Usability of a New eHealth Monitoring Technology That Reflects Health Care Needs for Older Adults with Cognitive Impairments and Their Informal and Formal Caregivers

Fatma Cossu-Ergecer[2,3], Marit Dekker[1], Bert-Jan F. van Beijnum[2] and Monique Tabak[1,2]
[1]*Roessingh Research and Development, Telemedicine Group, Enschede, The Netherlands*
[2]*University of Twente, Telemedicine Group, Enschede, The Netherlands*
[3]*TriviumMeulenbeltZorg, Enschede, The Netherlands*

Keywords: Health Monitoring, Subjective Monitoring, Cognitive Impairment, Technology, Ehealth, Informal Caregiver, Formal Caregiver, Home Care, Health Informatics.

Abstract: The aim of this study was to evaluate an eHealth monitoring application (HELMA) that provides insight in the health status of older adults with cognitive impairments (CI) independently living at home and their caregivers. A mixed-method approach was used to collect data on Usability (System Usability Scale) and Actual Use (Log data). Besides, a subgroup of participants were randomly selected and interviewed about their experiences with HELMA (Ease of Use, Perceived Usefulness, Behavioural Intention to Use and Attitude). Fifty-four older adults, fifteen formal and fourteen informal caregivers participated in this study. Results showed that HELMA is a useful supplement in the current care for older adults with cognitive impairments. The average SUS score of HELMA of formal caregivers indicated "good" usability. The questions of HELMA are clear. However, older adults lacked digital skills to use HELMA by themselves. Most of the participants (80%) used HELMA according to protocol, for a minimum of 4 weeks. The attitude towards willingness to learn and to use a technology were negative for almost all older adults. More attention to different implementation strategies is needed to increase the eHealth literacy of older adults with CI, to improve independent use of HELMA in the future.

1 INTRODUCTION

The prevalence of people with cognitive impairments (dementia) is increasing worldwide. The economic impact of dementia is high. People with dementia are confronted with a syndrome that increasingly affects their memory, thinking, behavior and ability to perform everyday activities (Burns, Jacoby, and Levy 1990; Jacoby and Levy 1990). This has severe implications on older adults' independence and quality of life (Urwyler et al. 2017). Dementia is overwhelming not only for the people who suffer from it, but also for their caregivers and families and impacts them physically, psychologically and economically (Nijhof 2013; Cahill, Begley, et al. 2007; Carswell et al. 2009).

In the Netherlands, a large number of older adults with cognitive impairments (CI) receive home care, allowing older adults to maintain their independence and quality of life. Home care takes place at the older adult's home. The care system is based on the active role and collaboration of various persons around the older adult, such as family members, caregivers, neighbors and general practitioners (Paganelli and Giuli 2011). However, this current home care system gives particular limitations. The consequences and chronic nature of cognitive impairments causes different care needs for the older adults (Boletsis and McCallum 2014). Therefore, some older adults may need more frequent visits than others, based on the severity of their physical and cognitive functioning (Cahill, Macijauskiene, et al. 2007). In the current care system, formal caregivers and informal caregivers get insight in the health status of the older adult during home visits of the older adult. However, most of the changes in symptoms happen in the absence of informal and formal caregivers and often older adults try to conceal their disability (Steeman et al. 2006). In addition, older adults have to provide information to the informal and formal caregivers

Cossu-Ergecer, F., Dekker, M., Beijnum, B-J. and Tabak, M.
Usability of a New eHealth Monitoring Technology That Reflects Health Care Needs for Older Adults with Cognitive Impairments and Their Informal and Formal Caregivers.
DOI: 10.5220/0006639301970207
In *Proceedings of the 11th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2018) - Volume 5: HEALTHINF*, pages 197-207
ISBN: 978-989-758-281-3

during the home visits, but since they suffer from cognitive impairments, this information cannot be considered as fully trustworthy and valid (Smith et al. 2005). Consequently, in the current care system, important information about the health status of the older adult might be missed and the care does not perfectly fit the needs of the older adult which decreases the quality of care, eventually increasing the healthcare costs (Wimo et al. 2013; Comas-Herrera et al. 2011). To improve the quality of care, a more frequent and targeted approach that fits the needs of the older adult seems important (Boletsis, McCallum, and Landmark 2015).

A promising method to overcome the limitations of current care are assistive technologies that can provide information about the real-time needs of the older adult. In the context of the globally aging population, many studies have underlined the possibilities of e-Health applications, due to increased easily usable internet connection and the advantages of accessibility, flexibility and personalized applications (Blusi, Dalin, and Jong 2014; Bujnowska-Fedak and Pirogowicz 2014; McKechnie, Barker, and Stott 2014). E- health is defined as "*health services and information delivered or enhanced through the Internet and related technologies" (Eysenbach 2001)*. Research indicated that the use of eHealth in the home setting is successful at supporting older adults with cognitive impairments and their caregivers by earlier detection of needs, increasing self-monitoring and thereby encouraging (Topo 2009; Nijhof et al. 2009; Lauriks et al. 2007). As such, eHealth can help in identifying care needs, risks and monitor disease progression (Lyons et al. 2015).

Although promising results regarding the use of e-health in this population of older adults, implementation is difficult as this is mostly an old population not familiar with these kinds of technologies and they suffer from cognitive impairments (Czaja et al. 2006). Different eHealth application frameworks show the importance of involving users early in the development process to get their perspective during continuous and systematic evaluations. This way, usability problems can be prevented and higher attrition rates can be achieved (Catwell and Sheikh 2009; van Gemert-Pijnen et al. 2011). As such, we used a user-centered design approach, involving all stakeholders in the development of a new e-health technology. We initiated a workshop at the elderly home TriviumMeulenbeltZorg (TMZ) in Enschede. The objective was to gather information with regards to older adults' daily needs and how technology could help to monitor this. As a result of this workshop, HELMA has been developed. HELMA is a remote health monitoring application that reflects health care needs of older adults with cognitive impairments in four health and well-being domains (physical, mental, environmental and social). The aim was to provide insight and detect changes (decline or progress) in the overall health status and well-being of older adults, which makes it possible to intervene more adequately when necessary and as such improving the quality of care. HELMA is based on the theoretical framework of OMAHA (Martin 2004; Koster and Harmsen 2015). OMAHA is used for problem classification to onset and changing of the care plan, at least once in six months.

