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Master Thesis

Home telemonitoring acceptance for eye care patients

Thomas Imhof

January 26, 2020

HOME TELEMONITORING ACCEPTANCE FOR EYE CARE PATIENTS

MEASURING WHAT FACTORS INFLUENCE HOME TELEMONITORING ACCEPTACE BY EYE CARE PATIENTS

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“Every morning in Africa a gazelle wakes up. It knows it must move faster than the lion or it will not survive. Every morning a lion wakes up and it knows it must move faster than the slowest gazelle or it will starve. It doesn't matter if you are the lion or the gazelle, when the sun comes up, you better be moving.”

Roger Bannister

Acknowledgements

Roger Bannister was the first man ever to run a four-minute mile, an accomplishment that was deemed physically impossible by many people. For years, many athletes had tried and failed to run a mile in less than 4 minutes. But, in 1954, a medical student named Roger Bannister busted through the four-minute barrier with 3:59.4 minutes. He did something no one thought was possible, and from that moment, people believed it could be done. From that day on, the four-minute mile was not deemed impossible. Within only 46 days from Bannister's accomplishment, another athlete broke his record. The "four-minute mile" has since been broken by over 1400 athletes.

In the past months, I have thrown myself in an, for me, unknown area of eHealth and eye-care technology at the University Medical Center Utrecht. I have dedicated my time and energy to writing this thesis to finish my master Business information technology at the University of Twente. I want to express my sincere gratitude to all who have helped me with reaching my goal of the completion of this master thesis.

First of all, I would like to thank Robert for his support, knowledge sharing, feedback, and supervising me in implementing the eHealth solution. His enthusiasm and passion for this project have always been motivating me. Secondly, I would like to thank my collogues at the UMCU and Easee B.V. for making my days enjoyable and memorable. Without their help, the project would not be as successful as it is at this moment.

I would also like to thank a few friends who made my time in Enschede worthwhile and helped me along the way. A special mention to Amit, Egle, Nivedita, Aimana, and Willem.

I would also like to show my gratitude to my girlfriend, Karlien, she has been incredibly supportive and always believed in me. Thanks to all family members who have supported me in doing my master's degree. I would like to specifically mention my grandfather as he is the one who inspired me to do an IT education.

Graduating for a Master of Science with remarkable grades is my "four-minute mile", it is an accomplishment that many people thought it would be impossible for me to do.

I broke a record today! Thanks to all the people who have supported me, and I want to thank you for that!

Thomas

Utrecht,
December 1, 2019

Abstract

Purpose: This research aims is to implement a new eHealth solution for eye-care at the University Medical Center Utrecht. Special attention will be given to the analysis of acceptance and adoption of telemonitoring services by patients.

Approach: A structured literature review about telemonitoring acceptance is conducted before conducting this research. Based on the results, a telemonitoring acceptance framework (TAF) which is an extension of the "unified theory of acceptance and use of technology" is developed. Also, a survey measurement model is developed to measure the constructs in the framework. This survey is administered among different patient groups and non-patient groups to assess the framework. Four iterations of the framework are analyzed to improve the model fit and reliability. The best model is used for the Structural Equation Model path analysis.

Based on the Design Science Research Methodology, a minimum viable product of an online eye exam is developed and implemented in the UMCU patient portal. This implementation is demonstrated and evaluated with a usability experiment. The MVP of the online eye exam is accessible via https://www.easee.online/nl/umcu/ .

Results & Conclusion

Data for assessing the telemonitoring acceptance framework was collected in November and December 2019. After the four iterations of model improvement, the reliability and quality of the measurement model were maximized for further analysis. However, the model fit is acceptable but not very impressive. The structural model path analysis showed that Performance Expectancy is significantly influencing Behavioural Intention (beta=1.113, P=.021). Trust (beta=0.865, P<.001) and Effort Expectancy (beta=0.241, P=.007) are significantly predicting Performance Expectancy. And finally, Self-Efficacy is influencing Effort Expectancy (beta=0.915, P<.001).

The evaluation of the MVP usability testing showed that the exam is hard to use for elderly people. They are less advanced in smartphone and computer use than we anticipated. Also, the instructions from the exam were hard to understand which resulted in catastrophic failures.

Recommendations

This research is the basis for a new telemonitoring acceptance framework. The framework and measurement model can be improved by having the survey translated by a professional, re-specifying or removing the questions with low internal reliability. Moreover, new data collection among a more homogeneous population will enable a more population-specific analysis of acceptance. The CORE-study will continue from January 2020 at the UMCU. This study will elaborate more on the usability, quality, validity and patient acceptance of the implemented online eye exam.

Table of Contents

List of figures

List of tables

List of equations

List of figures in the appendix

Acronyms

Acronym		Acronym	
AA	Affective Attitude	TA	Technology Anxiety
ACC	Acceptance	TAM	Technology Acceptance Model
ANN	Artificial Neural Network	TPB	Theory of Planned Behaviour
ATT	Attitude	TR	Trialability
BI	Behavioural Intention	UB	Use Behaviour
CA	Computer Anxiety	UTAUT	Unified Theory of Acceptance and Use of Technology
CAtt	Cognitive Attitude	VAB	Value Attitude Belief model
COM	Compatibility	WT	Waiting Time
DOC	Doctors Opinion		
ECUE	External Cues to Action		
EE	Effort expectancy	CORE	Cataract Online Refraction Evaluation
EM	Extrinsic Motivation	MORE	Manifest vs. Online Refractive Evaluation
FC	Facilitating Conditions	PROMISE	Prospective Longitudinal Online Remote Monitoring In Sight Evaluation
HBM	Health Belief Model	METC	Medisch-ethische toetsingscommissie
HEALTH	Self-reported Health Conditions	PROM	Patient Reported Outcome Measurement
HM	Hedonic Motivation	AVE	Average Variance Extracted
HT	Habit	CR	Construct/Composite Reliability
ICUE	Internal Cues to Action	UMC(U)	University Medical Center (Utrecht)
IDT	Innovation Diffusion Theory	JMIR	Journal of Medical Internet Research
IM	Intrinsic Motivation	TAF	Telemonitoring Acceptance Framework
INN	Innovativeness		
IQ	Information Quality		
MSS	Medical Service Satisfaction		
PBC	Perceived Behavior Control		
PBTA	Perceived Barriers of Taking Action		
PDT	Perceived Disease Threat		
PE	Performance Expectancy		
PEU/PEOU	Perceived Ease of Use		
PLS	Partial Least Squares		
PPC	Perceived Physical Condition		
PRel	Perceived Reliability		
PRisk	Performance Risk		
PS	Perceived Security		
PSR	Perceived Social Risk		
PU	Perceived Usefulness		
PV	Price Value		
RC	Resistance to Change		
SAN	Self-Actualization Need		
SC	Self Concept		
SCOM	mHealth Service Competence		
SE	Self Efficacy		
SEM	Structural Equation Model		
SI	Social Influence		
SM	mHealth Service Matching		
SN	Subjective Norm		
SR	Service Relevance		

1. Introduction

I conducted this study at the ophthalmology department of the University Medical Center Utrecht (UMCU), which is one of eight academic hospitals in the Netherlands. This hospital, with more than 11.000 employees, strives to improve healthcare by combining leading research, groundbreaking innovations, and collaboration with patients. The ophthalmology department originates from the "Koninklijk Ooglijders Gasthuis" which was founded in 1858 by prof. dr. F.C. Donders; the founder of ophthalmology in the Netherlands. In 1989, the department moved to the academic hospital, which is the current UMCU.

The ophthalmology department focuses on prevention, recognition, diagnosis, and treatment of diseases of the eye, visual system, eyelids, and expertise in the field of optics and refraction. They are specialized in complex, multifactorial, and rare diseases that need top-clinical diagnosis and treatment. The department has about 70.000 registered patient contact moments per year and carries out more than 3.500 surgeries yearly. [1]

1.1 Problem statement

Our world is changing faster than ever before. According to the Population Division of the United Nations, the current world population of 7.7 billion[2] will grow to 8.6 billion by 2030[3]. Besides the population growth, the pace of population aging is much faster than in the past. Expectations show that between 2015 and 2050, the proportion of the world population above 60 years will rise from 12% to 22% [4].
Part of this aging problem can be associated with a higher life expectancy caused by people's physical and social environments as well as their characteristics, genetics, healthy lifestyles, and better & accessible healthcare. In fact, according to the CPB[5], the life expectancy of a newborn girl in 2040 in the Netherlands will increase by three years from 83 to 86. Together with an increase in older adults, healthcare consumption will exponentially grow.

This trend is stressing healthcare systems and increasing healthcare costs as older people consume more healthcare services than young people. The average healthcare costs in the Netherlands for an 80-84-year-old are more than €15.000, while for a 20-24-year-old, this is around €2.000 [5]. Figure 1 shows the average healthcare costs of a Dutch citizen in 2005 by age and gender and shows that healthcare costs rise dramatically with age [6].

High healthcare costs for older people are partly caused by having a higher chance of chronic diseases and common health conditions related to age, such as hearing loss, cataracts, refractive errors, and diabetes. In the Netherlands (2016), at least 80% of the population above the age of 75 has consulted a general practitioner (GP) for chronic disease, and almost half (47%) is known to have more than one chronic disease. While for people younger than 40, the percentage of the population with a single chronic disease is 12% and 1,2% for multiple chronic diseases.

Therefore, the need for healthcare will rise, and the capacity of healthcare facilities will not be able to handle the future demand causing the wait times to see a GP or a medical specialist to rise. The traditional way of offering healthcare needs a radical change in order to keep healthcare accessible and affordable.

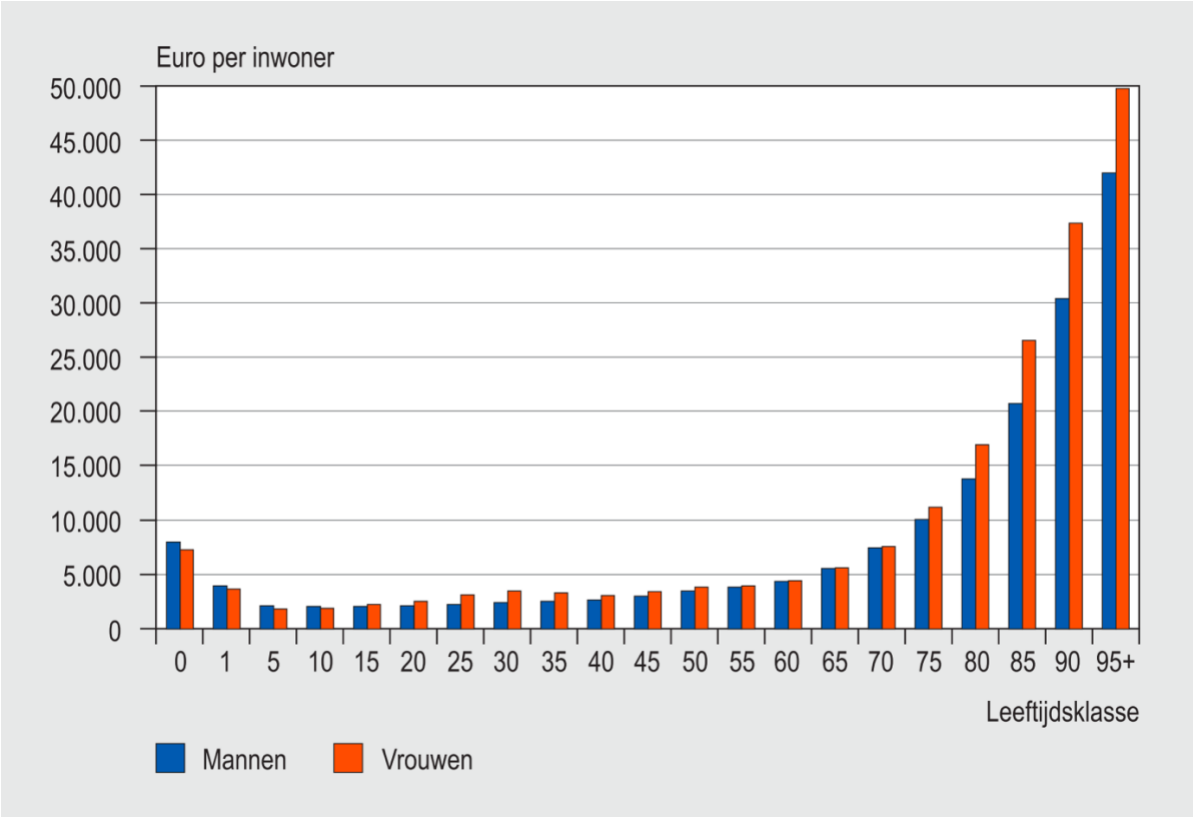

Figure 1 : Average healthcare costs per person in the Netherlands, by age and gender. [7]

1.2 Motivation

A medically validated online eye measurement system [8] will be implemented in a medical environment for research purposes. The online eye exam will be used during a trial period in cataract surgery care. Health assessment questionnaires, in combination with the online eye exam, are hypothesized to be a potential replacement to traditional consultation(s) after cataract surgery. However, the exam has never been used by a population older than 40 years old or with eye-diseases. Research has to be performed to validate the exam for an older population with cataracts.

The telemonitoring system is going to perform tasks that are traditionally performed by a human professional. With this telemonitoring solution, patients perform eye exams by themselves at home using the online eye exam. We expect that patient acceptance of the eye-exam is of crucial importance to the implementation success. Therefore, I am executing my master thesis on patient acceptance of telemonitoring systems using the online eye-exam implementation as a case study.

Cataract patients will be the focus population because of the high volume and large consumption of cataract care. Figure 2 illustrates the distribution of eye care in the Netherlands in 2017; it shows that more than 270.000 lens-related surgeries are performed, and this number is growing each year.

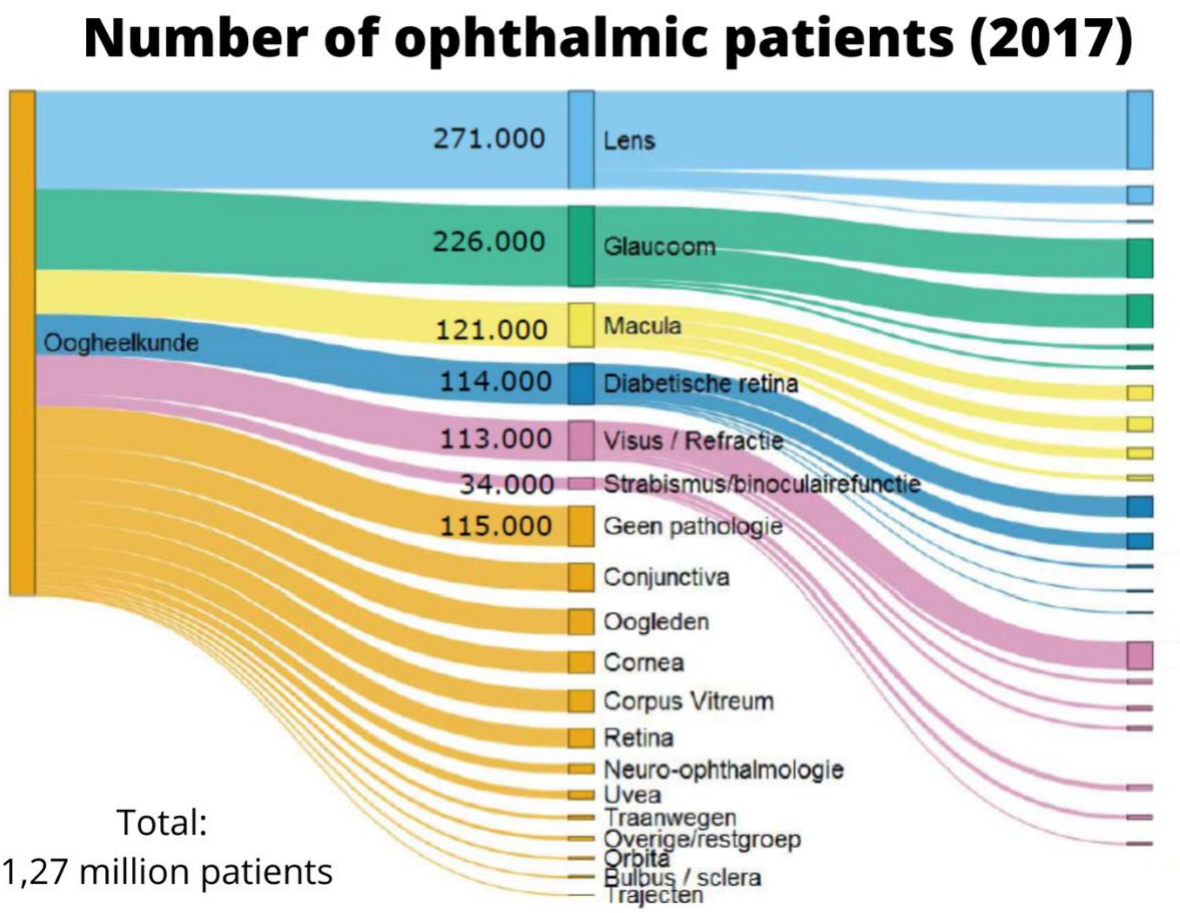

Figure 2: Amount of eye patients in 2017 per category in the Netherlands [9]

1.3 Potential solution

The use of new IT innovations will be indispensable in the future to realize this goal. Telemedicine is one of many novel service offerings for healthcare that is defined as the use of information and communication technology to monitor patients at a distance, independent of time and location. Telemonitoring systems can vary from fully independent to being supported by the patient, home-care nurse, or a medical professional. For example, cardiac monitoring, vital sign monitoring, activity monitoring, and diabetes blood sugar monitoring.

Useful and effective telemonitoring systems can help to make healthcare more efficient, reduce administrative tasks, and help in bringing care to the patient instead of bringing the patient to healthcare.

“These services have the potential to increase the accessibility of healthcare, to increase the quality of healthcare, and to lower healthcare costs” [10, p. 22]

1.4 Cataract

A cataract is an eye disease that is commonly related to age but can also be caused by trauma, radiation exposure. This disease causes cluttering of protein in the lens, which leads to a decreased vision. Symptoms can include blurry or clouded vision, faded colors, and light halos due to scattered light on the retina (Figure 3)

A cataract is besides a refractive error the number one cause of visual impairment in the world and causes half of all cases of blindness in the world. In the Netherlands only, more than 200.000 cataract surgeries are performed each year.

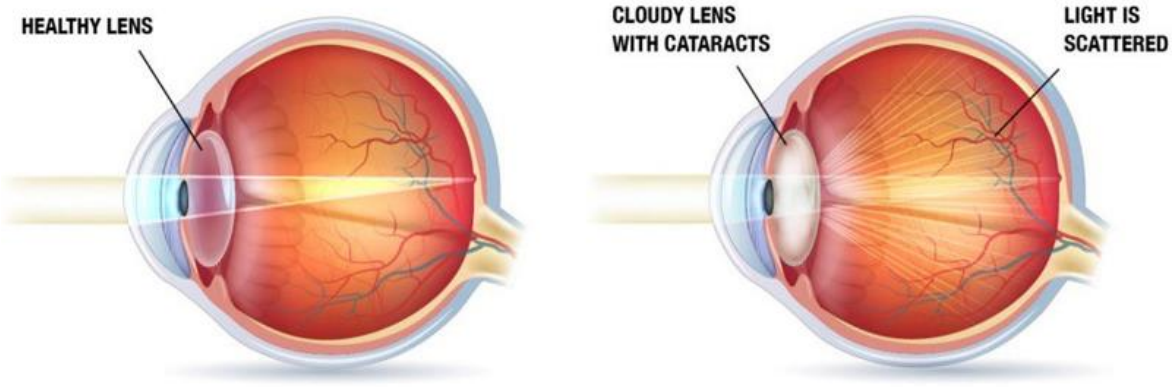

Figure 3: Cataract [11]
Left: Normal lens
Right: Cloudy cataract lens

Surgery

The most common surgery to cure cataract (phacoemulsification) is relatively simple. It involves extracting the lens with an ultrasound probe and replacing it with an artificial lens implant (Figure 4). On average, it takes about 20 minutes to perform the surgery.

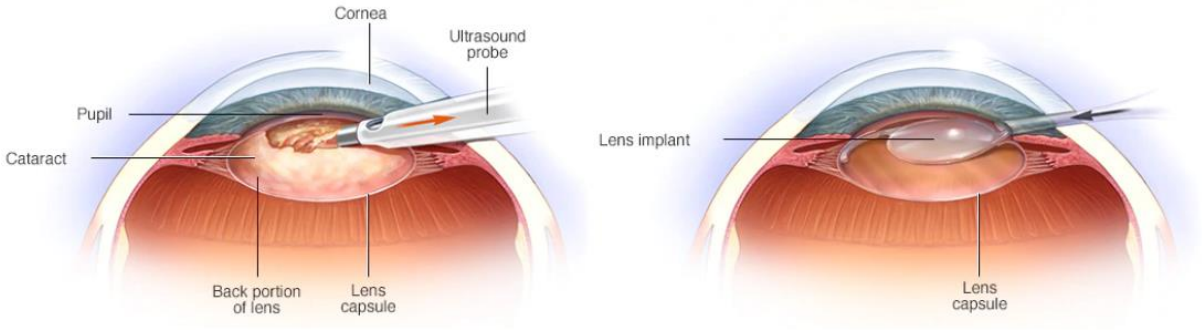

Figure 4: Cataract surgery [12]
Left: Lens extraction
Right: Lens implant

1.5 Easee B.V.

Easee B.V. is a small startup company located in Amsterdam, founded in 2016. Easee is focusing on the development of an Online software medical device for testing visual function. The exam takes about 15 minutes to complete and is accessible whenever, wherever, a user only needs a smartphone, computer, and 3 meters of space. [8]

The exam can be used to obtain a prescription for glasses and contact lenses without the need to visit an optician or optometrist. The patented online exam they developed contains tests for visual acuity, refractive error, cylindrical power, and axis. The validity is assessed in an open-label clinical trial, and the exam is certified as a CE class 1 Software Medical device. The University Medical Center Utrecht conducted the medical trial in the Netherlands in 97 healthy volunteers. This study, called the Manifest vs. Online Refractive Evaluation Trial (MORE Trial) [13], is published by the Journal of Medical Internet Research (JMIR).

Easee is operating in several market segments; a B2C, B2B2C market as well as a B2B market. Consumers can access the exam to perform an independent eye exam, but Easee also supplies integrations with online glasses retailers.

This project is executed in close collaboration with Easee B.V. as they supply the online eye exam, developers, technicians, and knowledge, which can provide help with the integration in the UMCU.

1.6 Research Objectives

The objective of this study is to implement an online eye exam in the UMCU for research purposes and to study the acceptance of home telemonitoring by patients. The goal is to gain more insight into patient perceptions and acceptance of home telemonitoring.

This implementation will be used to perform multiple studies concerning validation tests of the exam and compare the performance of physical consultations with online monitoring.

1.7 Research questions

Q1: What is the added value of healthcare telemonitoring?

- What is telemonitoring?
- What are the potential benefits for patients?
- What are the potential benefits for medical specialists?
- What benefits could an online eye exam bring to eye-care patients?

Q2: Identify current factors contributing to home telemonitoring acceptance by patients

- What acceptance frameworks can be used to assess healthcare telemonitoring acceptance?
- What healthcare-specific telemonitoring acceptance-factors are known in current literature?
- Propose a telemonitoring acceptance framework for eye-care patients
- Identify which analysis method is suitable for assessing an acceptance framework

Q3: Develop and implement a minimum viable product for home telemonitoring for cataract-patients

- What is the current situation of cataract patient care?
- Design a process for the use of an online eye exam for cataract patients
- Design requirements for an online eye exam for cataract patients
- Implement the product in a research setting

Q4: What factors contribute to patient home telemonitoring acceptance?

- Develop a survey for assessing research model constructs
- Confirmatory Factor Analysis
- Develop a structural equation model to test the framework

1.8 Research Methodology

The Design Science Research Methodology (DSRM) [14] is used as a research method for this study. This method is widely used in information system research and design science. It is focused on artifact design and development, which is then tested, evaluated, and implemented in the intended context. (Figure 5)

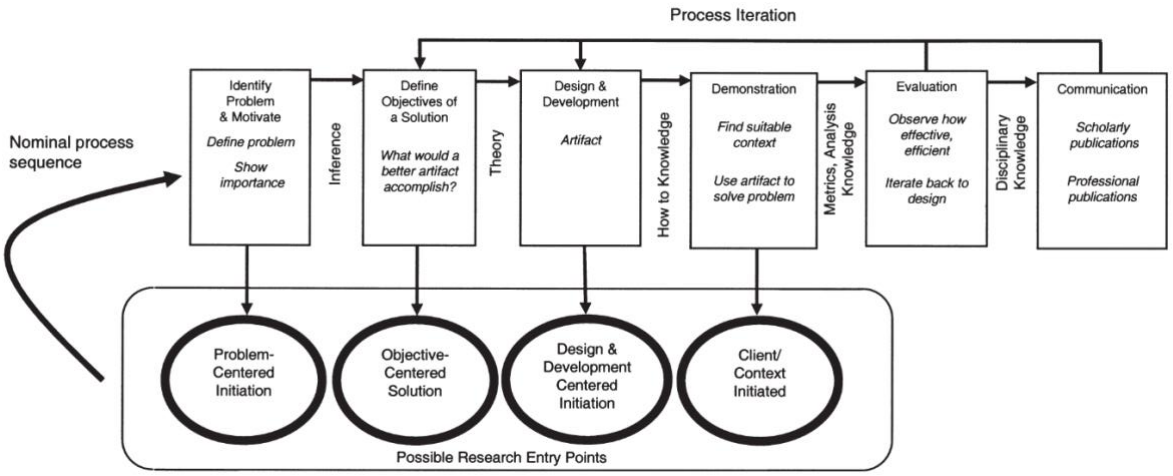

Figure 5: DSRM process model

The report is structured according to the DSRM process. The introduction identifies the problem and motivates the purpose. Defining the objectives of a solution is done in the literature review in chapter 2. Next, the design and development are discussed in chapter 3, 4, and 5, which respectively discusses the MVP design & development, the telemonitoring acceptance research model and data collection & analysis. Chapter 6 demonstrates the MVP and telemonitoring research model assessment. The results from the demonstration are evaluated in chapters 7, 8, and 9. Which respectively addresses the conclusion, discussion, and future recommendations. Finally, the findings and results are communicated in chapters 7, 8, and 9 and the master colloquium. Figure 6 shows the DSRM process with the input and output of each step. The far-right column in the figure shows the corresponding chapter.

