and cultural aspects, the simplified role of emotions, and the gap in time between intention to use and use (Bagozzi, 2008). Shachak and colleagues (2019) state that TAM is too simple and that many studies using TAM do not include the system's use. Because of this, the TAM contributes little to whether the system will be used. All things considered, it is important that future researchers who want to study the use of a particular eHealth service, look beyond the theoretical models, and address multiple aspects, such as those shown in Figure 7.1. This will ensure a better understanding regarding eHealth use.

How to improve eHealth use?

The studies presented within this thesis, show that a feature in eHealth services which has a major influence on its use is the inclusion of personalised content. When using eHealth services, users want at least content that is personalised towards their situation, as this is perceived as more useful (Van Velsen et al., 2013) and more effective in achieving behaviour change (Krebs et al., 2010). So, one way to improve eHealth use, is to include personalised content: this increases the perceived usefulness of eHealth, which subsequently affects the intention to continue use (**Chapter 3**). In two of the studies within this thesis (**Chapters 4** and **5**), lack of personalisation led to a decrease in using the eHealth services. The participants mentioned (they tend) to discontinue the study, because of receiving content that does not fit their situation (e.g. they are too healthy for the general advice given, or they need other physical exercises fitting their complaints). In both the eHealth services used within these chapters, COUCH (**Chapter 4**) and SELFBACK (**Chapter 5**), content is being personalised towards the user. But even with the personalisation that is present, there is a desire for even greater personalisation. It is difficult to have perfect personalisation for every user as everyone has different needs. For personalisation, several devices/techniques can be used, for example asking questions and using sensors (Beinema, 2021). These were also used to some extent in **Chapters 4** and **5** of this thesis, but the results show that this is not sufficient enough from the user's perspective.

A possible solution for improving the personalisation of eHealth services is to personalise accordingly to how users interact with the service. For example, looking at the SELFBACK app, when users do not perform a particular physical exercise within their weekly plan, this could be seen as an exercise they dislike or which does not fit their situation. An eHealth service can act upon this by sending for example a message to the user to ask whether (s)he wants to change that exercise. Or it could be done automatically when the system sees that exercise was performed only once. This is called dynamic personalisation (i.e. multiple assessments over time to personalise content). Krebs and colleagues (2010) showed that this type of personalisation is more effective than static personalisation (i.e. only one time input from user to personalise content). Another

solution for improving dynamic personalisation is to continue asking questions to gather information about one's personal life, and then give more targeted advice based on the answers. COUCH already included some of these questions like asking the user whether (s)he has a dog to walk with and whether (s)he does that, but that is not enough. If one answers 'No, I don't walk with my dog', the system does not gather more information on why this is the case. By gathering this extra information, the system could give more targeted advice to motivate the user to be active for example.

Looking at the studies conducted with Stranded, lack of personalisation was not a major topic of discussion. An explanation for this is that these participants were not interviewed to gather their experiences. The participants could only give their feedback about Stranded via e-mail or via an optional comment in a questionnaire. Some of these participants did mention that the physical exercises were not fitting to their health state. Within Stranded every user started at the same level of difficulty of the physical exercises. Personalisation here could be increased by including a baseline questionnaire to gather information about one's physique, and then choosing the level of difficulty based on these answers.

Besides personalising eHealth services, this thesis also shows other strategies which can be followed to maximise eHealth use. First, improving computer skills of users who perceive they possess low skills. The better the perceived computer skills, the more likely the users will continue using the service (see Chapter 2). When eHealth services are not understandable for the whole target population, their use will be low. eHealth needs to be inclusive for everyone (see whitepaper by Pharos expertisecentrum gezondheidsverschillen) (n.d.)). By educating users with low computer skills how to use the eHealth service and what the different functionalities are, these users will have a better understanding of the eHealth service. Secondly, including features within the eHealth service that comply to eHealth design principles for adults with an externally regulated motivation to live healthy. The higher the level of external regulation of older adults towards living a healthy life, the more likely they will drop-out from using eHealth services (see Chapter 2). If they receive stimuli that matches their motivation, drop-out could be prevented. Example stimuli are: showing users their progress within the eHealth service, giving users option to set their own goals, giving users compliments as rewards, and educating users about health topics (van Velsen et al., 2019). Thirdly, conducting a summative evaluation focusing on investigating barriers and facilitators the target population perceives when using an eHealth service. This evaluation needs to be conducted before its implementation, when the eHealth service is mature enough (i.e. TRL of at least 6). Some features of eHealth services can be perceived as barriers or as facilitators, and it is relevant to know which features these are (Lyzwinski et al., 2017). Based on this, the eHealth service can be adapted towards a better fit with the target

population, and its implementation will be more successful (Kruse et al., 2019; Lyzwinski et al., 2017). Chapter 5 of this thesis is an example of a study in which these barriers and facilitators are investigated. This paper is valuable for the implementation of the SELFBACK app, as the app can be adapted by eliminating the perceived barriers and reinforcing the presence of the perceived facilitators. With this, drop-out could be limited when it is implemented in the real-world. Altogether, to improve eHealth use among the target population, (1) the eHealth service needs to have personalised content, (2) the computer skills of users need to be sufficient, (3) the eHealth service needs to include features that comply to eHealth design principles for adults with an external regulated motivation to live healthy, and (4) before implementing the eHealth service, its barriers and facilitators need to be investigated.

All strategies mentioned to improve eHealth use are summarised in Textbox 7.1.

Textbox 7.1. Four strategies to improve eHealth use.

1. Include enough personalised content within the eHealth service.
2. Improve computer skills of users who perceive they possess low skills.
3. Include features within the eHealth service that comply to eHealth design principles for adults with an externally regulated motivation to live healthy.
4. Before implementing an eHealth service, conduct a summative evaluating focusing on investigating barriers and facilitators perceived by the target population.

Recommendations to improve summative eHealth evaluations

eHealth evaluations can be formative or summative. Formative evaluations are used during the development of the eHealth service to improve the process and eHealth service by assessing it, and summative evaluations are used when the eHealth service is developed to assess its effects and uptake (Kip & van Gemert-Pijnen, 2018; van Gemert-Pijnen et al., 2011). The Technology Readiness Levels (TRLs) could also be used for identifying when summative eHealth evaluations are needed. When an eHealth service has a TRL of at least 6, the evaluation needs to be summative. eHealth services with a low TRL need to have formative evaluations (e.g. focus groups identifying the important functionalities of eHealth or usability testing in a lab-setting) (Jansen-Kosterink et al., n.d.). The eHealth services used within the studies of this thesis, were already developed, usability tests were conducted and no major usability issues were present anymore and

were all at a TRL of at least 6. These eHealth services were steady enough and ready for use in the real-world. So, summative eHealth evaluations were needed and conducted.

Based on the experience gained within this thesis, I would like to give 3 recommendations on conducting summative eHealth evaluations.

1. Summative eHealth evaluations need to be conducted in a real-world setting.

A substantial amount of valuable eHealth services are (being) developed. When testing those in a real-world setting, researchers identify many issues which otherwise would go undetected. According to Taylor and colleagues (2013), evaluating new technologies has to be conducted in a real-world setting, to gain insight into long-term interaction between users and technologies. From this, researchers and developers will be more aware of how the technologies will be used when implemented in daily practice. Cudejko and colleagues (2021) reviewed literature about wearable technologies in real-world settings and mentioned that evaluating in a lab-setting differs from outcomes received by evaluating in a real-world setting. Furthermore, the renewed framework of evaluating eHealth (Jansen-Kosterink et al., 2016) states that real-world evaluations are needed when the eHealth service is ready to be tested for its effectiveness and adoption. These aspects will be best measured when they are evaluated just as how the services would be implemented for daily life use. The studies presented within this thesis are all conducted in a real-world setting. These studies provide insight in different aspects of eHealth use over a longer period of time. Altogether, for future summative eHealth evaluations, conducting the evaluations in a real-world setting is a must. With this, researchers can measure eHealth use, and they can be aware of the issues, barriers and facilitators users perceive, to address those and improve use.

2. eHealth services need to be evaluated with those people who actually need it.

During the studies conducted in this thesis, participants were recruited from the target population, but those participants still found it hard to see the benefit of using an eHealth service for themselves. Especially the target population ‘older adults’ is too broad, and distinction is needed. Participants of summative eHealth evaluations quickly think about others who could benefit from using such a technology, for example their friends or neighbours whose health state is (they think) less than theirs. Looking at previous literature, Oberschmidt and colleagues (2020) experienced in a workshop with older adults that these participants had difficulties with naming aspects of their daily lives they want to change, because they were already happy with their lives. However, when they thought about other older adults, they were able to mention some aspects that could be changed. When looking at the eHealth services used within this thesis, this case of not needing the eHealth service for your own daily life is especially prominent with the more

preventive kind of eHealth services, such as used in Chapters 2, 3 and 4. When someone is healthy, or thinks (s)he is healthy, it is difficult to see the added value of a preventive eHealth service. This could lead to a decline in the use of the eHealth service, and to a less positive experience with the eHealth service. This problem did not occur prominently in Chapter 5 where the used eHealth service had a clear purpose of improving physical complaints, and the study population also experienced these complaints. The participants of Chapter 5 were primarily looking for possible ways to relieve their pain, so they wanted to improve their health state. In the other studies of this thesis, the study populations were older adults in general, of which some perceive their health state as too good for the eHealth service. Altogether, this shows that involving the right representative study population gives outcomes which are better generalisable towards the final end-users when the eHealth service will be implemented. Glasgow (2007) also recommends future eHealth studies to include a representative study population consisting of people who need the eHealth service. Other literature shows that involving the target population in other stages of an eHealth service, such as the design or improvement of it, has a major positive influence on the uptake of the service (e.g. (Greenhalgh et al., 2015; Wherton et al., 2015)). I want to add to the body of literature the importance of involving a representative study population in the final studies (summative eHealth evaluations) where the eHealth service is (almost) ready to be implemented. By including the right study population, the eHealth service can be better adapted towards the end-users, and a step closer to sustainable implementation can be reached.