The aim of this study was to evaluate HELMA focusing on Perceived Usefulness, Ease of Use and Actual Use. We evaluated HELMA following the framework of DeChant et al (DeChant et al. 1996) in which the type of assessment is tailored to the development life cycle of the technology. We used a stage 1 approach in which we evaluated HELMA on technical efficacy and in terms of access and quality of HELMA.

2 METHODS

2.1 Study Design

A mixed method study was performed. We conducted a qualitative usability study (interviews and questionnaires), complemented with a quantitative study (datalog-analysis).

2.2 Participants and Setting

This study was performed at home care clients and informal and formal caregivers of TMZ. TMZ is a healthcare organization in the Netherlands especially for elderly with physical and/or cognitive impairments.

Participants recruited for this study were older adults with CI, formal and informal caregivers. Inclusion criteria for older adults were: 1) receiving home care of TMZ; 2) having cognitive impairments or dementia; 3) living independently at home. All formal caregivers were employees of TMZ.

To recruit participants, the first author organized workshops to inform formal caregivers about HELMA and asked them if they and the person they cared for were willing to participate. The formal caregivers were also informed about the inclusion criteria and based on that they asked the older adults

and informal caregivers to participate in this study. The Medical Ethical Committee of Medisch Spectrum at Twente declares that this study does not meet the criteria necessary for an assessment by a Medical Ethical Committee according to Dutch law. Informed consent was obtained from all participants. After that, participants were instructed about the use of HELMA and they received their log-in accounts. They could start using HELMA after that.
Eleven homecare teams from Enschede, Almelo and Borne were asked to participate in this study.

2.3 HELMA

HELMA helps to monitor the older adults' healthcare problems through a digital questionnaire which can be filled in by (1) the older adults; (2) informal caregivers and (3) formal caregivers. Main objectives of HELMA are: (1) providing insight in (changes in) health status of the older adult and (2) improving the quality of care of older adults. HELMA is web-based, therefore it is accessible through various devices: PC, laptop, tablet and smartphone. HELMA is used online in the home setting and results can be accessed via a secure web portal by the participants. HELMA consists of 24 questions about the general health, physical, mental, social, and environmental aspects of the older adult, based on the Omaha system (Koster and Harmsen 2015). For the older adult, a decision tree has been made so that older adults with CI are not overloaded with questions each time. HELMA always starts with one question each time (how are you feeling today?) and an accompanying question (did you use your medication?). Dependent on the answer of this first question (good/not good), older adults are asked to fill in more questions to specify their feelings on the specific four domains (mentally, socially, physically, environmentally). Depending on their answers, older adults receive a minimum of 2 and a maximum of 24 questions. Formal and informal caregivers fill in all 24 questions about the older adult every time. Formal caregivers were instructed to use HELMA at least ones a week and the informal caregiver were free to use HELMA.

The informal and formal caregivers and older adults are presented a global status overview of the health status of the older adult during the last week. A full view of all answers of both the caregivers and the older adults is presented and answers of both the caregivers and the older adults are compared. As such, informal and formal caregivers can see in a quick overview whether something has changed in the status of the older adult and whether he needs to adjust care and/or contact the person.

2.4 Procedure

HELMA is used between 23-11-2016 to 22-05-2017. Participants were instructed to use HELMA for a minimum of four weeks and at least once a week. Older adults had the opportunity to use HELMA as often as they wanted. The caregivers use HELMA when they visit the older adult at home. If older adults did not own a technology to use HELMA, they had the opportunity to use a laptop provided by the caregiver. Informal caregivers were not obligated to use HELMA, only if they wanted to.

2.5 Outcome Measures

2.5.1 Demographic Variables and Technology Use

We collected demographic variables including age, sex, cognitive functioning, and ADL functioning at baseline by means of a questionnaire as well as data about the use of technology of the participants. Cognitive functioning was measured with the Mini Mental State Exam (MMSE) (Folstein, Folstein, and McHugh 1975; Kurlowicz and Wallace 1999). The range of MMSE score is from 0 (highest cognitive impairments) to 30 (not cognitive impaired) (Murden et al. 1991). Self-report of the ability to perform activities of daily living (ADLs) were assessed with the Katz ADL (Katz et al. 1963). Older adults were scored on a scale of I to IV for independence in each of the six functions. A Score of I indicated full function, II indicate partial dependency and III or IV indicated depending on care (Demotte 2004). Higher scores on this scale indicated lower ability to perform activities of daily living.

2.5.2 Usability

To gain insight in the usability of HELMA, the System Usability Scale (SUS) is measured after the use of HELMA by older adults and informal and formal caregivers when used independently. The System Usability Scale (SUS) is a short ten items questionnaire to investigate the satisfaction with the application (Brooke 1996). Rating of the SUS is from one (disagree totally) to five (agree totally) and the range is a score from 0 to 100. A score higher than 70 is considered as good usability, a score of 85 or higher as excellent usability and a score of 90 or

higher indicates best imaginable. A score of 50 or lower is considered as poor or unacceptable usability (Bangor, Kortum, and Miller 2009; Held et al. 2016).