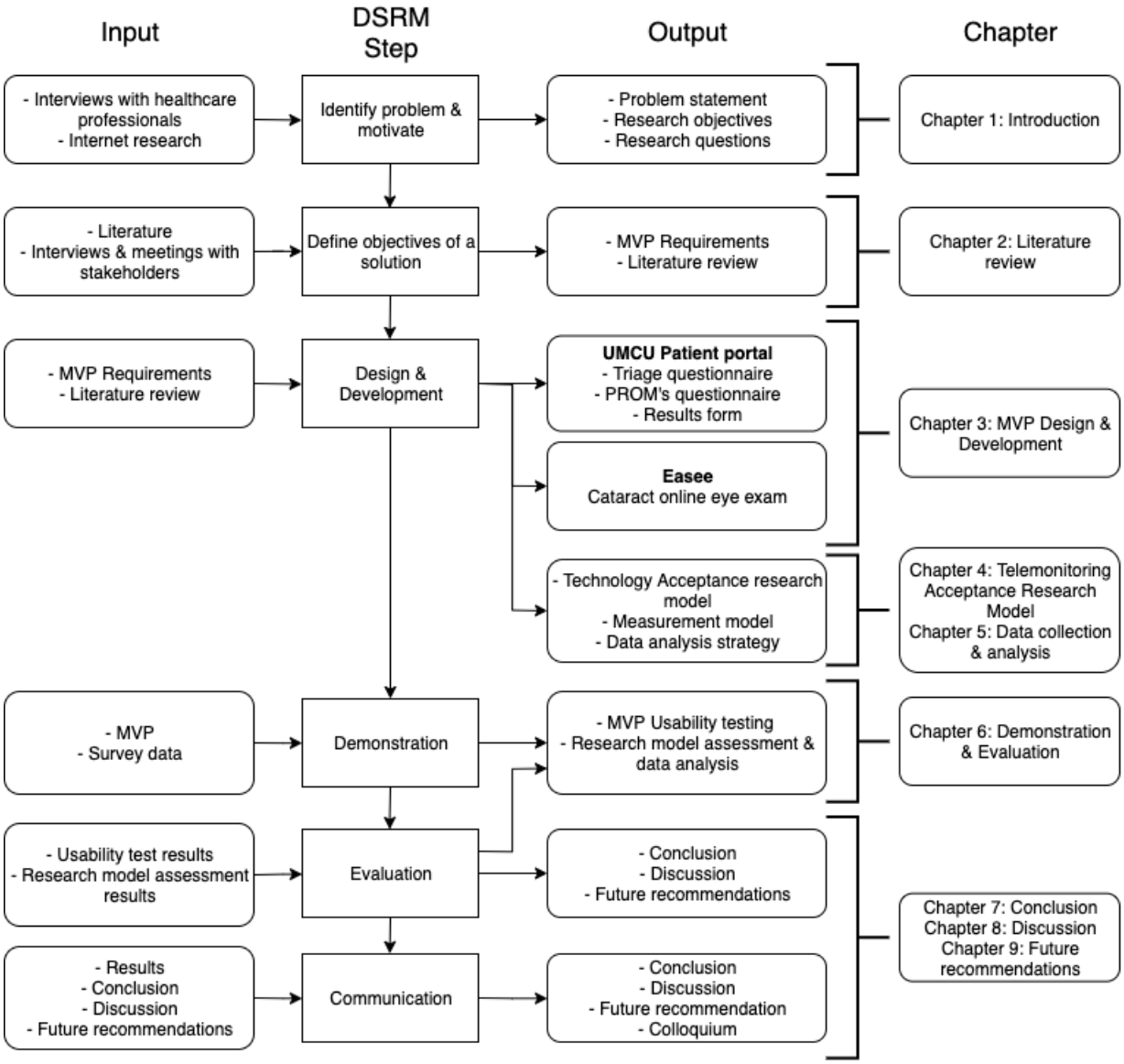

Figure 6: DSRM report structure

2. Literature review

The goal of this chapter is to show the history, developments, and concepts behind technology acceptance models. The literature review will give insights into how these frameworks and models are developed, which concepts they include, and what the thoughts behind these concepts are. Moreover, the review will give indications on which constructs and concepts are profoundly affecting technology acceptance.

The literature review focuses on healthcare telemonitoring acceptance for patients or users of telemonitoring tools. This focus is chosen to find healthcare/telemonitoring specific constructs that contribute to the acceptance and adoption of these technologies.

The first section will introduce basic and widely used technology acceptance models. The next section describes the literature search strategy. The results from the literature study are shown in the third section.

2.1 Acceptance models and conceptual framework

In the last decades, there have been several researchers addressing the adoption of new technology, and several theoretical models are proposed to explain and predict the acceptance and use of technology (Figure 7).

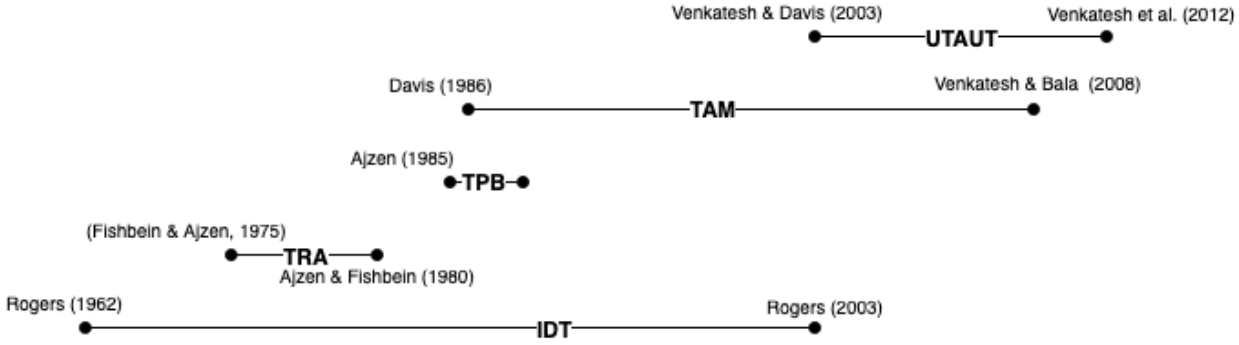

Figure 7: Timeline of acceptance models

One of them is the Technology Acceptance Model (TAM), which is still broadly used for explaining and predicting the acceptance of technology. It has first been introduced by Davis [15] and is an adaption of the Theory of Planned Behavior (TPB) [16] and the Theory of Reasoned Action (TRA) tailored for modeling user acceptance of information systems introduced by Fishbein & Ajzen [17] and Ajzen & Fishbein [18]. The goal of Davis' research was to pursue better measures for predicting the use of information technology across a wide range of end-user technologies and populations. The first version of this model is based on two theoretical constructs; perceived usefulness and perceived ease of use, which are theorized to be determinants of actual system use. The final version of the TAM is developed by Venkatesh & Davis [19], shown in Figure 8.

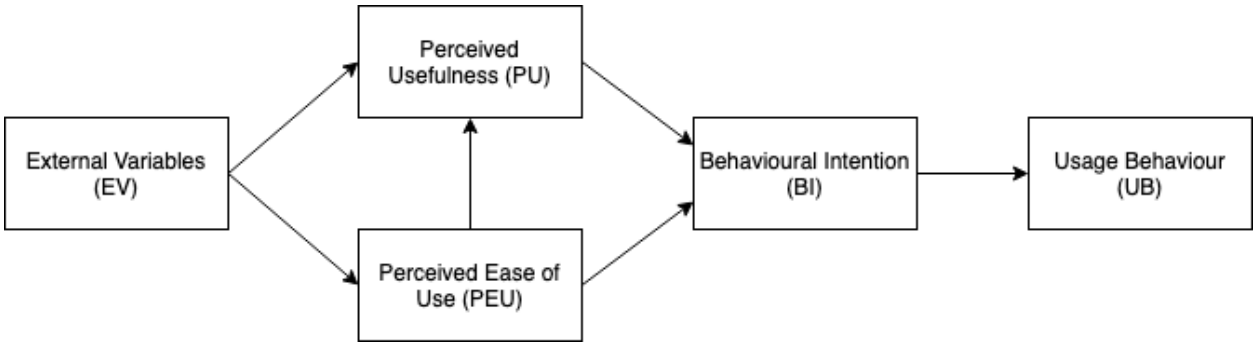

Figure 8: Technology Acceptance Model [19]

Venkatesh, Morris, Davis, & Davis [20] introduced the UTAUT model illustrated in Figure 9. They studied different acceptance models and theories and formulated the UTAUT model. They theorize that four constructs are directly determining user acceptance and use behavior; performance expectancy, effort expectancy, social influence, and facilitating conditions. Besides the four primary constructs, they theorize that gender, age, experience, and voluntariness of use are vital moderators. Empirical testing and cross-validation of the model provided strong support for the UTAUT model and the construct relationships; "UTAUT was able to account for 70 percent of the variance (adjusted R2) in usage intention" [20, p. 467].

In 2012, Venkatesh, Thong, & Xu [21] introduced an extension of the UTAUT model. This extension adds a few new constructs and relations. Hedonic Motivation, Price Value, and Habit are added to the model, all related to behavioral intention and the latter one also to use behavior. Also, the new model adds the relation between facilitating conditions and behavioral intention. All new relations are moderated by age, gender, and experience except for price value, which is not moderated by experience. Experience is moderating the relation between BI and UB. Note that this model dropped voluntariness of use as a moderating variable.

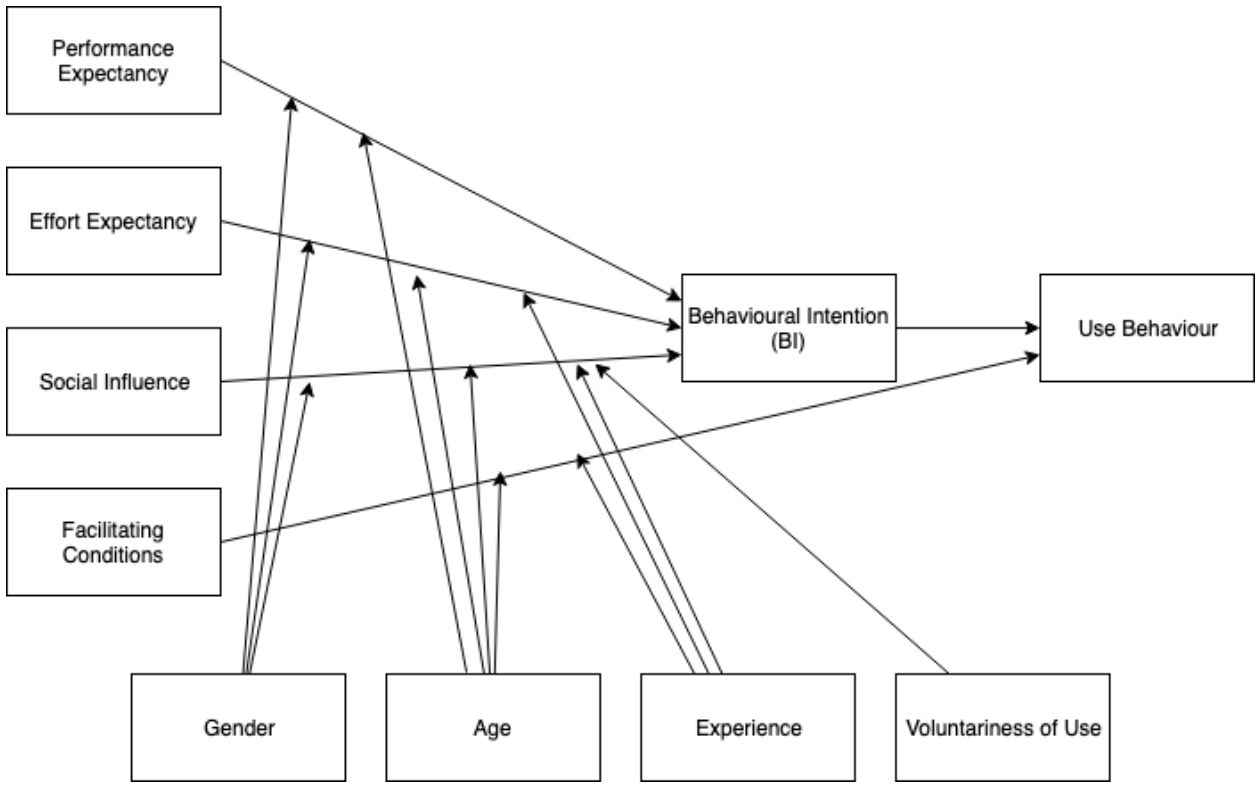

Figure 9: UTAUT model [20]

Other known models for IT acceptance are the Innovation Diffusion Theory (IDT) by Rogers [22] and the theory of planned behavior (TPB) by Ajzen [16]. The IDT describes the diffusion and decision-making process of using new technology. One interesting construct is the trialability construct, which is defined as "the degree to which an innovation may be experimented with on a limited basis" [22, p. 231]. It means that the user will have limited time to try and experiment with the new technology before actually using it for the primary purpose. According to Rogers [22], this construct will have a positive influence on innovation adoption and makes the innovation less uncertain.

The TPB is a theory that is not focused on IT acceptance but more on a psychological perspective of decision-making, attitude, and behavior. This theory is mainly used to describe what influences a person's behavior and actions.

2.2 Search Method

This systematic literature search was conducted in one month from March 10, 2019, to April 10, 2019, following the guidelines from Wolfswinkel, Furtmueller, & Wilderom [23]. The five stages defined by Wolfswinkel et al., [23] are used iteratively; (i) Define criteria for inclusion and exclusion and determine search terms, sources, and field of research. (ii) Search for literature (iii) Select and refine the sample (iv) Analyze the selection of literature (v) Present and structure the content.

The online bibliographic databases selected for this research are Scopus, PubMed, and Google scholar.

2.2.1 Inclusion criteria

We included studies that analyzed concepts and models of adoption and acceptance of telemonitoring systems for an elderly patient group. The articles had to meet the following criteria: (1) the individuals studied in the research were patients, (2) the article was written in the English language, (3) the article was published in a peer-reviewed journal, (4) the technology/intervention type addressed in the article is a patient telemonitoring technology where the main objective is to bring benefits to patients or improve the quality of healthcare delivery.

2.2.2 Exclusion criteria

Studies addressing the acceptance and adoption of telehealth systems by the healthcare provider (e.g., hospitals, nurses, general practitioners, medical specialists) and studies addressing electronic health records are excluded. Example of reasons for exclusion are (1) review papers or literature studies, (2) H-index of the publishing journal below 40, (3) articles addressing electronic health records, (4) the study did not examine factors explaining or predicting telemonitoring acceptance, (5) when surrogates(family or friends) were the primary user or benefiter of the technology.

2.2.3 Search strategy

The systematic search for literature started with constructing a list and mapping of relevant keywords and concepts to the research questions. The keywords are selected based on previous knowledge and relevant articles that discuss similar topics or performed similar studies. Part of constructing this list of concepts and keywords consisted of conducting an exploratory “general” literature search to gather more knowledge on the topic. To limit the search results, I filtered the search only to include English studies that were published between 2014 and the date of search (April 10). The search is conducted on Scopus with the following search terms:

(ehealth OR (healthcare AND information technology)) AND (adopt OR accept) AND (pubyear > 2013) AND (language = english)

The identified literature was screened in this first iteration, and more relevant keywords were found and subsequently used to construct a more detailed query employed in Scopus, PubMed, and Google Scholar:

(Technology acceptance OR tam OR utaut) AND (telehealth OR telemedicine OR ehealth OR telecare) AND (monitoring OR assessment OR self management)

The search strategy is visualized using a flow chart diagram (Figure 10) proposed in the PRISMA guidelines introduced by Moher, Liberati, Tetzlaff, & Altman [24].

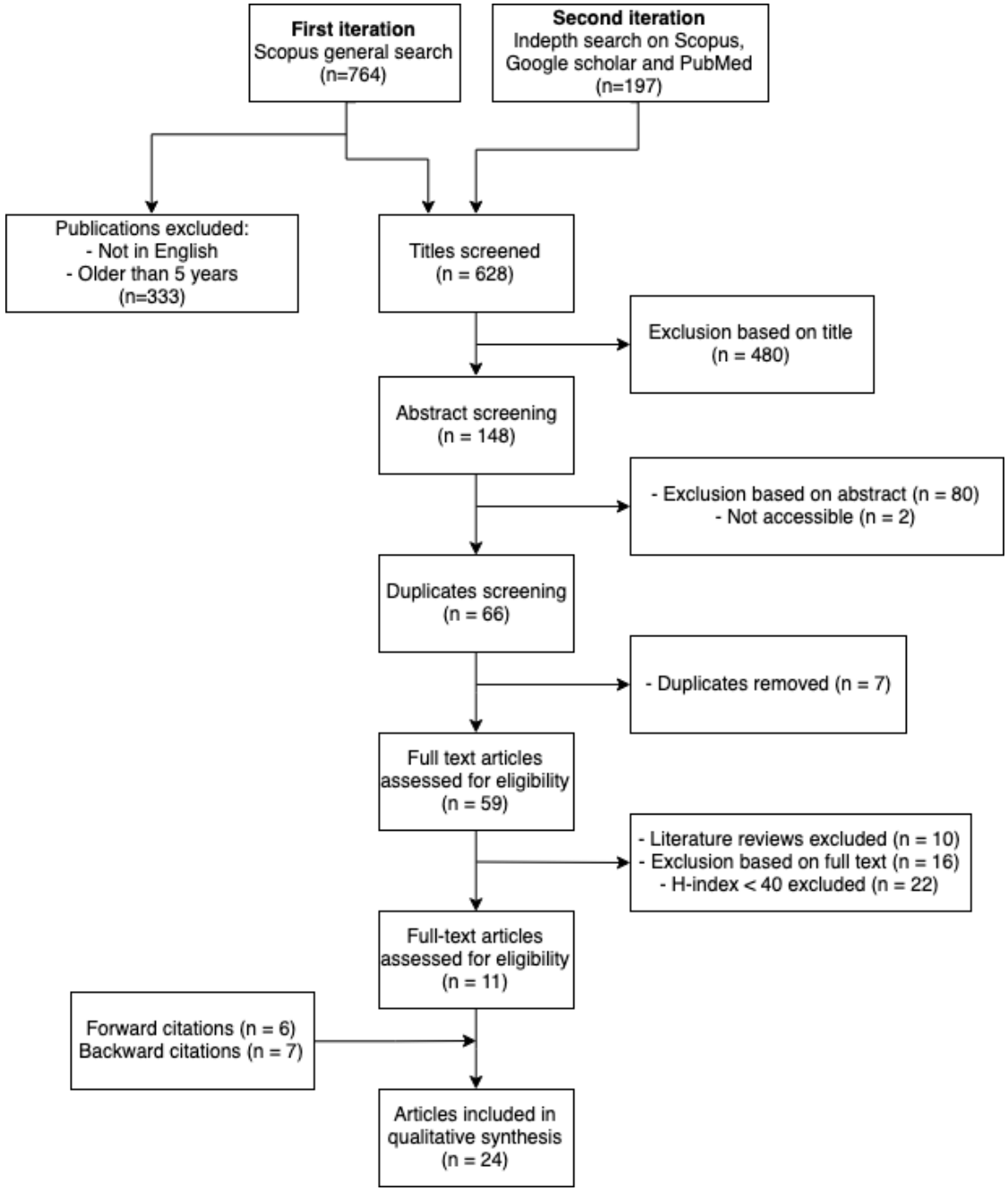

Figure 10: PRISMA flow chart diagram

2.2.4 Identification of included articles and data extraction

The literature searches resulted in 628 articles eligible for screening. The list of matched publications was first screened on title and abstract to check if the articles were relevant to the research topic and matched the criteria described in the search strategy. After screening, 480 articles are excluded based on the title,

80 articles are excluded based on abstract, and two publications were not accessible. In case the abstract did not provide sufficient information about the content, the article was retained for the next stage.

The full articles were retrieved, and duplicate publications were removed. Fifty-nine articles remained to be assessed for eligibility for inclusion in the review. From these articles, the literature and systematic reviews are excluded from further assessment.

Journals are assessed based on h-index to ensure the quality of the publications. Hodge & Lacasse [25] define h-index as "An h-index value of X is obtained if an entity has X publications that have all been cited at least X times" [25, p. 224]. This measure is obtained by using the Scimago ranking tool ("Scimago Journal & Country Rank," n.d.) on the 10th of April 2019. I decided to exclude articles with an H-index in the lower third of the selection based on the median of 61. From the selection, 22 articles with an h-index lower than 40 were excluded.

The articles are assessed on eligibility by reading the full texts, which lead to sixteen articles being excluded because they did not fit the inclusion criteria or were not relevant to the research question.

Finally, the remaining eighteen articles are checked for forward, and backward references/citations and are selected in the same iterative process for assessing articles as mentioned above and resulted in a selection of thirteen articles.

2.3 Literature study results

Based on the criteria and screening, the review includes 24 articles. For all included studies, a set of descriptive parameters and detailed information are extracted that describe the research goal, methodology, design, type of intervention, and outcomes (Appendix A).

Table 1: Literature study characteristics

	N=	%
Articles	24	100%
Qualitative	4	17%
Population Median	23	
Population Mean (std)	45 (49)	
Quantitative	20	83%
Population Median	285	
Population Mean (std)	331 (281)	
Framework		
TAM	10	42%
UTAUT	10	42%
UTAUT2	2	8%
TPB	1	4%
IDT	2	8%
Health belief model	1	4%
Motivational Model	1	4%
VAB	1	4%
No Framework	2	8%
Method		
Structural Equation Model	12	50%
Other statistical methods	7	29%
Artificial Neural Network	3	13%
Thematic analysis	4	17%
Country		
The Netherlands	8	33%
USA	4	17%
China	4	17%
Taiwan	3	13%
Bangladesh	4	17%
Other	4	17%

2.3.1 Study characteristics

The major part of the included studies is conducted in European and North American countries. However, Asian countries are also prominent.

Most studies performed quantitative research where the sample sizes ranged from 14 to 1121, with a median of 285. For the qualitative studies, the sample sizes ranged from 15 to, with a median of 23. Most studies used TAM and UTAUT as a reference framework for their research, and two exploratory studies did not use any reference framework.

The most used methodology for the analysis of the data was Structural Equation Modeling, which is a statistical method of analyzing causal relations between different constructs. The qualitative studies used thematic analysis to group the unstructured data onto constructs or themes.

The types of intervention/technology are common in the sense that they all are patient-benefit focused technologies. Some studies used a description of the technology as a reference for participants, while other studies used specific technologies and appliances (Appendix A).

2.3.2 Structural Equation Modelling

Most quantitative studies use structural equation modeling (SEM), also known as causal modeling or path analysis using latent variables, to analyze the data. This method is an integration of different statistical techniques. It involves complex multifactor constructs within systems of relationships rather than dependent and independent variables.

The primary purpose of SEM is path analysis using latent variables. These latent variables are often social scientific concepts and not directly observable. These variables can be measured using observable indicators of that variable, often measured by a survey. It makes a SEM an excellent method of analyzing data of the constructs from the acceptance frameworks.

2.3.3 TAM in telemedicine and e-Health

The native constructs of the TAM explained by Venkatesh & Davis [19] consists of four primary constructs. However, in the literature that uses TAM as a reference framework, a couple of authors extended or slightly changed the model to fit the healthcare environment. Table 2 summarizes the TAM constructs found in the reviewed literature, the articles mentioned are the articles in which the authors found that those constructs are supporting in acceptance and adoption.