3. Motivations of the study population need to be investigated regarding why they participate in a summative eHealth evaluation focusing on eHealth use.

This needs to be done in the pre-test questionnaire (i.e. the questionnaire that needs to be completed before using the eHealth service). In Chapter 6 of this thesis, some of the participants of summative eHealth evaluations mentioned that they decided to engage in the studies to help the researcher or to help future persons with the same needs. Also in the interviews of the studies in Chapter 4 and Chapter 5, some participants mentioned they used the eHealth service to help the researcher. In Chapter 6, it was also explained that participants with an altruistic motivation (i.e. motivated to participate in study to help others) are more likely to continue use the eHealth service during the study compared to participants with an intellectual motivation (i.e. motivated to participate in study because having interest in research question). Because of this, the use of eHealth measured in studies is difficult to generalise to a real-world situation where adults use the eHealth service for their own good. So, when assessing the use of eHealth services in studies, researchers need to take into account that the results could be slightly biased due to altruism people feel, i.e. the feeling of helping others. By investigating participants' motivations, researchers could indicate the presence of this bias.

The recommendations are summarised within Textbox 7.1. These show us that conducting summative eHealth evaluations with people who actually need these services and within care practices is essential. It is more difficult to recruit this group, but when this group is involved, the findings of the studies will be more meaningful and generalisable.

Textbox 7.2. Three advices to improve summative eHealth evaluations.

1. Conduct summative eHealth evaluations in a real-world setting.
2. Evaluate eHealth services among the people who actually need these.
3. Investigate the motivations of the study population why they participate in summative eHealth evaluations focusing on eHealth use.

Future research

The use of eHealth service in daily lives is still low compared to the current capabilities in technology use. Even though the COVID-19 pandemic gave a boost to the use of the services, there is still room for more possibilities and eHealth is still not embedded in current care practice (Amorim et al., 2021; Garattini et al., 2020). This subsection first describes considerations for future research, then it gives two practical tools which can be used within future eHealth evaluations, and finally it describes a note on publishing qualitative studies.

Considerations for future research

In this thesis, use of the different eHealth services was always assessed within a research setting. As shown in Chapter 6, use within a research setting could be biased if there are participants included who are using the eHealth service particularly for the researcher or for future patients. Participants reasoning to use eHealth probably varies between the two different settings. For reaching sustainable implementation of eHealth services, use needs also to be assessed outside the research setting, to better find out how the eHealth service is being used, by whom, and why. A way to do this is by retrospectively study this with eHealth services which are already implemented. From these studies we can learn better how to reach sustainable implementation of new eHealth services.

Within this thesis, use of eHealth services was only assessed among end-users, and healthcare professional or organisational views was not considered. However, these two views need to be addressed as well to reach sustainable implementation. First, to address the healthcare professional's view, this thesis shows the importance of future research to focus on investigating physical therapists' attitude towards blended treatment more in-depth. One of the most important factors in reaching sustainable implementation of

eHealth is healthcare professionals' acceptance (Wernhart et al., 2019). During the interviews conducted within Chapter 5, the role of the physical therapist in using eHealth was mentioned multiple times. The participants were positive regarding the use of eHealth by physical therapists, but reported that their physical therapist never incorporated it into the care. So, it is important to know why this is the case, to be able to create a shift in physical therapy care. In literature, there are already studies focusing on healthcare professionals' acceptance of eHealth in general. For example, Hennemann and colleagues (2017) found that healthcare professionals from German rehabilitation centres have a low acceptance of eHealth. Another study focusing only on opinions of physical therapists (in Spain), shows more optimistic results. It showed that physical therapists were aware of the (dis)advantages of eHealth, and thought that eHealth could be implemented only if the patients are actively involved in their treatment (de la Cal et al., 2021). However, as in the Netherlands eHealth is not being frequently used among physical therapists. It is important to study more in-depth the attitudes of physical therapists in the Netherlands, to be able to comply with the needs of patients to receive blended treatment (see Chapter 5).

Finally, to address the organisational view of eHealth services, the last consideration for future research is assessing the value of including the Social Return on Investment (SROI) within summative eHealth evaluations. This is not directly based on the findings of this thesis, but more from a personal interest and experience. The SROI is *"a framework for measuring and accounting for this much broader concept of value; it seeks to reduce inequality and environmental degradation and improve wellbeing by incorporating social, environmental and economic costs and benefits"* (Nicholls et al., 2012). With the SROI method, value of, for example, implementing a new eHealth service can be measured. Within this method all relevant stakeholders and all (non-)monetary input and outcomes are included. Currently, the use of the SROI method is not being used (frequently) in assessing the value of eHealth services. Talboom-Kamp and colleagues (2021) did use the SROI method in assessing the value of a Dutch national programme which supports self-management for adults with a chronic disease. From this paper, it can be derived that including an SROI analysis could give insight into the value of eHealth services. As outcomes of implementing eHealth services are mostly non-monetary, for example better health state of users or decrease in workload for the healthcare professionals, the SROI method can be the perfect solution. However, future research should assess the value of the SROI method within summative eHealth evaluations. I propose future researchers focusing on eHealth implementation should try this method and publish their experiences within a scientific journal.

Two practical tools

This thesis has resulted in two tools for future research. The first one is *a protocol for future summative eHealth evaluations*. In Chapter 4a, an extensive protocol is written down which can be used for future summative evaluations focussing on use, user experience, and potential health effects of an eHealth service with high TRL. This protocol describes a mixed methods approach, which will give researchers insight in three topics (use, user experience, potential health effects). By using this mixed methods approach, researchers can better explain their findings, because of including qualitative experiences to quantitative results (McKim, 2015). Especially in the healthcare setting, the use of mixed methods approach for evaluating innovations is valuable, because even when an innovation proved to be effective, its implementation can fail. By evaluating the innovation with a mixed methods approach, the findings can be better interpreted (Albright et al., 2013), which can improve its implementation.

The second tool is *a minimum list of demographic characteristics that need to be measured as demographic during summative eHealth evaluations among older adults*. In Chapter 2, two main characteristics appear to influence drop-out: perceived computer skills and external regulated motivation to live healthy. In papers reporting the results of summative eHealth evaluations, there are always some demographics included to describe the population. Most of the times these are the basic ones, like gender, age, educational level, and living situation. However, this thesis shows that the characteristics which also need to be included in any case, are perceived computer skills and external regulated motivation. By including this, researchers will be able to control the study population and to better analyse drop-outs. For example, to stratify the study population of a randomised controlled trial with older adults using an eHealth service on both characteristics, or in an observational study with a significant number of drop-outs, to check whether this is because of having a study population with older adults who have low computer skills or whose motivation to live healthy is highly external regulated.

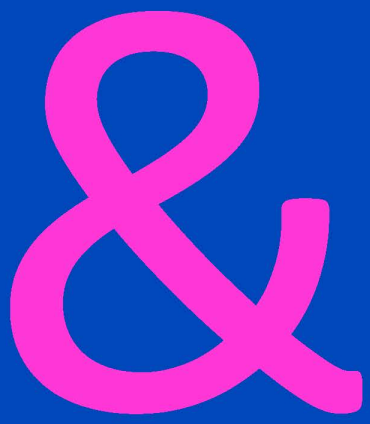
Publishing qualitative studies

A final note I want to make within this thesis is about publishing qualitative studies in scientific health journals. During publishing the studies, a difference was noticed in journals' view on the importance of the different studies. Currently, many health journals do not value qualitative studies as much as quantitative studies, especially the more clinical-oriented journals. On occasion, manuscripts were desk rejected because no or too little quantitative analyses were included. However, qualitative studies do have particular advantages compared to quantitative studies. For example, opinions and attitudes of participants can be included (Malterud, 2001a), participants can explain why they behave like they do (Moriarty, 2011), and findings can have more in-depth

explanations and can be better understood (Malterud, 2001b; Moriarty, 2011). The value of qualitative studies is currently already higher than for example in the late 90s (Collingridge & Gantt, 2008), but still not as high as quantitative studies for the health domain. A major challenge in publishing qualitative papers is also that journals often set a limit in word count for submissions. When writing a qualitative study, researchers can enrich their manuscript with quotes from participants, which gives readers a better insight into the different opinions. However, with a limit in word count, it is harder to include those, and a manuscript can be more superficial and therefore it is harder to prove its value.