2.5.3 Perceived Usefulness and Ease of Use

A subgroup of participants (older adults, formal and informal caregivers) were randomly selected to be interviewed about their experiences with HELMA and more in-depth information about the Perceived Usefulness and Ease of Use, after four weeks of using HELMA (T1).
Perceived Usefulness and Ease of Use was evaluated using the Technology Acceptance Model (TAM) (Davis 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh and Davis 2000; Or et al. 2011) which are two of the most common theories explaining acceptance of technology in literature. For this study we focused on four constructs of these models, being: Perceived Usefulness, Ease of Use, Behavioural Intention to Use and Attitude.

Perceived Usefulness and Ease of Use are measured after four weeks of using HELMA (T1) by means of an interview with a sub selection of older adults and informal and formal caregivers. Older adults, formal and informal caregivers were randomly selected from the users list of HELMA. Twenty participants, were interviewed to get information about their experiences of HELMA. This group consisted of ten older adults, five formal caregivers and five informal caregivers.

2.5.4 Actual Use of HELMA

The results of using HELMA were saved in log data. These log data contained information about the number of login in HELMA for each participant, the duration (e.g. how many minutes for filling in each questionnaire) and the frequency of viewing the weekly or monthly overview for informal and formal caregivers.

3 DATA ANALYSIS

The results of HELMA were quantitatively analyzed by using Excel. Graphs were made in Excel to show the number of login, the duration (e.g. how many minutes for each questionnaire) and the viewing the weekly or monthly overview for informal and formal caregivers.
The data of drop outs is not included in this study. Only the data of participants who fully completed four weeks of use were included.

The interviews were audio recorded, transcribed and qualitatively analysed using thematic analysis from Braun & Clarke (Meiland et al. 2014; Braun and Clarke 2006). The transcriptions were re-read and incremental coded by two researchers by noting the number of the participants who answered a same of response. The transcripts were read by both researchers and provided a code independently based on theories included in the UTAUT and TAM model. In case of disagreement, a third coder could be asked for advice. A coding scheme based on the category, the code and description was made for the interview questions. For example, the question 'Did the use of HELMA had an added value for you?' of the interview, was assigned to the code 'added value'. Some quotes from respondents, representative of the categories, were marked to add in the results. The codes that are equal or correspond to each other were assigned to one category. Several main codes were sub coded as positive, neutral or negative. Some transcripts were re-read by an external researcher to ensure that the categories and codes were correctly described in the coding scheme. When all interviews were coded, the results were analyzed.

4 RESULTS

A total of 54 older adults, 28 formal caregivers and 14 informal caregivers participated in the study. However, a total of 28 formal caregivers made an account and 15 of them completed the questionnaire.

None of the older adults were able to use HELMA by themselves and needed help from their informal and formal caregiver. As such, to be able to participate in the study informal and formal caregivers helped the older adults with completing HELMA after their routine care moment. For this, the caregiver opened the laptop or computer and logged in on the older adults' account. They read the question out loud. The older adult responded to the question asked and the caregiver filled in this answer for the older adult on the computer. After this, the formal caregiver had to log in on his own caregiver account, to be able to fill in HELMA from his perspective.

4.1 Participants' Demographics

In total, eleven older adults and four informal caregivers dropped out during the study. The reasons

for older adults dropping out were personal circumstances, such as lack of motivation (n=4), health problems (n=3), out of care (n=3) and one older adult (n=1) passed away. The reason for dropping out of informal caregivers were lack of time (n=2) or not giving care to the older adult anymore (n=2).

Demographic information at baseline for participants is summarized in table 1. Most of the older adults lived together with the partner. Only one informal caregiver used HELMA. The mean age of the older adults was 79.5, of the informal caregivers 64.0 and of the formal caregivers 31.0. Most of the participants were female. Fifty-four percent of the older adults indicated that they do not use a computer or laptop, and 43% did not have a technology (laptop, computer, tablet an, smartphone) at all. In contrast, all formal caregivers had 1 or more technologies at home or at work.
The mean MMSE score of older adults was 23.2, indicating mild cognitive impairments. The mean Katz ADL score of older adults was 2.3, indicating a partial dependency of care.

Table 1: Results of study population by Age, Gender and use of technology.

Type	Older adults (n=54)	Formal Caregiver (n=15)	Informal Caregiver (n=14)
Mean age in years (SD)	79.5 (9.1)	31 (11.2)	64 (11.2)
Gender, n (%)			
Male	20 (37)	1 (7)	5 (36)
Female	34 (63)	14 (93)	9 (64)
MMSE, mean (SD)	23.2 (7.2)	—	—
ADL Katz, mean (SD)	2.3 (1.2)	—	—
Use of technology, n (%)			
Computer/ laptop	25 (46)	15 (100)	13 (93)
Tablet	11 (20)	8 (53)	8 (57)
Smartphone	6 (11)	15 (100)	6 (43)
None of above mentioned	23 (43)	0 (0)	0 (0)

4.2 Usability

The System Usability Scale was completed from the perspective of the formal caregivers. The SUS was not filled in by any older adult or informal caregiver, because they have not used HELMA by themselves.
The mean SUS score is 72.2, indicating “good” usability of HELMA.

4.3 Actual Use of HELMA

HELMA was filled in from 51 different older adult accounts and 28 formal caregiver accounts. 43 older adults (80%) used HELMA at least four weeks.
Mean duration for each session was 1.6 minutes for older adults and 3.3 minutes for formal caregivers. The week overview is used by 21 formal caregivers and month overview by 11 formal caregivers.

4.4 Perceived Usefulness and Ease of Use

Ten older adults and five formal caregivers were interviewed to gain insight in the Ease of Use, Perceived Usefulness, Behavioural Intention to Use and Attitude of HELMA.

Informal caregivers couldn’t be interviewed about their experiences, as they didn’t make use of HELMA.