Table 2: TAM constructs found significant in the included literature

Construct	Description	Predictor of adoption	No predictor of adoption
Perceived Usefulness (PU)	"The degree to which a person believes that using a particular system would enhance his or her job performance" [27, p. 320]	[28], [29], [30], [31], [10], [32]	[33]
Perceived Ease of Use (PEU)	"The degree to which a person believes that using a particular system would be free of effort" [27, p. 320]	[28], [29], [31], [10], [32], [34]	[33], [30]
Behavioural Intention (BI)	"An individual's positive or negative feelings about performing the target behavior" [17, p. 216]	[28], [29], [30], [31], [10], [32], [35], [34]	
Subjective Norm (SN)	"The person's perception that most people who are important to him think he should or should not perform the behavior in question" [17, p. 302]	[29]	

Attitude	Attitude towards the act is defined as a "function of beliefs about the instrumentality of the object in obtaining goals and the value importance of those goals" [36, p. 469]	[28], [29], [32]	[33]
Cognitive attitude	"The cognitive attitude is defined as an individual's values and beliefs related to some objects" [35, p. 162], [37, p. 20]	[35]	
Affective attitude	"The affective attitude has been defined as how much a person likes something" [35, p. 162], [37, p. 20]	[35]	
Trialability	"The degree to which an innovation may be experimented with on a limited basis" [22, p. 231].	[33]	
Intrinsic Motivation	The perception that users will want to perform an activity "for no apparent reinforcement other than the process of performing the activity per se" [20, p. 428], [38, p. 1112]	[31]	
Innovativeness	''The relative willingness of a person to try a new product or service" [29, p. 282] "Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system." [22, p. 22]	[29]	
Service matching	"mHealth service matching reflects the degree to which an mHealth service could satisfy users' demands" [35, p. 162]	[35]	
Service Competence	"mHealth service competence refers to one's propensity to interact effectively with mHealth services and to experience opportunities to exercise and express one's capacities." [35, p. 163]	[35]	
Service relevance	"mHealth service relevance refers to what mHealth service individuals are able to perceive" [35, p. 163]	[35]	
Information seeking preference	Preference for obtaining additional information about a certain condition	[31]	
Satisfaction	Satisfaction with current medical care	[31]	
Internet dependence	Dependence on the internet for information and communication	[31]	

Medical Service Satisfaction (MSS) Affordability (AFF) Comfortable (COM) Professionalism (PRO) Safety (SAF) Waiting (WAT)	"Medical Service Satisfaction (MSS) is the patient's perception of the services of the existing healthcare system and it affects the patient's medical experience" [34, p. 120]	[34]
Acceptance		[34]
Information Quality (IQ)		[34]
Perceived disease threat HBM [39], [40]	"PDT includes perceived susceptibility (one's subjective perception of the risk of contracting a health condition) and perceived severity (feelings concerning the seriousness of contracting an ailment or of leaving it untreated)" [32, p. 308]	[32]
Perceived barriers of taking action HBM [39], [40]	"Refers to beliefs about costs or negative aspects of a course of action" [32, p. 308]	[32]
External cues to action HBM [39], [40]	Triggers to action: for example: "e.g., interpersonal interactions, the impact of media of communication, or receiving a postcard from the dentist" [40, p. 332]	[32]
Using the service at home	Home-environment sufficiency for performing the necessary exercises.	[10]
Service configuration	The configuration of how the solution is going to be used (additional, partial replacement, etc.)	[10]

Construct relations

In Table 2 above can be seen that the authors researched many different constructs. Most authors found significant relations between the primary constructs of the TAM. Figure 11 is showing a visualization of the found constructs and their relations. The relations shown are the ones that have been tested by at least two independent studies with at least one study finding a significant relation. The values of the relations are indicating how many studies found a significant relation out of the total amount of studies, which included the relation in their analysis (#significant/#total).

Most of the authors included the primary TAM constructs in their research. However, the only relationship that has been found significant by five out of five studies is the one from PEU and PU. The relations PU and BI and PEU and BI are found significant by half and one-third of the studies, which included these relations respectively. The attitude construct is a construct that is not included in the original TAM but is included in previous concept versions of the TAM and therefore studied by four authors. Most of them did find a significant effect of PU and PEU on attitude and attitude on BI.

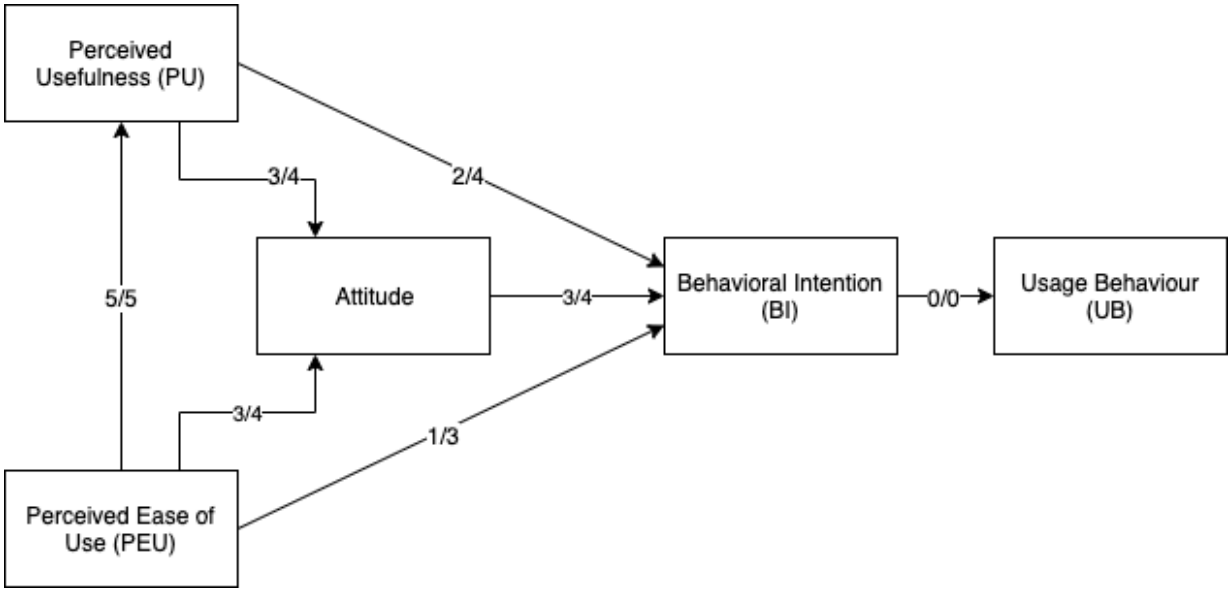

Figure 11: TAM relations

The fraction numerator in the labels is showing the number of studies that found a significant relation and the denominator shows the total amount of studies who studied the relation.

2.3.4 UTAUT in telemedicine and e-Health

The native constructs of the UTAUT model explained by Venkatesh et al. (2003) consist of six primary constructs with four moderating demographic variables. Table 3 summarizes the UTAUT constructs found in the reviewed literature.

Table 3: UTAUT constructs found significant in the included literature

Construct	Description	Predictor of adoption	No predictor of adoption
Behavioural Intention (BI)	Intention to use the system "The degree to which an individual intends to use" [41, p. 25]	[41], [42], [43], [44], [45], [30], [46], [47], [48], [49],	
Use Behaviour (UB)	Actual use behaviour	[46], [47], [43], [45],	
Performance Expectancy (PE)	"The degree to which an individual believes that using the system will help him or her to attain gains in job performance" [20, p. 447]	[41], [42], [43], [44], [45], [46], [47], [50], [48], [49], [30]	-
Effort Expectancy (EE)	"The degree of ease associated with the use of the system" [20, p. 450]	[41], [42], [43], [44], [45], [46] , [48], [49], [30]	[50], [47]
Social Influence (SI)	"The degree to which an individual perceives that important others believe he or she should use the new system" [20, p. 451]	[43], [44], [45], [30], [46], [47], [48], [49]	[50], [41], [42]
Facilitating Conditions (FC)	"The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" [20, p. 453]	[41], [43], [30], [47], [49]	[46], [48], [45], [50], [44]
Doctor's Opinion (DOC)	"Doctor's expert power influence" [41, p. 25]	[41]	
Computer Anxiety (CA) / Technology Anxiety / internet Anxiety	"Evoking anxious or emotional reactions when it comes to performing a behaviour (using a computer)" [20, p. 432]	[41], [45]	[44]
Perceived Security (PS)	"The degree to which using information technology enables the administration of personal health information" [41, p. 25]	[41]	
Self-Efficacy	"Refers to the person's belief that he or she is able to successfully use the internet." [42, p. 3]	[42]	[44]
Resistance to Change	Resistance to changing the way healthcare is delivered	[45]	
Health-related Internet and mobile use		[44]	
Permanent availability stress	Stress through permanent availability	[44]	
Healthcare knowledge	"The amount of knowledge participants feel they have regarding their health condition and care for their disease" [46, p. 53]	[46]	
Perceived reliability	The degree to which a consumer believes and trusts a new technology will perform a job consistently and accurately and safely as promised by the provider. [47]	[47]	
Hedonic Motivation	"The fun or pleasure derived from using a technology" [21, p. 161]	[50]	[43]

Habit	"the extent to which people tend to perform behaviors automatically because of learning" [21, p. 161]	[50]	
Perceived credibility	"The protection of users' personal information and transaction details from unauthorized entrance" [48, p. 311]	[48]	
Waiting time	"the degree to which an individual believes that using the mHealth-care system can save irrevocable time in receiving repeated health-care service and thereby keep a running daily professional life" [43, p. 178]	[43]	
Price Value	"consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them" [21, p. 161]	[43]	[47], [50]
Self-concept	"the degree to which a citizen's preference, in the light of self-intrinsic evaluation of one's own personality-related traits, is perceived to be congruent with the mHealth image" [43, p. 179]	[43]	
Performance risk	"The degree to which users believe the technology may bring unanticipated risks, such as safety risk, functionality risk, and privacy violation" [30, p. 164]	[30]	
Compatibility	"The degree to which a technology complies with the technical functionalities of other existing products (e.g., smartphones and tablets) and with the needs and lifestyles of users" [30, p. 163], [51][51]	[30]	
Self-reported health condition	"Self-reported health conditions (Health) reflects the current health status and conditions (e.g., hypertension, cardiovascular disease, and diabetes) and biophysical characteristics (e.g., visual and auditory ability, mobility, and cognitive ability) of respondents" [30, p. 164]	[30]	
Moderating demographic variables			
Education	The educational level of the participant	[42], [50]	[44]
Gender	Gender of the participant	[44]	[50]
Age	Age of the participant		[44], [50]

Construct relations

In Table 3 above can be seen that the authors study many different constructs. Most authors found significant relations between the primary constructs of the UTAUT framework, and some authors also included additional healthcare-related constructs in their research. Figure 12 is showing a visualization of the found constructs and their relations. The relations shown are the ones that have been tested by at least two independent studies with at least one study finding a significant relation. The values of the relations are indicating how many studies found a significant relation out of the total amount of studies which included the relation in their analysis (#significant/#total).

All included studies using the UTAUT framework supported the relationship between performance expectancy and behavioral intention. However, Alam et al. [47], Duarte & Pinho [50], and Or et al. [46] did not support the relationship between effort expectancy and behavioral intention. All studies that inspected the relationship between BI and UB confirmed this.

Additionally, only 6 out of 11 authors found a significant relationship between Social Influence and Behavioral Intention.

The most interesting construct is facilitating conditions as the original UTAUT model explains that FC is directly influencing use behavior, and the UTAUT2 model adds a relation between FC and UB. However, most authors did not study actual use behavior but mainly BI. Therefore, FC was often related to BI for structural model testing. Nevertheless, the results were very diverse as four authors found a significant relation between FC and BI, where five did not find a significant relation. Only Cranen et al. [43] found a significant relation between FC and UB, while three other authors did not find a significant relation.

Also, two studies found a significant relationship between effort expectancy and performance expectancy. Although the original UTAUT model did not include this relationship, the original TAM model included this relation and is found significant by five out of five TAM studies.

Additional Constructs

Six new construct relations to the UTAUT model have been studied with at least one author finding a significant relation resulting in four additional constructs in the model.

Technology Anxiety (TA) is found to influence behavioral intention by Hoque & Sorwar [39]. This construct is not studied often. However, I think that this construct is fundamental as the population that needs healthcare at this time are older people who have a higher chance of technology anxiety than a younger population.

The Price Value (PV) is studied by three authors and only found significant in one case. I think this concept does not belong in a model for a healthcare environment as the healthcare systems, insurances, and regulations are different for every person and country they live in. Therefore, I would recommend not to use this concept for assessing adoption in a future research model.

Self-Efficacy (SE) refers to the user's belief of being able to use the internet or e-health service successfully. One out of two authors supported a significant relationship between SE and BI. This construct is a belief of being able to independently use the service and might be an essential factor for older users to use an e-health service.

Hedonic Motivation (HM) is described as the fun or pleasure derived from using the technology and is found to be significantly related to BI by one author. In my opinion, this is an interesting construct, as this relation might only be valid in cases of voluntary use. Therefore, I would recommend doing more research on this relation in a situation of non-voluntary use of e-health.

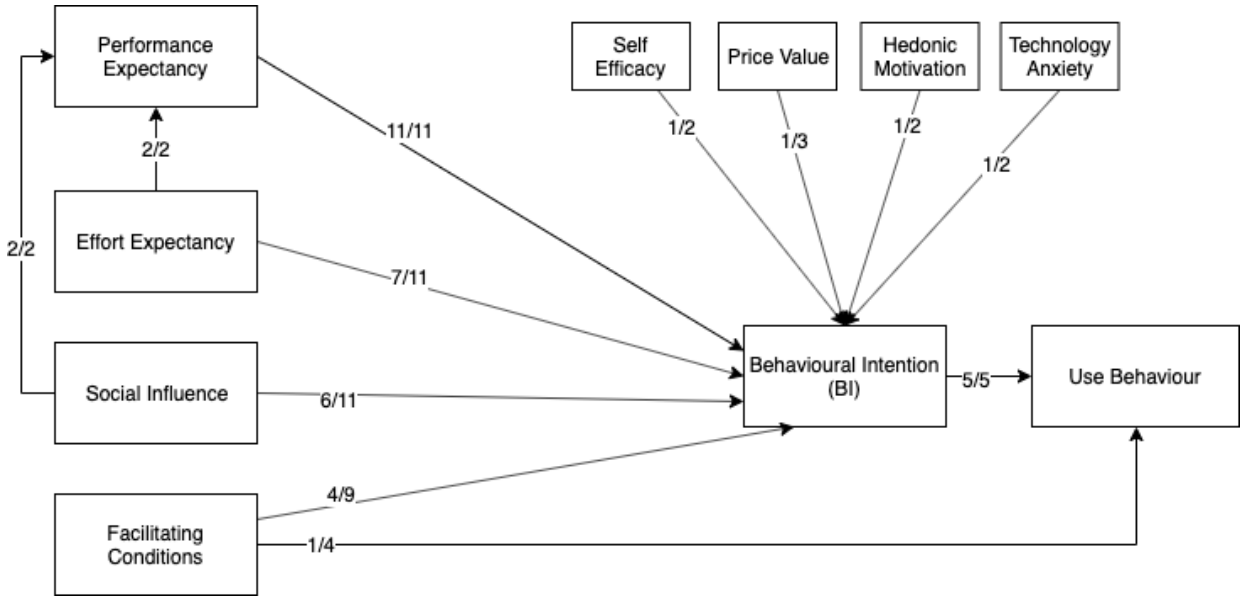

Figure 12: UTAUT relations

The fraction numerator in the labels is showing the number of studies that found a significant relation and the denominator shows the total amount of studies who studied the relation.

2.3.5 Other acceptance models

Huang [32] and Wilson & Lankton [31] combined the TAM with the Health Belief Model (HBM) and the Motivational Model, respectively. The results from these studies can be found in the TAM results section above. Van Middelaar et al. [52] and Van Velsen et al. [53] did not use any framework as they did a qualitative exploratory study.

Deng et al. [54] and Peeters et al. [55] used other acceptance models than the TAM and UTAUT models. Deng et al. [54] used the Value Attitude Belief model in combination with the Theory of Planned Behaviour as reference models for research. Peeters et al. [55] used the Innovation Diffusion Theory [22]. Table 4 shows the results of other significant acceptance model constructs.

Table 4: other constructs found significant in the included literature

Construct	Description	Predictor of adoption
VAB + TPB		
Perceived Value (PV)	"An individual's perception of his or her expected utility of mobile health services." [54, p. 215]	[54]
Attitude (ATT)	"An individual's attitude toward mobile health services" [54, p. 215]	[54]
Perceived Behavior Control (PBC)	"Perceptions of internal and external constraints on mobile health usage" [54, p. 215]	[54]
Resistant to change (RTC)	"An individual's unwillingness to change the way of health management and life style." [54, p. 215]	[54]
Technology anxiety (TA)	"An individual's apprehension when faced with the possibility of using mobile health services" [54, p. 215]	[54]
Self-actualization need (SAN)	"Intrinsic motivation to become everything that one is capable of becoming" [54, p. 215]	[54]
IDT		
Relative Advantage	"Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes." [22, p. 15]	[55]
Compatibility	"the degree to which an innovation fits with the existing values, past experiences and needs of potential adopters and can be assimilated into an individual's life" [55, p. 3185]	[55]
Complexity	the degree to which an innovation is perceived as difficult to understand and use." [55, p. 3185]	[55]
Observability	"the extent to which the results of an innovation are visible to others." [55, p. 3185]	[55]
Type of Contact	"on clients' initiative or also contact at a fixed time daily" [55, p. 3189]	[55]
Living Situation	"living alone or living with a partner, son or daughter" [55, p. 3189]	[55]

Care received	"receiving care, financed by national insurance of long-term care or not yet receiving care" [55, p. 3189]	[55]

Because the models in the table above are not studied by more than one author, the visualizations in Figure 13 and Figure 14 show no more than one out of one significant relation. Although the models are not used very often, the models show some similarities in constructs with the TAM or UTAUT model.

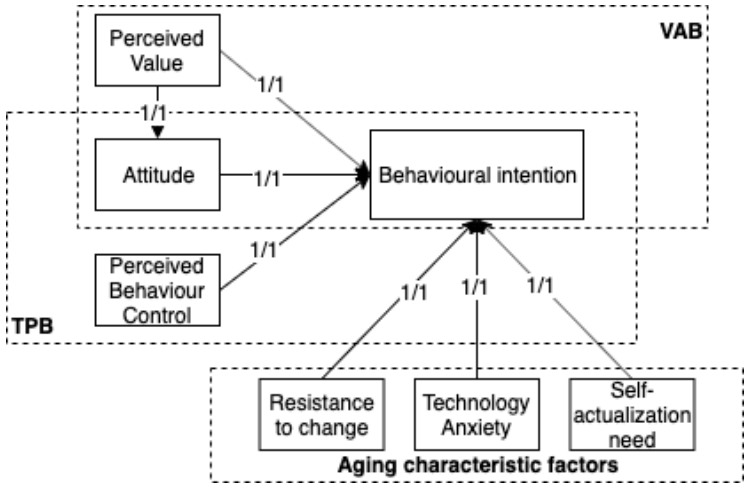

Figure 13: VAB + TPB relations
The fraction numerator in the labels is showing the number of studies that found a significant relation and the denominator shows the total amount of studies who studied the relation.

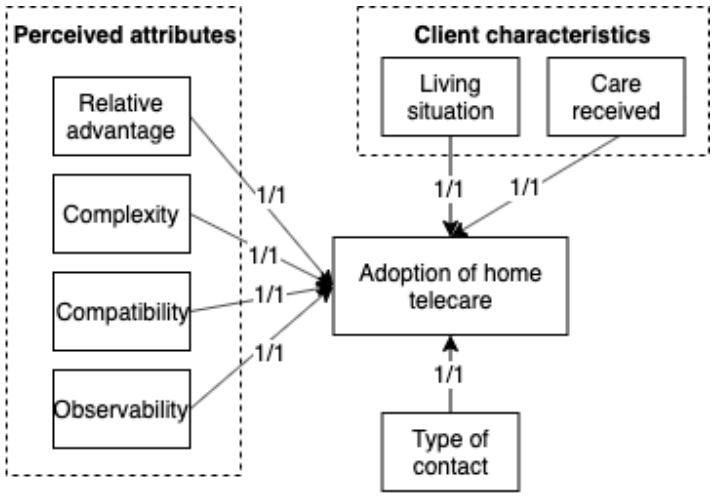

Figure 14: IDT relations
The fraction numerator in the labels is showing the number of studies that found a significant relation and the denominator shows the total amount of studies who studied the relation.

Attitude and technology anxiety are constructs I have discussed above and are studied in these models as well, where all acceptance models include the technology anxiety construct. This construct is considered an essential factor that is negatively influencing telemonitoring acceptance. It is also highly

relevant to the case study, which focuses on elderly cataract patients who did not grow up with these technologies and are more likely to experience technology anxiety.

3. MVP Design & Development

The case for this research is based on an implementation of the Easee online eye exam in the UMCU. The focus for this implementation is facilitating cataract patients with an online eye exam so they will be able to do measurements from home. However, cataract patients are a different user group than the current user group of the online eye exam, and therefore, a custom version for cataract patients is designed and developed to facilitate this user group.

The goal of this chapter is to explain the design and development of the Minimum Viable Product. The first section will describe the research plan and protocol of the underlying study from the UMCU. Afterward, the current cataract care process is discussed. Section 3 & 4 describes the design and development of the MVP. These sections are split between the UMCU patient portal and the Easee online eye exam.

3.1 Research plan & protocol

The minimum viable product and this thesis study is part of a bigger research project called the Cataract Online Refractive Evaluation Study (CORE study), which focuses on assessing the validity and quality of the Easee online eye exam for cataract patients. This research requires a study protocol, ethical approval, privacy impact assessment & implementation of the online eye exam in the UMC patient portal.

Cataract Online Refractive Evaluation Study (CORE Study)

The goal of this study is to assess the performance, reliability, and validity of an online eye exam telemonitoring service in the cataract care process compared to the measurements of a physical consult with an ophthalmologist.

Ethical Approval

There are rigorous requirements and regulations for performing medical research. International, national, and regional governments establish these legislations which need to be adhered to. Every medical study needs to be assessed by the Medisch Ethische Toetsingscomissie (METC), who are independently assessing if the study may continue. They look after the rights, safety, and duties of a participant. They decide how stressful the study is for participants and in which category this research is scaled.

This study aimed to be scaled in so-called “niet-WMO plichtig” research. It means that this study is not stressful for the participant and does not need extensive assessment by the METC.

Study Protocol

A study protocol is set up, which is describing the research team, objective, how the research is performed, and what data is gathered and used. It also describes all the conditions for participation. The study protocol can be found in Appendix B.

Data privacy Impact Assessment

The implementation of the online eye exam required a data privacy impact assessment. As we chose not to automate the data integration using an application program interface (API), there is no data going from the UMCU to Easee. This resulted in a positive assessment. However, a data processing agreement is added to the contract between Easee and the UMCU.

CORE invitation letter

The patient information letter (Appendix C) is an invitation letter that is sent to cataract patients when scheduled for the first consultation. Together with the information about the surgery, patients will get invited to participate in the CORE study. When patients would like to participate, they will need to sign the consent at the bottom of the letter. Additionally, the patient will receive instructions (Appendix D) on where to find the questionnaires and the online eye exam.

3.2 Current Cataract Care Process

This section aims to describe the current process of cataract care in the UMCU. The process models of cataract care in the UMCU are shown in Appendix E - Appendix I and are made in Dutch. Appendix I shows a decision tree that is used to decide on which consultations need to be scheduled for the patient. The general process consists of a pre-op consultation, surgery, post-op consultation, and a consultation one month after surgery. These consultations are shortly discussed below;

3.2.1 Diagnosis

The diagnosis process (Appendix E) is started when a patient gets a referral from a general practitioner to go to an ophthalmologist. The process consists of one or two consultations at the UMCU. The first consultation will consist of a visit to the ophthalmologist or assistant who will do the diagnosis and examination of the eye. There will be a decision on whether the surgery will be performed under local anesthesia or full anesthesia. When the decision is made to do surgery under full anesthesia, additional screenings will take place.

If the first consultation were with the surgeon, a second consultation would not take place. However, when a patient did not meet the surgeon, a second consultation with the surgeon will be planned less than two weeks from the date of surgery and is used to take the last measurements and to make appointments about post-op consultations and medication.

3.2.2 Surgery

The surgery (see Figure 4) will be a day-treatment, and in normal circumstances, the patient will leave the hospital at the end of the day. Appendix F shows the surgery procedure for local anesthesia, and Appendix G shows the process used for full anesthesia. An anesthesiologist is present during surgery when performed under full anesthesia.

3.2.3 Post-op consultation (1 day)

The ophthalmologist or assistant will check the eye's healing process and discusses this with the patient. If necessary, additional medication is prescribed, and a new consultation is planned for $\pm$ one month after surgery. (Appendix H)

3.2.4 Post-op consultation (1 month)

This consultation is used to check if the eye is completely healed and to give the patient a new prescription for glasses. The visual acuity, refractive error, and cylinder are measured so the patient can buy new glasses at any glasses store. (Appendix H)

3.3 Minimum Viable Product Design

The purpose of the telemonitoring service for cataract patients is to replace one or more of the current post-cataract-surgery consultations in the future. However, for the CORE-study described above, because of safety issues, the online eye exam will be used parallel to the current process.

3.3.1 UMCU Patient portal (Chipsoft HiX)

The UMCU patient portal [56] is a web-based portal for patients of the UMCU that will be used as a user platform in this implementation. Patients can access this protected environment by logging in with their DigiD to gain access to their medical information and patient file. In this portal, patients can schedule consultations, see treatment reports and scans, and answer questionnaires. The patient portal is directly connected to the Electronic Health Record (EHR) of the UMCU. By using this existing platform, the results from the questionnaires and online eye exams can be directly available to the practitioner.

3.3.2 CORE study process

Based on interviews with several ophthalmologists, surgeons, and stakeholders, I designed a process that will be executed by the patient when participating in the CORE study. The new process included two questionnaires, an online eye exam, and a form where patients can input their results.

A simplified overview of the cataract process in Figure 15 shows the CORE study situation on the right side of the figure. It shows that the patient will perform the online eye exam three times at around the same timeframes as the current consultations. The process of accessing the questionnaires and online eye exam for the patient is modeled in Figure 16.