Conclusion

This thesis aimed to contribute to our understanding of the (non-)use of eHealth. With these findings, we can work our way to reach sustainable implementation. However, it is only one part of the whole spectrum. Within this thesis, focus was always on the user perspective; the organisational/clinical or societal perspective was not considered. So, to what extent do the studies of this thesis contribute to sustainable implementation? We learned how drop-out can be prevented, how researchers can conduct summative eHealth evaluations, what the importance is of using a mixed methods approach in summative eHealth evaluations, why adults participate in summative eHealth evaluations, what the value is of using theoretical models in assessing eHealth use, and that patients are ready for receiving blended treatment. I propose that future researchers should focus on the other perspectives to further improve our understanding of the (non-)use of eHealth among the target population. Together we can reach sustainable implementation of eHealth services, and we can change the current practice of healthcare!



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Appendices

Appendix 2.1: Questionnaire

General demographics

1. What is your gender?
   - ☐ Male
   - ☐ Female

2. What is your age?

   …… years old

3. What is your highest level of education?
   - ☐ Primary school
   - ☐ Preparatory secondary vocational education
   - ☐ Higher general secondary education, pre-university education
   - ☐ Higher vocational education, university

4. What is your living situation?
   - ☐ Alone
   - ☐ Married/living together
   - ☐ Living together with my caregiver
   - ☐ Other

5. Which of the following categories best describes your work status?
   - ☐ Employed
   - ☐ Volunteer/caregiver
   - ☐ Retired
   - ☐ Job seeker
   - ☐ Other

6. Are you being supported by your family members/friends in your care process?
   - ☐ Yes
   - ☐ No

Attitude towards using technology (Agarwal & Prasad, 1998)

7. *How do you think about new technologies in general? Choose the answer that best fits your thoughts.*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
If I heard about a new information technology, I would look for ways to experiment with it.	☐	☐	☐	☐	☐	☐	☐
Among my peers, I am usually the first to try out new information technologies.	☐	☐	☐	☐	☐	☐	☐
In general, I am hesitant to try out new information technologies.	☐	☐	☐	☐	☐	☐	☐
I like to experiment with new information technologies.	☐	☐	☐	☐	☐	☐	☐

Perceived computer skills (Boot et al., 2015)

8. *How do you think about your computer skills? The statements below relate to your ability to perform a number of tasks with a computer. Choose the answer that best fits your computer use.*

	Never tried	*Not at all*	*Not very easily*	*Somewhat easily*	*Very easily*
I can use a computer keyboard to type.	☐	☐	☐	☐	☐
I can use a mouse.	☐	☐	☐	☐	☐
I can load ink into the printer.	☐	☐	☐	☐	☐
I can fix the printer when paper jams.	☐	☐	☐	☐	☐
I can open emails.	☐	☐	☐	☐	☐
I can send emails.	☐	☐	☐	☐	☐
I can find information about local community resources on the Internet.	☐	☐	☐	☐	☐
I can find information about my hobbies and interests on the Internet.	☐	☐	☐	☐	☐
I can use a computer to enter events and appointments into a calendar.	☐	☐	☐	☐	☐
I can check the date and time of upcoming and prior appointments.	☐	☐	☐	☐	☐

	Never tried	*Not at all*	*Not very easily*	*Somewhat easily*	*Very easily*
I can use a computer to watch movies and videos.	☐	☐	☐	☐	☐
I can use a computer to listen to music.	☐	☐	☐	☐	☐

Motivation to live healthy (van Velsen et al., 2019)

9. *We would like to look at your motivation to live a healthy life. We give you a number of statements, choose the answer that best fits your motivation.*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
I live healthy, because people around me reward me when I do.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I like to learn more about healthy living.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think others would disapprove of me if I did not.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I like to discover new ways to lead a healthier life.	☐	☐	☐	☐	☐	☐	☐
I live healthy, so that I get compliments from others.	☐	☐	☐	☐	☐	☐	☐

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
I do not think a healthy life really fits me.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think it is one of the best ways to develop other sides of myself.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think it is very interesting to learn how to live a healthier live.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because the people that are important to me would be angry at me if I did not.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think it is a good way to develop my strong suits.	☐	☐	☐	☐	☐	☐	☐
In the past, I had good reasons to live healthy, but nowadays I am doubting whether I want to continue healthy living.	☐	☐	☐	☐	☐	☐	☐

User expectation (Davis, 1989; Davis et al., 1989)

10. The following statements are about your expectations of Stranded. Choose the answer that best fits your expectations.

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
Using Stranded will help me understand my physical condition.	☐	☐	☐	☐	☐	☐	☐
Using Stranded will improve my physical condition.	☐	☐	☐	☐	☐	☐	☐
Using Stranded will improve my health.	☐	☐	☐	☐	☐	☐	☐
Using Stranded will give me insight in my health.	☐	☐	☐	☐	☐	☐	☐
It is clear and understandable how I will work with Stranded.	☐	☐	☐	☐	☐	☐	☐
I do not think I will have to think hard when working with Stranded.	☐	☐	☐	☐	☐	☐	☐
I think Stranded will be easy to use.	☐	☐	☐	☐	☐	☐	☐
I think it will be easy to get Stranded to do what I want it to do.	☐	☐	☐	☐	☐	☐	☐
I intend to use Stranded as often as necessary.	☐	☐	☐	☐	☐	☐	☐

Quality of life [EQ-5D-5L] (Van Reenen & Janssen, 2015)

11. *The following statements are about your quality of life. Under each heading, please tick the one box that best describes your health today.*

MOBILITY

- ☐ I have no problems in walking about
- ☐ I have slight problems in walking about
- ☐ I have moderate problems in walking about
- ☐ I have severe problems in walking about
- ☐ I am unable to walk about

SELF-CARE

- ☐ I have no problems washing or dressing myself
- ☐ I have slight problems washing or dressing myself
- ☐ I have moderate problems washing or dressing myself
- ☐ I have severe problems washing or dressing myself
- ☐ I am unable to wash or dress myself

USUAL ACTIVITIES (e.g. work, study, housework, family or leisure activities)

- ☐ I have no problems doing my usual activities
- ☐ I have slight problems doing my usual activities
- ☐ I have moderate problems doing my usual activities
- ☐ I have severe problems doing my usual activities
- ☐ I am unable to do my usual activities

PAIN/DISCOMFORT

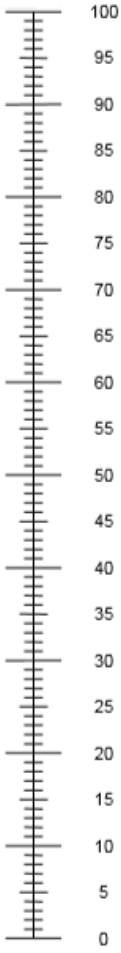
- ☐ I have no pain or discomfort
- ☐ I have slight pain or discomfort
- ☐ I have moderate pain or discomfort
- ☐ I have severe pain or discomfort
- ☐ I have extreme pain or discomfort

ANXIETY/DEPRESSION

- ☐ I am not anxious or depressed
- ☐ I am slightly anxious or depressed
- ☐ I am moderately anxious or depressed
- ☐ I am severely anxious or depressed
- ☐ I am extremely anxious or depressed

12. We would like to know how good or bad your health is **today**. The scale on the right side of the page is numbered from 0 to 100. 100 means the **best** health you can imagine. 0 means the **worst** health you can imagine. Mark an X on the scale to indicate how your health is **today**, and please write the number you marked on the scale in the box below.

The best health you can imagine



The worst health you can imagine

Quality of life [positive health] (Huber et al., 2016; van Velsen et al., 2019)

13. *A number of questions about positive health will follow. For each question, choose the number that best fits your health. On a scale of 1 (low) to 10 (high).*

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
How healthy do you think your body is? Do you feel fit? Are you in pain somewhere? Can you sleep and eat well?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
What do you think of your mental fitness? Can you concentrate well? Are you feeling well? Do you feel that you are in control of your life?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
We want to know how much satisfaction you get out of your life. Do you have a great zest for life? Do you have ideals that you want to achieve? Are you grateful for the things that life has given you?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Can you indicate what the quality of your life is? Do you enjoy life? Do you feel safe? Do you have the idea that your life is in balance? Do you have a comfortable life?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
What do you think of your social life? Do you have enough friends? Do you have others to do fun things with? Do you get help if you need it? Do you feel life you belong somewhere?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Can you indicate how well you can take care of yourself? Can you handle money well? Can you work? Do you know your limits? Can you ask for help if necessary?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Appendix 4A.1: Questionnaires

T0 Questionnaire

General demographics

1. What is your gender?
   - ☐ Male
   - ☐ Female

2. What is your age?

   ..... years old

3. What is your highest level of education?
   - ☐ Primary school
   - ☐ Preparatory secondary vocational education
   - ☐ Higher general secondary education, pre-university education
   - ☐ Higher vocational education, university