4.4.1 Perceived Usefulness

The first reactions about HELMA were positive (100%). Four older adults couldn’t answer the question due to severe cognitive impairments.
All formal caregivers and 30% of older adults were positive about one of the main aims of HELMA, being providing insight in the health status of older adults. All formal caregivers were positive about the usefulness as they said that HELMA provided them a good and clear overview about the needs at a distance. As an example, a formal caregiver said: ‘*you look at the overview of HELMA and you can see how the older adult was feeling in the past weeks’(FC2)*. Most formal caregivers (60 %) and older adults (50%) were positive about the second aim, being improving the quality of care because the service gave information about the health status to other informal and formal caregivers. Two formal caregivers (40%) were negative about this, as an example, a formal caregiver said: *‘Currently not, because we were very busy with it. However, if people are independent and can use it by themselves the quality of care will improve’(FC3).*
Furthermore, there are several advantages and disadvantages mentioned (see table 2). Two formal caregivers stated that the use of HELMA increased their digital skills. However, formal caregivers

(80%) stated the decision tree design as a disadvantage because this design gives limited questions when the older adult stated to be feeling good.

Table 2: Perceived Usefulness participants.

Topic	Older adults	Formal caregivers
First reaction (n)		
Positive	6	5
Neutral	0	0
Negative	0	0
Added value		
Insight health status (n)		
Positive	3	5
Neutral	2	0
Negative	3	0
Higher quality of care (n)		
Positive	4	3
Neutral	4	0
Negative	1	2
Advantages (n)		
- Personalized, better targeted care	1	1
- Improved social contact	1	
- Create time to think about the older adults' health status	1	1
- Feel useful because of participating in this study		1
- Gain digital skills		2
- Older adults' reassurance		1
- Decreases demand of care		1
- Gives more freedom to older adult		1
- Insight of patterns in health status		1
- Create new ways of communicating		1
Disadvantages (n)		
- Time consuming, lack of digital skills older adult		1
- Impersonalized care	1	1
- Lack of historic Information	1	
- Limited questions for the older adult when they feel good		4
- Limited questions to reflect health status for all domains		4
- Multiple interpretable questions		1
- Stressful to the older adult		1

4.4.2 Behavioral Intention to Use and Attitude

Most of the participants were willing to continue using HELMA in the future (50% older adults and 60% caregivers). Two of the formal caregivers didn't have the intention to continue using HELMA, because they thought it would be too stressful for the older adult (see table 3).

Most older adults' Attitude towards willingness to learn and to use a new technology were negative, because it was too difficult to learn to use HELMA with the current age, health status or digital skills. For example, one older adult said: '*No, I do not want to learn that anymore. I am 89 years old. I cannot learn that anymore' (C3).* However, all participants stated that they would recommend HELMA to others. Most of them (60% older adults and 60% caregivers) were positive about using new technologies that support efficient and effective healthcare (see table 3).

Table 3: Behavioral Intention to Use and Attitude participants.

Topics	Positive	Neutral	Negative	Missing
Older adults (n)				
Behavioral Intention to continue Using	5	0	3	2
Attitude				
-Willingness to learn	2	0	4	4
-Willingness to use new technology	3	1	6	0
-Recommendation to others	9	1	0	0
-Use new technology in homecare	6	2	0	2
Formal caregiver (n)				
Behavioral Intention to continue Using	3	0	2	0
Attitude				
-Willingness to use new technology	3	1	1	0
-Recommendation to others	5	0	0	0
-Use new technology in homecare	3	1	1	0
-Fear of incorrectness of outcome	1	0	0	4

4.4.3 Ease of Use

All participants were positive about the Ease of Use of HELMA (see table 4). They experienced the questions of HELMA as simple, interesting and clear, but it was impossible for the older adults to work with the service by themselves. They needed guidance from their formal or informal caregivers.

Table 4: Ease of Use participants.

Topic	Older adults	Formal caregivers
Ease of Use (n)		
Positive	9	5
Neutral	0	0
Negative	0	0
Questions clear (n)		
Positive	7	5
Neutral	0	0
Negative	0	0
Overview clear (n)		
Positive	-	4
Neutral	-	0
Negative	-	0

5 DISCUSSION AND RECOMMENDATIONS

The aim of this study was to evaluate the Perceived Usefulness, Ease of Use and Actual Use of HELMA. Results of the study showed that HELMA is a useful supplement in the current care for older adults with cognitive impairment. Most participants (60 % formal caregivers, 40% older adults) indicated that HELMA improved the quality of care. Besides, formal caregivers indicated that HELMA provides useful insight in the health status of older adults at a distance, even when they are not with an older adult. This gives them more information about the older adult before the home visit, also improving the quality of the care. These results are in line with those of previous studies who indicated that the use of eHealth in the home setting is successful at supporting older adults with cognitive impairment and their caregivers by earlier detection of needs (Duff and Dolphin 2007; Topo 2009; Nijhof et al. 2009; Lauriks et al. 2007). Such an identification of individual needs is the basis for a tailored intervention, which is important in light of the current demographic changes. Tailored and personalized interventions can improve the quality of care and enable older adults to live at home more independently for a longer period of time (Lauriks et al. 2007; Van Mierlo et al. 2012).

Most of the older adults (80%) used HELMA according to protocol, for a minimum of 4 weeks. One interesting finding is that most of those older adults (72%) indicated that they were feeling good, despite the fact that they have many health problems and receive home care. This result is in line with a recent study indicating that concealing the memory problems and presenting a hardfront to the world are a common phenomenon in people with CI (Graff et al. 2010; Nolte 2014). Although in some cases, the collected information of the older adult cannot be interpreted as objective data, it provides signals for formal caregivers to address the change in answers given over time. It can thus be suggested that HELMA fits the need of frequent health monitoring to detect the changes of health in absence of informal caregivers and to detect when older adults try to conceal their disability. These results corroborate the ideas of Nolte (Nolte 2014), who suggested that participants responded to questions even when they did not understand the questions and that information from informal and formal caregivers is important to address to be able to check the answers given by the older adults. This underlines the importance of including different perspectives in the health status of older adults as was implemented in HELMA. These different perspectives give a better insight in how the older adults is feeling compared with the opinion of the formal caregiver and highlights differences in answers given by the older adult and his/her formal caregiver.