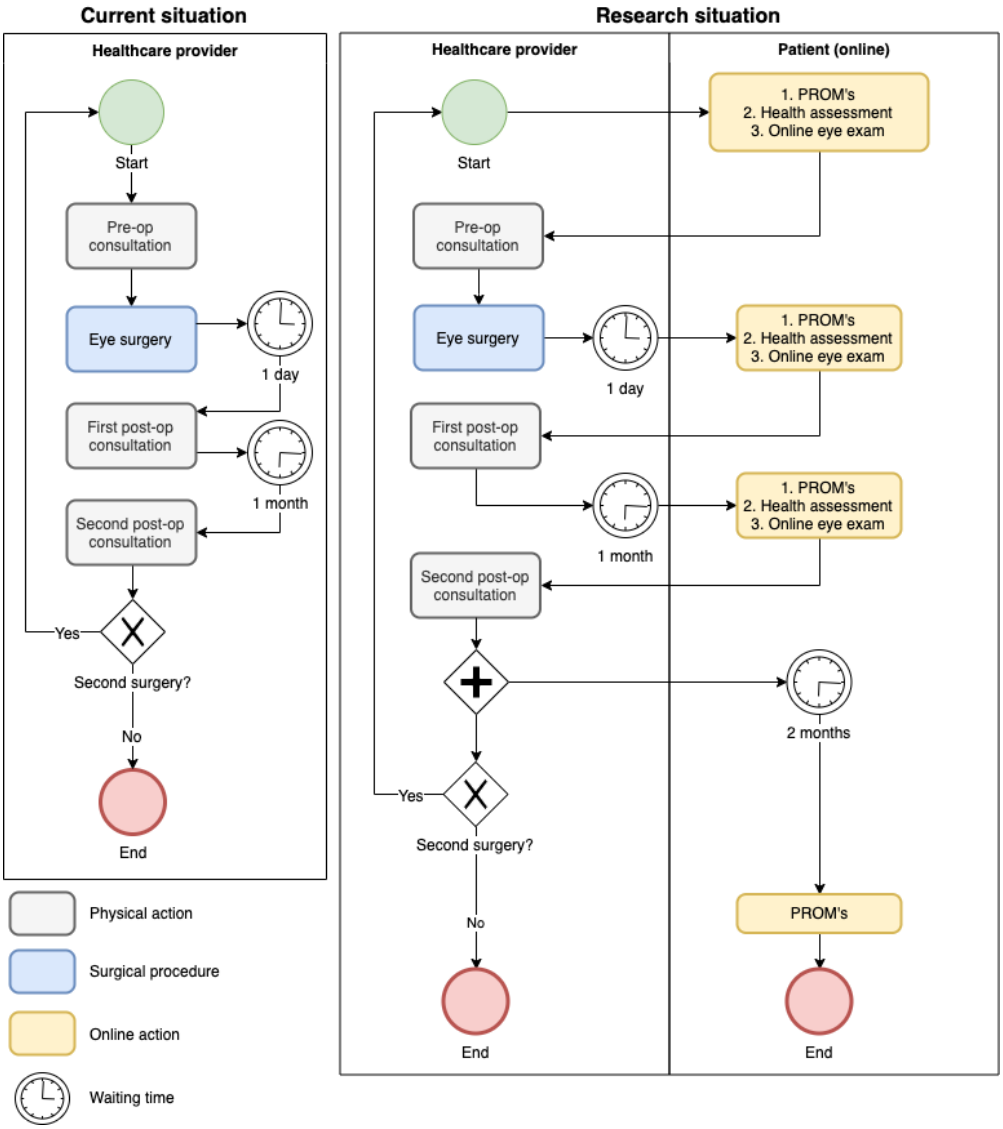

Figure 15: Comparison between current and future cataract care process

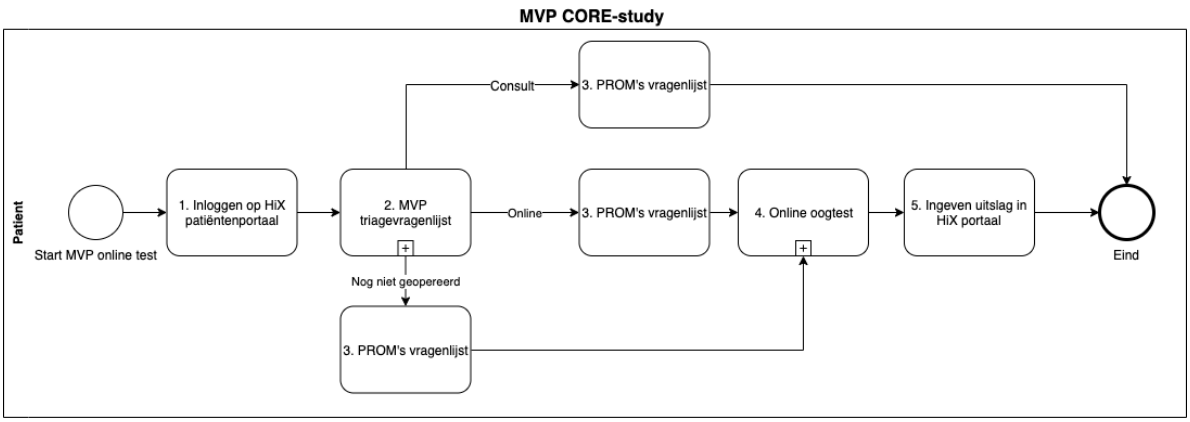

Figure 16: MVP online process

3.4 MVP development

There will be two questionnaires and one form available for patients in the patient portal in the "vragenlijsten" section. The first questionnaire is the Patient-Reported Outcome Measurements questionnaire (see 3.4.1.1). The second questionnaire is the triage-questionnaire (see 3.4.1.2). The results (see 3.4.1.3) form will redirect patients to the Easee exam environment (see 3.4.2) where they will perform the exam. The user then copies the results to the form, which will transform the data so that the results are available in the electronic health record.

3.4.1 UMCU Patient portal

3.4.1.1 Patient Reported Outcome Measurements (PROMs)

PROMs are questionnaires used to measure the outcome and satisfaction of healthcare service intervention from a patient perspective. The outcomes of these questionnaires can be used to monitor and evaluate individual patient outcomes of an intervention as well as be analyzed on a higher level to evaluate health professionals or organizations. Based on the outcome of the analysis, changes can be made to the intervention to serve the patient better, to adjust the treatment, and to improve the quality of the care delivered by the healthcare provider to ensure the highest possible quality of healthcare service delivery.

For many types of interventions, PROM questionnaires are standardized and scientifically validated by different researchers to ensure that the questionnaire covers the most critical patient aspects of a particular intervention. Also, most of them are translated into many different languages, which makes it possible to use the questionnaires in different countries. The questions are formulated as so-called 'quality of life' questions which collect data about symptoms and health condition.

The standardized PROM's questionnaire for cataract is called the Catquest-9SF, which is developed by Mats Lundström and translated into Dutch by the Rotterdam Eye Hospital [57]. This version is used to design and develop the questionnaire in the patient portal of the UMCU. Appendix J shows the final design of the PROMs questionnaire, and Appendix K shows the implemented and functional questionnaire in the UMCU patient portal.

3.4.1.2 Triage-questionnaire

The triage-questionnaire is built to assess the health and recovery process of a patient who had cataract surgery. The purpose of this questionnaire is to see if we can identify patients who are having post-op complications and issues based on the answers to the questions. The result of this questionnaire should determine if a patient is allowed and capable of doing an online eye exam instead of a face to face consultation with an ophthalmologist.

The design of the questionnaire is based on previous research on cataract post-op complications and pain [58]. Four cataract surgeons discussed the design of the questionnaire to validate the questions. In three iterations, additional questions were added to the questionnaire to cover most aspects of post-op cataract pain and complications. The final design can be found in Appendix L and Appendix M.

Screenshots of the final questionnaire can be found in Appendix N.

3.4.1.3 Results form

This form is built to replace a direct data transfer method as building an automated data transfer was found to be too expensive and time consuming for this study. Therefore, the results form is accessible from the patient portal so the patient can directly input the data from the eye exam into the patient portal. Here, they only have to input the most basic data together with a reference number. This reference number is used to obtain all data required for research.

Patients need to fill in 4 fields;

- Which eye they tested (left/right)
- How they performed the exam (with/without glasses)
- Visual Acuity result
- Reference number

These four fields can be directly copied from the easee.online environment. The final design of the questionnaire can be found in Appendix O.

Screenshots of the final questionnaire can be found in Appendix P

3.4.2 Easee online eye exam

In 2018 and 2019, the UMCU performed a validation study to assess the reliability and quality of the online eye exam for consumers that Easee developed. In the Manifest vs. Online Refractive Evaluation (MORE) trial [13], the eye exam is compared to a manifest eye measurement method used in the UMCU. This research shows that for the target population (healthy volunteers 18-40 years of age with a refraction error between -6 and +4 diopters (D)), the online eye exam was considered non-inferior to the traditional reference exam. They claim that the online exam is a safe and valid method for measuring visual acuity and refractive error.

The algorithm is capable of accurately measuring and reporting visual acuity, refractive error, and cylindrical power and axis. This patented technology is CE-certified (class 1) and meets all ISO-norms, among which ISO 8596:2017 concerning vision tests and the IEC 62304:2006 international standard for Medical Devices Software. Therefore, this is the world's first CE certified online eye exam.
Future developments of the eye test include pupillary distance calculation via webcam, a high myopia flow, reading glasses test, varifocal lens calculations, and interactive digital assistance. These innovations will broaden the possibilities to develop and online eye care platform even further.

The online exam can be executed using a computer or laptop in combination with a smartphone with an active internet connection. A smartphone is used as a remote control to give answers to the test, which is running on the computer.
After the user has registered or logged in and accepted the terms of conditions, the following six parts are executed to obtain a validated prescription:

1. Health questionnaire
2. Visual Acuity test (corrected and uncorrected)
3. Refractive error test
4. Cylindrical power and axis test
5. Results are checked and validated by an optometrist
6. The validated results will be available within 24 hours.

3.4.2.1 Cataract MVP

The standard flow of the online eye exam needed changes to be used for the UMCU implementation. Several features of the initial exam needed to be removed because they are not needed for patients. For example, the health assessment and payment can be removes as the patients already do a more extensive health assessment in the patient portal, and they do not have to pay for the exam results. A requirements document of the Easee exam is made during a brainstorming session and meeting with all stakeholders. The requirements can be found in Appendix Q. The process of the cataract flow of the Easee eye exam is modeled in Appendix R. Developers, and UX designers from Easee implement the modifications.

The MVP of the online eye exam is accessible via https://www.easee.online/nl/umcu/.

4. Telemonitoring Acceptance Research Model

The goal of this chapter is to introduce a new telemonitoring acceptance model as a research model for this study. I named this model the Telemonitoring Acceptance Framework (TAF). The section below describes and explains the research model and its hypothesized relationships.

4.1 Telemonitoring Acceptance Framework (TAF)

Based on the literature review, a model has been developed with the most relevant constructs found. The proposed model is an adaption of the UTAUT model and can be seen in Figure 17. I chose the UTAUT model as this model adds to the TAM and is most often used in literature. It incorporates the primary constructs of the model and additional constructs found in the included literature. The model does include actual use behavior, but this is not measurable the time period of this research. This means that this construct will not be measured in this study but will be included in a longitudinal study follow-up of the UMCU.

The proposed research model includes the additional constructs found in the literature that used the UTAUT model. Also, it includes trust and doctor's opinion as I think these constructs are very important and possibly directly or indirectly influence behavioral intention when a patient lays its trust in the hands of a doctor and his/her expertise and knowledge.

Technology Anxiety is found in three of the four different acceptance frameworks. This construct is hypothesized to be negatively affecting behavioral intention.

All hypotheses are shown in Figure 17 and explained below.

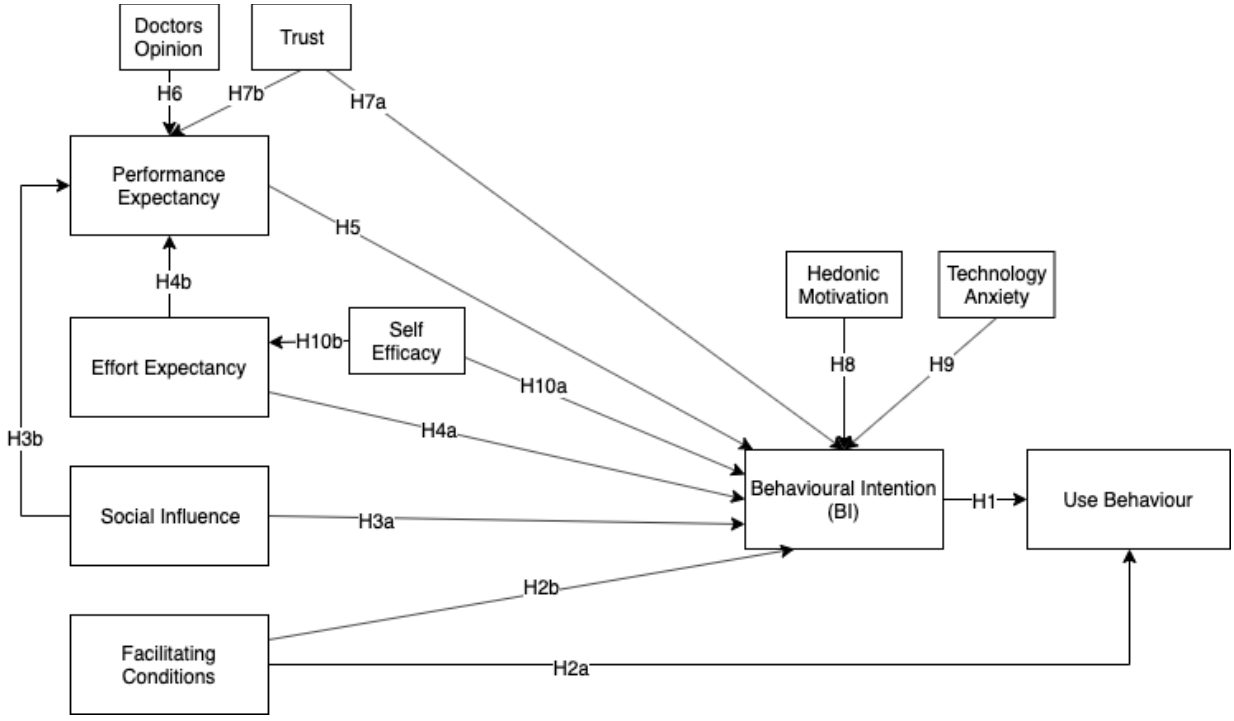

Figure 17: proposed research model
The labels show the hypotheses

H1: Behavioral intention (BI) positively influences the actual usage behavior in eHealth services.
H2a: Facilitating Conditions (FC) positively influences the actual usage behavior in eHealth services.
H2b: Facilitating Conditions positively influences the behavioral intention to adopt eHealth services.
H3a: Social Influence (SI) positively influences the behavioral intention to adopt eHealth services.
H3b: Social Influence positively influences the Performance Expectancy of eHealth services.
H4a: Effort Expectancy (EE) positively influences the behavioral intention to adopt eHealth services.
H4b: Effort Expectancy positively influences the Performance Expectancy of eHealth services.
H5: Performance Expectancy (PE) positively influences the behavioral intention to adopt eHealth services.
H6: Doctor's Opinion (DOC) positively influences the Performance Expectancy of eHealth services.
H7a: Trust (TRU) positively influences the behavioral intention to adopt eHealth services.
H7b: Trust positively influences the Performance Expectancy of eHealth services.
H8: Hedonic Motivation (HM) positively influences the behavioral intention to adopt eHealth services.
H9: Technology Anxiety (TA) negatively influences the behavioral intention to adopt eHealth services.
H10a: Self Efficacy (SE) positively influences the behavioral intention to adopt eHealth services.
H10b: Self Efficacy positively influences the Effort Expectancy in using eHealth services.

5. Data collection & analysis

A data collection and analysis method are needed to assess the constructs in the research model. Based on what I found in the literature research, I designed my own strategy to assess the research model. The data collection strategy is explained in the first section and will go deeper into the measurement model and participant selection. The next section is showing how I prepare the raw data I receive from participants and the measurement model. These preparations will make data analysis easier and more reliable. Finally, the data analysis section will describe the strategy I use to analyze, interpret and, evaluate the data and the results.

5.1 Data collection

5.1.1 Measurement model (operationalization)

A survey operationalizes the constructs of the research model where multiple questions measures each construct. The questions used to operationalize are gathered from all included studies, and the most relevant questions for my master thesis case study are chosen to represent the constructs.

The survey used to operationalize the constructs of the research model from the previous section is shown in Appendix S. The right column of the table shows the authors who included the particular question in their study to measure the construct. The questionnaire is translated in Dutch because this research is executed in a Dutch-speaking population at the University Medical Center Utrecht (see Appendix T).

The questions of the Dutch version of the survey have been reformulated to fit the purpose of testing the model before actual usage. While also being able to be used after usage of the online eye exam. Also, some words in the survey are changed to more easily understandable synonyms of the meaning of the words. The purpose of this is to match the B1 reading level of the average Dutch person. The questions are then randomized to be sure that participants will not fill in the same answer on purpose at similar questions measuring the same constructs.

An introduction and twelve questions are added for measuring moderating variables. The final survey can be found in Appendix U. This survey is made available on paper for use in the outpatient clinic at the hospital and also through Google forms to spread via e-mail.

Table 5: Likert scale

Scale	Label
1	Strongly disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly agree

The final measurement model of this study consists of 48 indicators describing ten latent constructs (BI, PE, EE, SI, FC, TA, HM, SE, TRUST and DOC) and is based on a five-point Likert-type scale (Table 5) ranging from 5 (strongly agree) to 1 (strongly disagree).

5.1.1.1 Participants

Patients who visit the outpatient clinic in the UMCU are invited to fill in the survey when waiting for their consultation. Most patients are accompanied by a family member who is also asked to fill in the survey.

The participants from the MORE trial [13] who have already used the online eye exam are invited via email to fill in the survey. Additionally, participants from previous ophthalmic research are invited by email to participate in this research. In total, we invited 515 participants from previous studies.

The data is collected in November & December of 2019.

5.2 Data preparation

5.2.1 Transformation

The data gathered from the survey is prepared for analysis, starting with data transformation as multiple sources needed to be combined. The data from the printed survey used in the outpatient facility of the UMCU is gathered and imported by hand in an excel sheet and then stored in a physical folder. All surveys received an identification number, which is also written on the printed survey for identification and backlog purposes. The online responses from the survey are automatically stored in an excel file.

As the online survey coded these responses in string type, the answers are transformed to numbers in order to perform statistical analysis. After transformation, small random samples are checked to verify the correct transformation. After transformation, the question items are re-ordered and grouped per construct.

5.2.2 Input accuracy

Input accuracy is assessed by conducting an analysis of the minimum and maximin of every construct. This indicated whether the dataset contains errors on the Likert scale. The errors are located, and if possible, the original data source is checked to find and repair the dataset.

Additionally, records that contain input errors in the original data source are excluded from further research (e.g., Multiple answers to one question).

5.2.3 Missing value analysis

The missing value identification and applying remedies are performed according to the four-step process of Hair et al. [59, p. 43]. The responses with more than 50% missing data are deleted from the sample as they miss too much data for further analysis.

5.2.4 Data imputation

Hair et al. [59, p. 43] mentions several data imputation techniques and explains the benefits and downsides of the different methods. The favorable method for data imputation with a low amount of missing data, in this case, is the complete case approach (also known as the LISTWISE method). Only cases with complete data are used for further analysis. This approach can only be used when the sample size is not majorly affected by the deletion of records with missing data.

5.3 Data analysis

The prepared data will be used to analyze the relations in the theoretical model for telemonitoring acceptance. The model is analyzed with the use of Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM). SEM is a complicated path analysis method that can deal with more than one relationship between constructs found in the model at the same time. It is most often used in social science research assessing unobservable, so-called latent constructs. SEM is used to analyze the structural relation between one or more measured variables and latent constructs.

SPSS statistics 25 is used to prepare the dataset and perform parts of the analysis. Further, SPSS AMOS 26 is a software tool for statistical analysis and modeling of Structural Equation Models. It features an easy graphical method to build and test models. Therefore, SPSS AMOS 26 is used to perform most data analysis of the CFA and SEM.

5.3.1 Confirmatory Factor Analysis

Multiple iterations of the model are tested to improve the reliability and model fit and to ensure the highest quality of the model. Improvements are made based on indicators of poor reliability, model fit, and modification indices of AMOS.

5.3.1.1 Measurement model reliability, validity & quality

The standardized factor loading between an indicator and construct has to be at least 0.5 to be reliable, and more favorable would be above 0.7.

Table 6: Cronbach alpha reference values

Cronbach's alpha (α)	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

The internal consistency of the measurement model is assessed using Cronbach's alpha (α), Construct Reliability (CR) and Average Variance Extracted (AVE). The reference values for the Cronbach Alpha are shown in Table 6, and the reference values for CR and AVE are shown in Table 7.

Table 7 : CR & AVE reference values

Indicator	Reliability
$CR \geq 0.7$	Good
$CR < 0.7$	Poor
$AVE \geq 0.5$	Good
$AVE < 0.5$	Poor

The Construct Reliability (CR), also known as Composite Reliability, is an indicator of the shared variance between the construct variables. The CR is calculated with the following formula.

Equation 1: $CR = \frac{(\sum \lambda)^2}{(\sum \lambda)^2 + (\sum \varepsilon)}$ where $(\sum \lambda)^2$ is the sum of the standardized factor loadings, squared. And $(\sum \varepsilon)$ is the sum of error variances.

The Average Variance Extracted (AVE) measurers the amount of variance captured by the construct in relation to the amount of variance due to measurement error. When the AVE is less than 0.5, the variance due to measurement error is larger than captured by the construct. This indicates that the validity of the variables, as well as the construct itself, is questionable [60]. The AVE calculated with the following formula.

Equation 2: $AVE = \frac{\sum \lambda^2}{n}$ where n is the number of indicators and $\sum \lambda^2$ is the sum of the squared standardized factor loadings.

5.3.1.2 Model fit

Several goodness-of-fit indices assess the overall model fit; the chi-square statistic/degree of freedom, P-Value, Root Mean Residual (RMR), Standardized RMR (SRMR), Goodness of Fit index (GFI), Adjusted GFI(AGFI), Comparative Fit Index (CFI), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Root mean square error of approximation (RMSEA) and PCLOSE. Table 8 shows the model fit indices reference values.

Table 8: Model fit indices reference values

Fit index	Recommended value
CMIN/df	< 3 good; < 5 acceptable
P value	> .05
RMR	≤ .05 good; ≤ .10 acceptable
SRMR	≤ .05 good; ≤ .10 acceptable
GFI	>.95 great; >.90 good; ≥.80 acceptable
AGFI	>.95 great; >.90 good; ≥.80 acceptable
CFI	>.95 great; >.90 good; ≥.80 acceptable
NFI	> .90
TLI	> .90
RMSEA	≤ .05 good; ≤ .10 acceptable
PCLOSE	> .05

5.3.2 Structural model path analysis

To execute the path analysis, the CFA model is transformed into a structural model. All hypothesized relationships in the research model are drawn. Except for the relationships to Use Behaviour as this construct is excluded. Use Behaviour could not be measured because the solution was not fully operational at the time of data collection.

5.3.3 Exploratory Data Analysis

This additional exploratory analysis is conducted to see if survey answers are correlated with the demographics of the participants. The analysis consists of;

- The construct means per age group
- Smartphone & computer use per age group and surgery (yes/no).

The results can be used to spot differences in participant and age groups, which can be more broadly examined in further research.

6. Demonstration & Evaluation

This chapter is demonstrating the MVP and evaluating its usability. Multiple volunteers have executed the online eye exam while being observed and interviewed.

Additionally, the second section of this chapter is demonstrating and evaluating the technology acceptance framework (research model). The results of the data analysis are shown and explained.

6.1 Minimum Viable Product

The MVP of the patient portal questionnaires and the online eye exam are tested and evaluated by conducting usability tests. Observations and interviews are used to discuss the MVP and evaluate its functionality and usability. The results are discussed below;

6.1.1 UMC patient portal usability test

The questionnaires in the patient portal were tested for usability by five volunteers. We provided them with the necessary information about the questionnaires and observed them while they performed the tasks. The test report can be found in Appendix S.

Results

The usability and design of the patient portal are not very promising. The design is not fitted for people with eye problems. The house-style design of the UMC is not optimized with large fonts, high contrast, and other helping features. Besides this, the call to action buttons on the website and the questionnaires are not very well placed. The questionnaires itself were excellent, and the questions were easy to answer. However, because of the design limitations of the portal, the guidance through the questionnaires was not clear and understandable.

The most essential and necessary future changes were:

- Make the URL to the online eye exam clickable
- Delete the “tussendoor opslaan” button, this confused users into thinking that they are finished.
- Give more explicit instructions on where to find the questionnaires once logged in. The button is hard to find.

6.1.2 Easee online eye exam

When the first version of the cataract exam was released, we gathered six volunteers in the age range of 65-85 who were willing to try the cataract exam. We set up three different test scripts to test different scenarios. The volunteers performed the eye exam in a home environment with their equipment. This way, we could test how they are using their computer and smartphone. We observed them during all the stages of the exam and only interrupted with catastrophic events.

We performed four individual tests and one exam where we instructed the volunteers to perform the test in pairs; one of them is doing the exam, one is operating the remote control. The pair-testing was an experimental test to see how they behave during the exam and how they performed.

Results

We identified two catastrophic events that happened multiple times. One of the events was an interrupted line of sight as we modified the exam to be able to sit in a chair during the exam. Although we changed the instructions to place a chair on a 3-meter mark, the instructions were not clear enough, which lead to the user placing the chair in front of the computer screen (3x). We had to interrupt to remove the chair before continuing.

The other catastrophic event is continuing with both eyes open while instructed to close the eye that is not being tested. We did not interrupt in this event as the instruction to close the eye is repeated during the exam, and we wanted to see if this event would self-correct.