4. What is your living situation?
   - ☐ Alone
   - ☐ Married/living together
   - ☐ Living together with my caregiver
   - ☐ Other

5. Which of the following categories best describes your work status?
   - ☐ Employed
   - ☐ Volunteer/caregiver
   - ☐ Retired
   - ☐ Job seeker
   - ☐ Other

Health literacy (Chew et al., 2004)

6. How often do you have problems learning about your medical condition because of difficulty understanding written information?
   - ☐ Never
   - ☐ Occasionally
   - ☐ Sometimes
   - ☐ Often
   - ☐ Always

7. How confident are you filling out medical forms by yourself?
   - ☐ Not at all
   - ☐ A little bit
   - ☐ Somewhat
   - ☐ Quite a bit
   - ☐ Extremely

8. How often do you have someone help you read hospital materials?
   - ☐ Never
   - ☐ Occasionally
   - ☐ Sometimes
   - ☐ Often
   - ☐ Always

Self-reported level of physical activity

9. How often do you engage in physical or sports activities?
   - ☐ Not at all
   - ☐ Not at all, but thinking about beginning
   - ☐ Less than 2.5 hours a week
   - ☐ More than 2.5 hours a week in the last six months
   - ☐ More than 2.5 hours a week for more than six months

Attitude toward using technology (Agarwal & Prasad, 1998)

10. *How do you think about new technologies in general? Choose the answer that best fits your thoughts.*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
If I heard about a new information technology, I would look for ways to experiment with it.	☐	☐	☐	☐	☐	☐	☐
Among my peers, I am usually the first to try out new information technologies.	☐	☐	☐	☐	☐	☐	☐

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
In general, I am hesitant to try out new information technologies.	☐	☐	☐	☐	☐	☐	☐
I like to experiment with new information technologies.	☐	☐	☐	☐	☐	☐	☐

Motivation to live healthy (van Velsen et al., 2019)

11. *We would like to look at your motivation to live a healthy life. We give you a number of statements, choose the answer that best fits your motivation.*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
I live healthy, because people around me reward me when I do.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I like to learn more about healthy living.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think others would disapprove of me if I did not.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I like to discover new ways to lead a healthier life.	☐	☐	☐	☐	☐	☐	☐
I live healthy, so that I get compliments from others.	☐	☐	☐	☐	☐	☐	☐
I do not think a healthy life really fits me.	☐	☐	☐	☐	☐	☐	☐

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
I live healthy, because I think it is one of the best ways to develop other sides of myself.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think it is very interesting to learn how to live a healthier live.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because the people that are important to me would be angry at me if I did not.	☐	☐	☐	☐	☐	☐	☐
I live healthy, because I think it is a good way to develop my strong suits.	☐	☐	☐	☐	☐	☐	☐
In the past, I had good reasons to live healthy, but nowadays I am doubting whether I want to continue healthy living.	☐	☐	☐	☐	☐	☐	☐

Self-Management Ability Scale – Short version (Schuurmans et al., 2005)

12. *The following questions are about all different kind of things in you daily living. E.g. things you do, your hobbies, your contacts with others, etc. The questions relate on your situation in general. Consider for example how it was in the last three months.*

	Never	*Almost never*	*Sometimes*	*Regularly*	*Often*	*Very often*
How often do you take the initiative to keep yourself busy?	☐	☐	☐	☐	☐	☐
How often do you take initiative to get in touch with people who are dear to you?	☐	☐	☐	☐	☐	☐
How often do you make an effort to have friendly contacts with other people?	☐	☐	☐	☐	☐	☐
Do you ensure you have enough interests on a regular basis (such as a hobby) to keep you active?	☐	☐	☐	☐	☐	☐
Do you devote some time and attention to those who are dear to you in order to maintain good contact?	☐	☐	☐	☐	☐	☐
Do you keep busy with the things you are good at so that you stay good at them?	☐	☐	☐	☐	☐	☐

	Zero	*One*	*Two*	*Three or four*	*Five or six*	*More than six*
How many hobbies or activities do you have on a regular basis?	☐	☐	☐	☐	☐	☐
Do you have different occasions on which you have friendly contact with others?	☐	☐	☐	☐	☐	☐
Are there certain things that you are good at?	☐	☐	☐	☐	☐	☐

	Never	*Almost never*	*Sometimes*	*Regularly*	*Often*	*Very often*
The activities I enjoy, I do together with others.	☐	☐	☐	☐	☐	☐
I sometimes help the people I care about.	☐	☐	☐	☐	☐	☐
Others benefit from the things I do for my pleasure.	☐	☐	☐	☐	☐	☐
Are you able to find agreeable activities?	☐	☐	☐	☐	☐	☐
Are you able to have friendly contacts with others?	☐	☐	☐	☐	☐	☐
Are you able to let others know that you care about them?	☐	☐	☐	☐	☐	☐

	Never	*Almost never*	*Sometimes*	*Regularly*	*Often*	*Very often*
When things go against you, how often do you think that it could always be worse?	☐	☐	☐	☐	☐	☐
When you have a bad day, how often do you think that things will be better tomorrow?	☐	☐	☐	☐	☐	☐
When things are not going so well, how often do you succeed in thinking positively?	☐	☐	☐	☐	☐	☐

Quality of life [EQ-5D-5L] (Van Reenen & Janssen, 2015)

13. *The following statements are about your quality of life. Under each heading, please tick the one box that best describes your health today.*

MOBILITY

- ☐ I have no problems in walking about
- ☐ I have slight problems in walking about
- ☐ I have moderate problems in walking about
- ☐ I have severe problems in walking about
- ☐ I am unable to walk about

SELF-CARE

- ☐ I have no problems washing or dressing myself
- ☐ I have slight problems washing or dressing myself
- ☐ I have moderate problems washing or dressing myself
- ☐ I have severe problems washing or dressing myself
- ☐ I am unable to wash or dress myself

USUAL ACTIVITIES (e.g. work, study, housework, family or leisure activities)

- ☐ I have no problems doing my usual activities
- ☐ I have slight problems doing my usual activities
- ☐ I have moderate problems doing my usual activities
- ☐ I have severe problems doing my usual activities
- ☐ I am unable to do my usual activities

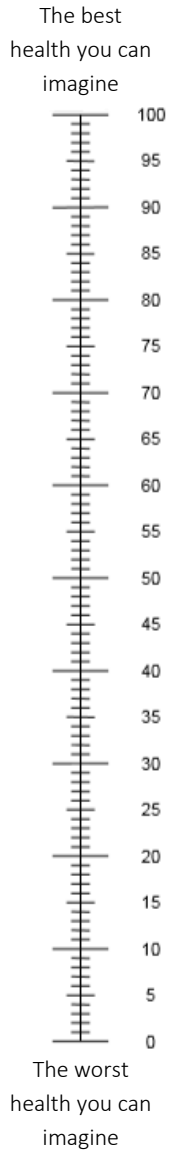
PAIN/DISCOMFORT

- ☐ I have no pain or discomfort
- ☐ I have slight pain or discomfort
- ☐ I have moderate pain or discomfort
- ☐ I have severe pain or discomfort
- ☐ I have extreme pain or discomfort

ANXIETY/DEPRESSION

- ☐ I am not anxious or depressed
- ☐ I am slightly anxious or depressed
- ☐ I am moderately anxious or depressed
- ☐ I am severely anxious or depressed
- ☐ I am extremely anxious or depressed

14. We would like to know how good or bad your health is **today**. The scale on the right side of the page is numbered from 0 to 100. 100 means the **best** health you can imagine. 0 means the **worst** health you can imagine. Mark an X on the scale to indicate how your health is **today**, and please write the number you marked on the scale in the box below.



Quality of life [positive health] (Huber et al., 2016; van Velsen et al., 2019)

1. *A number of questions about positive health will follow. For each question, choose the number that best fits your health. On a scale of 1 (low) to 10 (high).*

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
How healthy do you think your body is? Do you feel fit? Are you in pain somewhere? Can you sleep and eat well?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
What do you think of your mental fitness? Can you concentrate well? Are you feeling well? Do you feel that you are in control of your life?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
We want to know how much satisfaction you get out of your life. Do you have a great zest for life? Do you have ideals that you want to achieve? Are you grateful for the things that life has given you?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Can you indicate what the quality of your life is? Do you enjoy life? Do you feel safe? Do you have the idea that your life is in balance? Do you have a comfortable life?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
What do you think of your social life? Do you have enough friends? Do you have others to do fun things with? Do you get help if you need it? Do you feel life you belong somewhere?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Can you indicate how well you can take care of yourself? Can you handle money well? Can you work? Do you know your limits? Can you ask for help if necessary?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rating scale coaches

15. Please score each coach on a scale of 1 (low) to 10 (high).

Olivia Simons (physical activity)

1 2 3 4 5 6 7 8 9 10

François Dubois (nutrition)

1 2 3 4 5 6 7 8 9 10

Emma Li (social)

1 2 3 4 5 6 7 8 9 10

Helen Jones (cognitive)