All participants were positive about the Ease of Use of HELMA, however none of the older adults used HELMA by themselves. The use of HELMA was very difficult for the older adults, as most of them didn't use a computer or laptop at home. These results are in accordance with studies indicating that a small number of older people over the age of 65 in Europe own a laptop or computer (Irizarry, Downing, and West 2002; Magnusson, Hanson, and Borg 2004). In addition, sixty percent of the older adults in our study were not willing to use a new technology by themselves, because they thought that they wouldn't be able to learn it anymore and most of them indicated a lack of digital skills. Computer literacy is a major barrier in other studies as well where e-health is being used independently by older people (Lober et al. 2006; Charness and Boot 2009; Tacken et al. 2005). This e-health literacy calls for eHealth literacy interventions aiming at improving older older adults' ability to access and use eHealth applications, such as HELMA (Korda and Itani 2013; Segal et al. 2012). eHealth literacy refers to the "*set of skills and knowledge that are essential for productive interactions with technology-based health tools*" (Chan and Kaufman 2011). This should be taken into account when developing and implementing e-health services, especially when

they have cognitive impairments. It also highlights the importance of a user-centered design approach as suggested by van Gemert-Pijnen (van Gemert-Pijnen et al. 2011). In our study, older adults did not use HELMA, despite the user-centered design approach. One explanation for this might be that we involved them in the development of the content of HELMA, and not in the technology choices, as we expected them to be able to use a computer. In the future, this e-health literacy should be tested at forehand before implementing such new technologies. We recommend to focus on this e-health literacy in the implementation of HELMA by the older adults and informal and formal caregivers to enable older adults to make better use of HELMA in the future. This is in line with the literature, as a significant result found by Ellis and Allaire that a higher computer knowledge was associated with less computer anxiety and higher computer interest (Ellis and Allaire 1999). In addition, higher involvement of informal caregivers in the implementation of HELMA can motivate the older adult to use HELMA.

Despite the negative attitude towards learning new technologies, older adults were positive towards using new technologies by formal caregivers in homecare. In addition, most of the participants were willing to continue using HELMA in the future (50% older adults and 60% caregivers). All participants (all formal caregivers and 90% older adults) would recommend HELMA to others since it gives information about the older adults' needs. This indicates that the older adults have a positive attitude towards using HELMA in their home care, but with guidance of informal and formal caregivers. However, the negative attitude towards the willingness to learn and the willingness to use HELMA independently is important to take into account when implementing HELMA into daily practice of informal and formal caregivers. Many studies show that training adapted to the learning needs of older adults has a positive impact on attitude towards technology (Czaja and Sharit 1998; Jay and Willis 1992; Morris 1994; Kubeck 1999; Magnusson and Hanson 2004). Besides, persuasive elements should be used to support and motivate the users. The persuasive system Design model (PSD-model) (Kelders et al. 2012) and the Fogg Behavior Model (FBM) (Fogg 2009) can be used to develop a more persuasive eHealth design, because in terms of PSD, computers are seen as interactive technologies that can motivate and influence the older adult (Oinas-Kukkonen and Harjumaa 2008). One of the persuasive elements is tailoring and research showed that tailoring as an intervention strategy is effective in health (Broekhuizen et al. 2012; Wangberg, Bergmo, and Johnsen 2008) and gives knowledge about how the individual factors influence the health outcomes (Neafsey et al. 2008; Ownby, Hertzog, and Czaja 2012; Noureldin et al. 2012; Bosworth et al. 2009). In this perspective, it should be beneficial that HELMA tailors its content to the older adults' reading skills, technology experience, health literacy, age and health issues. Besides, to be successful in the future, the burden on the formal caregivers should not be increased too much, but should be supporting their care for the older adult. Increased burden has influence on higher illnesses in formal caregivers (Deeken et al. 2003; Dyck, Short, and Vitaliano 1999). Therefore, the interaction with the technology should be as minimal as possible, so that older adults can use HELMA by themselves. Different studies showed that other ways of interacting with these technologies increased the acceptance of eHealth services in low literacy people (Thornberry et al. 2002; Wolpin et al. 2010; Kim and Xie 2015). For example, a combination of text-to-speech or using touchscreens might be useful to integrate in HELMA to enable older adults to use HELMA by themselves.

5.1 Strengths, Limitations and Future Study

A strength of this study is that three different evaluating methods are used. In addition, a representative sample of older adults (54) in home care was used. Furthermore, HELMA was evaluated from different perspectives, namely older adults and informal formal caregivers. Caregivers play a crucial role in the success of the implementation of health monitoring. They have the digital skills and ability to learn to use HELMA rapidly (Chau and Hu 2002).

A limitation was that the older adults with high level of digital skills were underrepresented in this study. Older adults in this study with lack of digital skill have generally less health literacy. The literature shows that older people with less health literacy are less willing to participate in a study that uses questionnaires and are found to be less likely to use health information (Nijman et al. 2014). In a few years, the expectation is that the older people have more experience with use of internet, computer, smartphone and tablet. A future study is important, because this might allow older adults to use HELMA properly by themselves which might enhance positive results on HELMA.

6 CONCLUSIONS

Overall, the use of HELMA seems a useful option for providing eHealth monitoring for the detection of older adults' needs for their caregivers. Older adults with CI and formal caregivers are generally open minded towards using new e-Health technologies in home care. However, older adults lack the digital skills needed to use HELMA by themselves. More attention to different implementation strategies is needed to increase the eHealth literacy of older adults with CI, to improve independent use of HELMA in the future.

ACKNOWLEDGEMENTS

We would like to thank the informal and formal caregivers and clients of TriviumMeulenbeltZorg for participating in the development of HELMA and the actual study. Furthermore, the Roessingh Research and Development for the development of HELMA. This work was partly funded by the H2020 program (PHC-20-2014) within the IN LIFE project (grant no. 643442).