The experimental test with pairs was quite interesting as this resulted in a relaxed execution of the exam, better focus, better handling of the smartphone remote, and the users followed the instructions better.

Based on the usability test report, we set up action points for improvements. The most crucial action points are:

- Critically review instructions
    - Removing eyewear
    - Cover the correct eye
    - Audio and text synchronization
    - Include instructions for full-screen mode
- Include an illustration of the test setup. This illustration will give a better idea to the user of how they need to set up the environment; laptop/screen placement and chair placement.
- Improve the landing page for better instructions; they are allowed to have someone help them, but no one from the volunteers did. The option of using someone's help needs more attention as this can benefit them in the effort the exam takes.
- Improve the cataract flow according to the diagram; the flow we designed was not correctly implemented as the decision of when to do a cylinder test was not correct.
- Improve exit page usability; the exit page did not show any further instructions on where and how to enter the results in the UMCU patient portal. Additionally, the font size should be increased.

The full test report can be found in Appendix W.

6.2 Telemonitoring Acceptance Framework

This section is devoted to demonstrating the results of the assessment of the telemonitoring acceptance model according to the strategy explained in chapter 5.

6.2.1 Setting & Population

This research is conducted at the University Medical Center Utrecht. Patients and partners visiting the hospital outpatient care facility of ophthalmology received the survey. In total, 79 visitors to the outpatient care facility filled in the survey.

Additionally, 515 participants of previous ophthalmic research are invited to fill in the survey. This included patients from the MORE trial who have used the eye exam before. From a total of 515, 81 people responded.

Also, the research team spread the survey among family and friends, which resulted in 49 additional responses and a total response amount of 218.

Table 9 shows the study characteristics of the included participants in this study. The division between male and female is fairly distributed. However, the age distribution is not fairly distributed as more participants are aged 55 or above.

Table 9: Population Characteristics

Characteristic of participant	n	%
Gender		
Male	96	48%
Female	103	52%
Age (years old)		
<26	20	10%
26-35	28	14%
36-45	15	8%
46-55	30	15%
56-65	39	20%
66-75	41	21%
>75	25	13%
Unknown	1	1%
Had eye surgery		
Yes, less than 5 years ago	93	47%
Yes, more than 5 years ago	18	9%
No, but I'm having surgery soon	3	2%
No, never	84	42%
Unknown	1	1%
Educational level		
Primary education	4	2%
Secondary education	27	14%
MBO	65	33%
HBO	62	31%
University	38	19%
Other	3	2%
Previous eHealth experience		
Yes	62	31%
No	137	69%
Computer usage		
Many times per day	140	70%
Once a day	17	9%
Few times a week	23	12%
Few times a month	7	4%
Never	7	4%
Unknown	5	3%
Smartphone usage		
Many times per day	158	79%
Once a day	10	5%
Few times a week	11	6%
Few times a month	4	2%
Never	14	7%
Other	1	1%
Unknown	1	1%
Performed online eye exam		
Yes	17	9%
No	182	91%

The computer and smartphone use show that almost all participants use these technologies at least a few times a month.

The last item shows the number of participants who performed the Easee online eye exam before. Only 17 participants used the exam and already had previous experience, while 182 participants did not use the eye exam ever before.

6.2.1.1 Input accuracy

A minimum-maximum test is conducted to see if there are cases in the data which are out of range. Four items are found with a scale of 1-7 instead of 1-5. The original data source is investigated, and one record contained a wrong scale, the record originated from a physical paper survey, so the correct answers are checked and corrected in the source file. After correction, no other input accuracy errors were found.

One participant filled in more than one answer at many questions, and another participant wished not to be included. These two records are excluded from further research.

I found that the doctor's opinion construct has an inconsistent min-max ratio as more than half of the measured variables had a minimum of 2 or 3. As this is not out of range and should not affect the results, no remedy is applied.

6.2.1.2 Missing value analysis & data imputation

Responses with over 50% missing data (n=8) are deleted from the sample. After deletion, 9 cases were left with missing values in the construct survey items. According to Hair et al. [59, p. 46], missing data below 10% for individual cases can be ignored as they do not occur in a concentration of a specific subset of questions. Therefore, the extent of the missing data in these 9 cases is not substantial enough to warrant action before data imputation.

Table 10: Missing values

% missing	Cases (n)
8.33	1
6.25	1
4.17	2
2.08	5
4.327	9

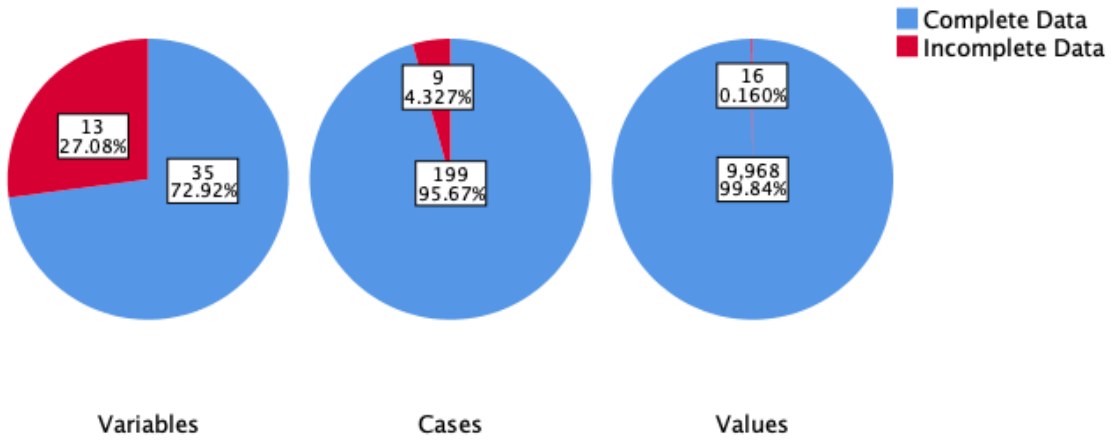

Figure 18: Overall summary of missing values

Because of the low percentage of cases with missing data, and the high sample size, the complete case approach (also known as LISTWISE method) is suitable and easy to apply. Only cases with complete data are used in further analysis while the sample size remains large enough. The final sample size is 199.

6.2.2 Confirmatory Factor Analysis

6.2.2.1 Measurement model reliability, validity & quality

Four iterations (Table 11) of model improvement are performed to improve reliability and model fit (see section X). Table 14 shows the results of the Cronbach Alpha, CR, and AVE analysis per model iteration.

Table 11: Model iteration

Iteration*	Improvements
1	All indicators
2	Indicators with weak relations excluded based on factor loadings (TRUST2, TRUST4, HM4, SE1, FC3 & DOC5)
3	Indicators excluded which indicated Cronbach's alpha improvement (SI4, SI5, FC4 & DOC6)
4	Indicator with low factor loading excluded (HM3) and modification indices applied

*A model iteration uses the previous model iteration as basis and applies additional improvements.

Running the analysis of model 1 (Appendix X) in Amos indicates whether the relation between the construct and the indicator is significant. All relations show a significant relation with the respective indicators at a 0.001 confidence level. However, when looking at the "standardized regression weights" estimations of the factor loadings, the estimated strengths (λ) of the relations between the indicators and the construct does not always show a strong relation. Some estimates show a low (below 0.5) relationship strength, while ideally, the strength should be above 0.7. Table 12 shows the indicators with a weak relationship. These results are similar to the Cronbach alpha results in Table 13 and confirm that these relations are weak and should be excluded.

Table 12: Factor loadings with weak relations

Indicator <--- Construct	Estimate
TRUST2 <--- TRUST	0.23
TRUST4 <--- TRUST	0.476
HM4 <--- HM	0.356
SE1 <--- SE	0.468
FC3 <--- FC	0.436
DOC5 <--- DOC	0.469

Table 13: Cronbach alpha results

Construct	Cronbach alpha (α)	Item deleted		Cronbach alpha (α) if item deleted	
BI	.942	-	-	-	-
PE	.843	-	-	-	-
EE	.850	EE1	-	.859	-
SI	.861	SI5	SI5 & SI4	.868	.874
FC	.701	FC3	FC3 & FC4	.706	.730
TA	.806	-	-	-	-
HM	.741	HM4	-	.759	-
SE	.608	SE1	-	.669	-
TRUST	.618	TR2	TR2 & TR4	.678	.727
DOC	.784	DOC5	DOC5 & DOC6	.786	.787

Based on the low factor loading indications of weak relationships in the analysis of model 1, model 2 (Appendix Y) excluded the relations between the related constructs and TRUST2, TRUST4, HM4, SE1, FC3 & DOC5 as these would improve the reliability. The results from model 2 (Table 14) confirm these improvements.

Model 3 (Appendix Z) also excluded the additional indicators found to improve internal reliability by the Cronbach Alpha indications if items are deleted. The results (Table 14) shows that this also improved reliability.

The last model (Appendix AA) is applying modification indices for improving model fit proposed by Amos. These modification indices introduced a covariance term between the error terms of PE2 & PE6 as well as a covariance term between the error terms of BI2 & BI5.

Table 14: Reliability analysis results per model iteration

	Cronbach alpha (α)				AVE				CR			
Model	1	2	3	4	1	2	3	4	1	2	3	4
BI	.942	.942	.942	.942	.77	.77	.77	.75	.94	.94	.94	.94
PE	.843	.843	.843	.843	.50	.50	.50	.50	.85	.85	.85	.85
EE	.850	.850	.859	.859	.55	.55	.62	.62	.86	.86	.87	.87
SI	.861	.861	.874	.874	.64	.64	.86	.86	.87	.87	.88	.88
FC	.701	.706	.730	.730	.42	.50	.64	.64	.73	.74	.77	.77
TA	.806	.806	.806	.806	.47	.47	.47	.47	.81	.81	.81	.81
HM	.741	.759	.759	.709	.43	.50	.50	.56	.73	.74	.75	.72
SE	.608	.669	.669	.669	.38	.51	.51	.51	.64	.67	.67	.67
TRUST	.618	.727	.727	.727	.35	.57	.57	.57	.65	.73	.73	.73
DOC	.784	.786	.787	.787	.41	.50	.50	.50	.80	.80	.80	.80

Reference values: AVE > 0.5; CR > 0.7

The results of the reliability analysis of the final model (4) show an excellent Cronbach alpha, AVE, and CR for the BI construct and good results for PE, EE, SI, FC, TRUST, and DOC. The SE construct shows a questionable Cronbach Alpha and a poor CR (below 0.7). The TA construct shows a poor CR, while the Cronbach alpha and CR are good.

6.2.2.2 CFA Model fit

The model fit is analyzed for the four different iterations of the CFA model. Table 15 shows the results of the CFA model fit analysis. The results for model four show the best fit for the model. The GFI and AGFI show a questionable fit. However, these fit indices are close to acceptable and are good enough to continue with further analysis. The P-value and PCLOSE show a poor fit. I was not able to improve the model fit any further, and I continues with the best fitting model (4) for the SEM analysis.

Table 15: CFA model fit results

Fit index	Recommended value	Model 1	Model 2	Model 3	Model 4	Model Fit conclusion
CMIN/df	< 3 good; < 5 acceptable	2.29	2.288	2.172	2.001	Good
P value	> .05 great	0.000	0.000	0.000	0.000	Poor
RMR	≤ .05 good; ≤ .10 acceptable	0.087	0.073	0.070	0.067	Acceptable
SRMR	≤ .05 good; ≤ .10 acceptable	0.1045	0.0928	0.0777	0.0752	Acceptable
GFI	>.95 great; >.90 good; ≥.80 acceptable	0.653	0.700	0.739	0.765	Questionable
AGFI	>.95 great; >.90 good; ≥.80 acceptable	0.605	0.648	0.685	0.714	Questionable
CFI	>.95 great; >.90 good; ≥.80 acceptable	0.782	0.829	0.862	0.886	Acceptable
NFI	> .90 great	0.673	0.732	0.774	0.799	Acceptable
TLI	> .90 great	0.762	0.808	0.842	0.869	Acceptable
RMSEA	≤ .05 good; ≤ .10 acceptable	0.081	0.081	0.077	0.071	Acceptable
PCLOSE	> .05 great	0.000	0.000	0.000	0.000	Poor

6.2.3 Structural Equation Model Analysis

6.2.3.1 SEM Model fit

The CFA model with the best fit (model 4) from the previous section is transformed into a structural model. The paths from all the hypothesis in the model are drawn. Error variance terms are added to the endogenous (dependent) constructs, while covariances are drawn between the exogenous (independent) constructs. See Appendix BB for the final structural model.

The results (Table 16) of the structural model fit test show similar results as the CFA model fit analysis. The model is acceptable for further analysis, and the modification indices in Amos show no new relations between constructs that could improve the model fit.

Table 16: Structural model fit results

Fit index	Recommended value	Structural model	Model Fit conclusion
CMIN/df	< 3 good; < 5 acceptable	2,11	Good
P value	> .05 great	0,000	Poor
RMR	≤ .05 good; ≤ .10 acceptable	0,074	Acceptable
SRMR	≤ .05 good; ≤ .10 acceptable	0.0809	Acceptable
GFI	>.95 great; >.90 good; ≥.80 acceptable	0,74	Questionable
AGFI	>.95 great; >.90 good; ≥.80 acceptable	0,69	Questionable
CFI	>.95 great; >.90 good; ≥.80 acceptable	0,871	Acceptable
NFI	> .90 great	0,784	Acceptable
TLI	> .90 great	0,855	Acceptable
RMSEA	≤ .05 good; ≤ .10 acceptable	0,075	Acceptable
PCLOSE	> .05 great	0,000	Poor

6.2.3.2 Path analysis

The SEM technique is used to interpret the causal model (Appendix BB). Table 17 and Figure 19 shows the standardized path coefficients and significance of the structural relationships. Hypothesis 1 and 2a are excluded in this study as we were not able to measure actual Use Behavior (UB) in the research period. Effort Expectancy (EE, standardized path coefficient=0,241) significantly and positively affects Performance Expectancy (PE); therefore, Hypothesis 4b is supported. Second, Performance Expectancy (PE, standardized path coefficient=1,113) significantly and positively affects Behavioral Intention (BI); therefore, Hypothesis 5 is supported. Further, Trust (TRUST, standardized path coefficient=0,865) significantly and positively affects Performance Expectancy (PE); therefore, Hypothesis 7b is supported. Finally, Self-Efficacy (SE, standardized path coefficient=0,915) significantly and positively affects Effort Expectancy (EE); therefore, Hypothesis 10b is supported. The other hypothesized relationships are not statistically significant; H2b, H3a, H3b, H4a, H6, H7a, H8, H9, and H10a are not supported.

Table 17: Path analysis results

Hypothesis				Path coefficient	t-value	p	Supported*
H1	UB	<---	BI	-	-	-	-
H2a	UB	<---	FC	-	-	-	-
H2b	BI	<---	FC	0,531	0,907	0,365	No
H3a	BI	<---	SI	0,101	0,704	0,481	No
H3b	PE	<---	SI	0,011	0,172	0,864	No
H4a	BI	<---	EE	-0,559	-1,481	0,139	No
H4b	PE	<---	EE	0,241	2,682	0,007	Yes
H5	BI	<---	PE	1,113	2,312	0,021	Yes
H6	PE	<---	DOC	-0,092	-1,905	0,057	No
H7a	BI	<---	TRUST	-0,339	-0,881	0,378	No
H7b	PE	<---	TRUST	0,865	5,284	***	Yes
H8	BI	<---	HM	0,771	1,022	0,307	No
H9	BI	<---	TA	-0,031	-0,18	0,857	No
H10a	BI	<---	SE	-0,625	-0,598	0,55	No
H10b	EE	<---	SE	0,915	5,822	***	Yes

*Statistically significant at .05 level

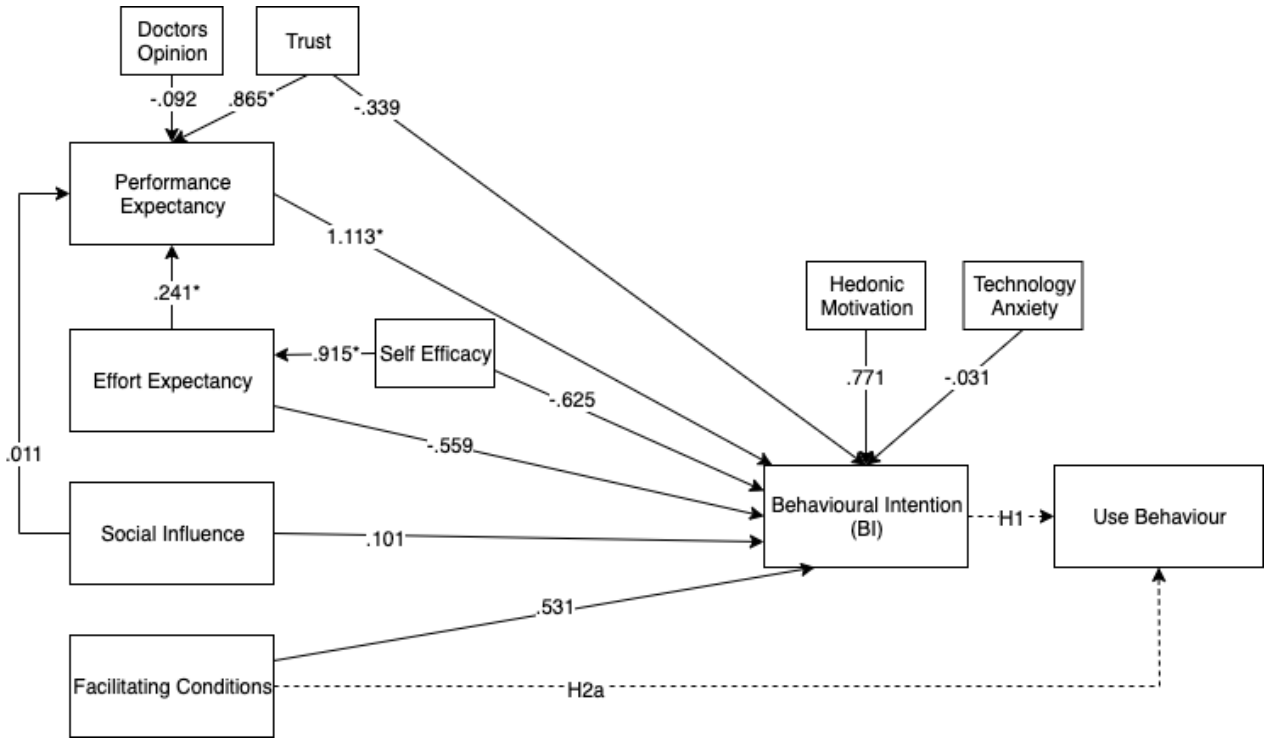

Figure 19: Research model results
The numbers show the path coefficients of the associated path.
*Statistically significant at .05 level

6.2.4 Exploratory Data Analysis

Figure 20 shows the mean of the constructs measured per age group. Here we can see the differences between age groups. The chart shows that Effort Expectancy and Facilitating Conditions are lower in the higher age groups. Also, Technology Anxiety is higher in these groups. These findings are confirmed by a correlation analysis (Table 18), which shows that age is significantly correlating with Effort Expectancy, Facilitating Conditions, Technology Anxiety, and Hedonic Motivation. However, these results do not imply causality and merely indicates that the constructs may be affected by age.

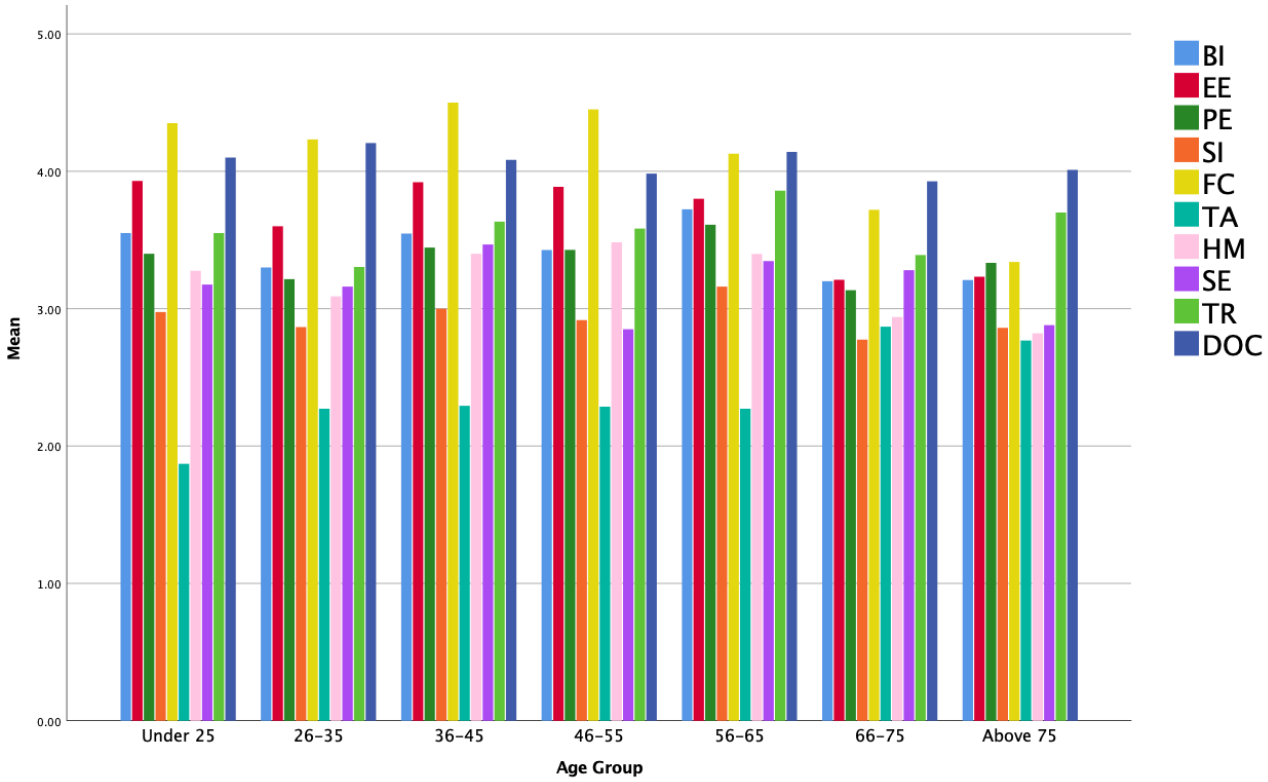

Figure 20: Construct means per age group

Table 18: Correlations between age and constructs

		Age	Mean BI	Mean EE	Mean PE	Mean SI	Mean FC	Mean TA	Mean HM	Mean SE	Mean TR	Mean DOC
Age	Pearson Correlation	1	-.074	-.310**	-.029	-.030	-.332**	.327**	-.149*	-.019	.071	-.089
	Sig. (2-tailed)		.299	.000	.680	.678	.000	.000	.036	.795	.317	.215
	N	198	198	198	198	198	198	198	198	198	198	198

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 21 shows the smartphone and computer use per age group and surgery (yes/no) group. In general, the smartphone and computer use amongst the elderly is less than for young to middle-aged adults. Moreover, Table 19 shows that there is a significant correlation between age and computer and smartphone use.

Table 19: Correlations between age, computer use & smartphone use

		Age
Age	Pearson Correlation	1
	Sig. (2-tailed)	
	N	198
Computer Use	Pearson Correlation	.215**
	Sig. (2-tailed)	.003
	N	193
Smartphone Use	Pearson Correlation	.309**
	Sig. (2-tailed)	.000
	N	196

**. Correlation is significant at the 0.01 level (2-tailed).

The results show that for the group that did have eye surgery, the smartphone and computer use is less in the high age groups. This can be caused by the fact that these people had or still have eye-diseases or poor visibility and therefore are unable or less able to use a smartphone or computer.