1 2 3 4 5 6 7 8 9 10

Carlos Silva (peer & support)

1 2 3 4 5 6 7 8 9 10

Rasmus Johansen (chronic pain)

1 2 3 4 5 6 7 8 9 10

Katarzyna Kowalska (diabetes)

1 2 3 4 5 6 7 8 9 10

T1 Questionnaire

1. **Self-Management Ability Scale – Short version** (Schuurmans et al., 2005)
2. **Quality of life [EQ-5D-5L]** (Van Reenen & Janssen, 2015)
3. **Quality of life [positive health]** (Huber et al., 2016; van Velsen et al., 2019)

User experience (Davis, 1989; Davis et al., 1989; Gefen et al., 2003; Harrison McKnight et al., 2002; Lavie & Tractinsky, 2004; Liu, 2003; Van der Heijden, 2004; van Velsen et al., 2015; Venkatesh & Davis, 2000)

4. *The following statements are about your user experience with COUCH. Choose the answer that best fits your experience.*

	Disgusting						*Enjoyable*
The COUCH app was …	1	2	3	4	5	6	7
	Dull						*Exciting*
The COUCH app was …	1	2	3	4	5	6	7
	Unpleasant						*Pleasant*
The COUCH app was …	1	2	3	4	5	6	7
	Boring						*Interesting*
The COUCH app was …	1	2	3	4	5	6	7

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
The COUCH app looks clean.	☐	☐	☐	☐	☐	☐	☐
The COUCH app looks clear.	☐	☐	☐	☐	☐	☐	☐
The COUCH looks pleasant.	☐	☐	☐	☐	☐	☐	☐
The COUCH app looks well balanced.	☐	☐	☐	☐	☐	☐	☐

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
The COUCH app looks pretty.	☐	☐	☐	☐	☐	☐	☐
I have a lot control over what I can do on the COUCH app.	☐	☐	☐	☐	☐	☐	☐
On the COUCH app I can choose freely what I want to see.	☐	☐	☐	☐	☐	☐	☐
I can determine for myself what happens on the COUCH app.	☐	☐	☐	☐	☐	☐	☐
The security of the COUCH app gives me a comfortable feeling.	☐	☐	☐	☐	☐	☐	☐
The law and security technology protect me well against problems with the COUCH app.	☐	☐	☐	☐	☐	☐	☐
My personal data are well protected when I use the COUCH app.	☐	☐	☐	☐	☐	☐	☐
The COUCH app is safe.	☐	☐	☐	☐	☐	☐	☐
Using COUCH helps me understand my physical condition.	☐	☐	☐	☐	☐	☐	☐

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
Using COUCH improves my physical condition.	☐	☐	☐	☐	☐	☐	☐
Using COUCH improves my health.	☐	☐	☐	☐	☐	☐	☐
Using COUCH gives me insight in my health.	☐	☐	☐	☐	☐	☐	☐
It is clear and understandable how I can work with the COUCH app.	☐	☐	☐	☐	☐	☐	☐
I do not have to think hard when working with the COUCH app.	☐	☐	☐	☐	☐	☐	☐
I find the COUCH app easy to use.	☐	☐	☐	☐	☐	☐	☐
I find it easy to get the COUCH app to do what I want it to do.	☐	☐	☐	☐	☐	☐	☐
If the COUCH app would be available for me, I would definitely use it.	☐	☐	☐	☐	☐	☐	☐
I would recommend the COUCH app to others.	☐	☐	☐	☐	☐	☐	☐
I hope that the COUCH app becomes available for me.	☐	☐	☐	☐	☐	☐	☐

System Usability Scale (Brooke, 1996)

5. *The following statements are about the user friendliness of the COUCH app. Indicate for each of the statements to what extent you agree with it.*

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*
I think that I would like to use the COUCH app frequently.	☐	☐	☐	☐	☐
I found the COUCH app unnecessarily complex.	☐	☐	☐	☐	☐
I thought the COUCH app was easy to use.	☐	☐	☐	☐	☐
I think that I would need the support of a technical person to be able to use the COUCH app.	☐	☐	☐	☐	☐
I found the various functions in the COUCH app were well integrated.	☐	☐	☐	☐	☐
I thought there was too much inconsistency in the COUCH app.	☐	☐	☐	☐	☐
I would imagine that most people would learn to use the COUCH app very quickly.	☐	☐	☐	☐	☐
I found the COUCH app very cumbersome to use.	☐	☐	☐	☐	☐
I felt very confident using the COUCH app.	☐	☐	☐	☐	☐
I needed to learn a lot of things before I could get going with this system.	☐	☐	☐	☐	☐

Willingness-to-pay

6. Are you willing to pay for using the COUCH app?
   - ☐ Yes
   - ☐ No

7. Imagine the COUCH app is available in the Play Store/App Store of your phone, how much euros are you willing to pay for it?
   - ☐ 0 euros per month
   - ☐ 5 euros per month
   - ☐ 10 euros per month
   - ☐ 20 euros per month

Applicability of the virtual coaches (Paap et al., 2018)

8. *The following statements provide a description of how you can think or feel about the relationship with the primary virtual coaches. Indicate for each of the statements to what extent you agree with it.*

	Physical activity coach (Olivia)	*Nutrition coach (François)*
A result from communicating with the coach is that it is more clear what to do to improve my situation.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
What I am doing via the coach, gives me new ways of looking at my problem.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never

	Physical activity coach (Olivia)	*Nutrition coach (François)*
I believe that the coach likes me.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
The coach and I work together in determining my goals.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
The coach and I respect each other.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
The coach and I are working towards mutually agreed upon goals.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never

	Physical activity coach (Olivia)	*Nutrition coach (François)*
I feel that the coach appreciates me.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
The coach and I agree on what is important for me to work on.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
I think the coach cares about me even when I do things that (s)he does not approve.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
I think the thing I do via/with the coach will help me achieve the changes I want.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never

	Physical activity coach (Olivia)	*Nutrition coach (François)*
The coach and I have established a good understanding of the kind of changes that would be good for me.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never
I believe the way the coach and I are working with my problem is correct.	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never	☐ Always ☐ Very often ☐ Often ☐ Sometimes ☐ Never

9. *Please indicate for each of the coaches whether you talked to him/her, whether you, if possible, would like to talk for a longer period of time with him/her, and which score on a scale from 1 (low) to 10 (high) want to give him/her.*

Physical activity coach (Olivia Simons)

a. Did you talk to the physical activity coach (Olivia Simons)?
   - ☐ Yes
   - ☐ No

b. If possible, would you like to talk for a longer period of time with the physical activity coach (Olivia Simons)?
   - ☐ Yes
   - ☐ No

c. Please score the physical activity coach (Olivia Simons) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

Nutrition coach (François Dubois)

d. Did you talk to the nutrition coach (François Dubois)?
- ☐ Yes
- ☐ No

e. If possible, would you like to talk for a longer period of time with the nutrition coach (François Dubois)?
- ☐ Yes
- ☐ No

f. Please score the nutrition coach (François Dubois) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

Social coach (Emma Li)

g. Did you talk to the social coach (Emma Li)?
- ☐ Yes
- ☐ No

h. If possible, would you like to talk for a longer period of time with the social coach (Emma Li)?
   ☐ Yes
   ☐ No

i. Please score the social coach (Emma Li) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

Cognitive coach (Helen Jones)

j. Did you talk to the cognitive coach (Helen Jones)?
   ☐ Yes
   ☐ No

k. If possible, would you like to talk for a longer period of time with the cognitive coach (Helen Jones)?
   ☐ Yes
   ☐ No

l. Please score the cognitive coach (Helen Jones) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

Peer and support coach (Carlos Silva)

m. Did you talk to the peer & support coach (Carlos Silva)?
   - ☐ Yes
   - ☐ No

n. If possible, would you like to talk for a longer period of time with the peer & support coach (Carlos Silva)?
   - ☐ Yes
   - ☐ No

o. Please score the peer & support coach (Carlos Silva) on a scale from 1 (low) to 10 (high)

   1 2 3 4 5 6 7 8 9 10

Chronic pain coach (Rasmus Johansen)

p. Did you talk to the chronic pain coach (Rasmus Johansen)?
   - ☐ Yes
   - ☐ No

q. If possible, would you like to talk for a longer period of time with the chronic pain coach (Rasmus Johansen)?
   - ☐ Yes
   - ☐ No

r. Please score the chronic pain coach (Rasmus Johansen) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

Diabetes coach (Katarzyna Kowalska)

s. Did you talk to the diabetes coach (Katarzyna Kowalska)?

☐ Yes
☐ No

t. If possible, would you like to talk for a longer period of time with the diabetes coach (Katarzyna Kowalska)?