REFERENCES

Bangor, Aaron, Philip Kortum, and James Miller. 2009. 'Determining what individual SUS scores mean: Adding an adjective rating scale', *Journal of usability studies*, 4: 114-23.

Blusi, Madeleine, Rolf Dalin, and Mats Jong. 2014. 'The benefits of e-health support for older family caregivers in rural areas', *Journal of telemedicine and telecare*, 20: 63-69.

Boletsis, Costas, and Simon McCallum. 2014. 'Connecting the player to the doctor: utilising serious games for cognitive training & screening', *Designing Self-care for Everyday Life.*: 5.

Boletsis, Costas, Simon McCallum, and Brynjar Fowels Landmark. 2015. "The use of smartwatches for health monitoring in home-based dementia care." In *International Conference on Human Aspects of IT for the Aged Population*, 15-26. Springer.

Bosworth, Hayden B., Maren K. Olsen, Janet M. Grubber, Alice M. Neary, Melinda M. Orr, Benjamin J. Powers, Martha B. Adams, Laura P. Svetkey, Shelby D. Reed, and Yanhong Li. 2009. 'Two Self-management Interventions to Improve Hypertension ControlA Randomized Trial', *Annals of internal medicine*, 151: 687-95.

Braun, Virginia, and Victoria Clarke. 2006. 'Using thematic analysis in psychology', *Qualitative research in psychology*, 3: 77-101.

Broekhuizen, Karen, Willemieke Kroeze, Mireille N. M. van Poppel, Anke Oenema, and Johannes Brug. 2012. 'A systematic review of randomized controlled trials on the effectiveness of computer-tailored physical activity and dietary behavior promotion programs: an update', *Annals of Behavioral Medicine*, 44: 259-86.

Brooke, John. 1996. 'SUS-A quick and dirty usability scale', *Usability evaluation in industry*, 189: 4-7.

Bujnowska-Fedak, Maria Magdalena, and Iwona Pirogowicz. 2014. 'Support for e-health services among elderly primary care patients', *Telemedicine and E-health*, 20: 696-704.

Burns, Alistair, Robin Jacoby, and Raymond Levy. 1990. 'Psychiatric phenomena in Alzheimer's disease. IV: Disorders of behaviour', *The British Journal of Psychiatry*, 157: 86-94.

Cahill, Suzanne, E. Begley, J. P. Faulkner, and I. Hagen. 2007. "It gives me a sense of independence"–Findings from Ireland on the use and usefulness of assistive technology for people with dementia', *Technology and Disability*, 19: 133-42.

Cahill, Suzanne, Jurate Macijauskiene, Aase-Marit Nygård, Jon-Paul Faulkner, and Inger Hagen. 2007. 'Technology in dementia care', *Technology and Disability*, 19: 55-60.

Carswell, William, P. J. McCullagh, Juan Carlos Augusto, Suzanne Martin, M. D. Mulvenna, H. Zheng, H. Y. Wang, J. G. Wallace, Kevin McSorley, and Barbara Taylor. 2009. 'A review of the role of assistive technology for people with dementia in the hours of darkness', *Technology and Health Care*, 17: 281-304.

Catwell, Lorraine, and Aziz Sheikh. 2009. 'Evaluating eHealth interventions: the need for continuous systemic evaluation', *PLoS medicine*, 6: e1000126.

Chan, Connie V., and David R. Kaufman. 2011. 'A framework for characterizing eHealth literacy demands and barriers', *Journal of medical Internet research*, 13.

Charness, Neil, and Walter R. Boot. 2009. 'Aging and information technology use: Potential and barriers', *Current Directions in Psychological Science*, 18: 253-58.

Chau, Patrick Y. K., and Paul Jen-Hwa Hu. 2002. 'Investigating healthcare professionals' decisions to accept telemedicine technology: an empirical test of competing theories', *Information & management*, 39: 297-311.

Comas-Herrera, Adelina, Sara Northey, Raphael Wittenberg, Martin Knapp, Sarmishtha Bhattacharyya, and Alistair Burns. 2011. 'Future costs of dementia-related long-term care: exploring future scenarios', *International Psychogeriatrics*, 23: 20-30.

Czaja, Sara J., Neil Charness, Arthur D. Fisk, Christopher Hertzog, Sankaran N Nair, Wendy A Rogers, and Joseph Sharit. 2006. 'Factors Predicting the Use of Technology: Findings From the Center for Research and Education on Aging and Technology Enhancement (CREATE)', *Psychology and Aging*, 21: 333-52.

Czaja, Sara J., and Joseph Sharit. 1998. 'Age differences in attitudes toward computers', *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 53: P329-P40.

Davis, Fred D. 1989. 'Perceived usefulness, perceived ease

of use, and user acceptance of information technology', *MIS quarterly*: 319-40.

DeChant, Hallie K., Walid G. Tohme, Seong K. Mun, Wendelin S. Hayes, and Kevin A. Schulman. 1996. 'Health systems evaluation of telemedicine: a staged approach', *Telemedicine Journal*, 2: 303-12.

Deeken, John F., Kathryn L. Taylor, Patricia Mangan, K. Robin Yabroff, and Jane M. Ingham. 2003. 'Care for the caregivers: a review of self-report instruments developed to measure the burden, needs, and quality of life of informal caregivers', *Journal of pain and symptom management*, 26: 922-53.

Demotte, R. 2004. "Aangepaste KATZ-schaal voor rusthuizen en thuisverpleging." In.: Het Staatsblad het Koninklijk Besluit.

Duff, Petrina, and Ciaran Dolphin. 2007. 'Cost-benefit analysis of assistive technology to support independence for people with dementia–Part 2: Results from employing the ENABLE cost-benefit model in practice', *Technology and Disability*, 19: 79-90.