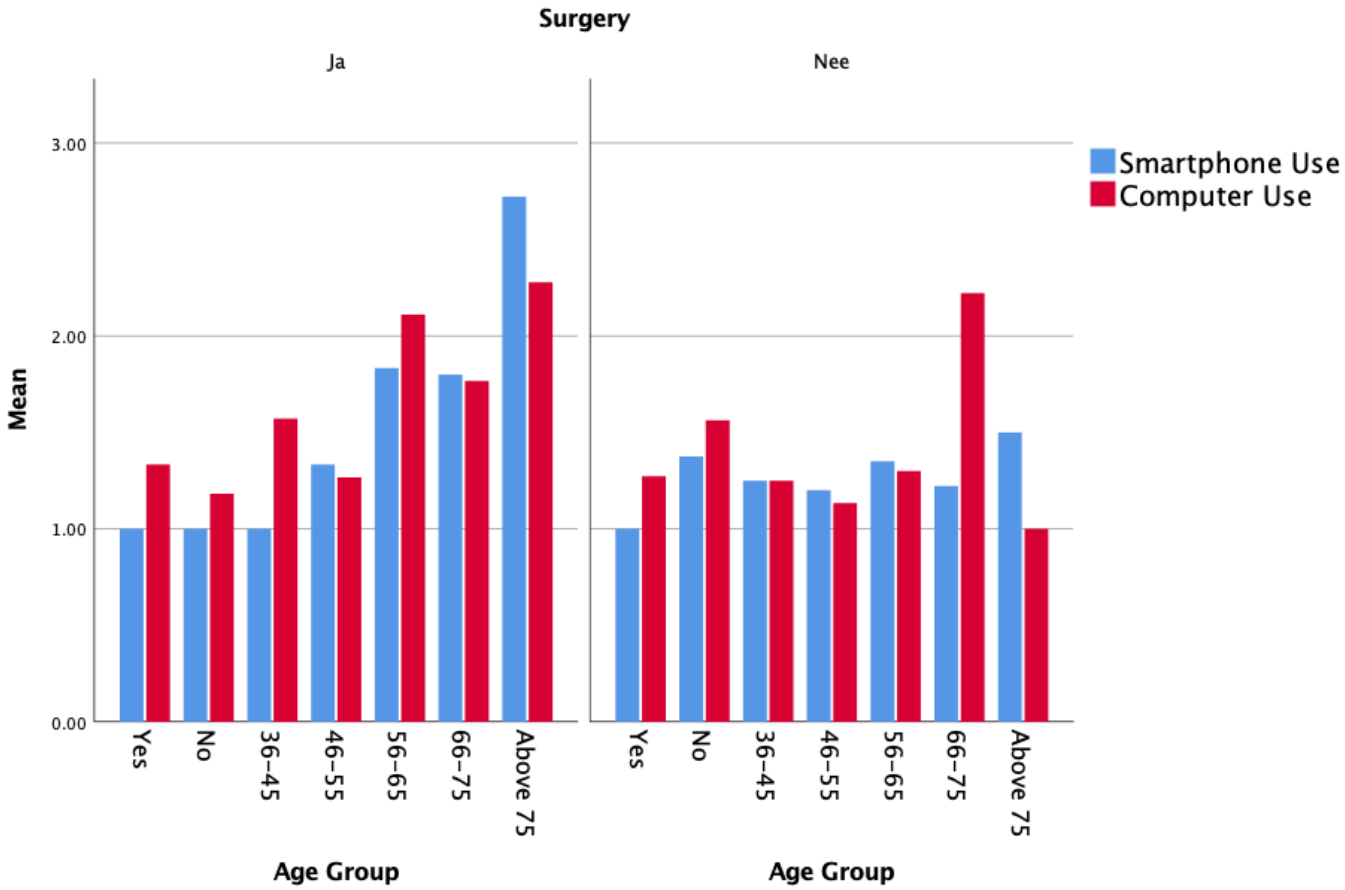

Figure 21: Mean of smartphone & computer use per age group (1= multiple times per day, 5=never). Left: had eye surgery. Right: did not have eye surgery.

7. Conclusion

The past ten months have been dedicated to the successful implementation of a minimum viable product of an online eye exam in a highly regulated and bureaucratic healthcare environment. The complex integration required excellent collaboration between several authorities, companies, and individuals.

This effort resulted in a validation study with over 200 participants divided between patients and non-patients, elderly and young adults, and with different technological experiences. The heterogeneous group of participants made this group excellent for validation of the technology acceptance framework and the measurement model.

This research aimed to identify the added value of healthcare telemonitoring and the factors contributing to its acceptance with the use of a case study.

As healthcare telemonitoring can improve the quality and accessibility of current healthcare practices, it will enable healthcare providers to help more patients and deliver healthcare more efficiently. Moreover, patients benefit from telemonitoring in several ways, including cost and time savings in traveling to the hospital as well as being able to live longer independently and track their healing process and health. However, electronic healthcare services are relatively new in the healthcare industry and are an emerging area in the past years. Additionally, the successful implementation of these systems is complex, and many initiatives do not reach the final implementation phase.

Jansen-Kosterink et al. [10] pointed out that telemedicine services are more likely to be successfully implemented in healthcare facilities when the service is accepted by end-users (patients and healthcare professionals). Therefore, the conceptualization of a new telemonitoring acceptance framework based on a thorough literature review in combination with an excellent case study and implementation is a perfect match for research and is an enabler for future research in telemonitoring use.

Current literature showed that several acceptance models are used for predicting telemedicine acceptance. The Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology are the most used frameworks. However, the UTAUT model is more extensively studied than the TAM and also features more significantly found relations of additional constructs.

I found that some primary constructs of these models are not well-performing in a healthcare environment. Facilitating conditions and social influence were not found significant by many authors. The UTAUT model proposes that facilitating conditions is related to use behavior. However, this is not found significant by most studies; four out of nine authors found a relation between FC and BI. This relation is fascinating as the original model did not confirm this relationship, but it seems to have an impact in a healthcare environment.

The case used for this research is an implementation of an MVP of an online eye exam aimed at cataract patients from the UMCU. The current cataract care processes are modeled in process diagrams, which are used as a basis for the design of the new process. During the development and implementation, three questionnaires are developed and implemented in the UMCU Patient Portal. The first questionnaire is a health assessment questionnaire that is going to be used to select patients

who are invited to participate in the online eye exam medical trial for cataract patients. It assesses their health, post-op complications, and complaints.

The second questionnaire is a predefined Patient Reported Outcome Measurements questionnaire that evaluates the cataract care results based on patient opinions. Finally, the last questionnaire consists of a form where a patient can input the measurement results from the online eye exam.

The initial online eye exam is customized and adapted for cataract patients based on a predefined list of requirements based on expert opinions and brainstorm sessions with stakeholders. The final MVP is tested by volunteers to check on usability, which resulted in a new list with future improvements to be made. These improvements are mostly focused on improving the instructions for the user, as these were unclear in many cases. Also, the UMCU patient portal can be improved by increasing the font size and increasing the text to background contrast. These improvements are documented and stored for future implementation.

A new Telemonitoring Acceptance Framework and measurement model is constructed based on the literature review results. Similar to most authors who performed technology acceptance research, we used a quantitative Structural Equation Modelling approach with data collection through a survey. The analysis of the SEM shows that Performance Expectancy is significantly influencing Behavioral Intention to use an online eye exam. Besides this, Trust and Effort Expectancy are significantly influencing Performance Expectancy, and Self Efficacy is significantly influencing Effort Expectancy.

The methodology used for assessing the acceptance framework proved very useful. However, most hypothesized relationships were not significant, which raises questions about the validity of the model and the data to assess the model. A confirmatory assessment of the model with new data will give additional insights into the validity and usability of the model in the context of healthcare telemonitoring services.

Contributions

The potential of new telemonitoring technology is at a stage that technology will support or even take over healthcare tasks traditionally performed by physicians. This research contributes to the exploration of web-based telemonitoring solutions in combination with patient acceptance and perception of these new technologies. We introduced a new Telemonitoring Acceptance Framework to assess patient acceptance and demonstrated the use of the model with an online eye exam implementation case. We realized the first implementation of an online eye exam in a hospital ever. This implementation contributes to realizing new ways of monitoring eye-patients. This implementation enables the UMCU to start with the Cataract Online Refractive Evaluation study in January 2020, which will further elaborate on validity, acceptance, and usability and will be the steppingstone to studying other eye-patient-groups. This first implementation and validation of reliability will incentivize more hospitals and clinics to innovate and apply telemonitoring services.

8. Discussion

The heterogeneity of the participants selected for this study resulted in a good span of participant characteristics. It enabled us to gather data about many different potential users and study their preferences and habits. Analyzing this data will help in selecting specific user groups that will benefit by using a telemonitoring solution and adapting the solution to their needs.

Seventeen out of 199 included participants who used the eye exam before and had extensive knowledge about the functionality of the service. The other participants needed to imagine what the eye exam is like, and what benefits it would have for them; these participants did not already form an opinion about the service. We can include these participants in follow up research after they have used the telemonitoring service. It allows for a comparison of the user perceptions of the service before and after usage and analysis of how trialability of the service can influence the constructs in the telemonitoring acceptance framework and the participant's behavioral intention.

The survey used in this research is translated from English without the help of a professional translator. Therefore, some questions might be interpreted differently than initially meant. This might be the cause of some questions having a weak Cronbach alpha and factor loading. Also, the TA and SE constructs show a questionable reliability. This can be improved in future research.

Nevertheless, the exploratory iterative method used in this study to improve the reliability and quality of the measurement model enabled us to improve the model as much as possible. However, this is not advisable for a confirmatory study of the research model as the model is changed to fit the data. Therefore, the CORE study should focus on obtaining new data with an updated measurement model and confirm the research model relationships.

Strengths

Extensive knowledge is acquired about organizational aspects of a healthcare authority on an individual as well as the national level. The knowledge about healthcare procedures will help with future implementations at other healthcare providers. Further, a lot of experience and knowledge is gained about the specific target group (eye-patients) and their needs. This knowledge will be used in future research, design, and development of the online eye exam and other (ophthalmic) telemonitoring solutions.

Also, the high-quality literature review and methodology resulted in the construction of a new telemonitoring acceptance framework with a measurement model. This framework and measurement model are an adaption of general technology acceptance models and specialize in telemonitoring services.

Considerations

Difficulties with the implementation and the bureaucratic healthcare environment have caused a postponed start of the clinical validation study of the online eye exam. Therefore, there is no clinical data available yet about the validity of the measurements of the online eye exam. However, the implementation finishes in January 2020, and the clinical (CORE) study will start in the first quarter of 2020. This longitudinal study will incorporate clinical measurements and patient acceptance.

Further, I expected to find more significant relationships between the constructs from the telemonitoring acceptance framework, especially the relations between the primary UTAUT constructs (BI, FC, SI, PE, EE). These constructs are the core of many acceptance models from the past decades, and many authors confirmed these relationships. Therefore, it is surprising that the results do not support most of these relations. However, the technology acceptance framework can be used in future research in a more controlled environment with a homogeneous population to confirm the validity of the model.

9. Recommendations for future research

The results, limitations, and considerations of this research lead to exciting opportunities for further that could improve the quality, extend knowledge, and enhance the telemonitoring acceptance framework. The key recommendations are listed below:

- The survey can be improved by consulting a professional translator to ensure high-quality translations and, therefore, correct interpretation by participants. Besides that, I would recommend to re-specify the survey based on the reliability analysis results and remove the questions with low internal reliability.
- Removing some constructs from the model and making it less complex might improve the model fit and making the results more interpretable for the researcher.
- Performing this research with another, a more specified and homogeneous population can improve the results and model fit. The CORE study will include patients who used the online eye exam. Using the service will cause less “guessing” of answers to questions and will enable the participant to form an opinion about the online eye exam. This will result in an equal interpretation, perception and clearer image of how the solution functions, and how it benefits the participant.
- Factors that lead to poor acceptance can be investigated by conducting semi-structured interviews that help clarify thoughts behind the answers in the survey. Therefore, I would recommend performing interviews with patients who used the online eye exam and also filled in the survey.
- Trialability is a construct that is important to consider in a model for telehealth adoption and acceptance. Cranen et al. [30] found that trialability has a positive influence on perceived usefulness and perceived ease. This can easily be assessed by letting patients fill in the survey before and after a trial of the online eye exam. The CORE study, which is longitudinal, will be perfect for measuring the acceptance before and after use.
- More exploratory analysis of patient acceptance can be performed based on other variables. With the postal codes, we can define socioeconomic status and also travel time/distance to the hospital and use that to see if that correlates with one or more constructs.
- Not many studies performed experiments with telemedicine technology. They used the concept of a telemedicine service with its capabilities. However, answers to the survey will be perceptions of the service. Therefore, experiments with actual telemedicine implementations are necessary to be able to obtain high-quality data on the patient’s perception of certain services. A limitation of such an experiment is the generalizability because this focuses on specific characteristics of the service.

MVP design recommendations

- Additional analysis can be performed concerning design choices to improve acceptance. Further investigation would give more in-depth insights into what design choices of web-based telemonitoring tools are affecting patient/user acceptance.
- The MVP can be improved by developing an API and integrating this with the UMCU portal. This will enable automated data flow between Easee and the UMCU. It will make the process easier for the patient, and it will be safer and more reliable.
- The triage questionnaire can be improved to predict post-op complications better and assess patient health based on the results of the CORE study.
- The patient portal can be improved by increasing the font size and make texts better readable for eye-patients.
- I would recommend implementing a font size selector in the Easee exam. This selector will make the exam more adaptable to eye care patients with different visual needs.

Future research will give more insights into adapting services to patient preferences and can show how researchers, developers, and practitioners can contribute to patient acceptance of telemonitoring services.

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Appendices

Appendix A: Characteristics of included studies

Author (year)	Description of study & data collection	Participants and characteristics	Study design, method, and country	Frameworks and additional constructs	Type of intervention or technology	Outcome and main results
Alam, Hoque, Hu, & Barua (2020) [47]	A survey instrument is used in interviews to obtain information on the research model constructs of mHealth adoption.	N=296 Age: 18 to 40 Previous experience with mHealth	Quantitative PLS-SEM Private and public hospitals in Dhaka, Bangladesh	UTAUT Price value (PV) Perceived reliability (PR)	mHealth	This study agrees to the original constructs of the UTAUT model and additionally found perceived reliability to be vital for the adoption of mHealth in Bangladesh. EE and PV are not significantly influencing BI
Cimperman, Makovec Brenčič, & Trkman (2016) [41]	A survey instrument was administered, and the data was analyzed to find the causal effects of seven hypothesized predicting factors.	N=400 Age: 50 and above	Quantitative SEM path analysis Slovenia	UTAUT Doctors opinion (DOC) Computer anxiety (CA) Perceived security (PS)	Home Telehealth Services (HTS) were introduced as a bundle of functionalities, representing future services that currently do not exist. This enabled users' perceptions to be measured on the conceptual level, rather than attitudes to a specific technical solution.	This study found four factors (EE, PE, PS, FC) that influence the BI to use HTS. Meanwhile, they found that DOC and CA significantly influence PE and EE respectively. SI is not significantly influencing BI. The final extended UTAUT model explained 77% of the total variance in BI. A physicians' opinion significantly influences the perception of HTS performance expectancy.

Cranen, Veld, Ijzerman, & Vollenbroek-Hutten (2011) [33]	This study aims to investigate whether patients' perceptions regarding a Web-based telemedicine service, for instruction and monitoring of an exercise program, change after brief use. Their perceptions are measured using a questionnaire and were administered to both the control and experimental group before and after the experimental group's intervention. Both groups are compared with respect to changes in perception.	N= 30 Age: 40,4 ± (19,7) Chronic pain	Quantitative ANCOVA & t-test The Netherlands	TAM Trialability (Innovation diffusion theory)	Web based telemedicine service (specific service) Online exercise instruction, motivation agenda, monitoring by therapist and e-consultations (video, phone, e-mail)	The result of the ANCOVA test revealed a significantly greater change in the constructs of PU and PEOU for the experimental group than for the control group which indicates that patients developed a more positive perception of usefulness and ease of use after they used the telemedicine service. Attitude and intention showed no statistical change.
Cranen et al. (2012) [49]	Face-to-face semi-structured interviews are used to explore patients' perceptions regarding telerehabilitation services and the factors that influence behavioural intention. The patients' arguments are mapped to the UTAUT model and the data is arranged into subthemes.	N= 25 Age: 22 to h77 Mean ± std = 39.8 ± 14.1 Chronic pain	Qualitative Thematic analysis The Netherlands	UTAUT	Telerehabilitation service	Perceived usefulness and facilitating conditions are found to cover many themes identified as influencing behavioural intention. Fewer themes arose in social norm and ease of use. Adoption barriers identified included doubts about the effectiveness of telerehabilitation because of diminished face-to-face therapist contact, fellow sufferer contact, and feelings of alienation.
de Veer et al. (2015) [42]	A pre-structured questionnaire is used to gain insight into the intention of older people to use e-Health applications based on the UTAUT model including age, sex, and education. Also, this study examined what older people perceive to be characteristics of e-Health.	N=1014 Age: 57 to 77	Quantitative Nested Linear Regression Analysis The Netherlands	UTAUT Self-Efficacy	e-Health	This study found that community-dwelling older people are open-minded towards e-Health. Performance expectancy, effort expectancy, and self-efficacy were found to be the most important determinants for the intention to use e-Health. While social influence was of less importance. They also found that motivating older people by showing potential benefits and letting them practice is important.

Deng, Mo, & Liu (2014) [54]	This study is focused on examining the differences in mobile health adoption between the middle and older aged citizens using a research model based on VAB and TPB in combination with four aging characteristics. The data for this research is collected from a survey.	N=424 Middle age group: 40-59(51,4%) Older age group: 60> (48,6%) Community service centers	Quantitative SEM China	- Value Attitude Behavior model - TPB - Age characteristic constructs (Perceived physical condition, Resistance to change, Technology anxiety, and Self-actualization need)	m-Health	In both groups, perceived value, attitude, and perceived behaviour control were found as a determinant for behaviour intention where PV also significantly influences attitude. However, SN and perceived physical condition showed no significant relation with BI. Resistance to change was an antecedent for behaviour intention for the middle age group. While for the older age group, technology anxiety and self-actualization need had a significant impact on behaviour intention.
Duarte & Pinho (2019) [50]	This study examines the UTAUT2 dimensions based on data collected through a survey. The research propositions offered are based on previously studied constructs who do not present a consistent effect on adoption. Therefore, the authors are stating that the UTAUT2 dimensions are not, by themselves, either necessary or sufficient to influence mobile health adoption	N=120 Age 18-39 (83%) Current m-Health users	Quantitative Partial Least Squares (PLS-SEM) and a fuzzy-set qualitative comparative analysis. Portugal	UTAUT2	m-Health service	No UTAUT2 dimension by itself is necessary or sufficient to explain mHealth adoption. Performance expectancy is assumed to be of particular importance as it presents in every configuration and also is the best predictor of mHealth adoption is the PLS analysis. The fsQCA also shows that namely young and well-educated people, as well as women, are more prone to adopt mHealth.
Dwivedi, Shareef, Simintiras, Lal, & Weerakkody (2016) [43]	The authors are researching which antecedents will affect the adoption of mHealth monitoring. A questionnaire was developed to measure the variables. They also focused on cultural differences in mHealth adoption and therefore performed the same study in three different countries.	USA N= 387 Canada N= 359 Bangladesh N=375 Average age: USA: 53 Canada: 55 Bangladesh: 56 Diabetic patients who are taking traditional healthcare services.	Quantitative Path analysis (SEM) USA, Canada, Bangladesh	UTAUT & UTAUT2 Waiting time Self-concept	A proposed mHealth service for blood pressure, glucose, and cholesterol monitoring. Sensors and wearables with WiFi connection.	The path analysis shows that Hedonic motivation was not significant for the US and Canadian users while self-concept was insignificant for Bangladeshi users. Effort expectancy and facilitating conditions are found to be the two biggest contributors to behavioural intention in all three countries. However, the authors state that this adoption behaviour cannot be generalized to other cultures.

Giger et al. (2015) [61]	This study is aimed at researching the telemonitoring adoption trends over time of use. They hypothesize that over time, there will be a linear trend of SN, PU, PEU, and BI. They gather data by conducting 2-week interval interviews over a 14-week period.	N= 14 Age group: 61-90 Hypertension, Rheumatoid arthritis, visual impairment, Diabetes, and COPD.	Quantitative Growth curve methods and bootstrap resampling. USA	TAM Subjective norm	A remote patient monitoring system (1) Honeywell HomMed Genesis Touch Samsung tablet (2) A&D Bluetooth Blood Pressure Monitor (3) Bluetooth Oximeter (4) Honeywell Wireless Scale.	Data showed that only subjective norm was significantly predicted by time. The author mentioned that the levels of PU, PEU, and BI were high and stable but did not show a significant linear trend.
Hennemann, Beutel, & Zwerenz (2016) [44]	This study aimed to (1) determine acceptance of Web-based aftercare and (2) explore its drivers and barriers in different subgroups of a mixed inpatient sample. To collect the data, the researchers used a survey based on a qualitative pilot study.	N= 338 Age: 14 and above (73% is above 40) Psychosomatic, cardiologic, orthopedic, pediatric, and substance-related disorders At least two weeks of treatment or half treatment completed	Quantitative Multiple hierarchical regression Germany	UTAUT - Health-related internet and mobile use - Knowledge of eHealth interventions - eHealth literacy - IT literacy - Internet anxiety - Permanent availability stress - Risk of incapacity to work - Mental distress - Self-efficacy	eHealth web-based aftercare	The data analysis supported the viability of the UTAUT model in assessing acceptance and the authors found that social influence, performance and effort expectancy as well as stress through permanent availability, predicted acceptance. The authors also found that time and local flexibility are the primary advantages of web-based aftercare while impersonality of web-based aftercare was the primary disadvantage.
Hoque & Sorwar (2017) [45]	This study aimed to develop and test a theoretical model and determine the key factors of mHealth adoption among elderly users. Structured questionnaires based on the theoretical model constructs were used to gather data from the participants.	N=274 Age: 60 and above 72% of the respondents suffered from at least one chronic medical condition.	Quantitative PLS-SEM Bangladesh	UTAUT Technology Anxiety Resistance to change	mHealth	This study confirmed that the modified UTAUT model is applicable in the mHealth domain and showed that the added Technology Anxiety and resistance to change constructs significantly influenced the behavioural intention of the elderly in developing countries. However, the results suggest that there is no significant relationship between facilitating conditions and behavioural intention and actual use behaviour.

Huang (2010) [32]	The goal of this study was to develop and test a remote health monitoring adoption model that is based on TAM and HBM where the focus is placed on testing the feasibility of establishing such a model by artificial neural networks.	N= 369 Age: 15 and above; 35–44 (34%) 45–54 (28%) 55–64 (27%) Taiwan International Senior Lifestyle and Health Care Exhibition	Quantitative Artificial neural network: Feedforward neural network Taiwan	Healthcare Information Adoption Model (TAM and Health Belief Model)	Remote monitoring	The results of the study showed that the effects of PEOU, PUB, PDT, PBTA, ECUE and ICUE on ATT and the effect of PEOU on PUB are significant. However, they found that attitude does not vary significantly with ICEU. These results indicate that it is feasible to construct a remote monitoring adoption model with ANN based on the healthcare information adoption model.
Huang (2011) [28]	This study employed a backpropagation network to analyze the adoption model of telecare. This method is chosen to enrich the knowledge of using non-linear structural models for studying telecare adoption.	N= 295 Age: 60 and above Taiwan International Senior Lifestyle and Health Care Exhibition	Quantitative Artificial neural network: Backpropagation network Taiwan	TAM	Telehealth	The results of the study show a significant effect of PU and PEOU on attitude where PU is the most significant. They also show the significant effect of PEOU on ATT and ATT on BI. These results are consistent with previous research which indicates that it is feasible to construct a telecare adoption model with BPN method of ANN.
Huang (2013) [29]	This study aims to explore the individuals' telecare adoption, willingness and behavioural intention to use telecare.	N= 369 Age: 15 and above; 35–44 (34%) 45–54 (30%) 55–64 (13%) Taiwan International Senior Lifestyle and Health Care Exhibition	Quantitative SEM Taiwan	TAM Subjective norm Innovativeness	Telehealth	The results of the hypothesis testing show that SN is significantly affecting both PU and BI. PEOU and PU are significantly affecting ATT. Significant relations are also found between, Innovativeness and PEOU, PEOU and PU, and between ATT and BI. They did not find a significant relation between Innovativeness and PU and between PU and BI.

Jansen-Kosterink et al. (2019) [10]	This exploratory research was focused on identifying factors that contribute or hinder the acceptance of an online telemedicine service for rehabilitation care. An interview guide was developed to provoke discussions among participants on different topics of the telemedicine service. These discussions are transcribed and coded using thematic analysis.	N=118 Age: 18 and above. Chronic diseases Obstructive Pulmonary Disease (COPD) chronic low back pain (CLBP) whiplash associated disorder (WAD)	Qualitative exploratory Thematic analysis The Netherlands	TAM and UTAUT Advantages & disadvantages - Expected clinical effectiveness - Learnability - Using the service at home - Intention to use Service configuration	Online telemedicine portal for outpatient rehabilitation therapy	The main advantages mentioned were no need to travel, independency from the physical facility, good instructions, extrinsic motivation and the ability for online mentoring. However, the disadvantages mentioned are based on insufficient intrinsic motivation, self-discipline, and impersonality of the communication. Most participants thought that using an online therapy is less effective than the traditional therapy but also thought it was easy to learn and that they had sufficient space at home to perform the exercises and indicated that they were willing to use the service during their outpatient rehabilitation program. However, they saw this therapy as additional care rather than replacement.
Li, Ma, Chan, & Man (2019) [30]	This study explored the factors for the acceptance of smart wearable devices for health monitoring among older adults. Face-to-face interviews, rather than self-administered reporting, were conducted to answer the close-ended questions from the two-part questionnaire (acceptance of smart wearable systems and demographics).	N=146 Age: 60 and above Non-users of smart wearable systems	Quantitative The effects of demographic variables on IU were examined using Kruskal–Wallis tests. The measurement model was analyzed with SEM. China (Hong Kong)	Smart wearable acceptance model (SWAM) based on TAM and UTAUT. -Compatibility (COM) -Self-reported health conditions (Health) -Perceived social risk (PSR) -Performance risk (PR)	Smart wearable health monitoring devices	The results show the significant roles of PU, COM, FC, and Health in directly predicting the UI where PU is the major and most significant predictor. FC is found to directly contribute to UI and PEOU. “The significant effects of compatibility on attitudinal variables imply that smart wearable systems should be compatible with current communication technologies and age-friendly for older adults” (p. 168) Health and PR are significant negative predictors. Remarkably, PSR is the only predictor that is found to have no significant direct or indirect relation with UI.