☐ Yes
☐ No

u. Please score the diabetes coach (Katarzyna Kowalska) on a scale from 1 (low) to 10 (high)

1 2 3 4 5 6 7 8 9 10

T2 Questionnaire

1. Did you use COUCH in the past four weeks?
   - ☐ Yes
   - ☐ No

2. Can you indicate why you have (not) used COUCH in the past four weeks?

   _____
   _____
   _____
   _____
   _____

3. **Self-Management Ability Scale – Short version** (Schuurmans et al., 2005)
4. **Quality of life [EQ-5D-5L]** (Van Reenen & Janssen, 2015)
5. **Quality of life [positive health]** (Huber et al., 2016; van Velsen et al., 2019)

Appendix 4A.2: Informed consent

User experience, use and potential health effect of Council of Coaches

I have read the subject information form. I was also able to ask questions. My questions have been answered to my satisfaction. I had enough time to decide whether to participate.

I know that participation is voluntary. I know that I may decide at any time not to participate after all or to withdraw from the study. I do not need to give a reason for this.

I give permission for the collection and use of my data to answer the research question in this study

I know that some people may have access to all my data to verify the study. These people are listed in this information sheet. I consent to the inspection by them.

I | do / do not | consent to being contacted again after this study for a follow-up study.

I want to participate in this study.

Name of study participant:

Signature: Datum: ___ / ___ / _____

I hereby declare that I have fully informed this study subject about this study.

If information comes to light during the course of the study that could affect the study subject's consent, I will inform him/her of this in a timely fashion.

Name of investigator:

Signature: Datum: ___ / ___ / _____

The study subject will receive the full information sheet, together with a signed copy of the consent form.

Appendix 5.1: Semi-structured interview guideline

Topic	Question(s)
Why participated – Needs from study	1. What made you say yes to participate in the SELFBACK study? a. *Follow-up*: What was it (the kind of help) you thought you needed?
Self-management before study	2. How did you manage your low back or neck pain before SELFBACK? a. *If contact with healthcare professional*: What type of help/advices did you receive from the HCPs you consulted previously
Involvement of healthcare professional during study	3. Did you seek help anywhere for your low back or neck pain during the previous six weeks? a. *If yes*: Were his/her advices conflicting with the ones given in the SELFBACK app? b. *If yes*: How did the use of the SELFBACK app fit with the care/advices received by the HCP? Supplement?
Use of SELFBACK app	4. How much did you use the SELFBACK app during the previous six weeks?
Facilitators for using the SELFBACK app	5. What is the main motivation for you to start using the SELFBACK app (over other options)? a. *Follow up:* Are there any other reasons? b. *Follow up:* Give an example 6. What is the most important reason for you to recommend the SELFBACK app to others with low back and/or neck pain? a. *Follow up:* Give an example 7. What makes you want to continue use the SELFBACK app?

Topic	Question(s)
Barriers when using the SELFBACK app	8. What is the most important reason for you to **not** use the SELFBACK app? a. *Follow up:* Are there any other reasons? b. *Follow up:* Give an example 9. What is the most important reason for you to **not** recommend the SELFBACK app to others with low back or neck pain? a. *Follow up:* Give an example 10. Is there something stopping you from using the SELFBACK app? a. *If yes:* What is that something?
Use of SELFBACK app	11. How do you use the app? a. *Follow-up:* Was that also how you used it in the beginning? 12. Which part(s) of the app content have you valued the most? 13. What has it meant for you to use the app?
Future use of SELFBACK app	14. Would you recommend the SELFBACK app to others with low back or neck pain? [Yes/no answer] 15. If the SELFBACK app would be available for you, would you use it? a. *Follow-up:* What could make you (don't) want to do it?
Willingness to pay for using SELFBACK app	16. Are you willing to pay for the SELFBACK app if you would receive this as a self-management tool? a. *If yes:* How much are you willing to pay per month? 17. Are you willing to pay in general for these kinds of apps? [Yes/no answer]
General opinion/ experience	18. What do you think about this 'self-management' that SELFBACK is aiming to support? 19. What do you think about using eHealth apps designed to help you get/feel better?

Appendix 5.2: Coding tree barriers and facilitators

Main category	Sub-category
Content factors	- Action plans - Feedback - Goal setting - Incentives - Reminders - Rewards - Self-monitoring tools - Social support features
Delivery factors	- Aesthetics and design - Challenge - Complexity - Control features - Credibility features - Familiarity - Guidance - Interactivity - Message tone - Mode of delivery - Narrative - Novelty - Personalisation - Professional support features
Population factors	- Demographic characteristics - Physical characteristics - Psychological characteristics
Setting factors	- Access to technology - Social/physical environment - Time
Other factors	- Health-related factors - Research-related factors - More

Appendix 5.3: Total overview of perceived barriers and facilitators

Barrier	N	Facilitator	N
Mode of delivery [delivery factors]	14	Action plans [content factors]	29
Novelty [delivery factors]	9	Health-related factors [other]	20
Health-related factors [other]	8	Research-related factors [other]	9
Psychological characteristics [population factors]	7	Access to technology [setting factors]	7
Goal setting [content factors]	6	Rewards and incentives [content factors]	5
Time [setting factors]	4	Goal setting [content factors]	5
Action plans [content factors]	3	Raising awareness [other]	4
Professional support features [delivery factors]	3	Learning to live with pain [other]	4
Feedback [content factors]	2	Reminders [content factors]	3
Personalisation of content [delivery factors]	2	Aesthetics and design [delivery factors]	3
Rewards and incentives [content factors]	1	Mode of delivery [delivery factors]	3
Social/physical environment [setting factors]	1	Positive prompt or nudge [other]	3
No added value [other]	1	Curiosity towards the app [other]	3
Not better than physical therapy [other]	1	Assessing app [other]	3
No scientific evidence [other]	1	Control features [delivery factors]	2
Problems with technology in general [other]	1	If it does not help, it will not hurt [other]	2
Do not need the app [other]	1	Learning ways to self-manage pain [other]	2
-	-	Feedback [content factors]	1
-	-	Novelty [delivery factors]	1
-	-	Psychological characteristics [population factors]	1
-	-	Time [setting factors]	1

Barrier	N	Facilitator	N
-	-	Adhering to app [other]	1
-	-	Comparing SELFBACK app with other app [other]	1
-	-	Replacing physical therapy [other]	1
-	-	Status of research centre [other]	1

Appendix 6.1: Questionnaire

1. What is your gender?
   - ☐ Male
   - ☐ Female

2. What is your age?

   ..... years old

3. Through which channel did you find out about this study?
   - ☐ Advertisement in local newspaper
   - ☐ Advertisement on social media
   - ☐ Flyer
   - ☐ Friend/family/colleague
   - ☐ E-mail from research panel
   - ☐ Other channel

4. Why did you want to participate in this study?

   _____
   _____
   _____

5. What were your expectations prior to this study?

   _____
   _____
   _____

6. Have these expectations been met?
   - ☐ Yes
   - ☐ No

7. Please indicate why this study has fulfilled your expectations / Please indicate why this study has not fulfilled your expectations

   _____
   _____
   _____

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Appendix 2.1

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Appendix 4A.1

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Summary

While there are many different eHealth services (being) developed, its use among the target population is still low. eHealth services can be a solution for many problems in healthcare (e.g. long waiting lists, limited capacity of healthcare demands, rising costs). However, if the target population does not use those services in daily lives, can eHealth even be proposed as a solution to healthcare problems? When implementing eHealth services, we experience high drop-out rates among the end-users. To decrease these drop-out rates, researchers need to pay attention to eHealth use in evaluations. Lots of eHealth evaluations focus primarily on its clinical efficacy. Whilst it is important to know the effectiveness of eHealth services, it is also important to assess whether these services will be used among the target population in a real-world setting. By conducting uncontrolled studies in a real-world setting, we can better focus on peripheral issues which lead to eHealth use. In this thesis, it is being investigated why eHealth services are (not) being used by the target population. **The aim of this thesis was to increase our understanding about the (non-)use of eHealth services among the target population in a real-world setting.**

In the study described in **Chapter 2**, it was explored which demographics and personality traits of older adults can predict dropping out of an eHealth service. Within this observational study, older adults had access to an eHealth service for 4 weeks, which they could use in a real-world setting. At start of the study, all participants (N=90) completed an online questionnaire measuring a lot of demographics and personality traits. These demographics and personality traits were based on previous literature focussing on drop-out in eHealth. The results of the survival and Cox-regression analyses showed two factors that predict drop-out in eHealth among older adults. First, perceived computer skills influences drop-out: the higher an older adult perceives his/her computer skills, the lower the chance is to drop out. Second, the motivation type external regulation to live healthy influences drop-out: the more external regulated an older adult's motivation is to live healthy, the higher the chance is to drop out. To prevent drop-out in these groups, training is needed to improve an older adult's perceived computer skills, and an eHealth service needs to include options which influence the external regulated motivation type (e.g. giving compliments, educating older adults).

Now we know older adults' demographics and personality traits that predict drop-out in eHealth, but we also need to take into account other factors that influence the use of eHealth. In the study of **Chapter 3**, a model based on the Technology Acceptance Model (TAM) was developed to investigate which determinants explain older adults' use and intention to continue use a gamified eHealth service. Seventy-two older adults were included in this study. These older adults could use a gamified eHealth service for 4 weeks

in a real-world setting. With Partial Least Squares Structural Equation Modelling, the developed model was assessed. This analysis showed that the TAM did not fully predict the use of and intention to continue using a gamified eHealth service. The perceived ease of use influenced the use of the gamified eHealth service, and perceived usefulness influenced the intention to continue use this service. But previous use did not influenced older adults ' intention to continue use the eHealth service.