Dyck, Dennis G, Robert Short, and Peter P Vitaliano. 1999. 'Predictors of burden and infectious illness in schizophrenia caregivers', *Psychosomatic medicine*, 61: 411-19.

Ellis, R Darin, and Jason C Allaire. 1999. 'Modeling computer interest in older adults: The role of age, education, computer knowledge, and computer anxiety', *Human Factors*, 41: 345-55.

Eysenbach, Gunther. 2001. 'What is e-health?', *Journal of medical Internet research*, 3.

Fogg, Brian J. 2009. "A behavior model for persuasive design." In *Proceedings of the 4th international Conference on Persuasive Technology*, 40. ACM.

Folstein, Marshal F, Susan E Folstein, and Paul R McHugh. 1975. '"Mini-mental state": a practical method for grading the cognitive state of patients for the clinician', *Journal of psychiatric research*, 12: 189-98.

Graff, Maud, Margot van Melick, Marjolein Thijssen, Patricia Verstraten, and Jana Zajec. 2010. '3 Dementie.' in, *Ergotherapie bij ouderen met dementie en hun mantelzorgers* (Springer).

Held, Jeremia P, Bart Klaassen, Bert-Jan F van Beijnum, Andreas R Luft, and Peter H Veltink. 2016. 'Usability evaluation of a VibroTactile Feedback system in stroke subjects', *Frontiers in bioengineering and biotechnology*, 4.

Irizarry, Carol, Andrew Downing, and Deborah West. 2002. 'Promoting modern technology and internet access for under-represented older populations', *Journal of Technology in Human Services*, 19: 13-30.

Jacoby, R., and R. Levy. 1990. 'Psychiatric phenomena in Alzheimer's disease', *Br J Psychiatry*, 157: 72-94.

Jay, Gina M, and Sherry L Willis. 1992. 'Influence of direct computer experience on older adults' attitudes toward computers', *Journal of Gerontology*, 47: P250-P57.

Katz, Sidney, Amasa B. Ford, Roland W. Moskowitz, Beverly A. Jackson, and Marjorie W. Jaffe. 1963. 'Studies of illness in the aged: the index of ADL: a standardized measure of biological and psychosocial function', *Jama*, 185: 914-19.

Kelders, Saskia M., Robin N. Kok, Hans C. Ossebaard, and Julia E. W. C. Van Gemert-Pijnen. 2012. 'Persuasive system design does matter: a systematic review of adherence to web-based interventions', *Journal of medical Internet research*, 14.

Kim, Henna, and Bo Xie. 2015. 'Health literacy and internet-and mobile app-based health services: A systematic review of the literature', *Proceedings of the Association for Information Science and Technology*, 52: 1-4.

Korda, Holly, and Zena Itani. 2013. 'Harnessing social media for health promotion and behavior change', *Health promotion practice*, 14: 15-23.

Koster, Nicole, and Jeroen Harmsen. 2015. *Het Omaha system: een introductie* (Qwertypub).

Kubeck, Jean E. 1999. 'Finding Information on The World Wide Web: Exploring Older Adults'exploration', *Educational Gerontology*, 25: 167-83.

Kurlowicz, Lenore, and Meredith Wallace. 1999. 'The mini-mental state examination (MMSE)', *Journal of gerontological nursing*, 25: 8-9.

Lauriks, Steve, Annika Reinersmann, Henriëtte Geralde Van der Roest, FJM Meiland, Richard J Davies, Ferial Moelaert, Maurice D Mulvenna, Chris D Nugent, and Rose-Marie Dröes. 2007. 'Review of ICT-based services for identified unmet needs in people with dementia', *Ageing research reviews*, 6: 223-46.

Lober, William B, B Zierler, A Herbaugh, Sally E Shinstrom, Anna Stolyar, Eung-Hun Kim, and Yongmin Kim. 2006. "Barriers to the use of a personal health record by an elderly population." In *AMIA Annual Symposium Proceedings*, 514. American Medical Informatics Association.

Lyons, Bayard E, Daniel Austin, Adriana Seelye, Johanna Petersen, Jonathan Yeargers, Thomas Riley, Nicole Sharma, Nora Mattek, Hiroko Dodge, and Katherine Wild. 2015. 'Corrigendum: Pervasive computing technologies to continuously assess Alzheimer's disease progression and intervention efficacy', *Frontiers in aging neuroscience*, 7.

Magnusson, Lennart, and Elizabeth Hanson. 2004. '2.2 IT Support for Family Members of Older People', *The Needs of Family Members*, 1: 20.

Magnusson, Lennart, Elizabeth Hanson, and Martin Borg. 2004. 'A literature review study of information and communication technology as a support for frail older people living at home and their family carers', *Technology and Disability*, 16: 223-35.

Martin, Karen S. 2004. *The Omaha System: A key to practice, documentation, and information management* (WB Saunders Co).

McKechnie, Vicky, Chris Barker, and Josh Stott. 2014. 'Effectiveness of computer-mediated interventions for informal carers of people with dementia—a systematic review', *International Psychogeriatrics*, 26: 1619-37.

Meiland, FJM, BJJ Hattink, T Overmars-Marx, ME De Boer, A Jedlitschka, PWG Ebben, Ir INW Stalpers-Croeze, S Flick, J Van der Leeuw, and IP Karkowski. 2014. 'Participation of end users in the design of assistive technology for people with mild to severe

cognitive problems; the European Rosetta project', *International Psychogeriatrics*, 26: 769-79.

Morris, J. Morgan. 1994. 'Computer training needs ofolder adults', *Educational Gerontology: An International Quarterly*, 20: 541-55.

Murden, Robert A., Thomas D. McRae, Steven Kaner, and Mary E. Bucknam. 1991. 'Mini-Mental State Exam Scores Vary with Education in Blacks and Whites', *Journal of the American Geriatrics Society*, 39: 149-55.