Or et al. (2011) [46]	This study is focused on a better understanding of the acceptance factors of web-based patient-centered self-management systems among home-care patients. This research is conducting a secondary analysis of the data collected in a previous larger study called the HeartCare II study.	N= 101 Age: 28-90 Mean: 62.5 (SD 12.3) Chronic cardiac disease related to coronary artery disease and/or congestive heart failure and a normal vision with corrective lenses.	Quantitative Latent variable modeling with item parceling. USA	UTAUT Patient-centered factors: - perceived upper extremity functional ability - perceived visual functional status - health information seeking preference - healthcare knowledge	Web-based self-management home care	In the model, perceived usefulness significantly predicted behavioral intention. EE and SI significantly predicted PU. Perceived effective use was found to be influenced by healthcare knowledge, BI, and PU, where the latter one was not hypothesized. The authors did not find a significant relationship between the other patient-centered factors and BI. Neither was FC influencing other constructs. Also, they found that SN was not influencing BI but instead PU. Also, EE was not influencing BI directly.
Peeters, de Veer, van der Hoek, & Francke (2012) [55]	This research aimed to gain insight into how patient characteristics and characteristics of home telecare contacts influence the adoption of home telecare. Another goal of this study was to verify the applicability of Rogers IDT attributes for influencing home telecare adoption. They developed a questionnaire that addressed patients' perceived attributes of home telecare as well as their characteristics.	N= 254 Age: 36–97 Mean: 77,8 94% with chronic diseases	Quantitative ANOVA, regression analysis The Netherlands	Diffusion of innovation theory Excluding trialability	Home telecare	From the analysis between the patient characteristics and the perceived attributes. A clients' living situation seems to be related to observability. Also, the care received is significantly related to the perceived attributes. Type of contact seems to be related to the perceived attributes. The final analysis showed that all perceived attributes of home telecare are associated with the patients' adoption.

Quaosar, Hoque, & Bao (2017) [48]	The goal of this study is to identify the factors that influence the adoption and intention to use mHealth among the elderly in a developing country. The data used for this research is collected through a two-section questionnaire assessing demographic profiles and measuring the model variables.	N= 245 Age: 60 and above	Quantitative PLS-SEM Bangladesh	UTAUT Perceived credibility	m-Health	The results of this research confirmed the usability of the UTAUT model to predict the elderly's intention to use mHealth. They show that PE, EE, and SE have a significant effect on the intention to use mHealth services. They also show a significant relationship between PC and BI. However, this study did not find any significant relationship between FC and the elderly's behavioral intention and actual use of m-health services.
Van Middelaar et al. (2018) [52]	This research aims to explore factors that influence initial and sustained engagement with an interactive internet platform for cardiovascular self-management. Transcripts and field notes from semi-structured interviews are coded using an iterative thematic analysis.	N=20 Age: 65 and above HATICE participants with increased risk of cardiovascular disease	Qualitative Thematic analysis The Netherlands	No framework Initial & sustained engagement	Internet platform for cardiovascular self-management	Initial engagement: -perceived computer literacy, usability and anticipated benefits of the platform, with special attention to the computer skills and preferences of older people. Sustained engagement: Regular automatic and personal reminders, clear expectations, incorporation into a daily routine and social support Besides the above factors, the authors identified the support of a coach as a crucial factor of initial and sustained engagement.
Van Velsen et al. (2016) [53]	This research aimed to identify factors for determining trust in portals for rehabilitation therapy for patients and healthcare providers. The focus groups discussed what makes up trust in a rehabilitation portal, what effect specific design cues have, and how much the participants trust the use of activity sensor data for informing treatment.	N(patients)=15 Age: 41-66 Chronic pain, cerebral infarction and cerebrovascular accidents	Qualitative Thematic analysis The Netherlands	Trust concept - patient journey - Models of trust - trust cues - sensor data	Portal for rehabilitation therapy	Factors identified that shape patient trust in treatment and technology: - Effectiveness - Clarity - The collaborative decision between healthcare professionals and patients. - Level of control - Privacy - Data preservation - Usability

Wang et al. (2018) [35]	This research aimed to develop a model to investigate the impact of different service characteristics and moderating effect of service relevance on attitude and use intention The data for this research is gathered through a survey. There were a lot of invalid questionnaires probably caused by a lack of understanding of the questions. Those were excluded from the study.	N=217 Age: 51 and above (90%)	Quantitative SEM China	TAM - mHealth service matching & competence - mHealth service relevance - Affective & cognitive attitude	m-Health	The results show that mHealth service matching & competence significantly influence cognitive and affective attitude. Also, the attitude factors are both found to influence Use Intention. The moderating role of service relevance is only found on the relation between affective attitude and use intention and not between cognitive attitude and use intention.
Wilson & Lankton (2004) [31]	The goal of this research is to model the acceptance of provider-delivered e-health services (before development) by applying IT-acceptance models. Data was gathered through an online questionnaire administered to subjects who registered for access to e-health services.	N= 163 Age average: 50 79% was female	Quantitative SEM USA	Combination of TAM & Motivational Model - Satisfaction - Health care knowledge - Information-seeking preference - Healthcare need - Internet dependence	e-Health	The results of the integrated model showed no better fit statistics than both the TAM & motivational model constructs on its own. Therefore, the integrated model is no better fit than TAM or the motivation model. IM is found to be predicted by satisfaction and internet dependence where the latter also predicts PU. Also, information-seeking preference predicts PEOU. Further, the results show that healthcare need and healthcare knowledge are not influencing any model constructs.
Zhou et al. (2019) [34]	The goal of this study is to explain the mechanism that determines the intentions of elderly patients to use telemedicine services. The structured questionnaire used to gather data was divided into two parts; one for demographic information and the other for variable measurements.	N= 436 Age: 60 and above Chronic disease patients	Quantitative SEM China	TAM - Medical service satisfaction (affordability (AFF) Comfortable (COM) Professionalism (PRO) safety (SAF) waiting time (WAT)) - Information quality - Telehealth BI (TBI) - Physical medial BI (PBI)	Telehealth	From the analysis, only the relationship between acceptance and offline medical services BI is not supported. A complete mediation of ACC was found between EOU and PBI. Also, a partial mediation was found between IQ and TBI and between MSS and TBI. The authors conclude that telehealth services will be supplemental to existing medical services rather than an alternative.

Cataract Online Refraction Evaluation

(CORE-study)

Study protocol

Version 1.0, 30-07-2019

PROTOCOL TITLE ‘Cataract Online refraction evaluation’

Short title	**CORE study**
Version	Version 1.0
Date	30-07-2019
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PROTOCOL SIGNATURE SHEET

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND RELEVANT DEFINITIONS

ASA	ASA physical status classification system
BV	Besloten vennootschap
GCP	Good Clinical Practice
GDPR	General Data Protection Act (in Dutch: Wet Algemene Vordering Gegevensbescherming)
IC	Informed Consent
PROM(s)	Patient reported outcome measure(s)
ROC	Receiver operator characteristics
Sponsor	The sponsor is the party that commissions the organisation or performance of the research, for example a pharmaceutical company, academic hospital, scientific organisation or investigator. A party that provides funding for a study but does not commission it is not regarded as the sponsor, but referred to as a subsidising party.
UDVA	Uncorrected distance visual acuity
WGBO	Wet geneeskundige behandelings overeenkomst

SUMMARY

Rationale: Cataract is widely prevalent in especially elderly and cataract extraction surgery has thus become one of the most performed surgeries worldwide. In recent decades the safety of cataract surgery has greatly improved and it is considered one of the safest surgeries to be performed. Postoperative management consists of routine examinations at one day, to ascertain no adverse events have occurred immediately after surgery, and ~4 weeks, to determine the refractive error. The incidence of serious adverse events following cataract surgery is estimated to be 1%. Therefor the majority of patients visits after cataract surgery will be uneventful. Nonetheless valuable time and hospital resources are consumed. Remote monitoring could replace clinical examinations in selected patient groups. However, employing digital remote monitoring which the patient can use independently has not been validated in practice.

Objective: Determining the validity of an online remote monitoring platform for cataract care.

Study design: Prospective observational

Study population: All patients undergoing non-combined cataract surgery and willing to participate in remote monitoring.

Study parameters/endpoints: health status measured using health questionnaires, postoperative uncorrected distance visual acuity, postoperative refractive error.

Nature and extent of the burden and risks associated with participation, benefit and group relatedness: There is no risk or additional burden associated with participating.

INTRODUCTION AND RATIONALE

Cataract is one of the leading causes of reversible visual impairment worldwide.[62] Cataract is de clouding of the natural lens, often due to aging, and most seniors will experience some degree of clouding which can affect their visual acuity.[63] The main treatment for cataract is surgical extraction of the cloudy natural lens and implantation of a clear artificial lens.[63] Due to increasing life expectancy, especially in developed countries, cataract is more prevalent and cataract surgery has become one of the most performed surgeries. Between 2012 and 2016 the number of annual cataract surgeries performed in the Netherlands increased with 25% to 175.000 procedures and is expected to keep increasing.[64]

In the past decades new techniques and technologies have revolutionized cataract surgery making it one of the safest surgeries which are performed.[65] Serious adverse events are rare with an estimated incidence of 1%.[66] This low rate of adverse events has led to the majority of cataract surgeries are performed in day-care and are not admitted to the hospital for more than a few hours. The postoperative care of cataract surgery currently consists of routine examinations one day after surgery and ~1 month after surgery. The main purpose of the examination one day after surgery is to ascertain no serious adverse events have occurred immediately after surgery.[67] At ~1 month after surgery the residual refractive error is determined and routine postoperative cataract care is finished. Before and after surgery health questionnaires, patient reported outcome measures (PROM), are taken to improve quality of care.[64], [68] The last PROM questionnaire is taken 3 months after surgery.

Because of the low incidence of serious adverse events the majority of postoperative examinations after cataract surgery will be uneventful. Nevertheless because of the amount of cataract surgeries performed the postoperative care of cataract patients takes up a considerable amount of hospital time and resources. To maximize the efficiency of postoperative cataract care several clinics replaced the clinical examination the day after surgery by a telephone consultation.[66] Nonetheless telephone consultations lack objective outcome parameters and still requires substantial hospital resources.

To improve the quality of care compared to telephonic consultations and maximize efficiency of available resources remote monitoring can be employed. A remote monitoring platform could automatize postoperative cataract care and provide objective outcome parameters (e.g. visual acuity). The remote monitoring platform employs validated tests and questionnaires currently used for postoperative cataract care.

The visual acuity and refractive error are determined using the validated technology of the medical technology company Easee B.V. The patient can individually assess their visual acuity and refractive error using a smartphone and computer/television screen. A recent performed clinical trial found the Easee digital refraction test to be non-inferior in healthy controls to a manifest refraction performed in a hospital setting.[68] Moreover, the visual acuity measurement showed a strong correlation with the hospital visual acuity measurements in healthy and eyes with visual impairing conditions.
In summary, a remote monitoring platform is an accessible and safe to use tool for patients. Remote monitoring saves both patient and hospital time and puts less strain on valuable resources.

Nonetheless, a remote monitoring tool has not been evaluated in practice. In addition, the adoption and acceptance of a remote monitoring tool by patients is crucial for its success and is it unclear which factors are contributing to the adoption of remote monitoring.
In this prospective observational study we aim to investigate the validity of remote monitoring in postoperative cataract care and which patients most benefit of remote monitoring.

OBJECTIVES

Primary Objective:

Determining the validity of an online remote monitoring platform for cataract care.

The primary research question is;
Can an unsupervised remote monitoring platform determine the health status, visual acuity and refractive status of patients undergoing cataract surgery?

Secondary research questions:
- How sensitive is the remote monitoring platform in determining the necessity of clinical follow-up?
- Which pre-specified preoperative and perioperative factors will likely result in a medical intervention and/or additional follow-up?
- What is the response rate for the PROM questionnaire?
- Which factors influence adoption of remote monitoring?

STUDY DESIGN

The CORE study is a prospective observational study. All patients planned for cataract surgery have access to the remote monitoring platform.

STUDY POPULATION

Population (base)

All patients with cataract and are planned for non-combined cataract surgery at the University Medical Center Utrecht. The University Medical Center Utrecht yearly performs 476 non-combined cataract surgeries.

Inclusion criteria

Subject must meet the following criteria to be included in the study:

- planned for phacoemulsification cataract extraction and intra-ocular lens implantation
- 18 years or age
- Be able to fill out the health questionnaire and perform the online refraction.

Exclusion criteria

- Cataract extraction surgery combined with other procedures, including: keratoplasty, vitrectomy, glaucoma filter implants.
- Not have access to the digital requirements to take the online health questionnaire and/or perform the online refraction.
- Insufficient command of the Dutch or English language to understand the questionnaires and online refraction.

Sample size calculation

The UMC Utrecht yearly performs 476 cataract surgeries. All patients scheduled for uncombined cataract surgery will be invited to use the remote monitoring platform. The conversion rate from invitation to study participation is unknown.

METHODS

Study parameters/endpoints

Main study parameter/endpoint

The unsupervised online remote monitoring consists of three parameters; specifically the outcome of the health questionnaires, the uncorrected visual acuity, and the refractive error.

The health questionnaire consists a validated patient reported outcome questionnaire (CatQuest 9-SF-NL; see appendix I).[58] The visual acuity and refractive error are measured using the digital refractive exam, as described in the MORE-trial.[68] The visual acuity is measured in Snellen decimal and will be recalculated to logarithmic values. The refractive error is assessed in a spherical, cylindrical, and axis component. The components will be transformed into two types of vectors; the Fourier power vector and the spherical equivalent.[69]

Secondary study parameters/endpoints (if applicable)

In addition to the PROMs questionnaire, the online tool assesses the eligibility of a post-surgery patient to undergo remote monitoring. The triage questionnaire assesses the

patients' health status and indicates if a clinical examination is indicated (see appendix II & III). Outcomes of this triaging-questionnaire will be compared to outcomes of the routine clinical examination. The sensitivity for necessitating clinical examination of the online remote monitoring tool will thus be determined. Clinical consultations will be graded accordingly, and any changes in postoperative management are considered relevant events. This includes: medical interventions (i.e. surgical and pharmaceutical), additional clinical examinations, intraocular pressure increase ≥10 mmHg compared to baseline.

All relevant preoperative, perioperative and postoperative factors and events which could resulting in a change postoperative medical management are collected. These are formulated based on the existing *Kwaliteitsregistratie Catatarct* operaties and adhere to the European EUROQUO standardized cataract registration systems.[70] An overview of factors which will be collected is given in table 1.
The response rate for the CatQuest 9-SF-NL in the remote monitoring environment will be determined and compared to existing response rate of paper-based response rates for the CatQuest 9-SF-NL.

To determine which factors influence the adoption of remote monitoring by patients a custom questionnaire has been developed (see appendix IV). A model will be used to determine which factors and associations influence the adoption of digital remote monitoring. Factors which will be investigated include; performance expectancy, effort expectancy, social influence, facilitating condition, technology anxiety, resistance to change, behavioural intention, use behaviour (see appendix IV)

Table 1. overview of patient and surgical factors	
Factors:	Inter factor stratification:
ASA classification[71]	ASA 1: healthy patient and no fear of ophthalmic surgery
	ASA 2: patient with mild systemic diseases
	ASA 3: patient with serious systemic diseases
	ASA 4: Patient with a serious systemic disease that is a constant threat to life.
	ASA 5: A moribund person who is not expected to survive without the operation.
	ASA 6: declared clinically death, whose organs are being removed for donor purposes.
Preoperative best corrected visual acuity	
Visual impairing ocular comorbidity	- none
	- corneal disease
	- diabetic retinopathy
	- Age related macular degeneration

	- other retinopathy
	- glaucoma
	- uveitis
	- amblyopia
	- other
Complicating ocular comorbidity	- none
	- white cataract
	- pseudo-exfoliation
	- cornea clouding
	- small pupil
	- prior corneal surgery
	- prior refractive surgery
	- prior pars plana vitrectomy
	- other
Perioperative complications	- posterior capsule rupture without vitreous loss
	- posterior capsule rupture with vitreous loss
	- zonulolysis
	- anterior capsule tear
	- lens luxation
	- iris prolapse
	- other iris damage
	- other ophthalmic complications, including: dropped nucleus, expulsive or retro bulbar haemorrhage,
	- other non-ophthalmic complications
Biometry target refractive outcome	- non-emmetropic
	- emmetropic (+0.50 to -0.50 dioptres)

The response level of the PROM questionnaire will be measured and compared to current response levels for paper-based PROM questionnaires.

Other study parameters (if applicable)

Study procedures

All data obtained during the study will be extracted from the electronic patient file. Obtained data will include; age, sex, surgery report, pre- and postoperative measurements up to 4 months.

Withdrawal of individual subjects

Subjects can leave the study at any time for any reason if they wish to do so without any consequences. The investigator can decide to withdraw a subject from the study for urgent medical reasons.

Specific criteria for withdrawal (if applicable)

Replacement of individual subjects after withdrawal

Subjects who withdraw will be replaced.

STATISTICAL ANALYSIS

The source data will be stored in the electronic patient record and the Easee online test. All data will be collected using Castor EDC and analysed using IBM SPSS (SPSS Inc., Chicago, IL, USA).

Data will be collected and analysed preoperative (i.e. baseline) and at three postoperative time points. Patients will be instructed to access the remote monitoring just prior to their hospital visit. Though since patients have continuous access to the online service, the could potentially enter data at many time points. The first postoperative time point is defined as the first measurement after surgery, preferable prior to the face-to-face consultation, and otherwise acceptable up to 3 days after surgery. The second postoperative time point is defined as the measurement closest to 4 weeks, preferable just prior, but not earlier than 3 weeks and not later than 6 weeks after surgery. The third postoperative time point is defined as the measurement closest to 12 weeks postoperative (~3 months), preferable just prior, not earlier than 9 weeks, and not later than 15 weeks.

All quantitative variables will be summarized, including: the frequency, absolute value, percentages, mean, standard deviation and range. The data will be tested for equal distribution, if not normally distributed the corresponding non-parametric test will be used.

The results will be stratified for the presence of 1) ocular comorbidity, 2) visual impairing comorbidity, and 3) complications during surgery.

Primary study parameters

The compound score of the CatQuest 9-SF-NL of postoperative measurement 1 and 2 will be compared to the baseline measurement of the CatQuest 9-SF-NL. Adhering to the international guidelines issued by ICHOM .[70], [72]

The uncorrected distance visual acuity (UDVA) and refractive error measured using online remote monitoring will be compared the routine clinical examination. The logMAR UDVA will be compared using a paired sample t-test. The refractive error is converted to a vector and compared with the second postoperative measurement using an intra-class correlation coefficient and Bland-Altman plot to visualize differences.

Secondary study parameter(s)

The ability of the triage questionnaire combined with the visual acuity test in necessitating clinical follow up will be determined using a
analysis. Necessitating clinical follow-up is defined as all clinical interventions and/or additional follow-up indicated at the one day postoperative consultation.

In addition analysis which patient groups in which preoperative identified comorbidity and/or perioperative complication (sub)group are likely to need a medical intervention and/or additional follow up.

The response level of the CatQuest 9-SF-NL questionnaire will be determined using percentages. This will descriptively be compared to reported response levels of the CatQuest 9-SF-NL.

Factors associated with adoption and acceptance will be measured in acustom questionnaire. The independent factors will be assessed using a Structural Equation Modelling- model to determine their respective effect. Associations between factors will be determined using a path analysis.
In order to determine the validity of the questions to the corresponding factor a confirmatory factor analysis will be used.

Other study parameters

ETHICAL CONSIDERATIONS

Regulation statement

The study will be designed and implemented according to ‘gedragscode gezondheidsonderzoek’ en ‘toetsingscriteria eenvormige toetsing’ that consist of the laws: ‘WGBO’ (Wet op de Geneeskundige BehandelingsOvereenkomst) and ‘GDPR’ (in Dutch: Algemene Verordening Gegevensbescherming)

Recruitment and consent

All patient scheduled for non-combined cataract surgery will be invited to use remote monitoring. Information on the remote monitoring and this study is added to the standard information folder patients receive. All patients subsequently have a routine pre-operative consultation with their surgeon, and as such have the opportunity to ask additional questions on the research program. Patients are asked informed consent for the prospective collection of data for research, and for the data transfer between the UMCU and Easee BV when they enter the remote monitoring environment (the so called profile in the UMCU portal). Patient who do not give consent cannot use the remote monitoring tool.

ADMINISTRATIVE ASPECTS, MONITORING AND PUBLICATION

Handling and storage of data and documents

The remote monitoring platform is an application in the UMC portal and partly integrated in the electronic patient record. The questionnaires will be filled in in the UMC portal environment after which the outcomes will directly be recorded in the electronic health record. After completing the questionnaires patients are redirected to the Easee URL. The online refraction exam asks patients to register and perform the exam. Registering is necessary to identify and retrieve the data. A numeric identifier will be added to the profile. The data gathered by Easee BV are stored in a GDPR approved cloud solution in Europe.

After completion of the Easee test, the UDVA, and the six-digit identifier number will be shown to the patient. The patient has to copy these two numbers into the UMCU portal. The refraction measurement will be logged and retrieved using the reference number for study purposes. The refraction data as such will not be entered in the UMCU portal/EHR.

Study measurements will be collected using Castor electronic data capture tool. The data is stored in GDPR compliant severs. The collected data will be coded and handled confidentially. The research team will have access to the data. The subject decoding will be kept in a separate secure file and the key will be kept by the principal investigator. No human material will be kept in regard to this study.

The original data will be stored will be stored and kept in a secure folder on the UMC servers, which will be back-up every day. All steps of the analysis will be documented. The data and analysis will be archived for 15 years after the study has ended.

The investigator will notify the dHS Research Office (DHS_onderzoeksbureau@umcutrecht.nl) of the end of the study. The end of the study is defined as when the data is collected.

Appendix I

Patient reported outcome measures cataract (catquest-9SF NL).[73]

A. Vindt u dat uw huidige gezichtsvermogen op een of andere manier moeilijkheden veroorzaakt in uw dagelijks leven?

Ja, zeer grote moeilijkheden	Ja, grote moeilijkheden	Ja, enige moeilijkheden	Nee, geen moeilijkheden	Ik kan niet kiezen
☐	☐	☐	☐	☐

B. Bent u tevreden of ontevreden over uw huidige gezichtsvermogen?

Zeer ontevreden	Tamelijk ontevreden	Tamelijk tevreden	Zeer tevreden	Ik kan niet kiezen
☐	☐	☐	☐	☐

C. Hebt u moeite met de volgende activiteiten als gevolg van uw gezichtsvermogen? Zo ja, in welke mate? Zet in elke rij slechts één vinkje in het hokje dat volgens u het beste past bij uw situatie.

	Ja, zeer grote moeite	Ja, grote moeite	Ja, enige moeite	Nee, geen moeite	Ik kan niet kiezen
Krantenteksten lezen	☐	☐	☐	☐	☐
Gezichten herkennen van mensen die u ontmoet	☐	☐	☐	☐	☐
De prijzen van producten zien tijdens het winkelen	☐	☐	☐	☐	☐
Zien waar u loopt op ongelijke ondergrond, bijvoorbeeld op straatkeien	☐	☐	☐	☐	☐
Zien om te kunnen handwerken of houtbewerken etc.	☐	☐	☐	☐	☐
Ondertitels op TV lezen	☐	☐	☐	☐	☐
Zien om te kunnen deelnemen aan een activiteit/hobby waar u zich voor interesseert	☐	☐	☐	☐	☐

Appendix II

Triage questionnaire online remote monitoring platform.