In **Chapter 4,** a case study was presented which shows how you can evaluate an eHealth service in a real-world setting. A summative observational study was conducted with 51 older adults who could use a virtual coaching system for 4 to 8 weeks. In this summative evaluation, mixed methods was used to focus on use, user experience and potential health effects. **Chapter 4** is divided into **Chapter 4a** and **Chapter 4b**. In **Chapter 4a**, a protocol of this study was included which can be followed for other eHealth evaluations focussing on the same topics. In **Chapter 4b**, the results of this summative evaluation were presented. This evaluation showed that the number of older adults using the virtual coaching system declined over time, that the use of this system was mostly once a week, that this system was easy to use, and that on an individual level, minimal clinical important differences were found in different health variables. Furthermore, the results in this chapter highlight the importance of the mixed methods used. Due to this research method, more in-depth data was gathered about the quantitative results found.

As the study described in **Chapter 4** showed us the value of using qualitative data to gather in-depth experiences of users, the study in **Chapter 5** focused on qualitatively investigating barriers and facilitators adults with neck and/or low back pain (NLBP) perceive when using an mHealth app. In this study participants were interviewed to identify these factors. Thirty-two adults with NLBP were included, and they could use a self-management mHealth app for 6 weeks in the real-world setting. The top three most mentioned barriers that were perceived by these adults were mode of delivery of the mHealth app, novelty of the app, and health-related factors. The top three most mentioned facilitators to use the app were the inclusion of action plans, health-related factors, and access to technology. In this chapter, practical implications were given on how to tackle the barriers and how to reinforce the presence of the facilitators. This could increase eHealth use among this target population. Finally, this study also shows that adults with NLBP are ready and willing to receive blended treatment combining eHealth with face-to-face appointments, but most physical therapists are not.

In multiple chapters different aspects of eHealth (non-)use were discussed. However, to better understand why the target population does not use eHealth in daily live, the study described in **Chapter 6** identified the reasons of potential end-users to participate in eHealth studies, the influence of these reasons on the use of eHealth, and their

expectations about these studies. The participants of different studies were asked to complete a short online questionnaire. This questionnaire focused on their reasons to participate, their expectations, and whether the study met their expectations. A total of 131 adults from three eHealth studies completed this questionnaire. Four categories for reasons to participate in these studies were identified: intellectual motivation, health motivation, altruistic motivation and other motivations. The most mentioned category was health motivation, e.g. participating to improve my health, or to feel more fit. Between two motivation categories there was a difference in use of eHealth: people with an intellectual motivation to participate in eHealth evaluations are more likely to drop out compared to people with an altruistic motivation to participate. The results showed that including altruistic motivated adults in your study population, biases the study findings.

Finally, Chapter 7 concluded this thesis by discussing the main findings. First, the use of eHealth and the intensity of use among different eHealth services is discussed. Within this thesis, three different eHealth services are evaluated in summative studies. These eHealth services are compared to each other in their use and intensity of use. This comparison shows that among older adults, a part of the users will stop using eHealth, but if there is enough variation in the content of the eHealth service, the remaining users will use the eHealth service more intensive. The comparison also shows that when using an eHealth service for a specific physical complaint, decline in users is less apparent, compared to using an eHealth service for more general health promotion or prevention. Second, different aspects which can be used to measure eHealth use, and how eHealth use can be improved were discussed. These aspects were related to the user, the technology, and the interaction of those two. Based on these aspects, strategies for improvements were given. Third, within this chapter, three recommendations on improving summative eHealth evaluations were given. These were: (1) conducting summative eHealth evaluations in a real-world setting, (2) evaluating the eHealth service with those people who actually need it, and (3) investigating motivations of the study population for participating in summative eHealth evaluations. Fourth, this chapter focused on future research by (1) discussing considerations for future research (i.e. four perspectives for future studies to focus on), (2) by discussing the two practical tools that were derived from this thesis and that can be used in future studies (i.e. protocol for summative eHealth evaluations and a minimum list of demographic characteristics to include in studies), and (3) by discussing a note on publishing qualitative studies (i.e. health journals need to be more open towards publishing these studies). Finally, this chapter ends with concluding words.

Samenvatting

Ondanks dat er veel verschillende eHealth toepassingen zijn/worden ontwikkeld, is het gebruik ervan onder de beoogde doelgroep(en) nog steeds laag. eHealth toepassingen kunnen een oplossing zijn voor veel problemen in de gezondheidszorg (bijvoorbeeld lange wachtlijsten, beperkte capaciteit ten aanzien van de zorgvraag en stijgende kosten). Echter, als de doelgroep deze toepassingen niet in het dagelijks leven gebruikt, kan eHealth dan wel worden opgedragen als een oplossing voor problemen in de gezondheidszorg? Bij de implementatie van eHealth toepassingen ervaren we hoge uitvalpercentages onder de eindgebruikers. Om deze uitvalpercentages te verminderen, zouden onderzoekers tijdens evaluaties aandacht moeten besteden aan het gebruik van eHealth. Veel eHealth evaluaties richten zich voornamelijk op de klinische effectiviteit. Hoewel het belangrijk is om de effectiviteit van eHealth toepassingen te onderzoeken, is het ook belangrijk om te beoordelen of deze toepassingen in de werkelijke setting door de doelgroep zullen worden gebruikt. Door ongecontroleerde studies uit te voeren in het dagelijks leven van de doelgroep, kunnen we ons beter focussen op de randvoorwaarden van eHealth gebruik. In dit proefschrift wordt onderzocht waarom eHealth toepassingen (niet) worden gebruikt door de doelgroep. **Het doel van dit proefschrift was om ons begrip over het (niet) gebruiken van eHealth toepassingen onder de doelgroep in de werkelijke setting te vergroten.**

In de studie omschreven in **Hoofdstuk 2** werd onderzocht welke demografische gegevens en persoonlijkheidskarakteristieken van oudere volwassenen kunnen voorspellen of iemand stopt met het gebruiken van de eHealth toepassing. Binnen deze observationele studie hadden oudere volwassenen gedurende 4 weken toegang tot een eHealth toepassing, welke ze in hun eigen leefomgeving konden gebruiken. Aan het begin van het onderzoek vulden alle deelnemers (N=90) een online vragenlijst in bestaande uit demografische gegevens en persoonlijkheidskarakteristieken. Deze demografische gegevens en persoonlijkheidskarakteristieken waren gebaseerd op eerdere literatuur ten aanzien van uitval bij eHealth. De resultaten van de survival- en Cox-regressieanalyses lieten zien dat er twee factoren zijn welke uitval in eHealth onder oudere volwassenen kunnen voorspellen. Ten eerste beïnvloedt de ingeschatte computervaardigheden uitval: hoe hoger een oudere volwassene zijn/haar computervaardigheden inschat, hoe kleiner de kans is dat hij/zij uitvalt. Ten tweede beïnvloedt het motivatietype externe regulatie om gezond te leven ook uitval: hoe meer extern gereguleerd de motivatie van een oudere volwassene is om gezond te leven, hoe groter de kans is dat hij/zij uitvalt. Om uitval in deze groepen te voorkomen, is scholing nodig om de ingeschatte computervaardigheden van een oudere volwassene te verhogen, en moet een eHealth toepassing opties bevatten die van invloed zijn op het motivatietype externe regulatie (bijvoorbeeld complimenten geven, scholing geven).

Nu kennen we de demografische gegevens en persoonlijkheidskarakteristieken van oudere volwassenen die uitval in eHealth voorspellen, maar we moeten ook rekening houden met andere factoren die het gebruik van eHealth beïnvloeden. In de studie van Hoofdstuk 3 is een model ontwikkeld op basis van het Technologie Acceptatie Model (TAM) waarmee onderzocht werd welke determinanten het gebruik van eHealth en de intentie om eHealth te gebruiken onder oudere volwassenen verklaren ten aanzien van een gegamificeerde eHealth toepassing. Tweeënzeventig oudere volwassenen werden in deze studie geïncludeerd. Deze oudere volwassenen hebben een gegamificeerde eHealth toepassing gedurende 4 weken kunnen gebruiken in hun dagelijks leven. Met *Partial Least Squares Structural Equation Modelling* werd het ontwikkelde model beoordeeld. Uit deze analyse bleek dat de TAM het gebruik van een gegamificeerde eHealth toepassing en de intentie om een gegamificeerde eHealth toepassing te blijven gebruiken niet volledig voorspelde. Het ervaren gebruiksgemak beïnvloedde het gebruik van de gegamificeerde eHealth toepassing en het ervaren bruikbaarheid beïnvloedde de intentie om deze toepassing te blijven gebruiken. Echter had de wijze waarop de gegamificeerde eHealth toepassing eerder gebruikt werd, geen invloed op de intentie van oudere volwassenen om de eHealth toepassing te blijven gebruiken.