Neafsey, Patricia J., Elizabeth Anderson, Sheri Peabody, Carolyn A. Lin, Zoe Strickler, and Kathlea Vaughn. 2008. 'Beta testing of a network-based health literacy program tailored for older adults with hypertension', *Computers, informatics, nursing: CIN*, 26: 311.

Nijhof, N., Jewc van Gemert-Pijnen, Daj Dohmen, and E. R. Seydel. 2009. 'Dementie en technologie. Een studie naar de toepassingen van techniek in de zorg voor mensen met dementie en hun mantelzorgers', *Tijdschrift voor gerontologie en geriatrie*, 40: 113-31.

Nijhof, Nienke. 2013. *eHealth for people with dementia in home-based and residential care* (Universiteit Twente).

Nijman, Jessica, Michelle Hendriks, Anne Brabers, Judith de Jong, and Jany Rademakers. 2014. 'Patient activation and health literacy as predictors of health information use in a general sample of Dutch health care consumers', *Journal of health communication*, 19: 955-69.

Nolte, Isabel. 2014. 'Reis naar het verleden-Reminiscentiekoffers voor ouderen met dementie', University of Twente.

Noureldin, Marwa, Kimberly S Plake, Daniel G Morrow, Wanzhu Tu, Jingwei Wu, and Michael D Murray. 2012. 'Effect of health literacy on drug adherence in patients with heart failure', *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, 32: 819-26.

Oinas-Kukkonen, Harri, and Marja Harjumaa. 2008. "Towards deeper understanding of persuasion in software and information systems." In *Advances in Computer-Human Interaction, 2008 First International Conference on*, 200-05. IEEE.

Or, Calvin KL, Ben-Tzion Karsh, Dolores J Severtson, Laura J Burke, Roger L Brown, and Patricia Flatley Brennan. 2011. 'Factors affecting home care patients' acceptance of a web-based interactive self-management technology', *Journal of the American Medical Informatics Association*, 18: 51-59.

Ownby, Raymond L, Christopher Hertzog, and Sara J Czaja. 2012. 'Tailored information and automated reminding to improve medication adherence in Spanish- and English-speaking elders treated for memory impairment', *Clinical gerontologist*, 35: 221-38.

Paganelli, Federica, and Dino Giuli. 2011. 'An ontology-based system for context-aware and configurable services to support home-based continuous care', *IEEE Transactions on Information Technology in Biomedicine*, 15: 324-33.

Segal, Jeffrey, Michael Sacopulos, Virgil Sheets, Irish Thurston, Kendra Brooks, and Ryan Puccia. 2012. 'Online doctor reviews: do they track surgeon volume, a proxy for quality of care?', *Journal of medical Internet research*, 14.

Smith, Sarah C., Joanna Murray, Sube Banerjee, Beth Foley,Joanna C Cook, Donna L Lamping, Martin Prince, Rowan H Harwood, Enid Levin, and Anthony Mann. 2005. 'What constitutes health-related quality of life in dementia? Development of a conceptual framework for people with dementia and their carers', *International journal of geriatric psychiatry*, 20: 889-95.

Steeman, Els, De Casterlé, Bernadette Dierckx, Jan Godderis, and Mieke Grypdonck. 2006. 'Living with early-stage dementia: A review of qualitative studies', *Journal of advanced nursing*, 54: 722-38.

Tacken, Mart, Fiorella Marcellini, Heidrun Mollenkopf, Isto Ruoppila, and Zsuzsa Szeman. 2005. 'Use and acceptance of new technology by older people. Findings of the international MOBILATE survey: 'Enhancing mobility in later life'', *Gerontechnology*, 3: 126-37.

Thornberry, Jutta, Brinda Bhaskar, Barbara Wesley, and Megan Adamson. 2002. 'Audio Computerized Self-report Interview Use in Prenatal Clinics', *CIN: Computers, Informatics, Nursing*, 20: 46-52.

Topo, Päivi. 2009. 'Technology studies to meet the needs of people with dementia and their caregivers: a literature review', *Journal of applied Gerontology*, 28: 5-37.

Urwyler, Prabitha, Reto Stucki, Luca Rampa, René Müri, Urs P Mosimann, and Tobias Nef. 2017. 'Cognitive impairment categorized in community-dwelling older adults with and without dementia using in-home sensors that recognise activities of daily living', *Scientific Reports*, 7: 42084.

van Gemert-Pijnen, Julia EWC, Nicol Nijland, Maarten van Limburg, Hans C Ossebaard, Saskia M Kelders, Gunther Eysenbach, and Erwin R Seydel. 2011. 'A holistic framework to improve the uptake and impact of eHealth technologies', *Journal of medical Internet research*, 13.

Van Mierlo, Lisa D., Franka J. M. Meiland, Henriëtte G. Van der Roest, and Rose-Marie Dröes. 2012. 'Personalised caregiver support: effectiveness of psychosocial interventions in subgroups of caregivers of people with dementia', *International journal of geriatric psychiatry*, 27: 1-14.

Venkatesh, Viswanath, and Fred D. Davis. 2000. 'A theoretical extension of the technology acceptance model: Four longitudinal field studies', *Management science*, 46: 186-204.

Wangberg, Silje C., Trine S. Bergmo, and Jan-Are K. Johnsen. 2008. 'Adherence in Internet-based interventions', *Patient preference and adherence*, 2: 57.

Wimo, Anders, Linus Jönsson, John Bond, Martin Prince, Bengt Winblad, and Alzheimer Disease International. 2013. 'The worldwide economic impact of dementia 2010', *Alzheimer's & Dementia*, 9: 1-11. e3.

Wolpin, Seth, Donna L. Berry, Ann Kurth, and William B. Lober. 2010. 'Improving health literacy: a web application for evaluating text-to-speech engines', *CIN: Computers, Informatics, Nursing*, 28: 198-204.