In Hoofdstuk 4 werd een casus gepresenteerd waarin beschreven wordt hoe een eHealth toepassing in een werkelijke setting geëvalueerd kan worden. Een summatieve observationele studie werd uitgevoerd met 51 oudere volwassenen die gedurende 4 tot 8 weken een virtueel coachingsysteem konden gebruiken. In deze summatieve evaluatie werden gemengde methoden (*mixed methods*) gebruikt, waarin de focus lag op gebruik, gebruikerservaring en potentiële gezondheidseffecten. Hoofdstuk 4 is onderverdeeld in Hoofdstuk 4a en Hoofdstuk 4b. Hoofdstuk 4a weergeeft een protocol van deze studie, welke gebruikt kan worden voor andere eHealth evaluaties die zich op dezelfde onderwerpen richten. In Hoofdstuk 4b werden de resultaten van deze summatieve evaluatie gepresenteerd. Uit deze evaluatie bleek ten eerste dat het aantal oudere volwassenen dat het virtuele coachingsysteem gebruikte in de loop van de tijd afnam, ten tweede dat het gebruik van dit systeem meestal één keer per week was, ten derde dat dit systeem gemakkelijk te gebruiken was en tot slot dat op individueel niveau minimale klinisch belangrijke verschillen (*minimal clinically important differences*) werden gevonden in verschillende gezondheidsvariabelen. Bovendien benadrukken de resultaten in dit hoofdstuk het belang van de gebruikte methode: mix tussen kwantitatief en kwalitatief. Door deze onderzoeksmethode werden meer diepgaande gegevens verzameld over de gevonden kwantitatieve resultaten.

De studie in Hoofdstuk 4 liet ons de waarde zien van het gebruik van kwalitatieve gegevens om diepgaande ervaringen van gebruikers te verzamelen. De studie in Hoofdstuk 5 richtte zich op het kwalitatief onderzoeken van barrières en *facilitators* die

volwassenen met nek- en/of lage rugpijn (NLRP) ervaren bij het gebruiken van een mHealth-app. Om deze factoren te identificeren, werden de deelnemers geïnterviewd. Tweeëndertig volwassenen met NLRP werden geïncludeerd. Zij konden een zelfmanagement mHealth-app gebruiken gedurende 6 weken in hun dagelijks leven. De top drie meest genoemde barrières die door deze volwassenen werden ervaren, waren de wijze van levering van de mHealth-app, nieuwheid van de app en gezondheidsgerelateerde factoren. De top drie van meest genoemde *facilitators* om de app te gebruiken waren de actieplannen, gezondheidsgerelateerde factoren en toegang tot technologie. In dit hoofdstuk werden praktische implicaties beschreven over hoe de barrières kunnen worden aangepakt en hoe de aanwezigheid van de *facilitators* kan worden versterkt. Dit zou het gebruik van eHealth onder deze doelgroep kunnen vergroten. Ten slotte liet de studie in dit hoofdstuk ook zien dat volwassenen met NLRP klaar en bereid zijn om een gemengde behandeling te krijgen waarin eHealth gecombineerd wordt met face-to-face afspraken, maar dat de meeste fysiotherapeuten dat niet zijn.

In meerdere hoofdstukken werden verschillende aspecten van het (niet) gebruiken van eHealth besproken. Daarnaast zijn er, in de studie beschreven in Hoofdstuk 6, een aantal factoren geïdentificeerd om beter te begrijpen waarom de doelgroep niet dagelijks gebruik maakt van eHealth, namelijk: de redenen van potentiële eindgebruikers om deel te nemen aan eHealth evaluaties, de invloed van deze redenen op het gebruik van eHealth en hun verwachtingen over deze evaluaties. De deelnemers werden hierbij gevraagd om een korte online vragenlijst in te vullen. Deze vragenlijst richtte zich op hun redenen om deel te nemen, hun verwachtingen betreffende het onderzoek en of het onderzoek aan hun verwachtingen voldeed. In totaal vulden 131 volwassenen uit drie eHealth evaluaties deze vragenlijst in. Vier categorieën voor redenen om deel te nemen aan deze evaluaties werden geïdentificeerd: intellectuele motivatie, gezondheidsmotivatie, altruïstische motivatie en overige motivaties. De meest genoemde categorie was gezondheidsmotivatie, bijvoorbeeld meedoen om mijn gezondheid te verbeteren, of om me fitter te voelen. Tussen twee motivatiecategorieën zat er een verschil in het gebruiken van eHealth: mensen met een intellectuele motivatie om deel te nemen aan eHealth-evaluaties haakten eerder af dan mensen met een altruïstische motivatie om deel te nemen. De resultaten lieten zien dat het includeren van altruïstisch gemotiveerde volwassenen in een onderzoekspopulatie de onderzoeksresultaten vertekent.

Ten slotte sloot Hoofdstuk 7 dit proefschrift af met een discussie van de belangrijkste bevindingen. Ten eerste wordt het gebruik van eHealth en de intensiteit van het gebruik tussen verschillende eHealth toepassingen besproken. Binnen dit proefschrift werden drie verschillende eHealth toepassingen geëvalueerd in summatieve studies. Deze

eHealth toepassingen werden met elkaar vergeleken in hun gebruik en gebruiksintensiteit. Uit deze vergelijking bleek dat onder ouderen een deel van de gebruikers zal stoppen met het gebruik van eHealth, maar indien er voldoende variatie is in de inhoud van de eHealth toepassing, zullen de resterende gebruikers intensiever gebruik maken van de eHealth toepassing. Uit de vergelijking blijkt ook dat bij het gebruik van een eHealth toepassing voor een specifieke fysieke klacht, de afname van gebruikers minder duidelijk is vergeleken met het gebruik van een eHealth toepassing welke zich richt op meer algemene gezondheidsbevordering of -preventie. Ten tweede werden verschillende aspecten besproken die gebruikt kunnen worden om het gebruik van eHealth toepassingen te meten en hoe het gebruik van eHealth kan worden verbeterd. Deze aspecten hadden betrekking op de gebruiker, de technologie en de interactie tussen die twee. Op basis van deze aspecten werden strategieën voor verbeteringen beschreven. Ten derde werden in dit hoofdstuk drie aanbevelingen gegeven over het verbeteren van summatieve eHealth-evaluaties. Dit waren: (1) het uitvoeren van summatieve eHealth-evaluaties in een werkelijke setting, (2) het evalueren van de eHealth toepassing met die mensen die het echt nodig hebben, en (3) het onderzoeken van motivaties van de onderzoekspopulatie voor deelname aan summatieve eHealth-evaluaties. Ten vierde richtte dit hoofdstuk zich op toekomstig onderzoek door (1) overwegingen voor toekomstig onderzoek te bespreken (d.w.z. vier perspectieven voor toekomstige studies om op te focussen), (2) de twee praktische producten die uit dit proefschrift zijn afgeleid en die in toekomstige studies kunnen worden gebruikt te bespreken (d.w.z. protocol voor summatieve eHealth-evaluaties en een minimale lijst van demografische kenmerken om in studies op te nemen), en (3) door een bevinding over het publiceren van kwalitatieve studies te bespreken (d.w.z. gezondheidstijdschriften moeten meer openstaan voor het publiceren van deze studies). Tot slot eindigt dit hoofdstuk met afsluitende woorden.

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About the author

Marian Hurmuz was born in Almelo, the Netherlands, on the 13th of August, 1994. In 2012, she started with the bachelor study Health Sciences at the University of Twente, Enschede, the Netherlands. In 2015, she started the master Health Sciences in which she followed the Health Service & Management track. She obtained her master degree in 2016. During her study, Marian was interested in multiple things, including conducting evaluations of interventions. This was also reflected within both her bachelor thesis and master thesis. Within her bachelor thesis, she evaluated an intervention focusing on overweight children together with two co-students. Within her master thesis, she evaluated the effects of conducting medication reviews in polypharmacy patients. Her master thesis was also published partly in a scientific journal.

After her master, Marian started working in an innovation lab consisting of young academics. Within this innovation lab, they helped different care and welfare organisations with answering pending questions and problems they encounter. During her time there, Marian helped six care organisations with various questions. For example, working as a project assistant to help with designing and implementing a social intranet, working as a researcher to investigate possibilities for eHealth in maternity care, and working as an advisor to improve the digital learning resources.

During one of these assignments, Marian came into contact with an employee of Roessingh Research and Development (RRD), in Enschede, who told her about the open position for junior researcher at RRD. In February 2019, Marian started working as a junior researcher and PhD candidate at RRD and the University of Twente. She worked in different European projects, such as FRAIL (Eurostars-2), Council of Coaches (Horizon 2020) and Back-UP (Horizon 2020). Within these projects, she conducted several studies, which are presented within this thesis. Besides those projects, Marian also worked within other European and national projects, which are not included within this thesis.

At the time of writing (April 2022), Marian is still working at RRD for some final weeks. After finalising her PhD, she wants to continue working in a function focusing on eHealth.

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The following publications have been published in the Progress range by Roessingh Research and Development, Enschede, the Netherlands. Copies can be ordered, when available, via info@rrd.nl.

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