1. **Bent u al aan uw oog geopereerd?**
    i. Ja (Door naar vraag 2)
    ii. Nee (afbreken vragenlijst, score A=1)
2. **Aan welk oog bent u geopereerd?**
    i. Links (Door naar vraag 3)
    ii. Rechts (Door naar vraag 3)
3. **Heeft u het verband verwijderd?**
    i. Ja (Door naar vraag 4)
    ii. Nee (melding: Verwijder het verband en maak het oog voorzichtig schoon) (Door naar vraag 4)
4. **Heeft u pijn gehad aan het oog?**
    i. Ja (geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10)
        i. >=8 (score B=1) (Door naar vraag 5)
        ii. <8 (Door naar vraag 5)
    ii. Nee (Door naar vraag 5)
5. **Heeft u nu pijn aan het oog?**
    i. Ja (geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10)
        i. >=6 (Score B=1) (Door naar vraag 6)
        ii. <6 (Door naar vraag 6)
    ii. Nee (Door naar vraag 6)
6. **Heeft u een zandkorrel gevoel in het oog?**
    i. Ja (Door naar vraag 7)
    ii. Nee (Door naar vraag 7)
7. **Brandt het oog?**
    i. Ja (Door naar vraag 8)
    ii. Nee (Door naar vraag 8)
8. **Jeukt het oog?**
    i. Ja (Door naar vraag 9)
    ii. Nee (Door naar vraag 9)
9. **Heeft u een drukkend gevoel in uw oog?**
    i. Ja (Door naar vraag 10)
    ii. Nee (Door naar vraag 10)

10a. Dek uw <u>niet</u> geopereerde oog af. Kunt u uw vingers tellen met uw geopereerde oog?

i. Ja (door naar vraag 11)

ii. Nee (door naar vraag 10b)

10b. Dek uw <u>niet</u> geopereerde oog af. Kunt u handbewegingen zien met uw geopereerde oog?

i. Ja (afbreken vragenlijst en score A=2)

ii. Nee (door naar vraag 10c)

10c. Dek uw <u>niet</u> geopereerde oog af. Kunt u licht en donker zien met uw geopereerde oog?

i. Ja (afbreken vragenlijst en score A=2)

ii. Nee (afbreken vragenlijst en score A=2)

11. Is het oog gevoelig voor licht?

i. Ja (Door naar vraag 12)
ii. Nee (Door naar vraag 12)

12. Ziet u bijzonderheden aan het geopereerde oog?

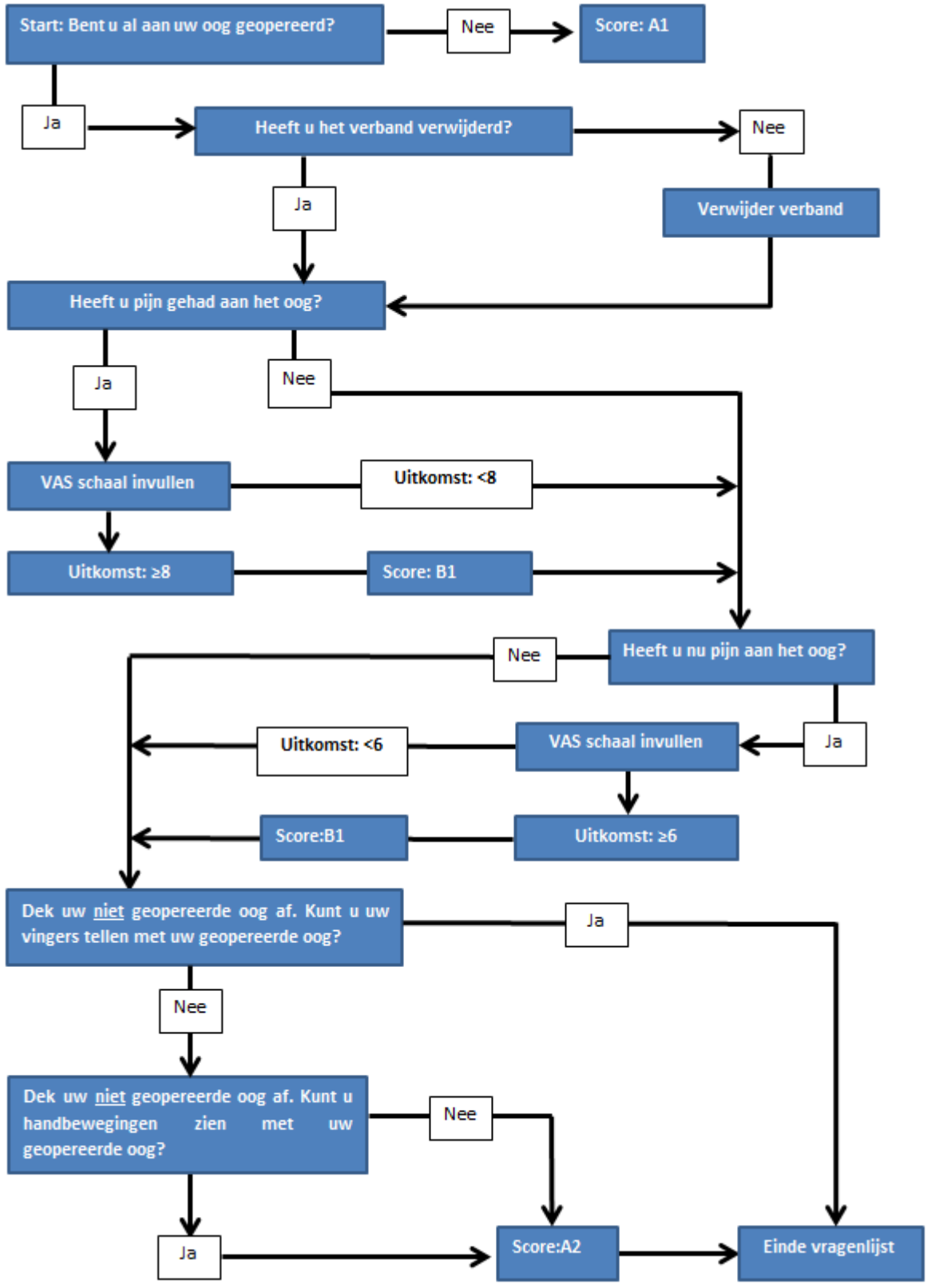
i. Ja, namelijk... (vrije tekst)
ii. Nee (Door naar vraag 13)

13. Heeft u andere klachten aan het geopereerde oog?

i. Ja, namelijk... (vrije tekst)
ii. Nee

Appendix III:

*Flowchart scoring and outcome scoring of the online monitoring triage questionnaire.**



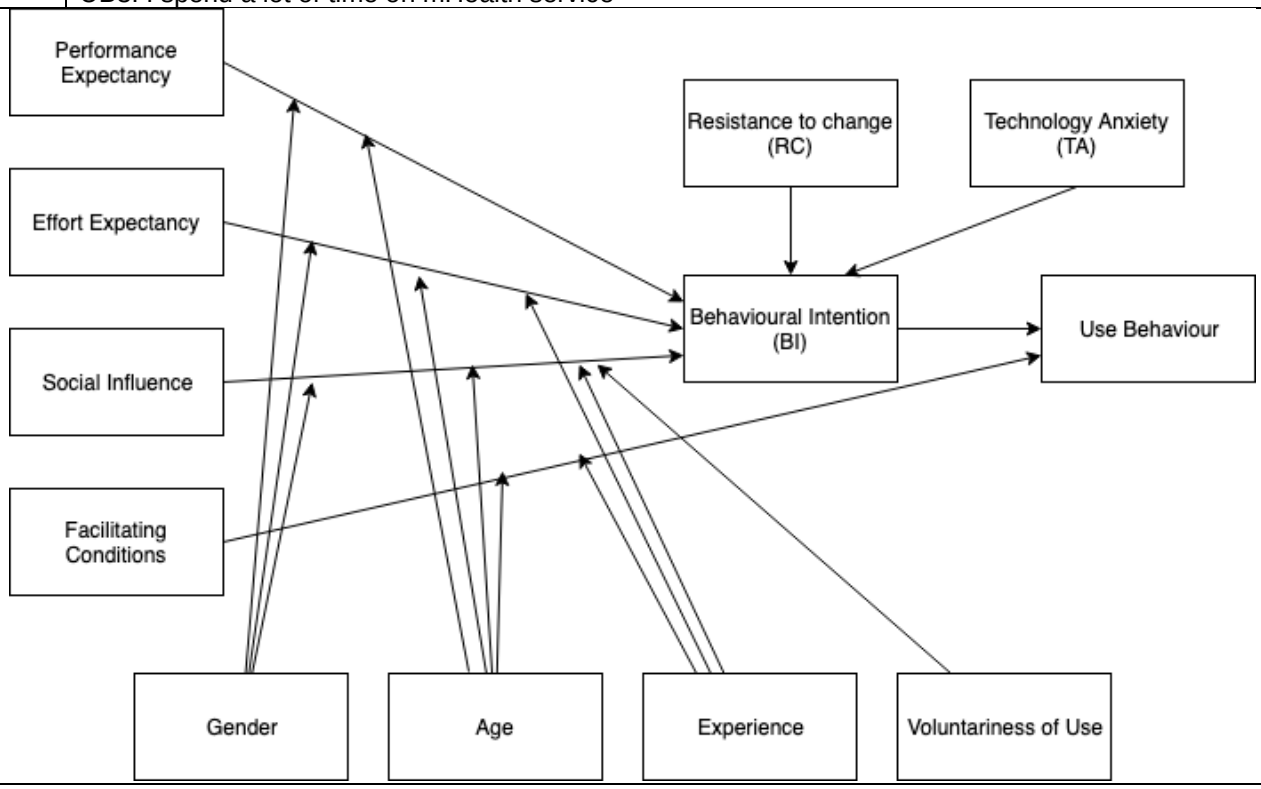
only questions which impact the scoring are shown. See full questionnaire in appendix II.

Table 2. Potential outcomes of the triage questionnaire

Score:	Outcome:
A=0 & B=0 (default score)	Eligible for online remote monitoring
A=1 & B=0	Eligible for online remote monitoring, but did not yet underwent surgery
A=2 & B=0	Patient has a poor visual acuity and not eligible for the online eye test.
A=0 & B=1	Patient has a good visual acuity and is eligible for the online eye test. However, a clinical examination is recommended due to pain.
A=2 & B=1	Patient has a poor visual acuity and is not eligible for the online eye test. In addition a clinical examination is recommended due to pain.

Appendix IV: custom questionnaire and assessment model

Construct	Questions
Performance Expectancy (PE)	PE1. I find mHealth service useful in my daily life. PE2. Using mHealth service helps me accomplish things more quickly. PE3. Using mHealth service increases my productivity.
Effort Expectancy (EE)	EE1. Learning how to use mHealth service is easy for me. EE2. My interaction with mHealth service is clear and understandable. EE3. I find mHealth service easy to use. EE4. It is easy for me to become skillful at using mHealth service.
Social Influence (SI)	SI1. People who are important to me think that I should use mHealth service. SI2. People who influence my behavior think that I should use mHealth service. SI3. People whose opinions that I value prefer that I use mHealth service.
Facilitating Condition (FC)	FC1. I have the resources necessary to use mHealth service. FC2. I have the knowledge necessary to use mHealth service. FC3. mHealth is compatible with other technologies I use.
Technology Anxiety (TA)	TA1. Using mHealth services would make me very nervous. TA2. Using mHealth services make me worried. TA3. Using mHealth services may make me feel uncomfortable. TA4. Using mHealth services may make me feel uneasy and confused.
Resistance to Change (RC)	RC1. I don't want the mHealth services to change the way I deal with health relevant problems. RC2. I don't want the mHealth services to change the way I keep myself healthy. RC3. I don't want the mHealth services to change the way I interact with other people.
Behavioral Intention (BI)	BI1. I intend to use mHealth service in the future. BI2. I will always try to use mHealth service in my daily life. BI3. I plan to use mHealth service frequently.
Use Behavior (UB)	UB1: mHealth service is a pleasant experience. UB2: I use mHealth service currently. UB3: I spend a lot of time on mHealth service



Appendix C: CORE invitation letter

Informatiebrief deelname aan medisch-wetenschappelijk onderzoek

Titel: digitale monitoring na een staaroperatie

Geachte heer/mevrouw,

Wij vragen u om mee te werken aan medisch-wetenschappelijk onderzoek. U ontvangt deze brief omdat u binnenkort een staaroperatie ondergaat en gebruik kunt maken van digitaal monitoren op afstand. Hiermee kunt u thuis de gezondheid van u oog controleren.

Meedoen aan medisch-wetenschappelijk onderzoek is vrijwillig, maar om mee te doen is wel uw toestemming nodig. Voordat u beslist of u wilt meedoen aan dit onderzoek, geven wij u uitleg wat het onderzoek inhoudt. Lees de informatie in de brief rustig door. Aan het eind van de brief staan de contactgegevens van de onderzoeker als u nog vragen heeft. U kunt er ook over praten met uw partner, vrienden of familie.

1. Algemene informatie en doel van het onderzoek

Dit onderzoek wordt uitgevoerd door de afdeling oogheelkunde van het Universitair Medisch Centrum Utrecht. Alle patiënten die een staaroperatie ondergaan worden voor dit onderzoek uitgenodigd. Het doel van dit onderzoek is om te bepalen of digitaal monitoren na een staaroperatie veilig kan en voor welke patienten dit het beste geschikt is.

2. Wat meedoen inhoudt

U krijgt toegang tot de online oogtesten in het patiëntenportaal. Dit is de online omgeving van het UMC Utrecht, waar u als patient zelf kan inloggen met een DigID. Digitaal monitoren houdt in dat u via het internet vragenlijsten invult en een test uitvoert waarbij u gezichtsscherpte gemeten wordt. U voert de metingen thuis uit met behulp van een smartphone en een computer. Dit kost ongeveer 10-20 minuten van uw tijd.
Als u meedoet aan het onderzoek, vragen wij uw toestemming om medische gegevens uit uw dossier te gebruiken voor het onderzoek. Daarnaast vragen wij u op 4 specifieke momenten digitale monitoring te gebruiken, namelijk voor de operatie, 1 dag na de operatie, 1 maand en 3 maanden na de operatie. De volgende gegevens halen wij uit uw dossier: uw oogheelkundige voorgeschiedenis, de uitslagen van de digitale monitoring en het oogheelkundig onderzoek voor en na de operatie.

Mogelijke voor- en nadelen

U heeft zelf geen voordelen of nadelen aan meedoen met dit onderzoek. Met digitaal monitoren kunt u zelf u gezichtsscherpte voor en na de operatie in de gaten houden.
Uw deelname aan dit onderzoek draagt bij aan het ontwikkelen van digitaal monitoren na staaroperatie in de toekomst.

3. Als u niet wilt meedoen of wilt stoppen met het onderzoek

U beslist zelf of u meedoet aan het onderzoek. Deelname is vrijwillig. Als u niet wilt meedoen, krijgt u dezelfde behandeling en behoud u toegang tot digitaal monitoren. Als u wel meedoet, kunt u zich altijd bedenken en toch stoppen, ook tijdens het onderzoek. U hoeft niet te zeggen waarom u stopt. Wel moet u dit direct melden aan de onderzoeker. De gegevens die tot dat moment zijn verzameld, worden gebruikt voor het onderzoek.

4. Gebruik van uw gegevens

Voor dit onderzoek worden uw persoonsgegevens verzameld, gebruikt en bewaard. Het gaat om gegevens zoals uw geslacht, geboortedatum, postcode en om gegevens over uw gezondheid. Het verzamelen, gebruiken en bewaren van uw gegevens is nodig om de vragen die in dit onderzoek worden gesteld te kunnen beantwoorden. Om uw gezichtsscherpte te bepalen werken wij samen met een derde partij, zij verzamelen uw leeftijd, email adres en hebben toegang uw meetresultaat.

In rapporten en publicaties over het onderzoek zijn de gegevens niet tot u te herleiden. Bij het verwerken van uw gegevens houden wij ons aan de Algemene Verordening Gegevensbescherming. Wat dit precies voor u betekent kunt u lezen in de bijlage. Wij vragen voor het gebruik van uw gegevens uw toestemming.

5. Vergoeding voor meedoen

Voor het meedoen aan dit onderzoek krijgt u geen onkostenvergoeding.

6. Ondertekening toestemmingsformulier

Wanneer u voldoende bedenktijd heeft gehad en al u vragen heeft kunnen stellen vragen wij u een beslissing tot deelname aan dit onderzoek te maken. Indien u toestemming geeft, vragen wij u dit op de bijbehorende toestemmingsverklaring schriftelijk te bevestigen. U kunt het ingevulde toestemmingsformulier met de retourenvelop terugsturen. Door uw schriftelijke toestemming geeft u aan dat u de informatie heeft begrepen en instemt met deelname aan het onderzoek. Wij sturen u een getekende kopie van het toestemmingsformulier terug.

7. Heeft u vragen?

Als u vragen heeft over het onderzoek kunt u contact opnemen met het onderzoeksteam. U kunt vragen per email of telefonisch stellen. Uw email kunt u sturen naar core@umcutrecht.nl of u kunt bellen naar 088-7551683

Indien u klachten heeft over het onderzoek, kunt u dit bespreken met het onderzoeksteam of uw behandelend arts. Wilt u dit liever niet, dan kunt u zich wenden tot de klachtenbemiddelaars. Deze zijn

bereikbaar via tel. 088-75 562 08. Of digitaal via: http://www.umcutrecht.nl/nl/Ziekenhuis/Ervaringen-van-patienten/Een-klacht-indienen.

Met vriendelijke groet,

Namens het onderzoeksteam,
Dr. R.P.L. Wisse, oogarts
M.B. Muijzer, optometrist
Prof dr. S.M. Imhof, afdelingshoofd

Bijlagen:
1. Aanvullende informatie over verwerking van uw gegevens
2. Toestemmingsformulier
3. Evt. andere bijlagen

Bijlage 1: Aanvullende informatie over verwerking van uw gegevens

Vertrouwelijkheid van uw gegevens
Om uw privacy te beschermen krijgen uw gegevens een code. Uw naam en andere gegevens die u direct kunnen identificeren worden daarbij weggelaten. Alleen met de sleutel van de code zijn gegevens tot u te herleiden. De sleutel van de code blijft veilig opgeborgen in de lokale onderzoeksinstelling. De gegevens die van de derde partij naar de opdrachtgever, het UMC Utrecht, worden gestuurd bevatten alleen de code, maar niet uw naam of andere gegevens waarmee u kunt worden geïdentificeerd. Ook in rapporten en publicaties over het onderzoek zijn de gegevens niet tot u te herleiden.

Toegang tot uw gegevens voor controle
Sommige personen kunnen op de onderzoekslocatie toegang krijgen tot uw gegevens. Ook tot de gegevens zonder code. Dit is nodig om te kunnen controleren of het onderzoek goed en betrouwbaar is uitgevoerd. Mensen die uw gegevens kunnen inzien zijn: het onderzoeksteam en de Inspectie Gezondheidszorg en Jeugd. Zij houden uw gegevens geheim. Wij vragen u voor deze inzage toestemming te geven.

Bewaartermijn gegevens
Uw gegevens moeten 15 jaar worden bewaard op de onderzoekslocatie.

Bewaren en gebruik van gegevens voor ander onderzoek
Uw gegevens kunnen na afloop van dit onderzoek ook nog van belang zijn voor ander wetenschappelijk onderzoek naar digitaal monitoren. Daarvoor zullen uw gegevens 15 jaar worden bewaard. U kunt op het toestemmingsformulier aangeven of u hier wel of niet mee instemt. Indien u hier niet mee instemt, kunt u gewoon deelnemen aan het huidige onderzoek.

Intrekken toestemming
U kunt uw toestemming voor gebruik van uw persoonsgegevens altijd weer intrekken. De onderzoeksgegevens die zijn verzameld tot het moment dat u uw toestemming intrekt worden nog wel gebruikt in het onderzoek.

Meer informatie over uw rechten bij verwerking van gegevens
Voor algemene informatie over uw rechten bij verwerking van uw persoonsgegevens kunt u de website van de Autoriteit Persoonsgegevens raadplegen.

Bij vragen over uw rechten kunt u contact opnemen met de verantwoordelijke voor de verwerking van uw persoonsgegevens. Voor dit onderzoek is dat:

UMC Utrecht. Zie informatiebrief voor contactgegevens van het onderzoeksteam en zie website: https://www.umcutrecht.nl/nl/Ziekenhuis/In-het-ziekenhuis/Regels-en-rechten/Rechten

Bij vragen of klachten over de verwerking van uw persoonsgegevens raden we u aan eerst contact op te nemen met de onderzoekslocatie. U kunt ook contact opnemen met de Functionaris voor de Gegevensbescherming van het UMC Utrecht, privacy@umcutrecht.nl of de Autoriteit Persoonsgegevens.

Bijlage 2: Toestemmingsformulier deelnemer

digitale monitoring na een staaroperatie: de CORE studie

- Ik heb de informatiebrief gelezen (versie 1, dd 15-08-2019). Ook kon ik vragen stellen. Mijn vragen zijn voldoende beantwoord. Ik had genoeg tijd om te beslissen of ik meedoe.

- Ik weet dat meedoen vrijwillig is. Ook weet ik dat ik op ieder moment kan beslissen om toch niet mee te doen of te stoppen met het onderzoek. Daarvoor hoef ik geen reden te geven.

- Ik geef toestemming voor het verzamelen en gebruiken van mijn gegevens voor de beantwoording van de onderzoeksvraag in dit onderzoek.

- Ik weet dat voor de controle van het onderzoek sommige mensen toegang tot al mijn gegevens kunnen krijgen. Die mensen staan vermeld in de bijlage bij deze informatiebrief. Ik geef toestemming voor die inzage door deze personen.

- Ik geef toestemming voor het doorsturen in het kader van dit onderzoek van mijn gegevens. Gegevens moeten gecodeerd worden overgedragen en zonder mijn naam en andere persoonlijke gegevens die mij direct kunnen identificeren.

- Ik geef □ **wel**
  □ **geen** toestemming om mijn persoonsgegevens langer te bewaren en te gebruiken voor toekomstig onderzoek naar digitaal monitoren.

- Ik geef □ **wel**
  □ **geen** toestemming om mij na dit onderzoek opnieuw te benaderen voor een vervolgonderzoek.

- Ik wil meedoen aan dit onderzoek.

Naam deelnemer:

Handtekening: Datum : __ / __ / __

Ik verklaar dat ik deze deelnemer volledig heb geïnformeerd over het genoemde onderzoek.

Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de deelnemer zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker (of diens vertegenwoordiger):

Handtekening: Datum: __ / __ / __

---

* Doorhalen wat niet van toepassing is.

De deelnemer ontvangt een volledige informatiebrief, samen met een kopie van het getekende toestemmingsformulier.

Appendix D: Patient instruction letter

Geachte heer/ mevrouw,

U neemt deel aan de studie 'CORE studie: de evaluatie van een online oogmeting voor staarpatiënten".
In het kader van deze studie willen wij u graag verzoeken de vragenlijsten in het patientenportaal in te vullen op een dag voor uw staaroperatie, een dag na uw staaroperatie, een maand na uw staaroperatie en 3 maanden na uw staaroperatie.

De vragenlijsten bestaat uit 3 delen en bevatten vragen die betrekking hebben op uw gezichtsvermogen, uw algemene gezondheid, het uitvoeren van de online oogmeting en het invullen van de resultaten. Het invullen duurt ongeveer 30 minuten.
We verzoeken u om de vragenlijsten in onderstaande volgorde uit te voeren:

1. Vragenlijst visueel functioneren
2. Gezondheidsvragenlijst online oogmeting
3. Online oogmeting

We verzoeken u vriendelijk om alle vragen te beantwoorden.

Kies bij elke vraag het antwoord dat het best uw situatie beschrijft.
Neem zo veel tijd als u nodig hebt om elke vraag te beantwoorden.
Probeer zo goed mogelijk antwoord te geven op de vragen.
Er zijn geen goede of foute antwoorden.
Beantwoord alstublieft elke vraag (tenzij u wordt gevraagd vragen over te slaan omdat ze op u niet van toepassing zijn).
Vul de vragenlijsten in zonder uw antwoorden met uw vrienden of familie te bespreken.

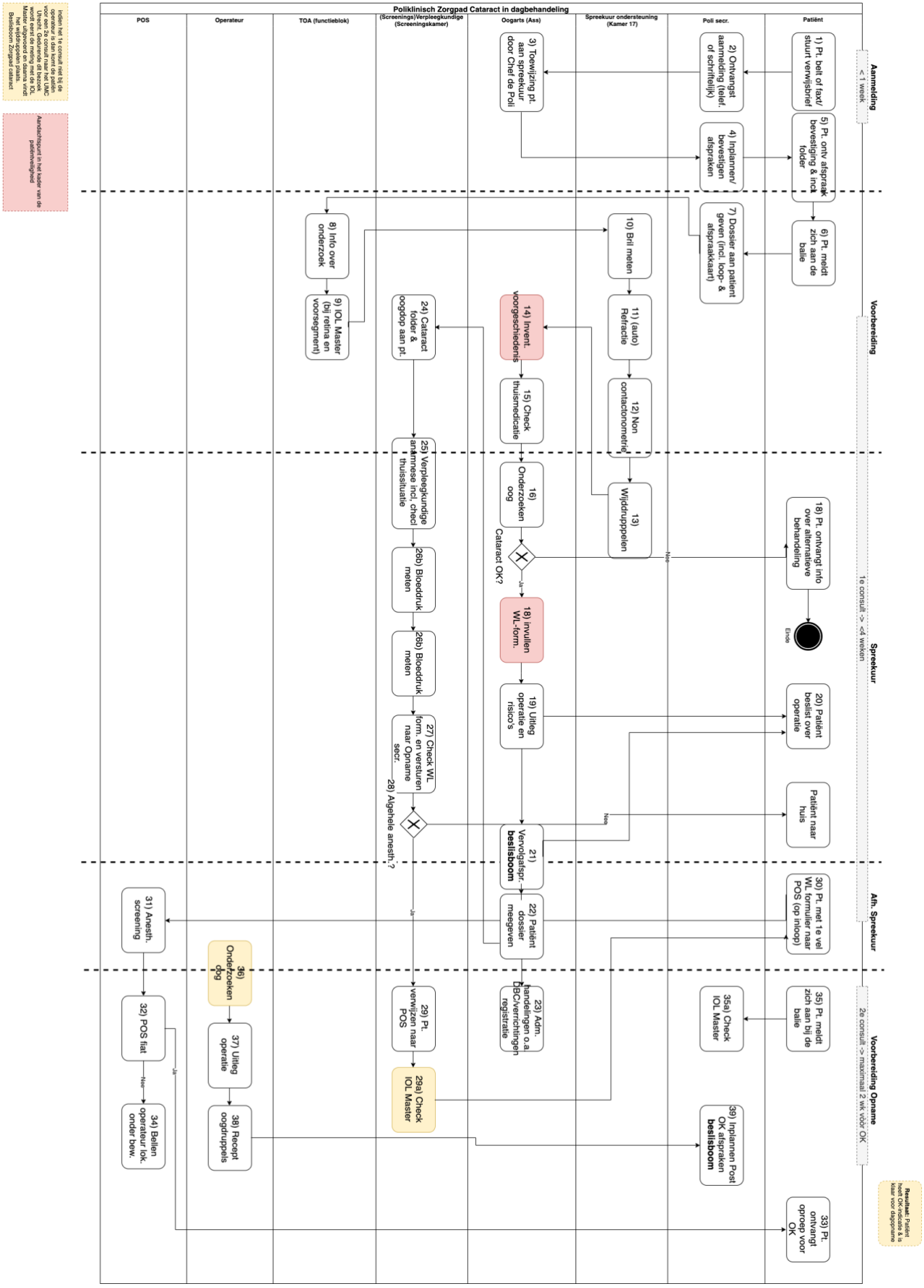
Indien u moeite heeft met het invullen van de onderstaande vragen dan kunt u ons gerust om hulp vragen.
U kunt dan bellen met dhr. M B Muijzer op 088-755 95 53 of mailen naar core@umcutrecht.nl

Bezoekadres
Heidelberglaan 100
3584 CX Utrecht

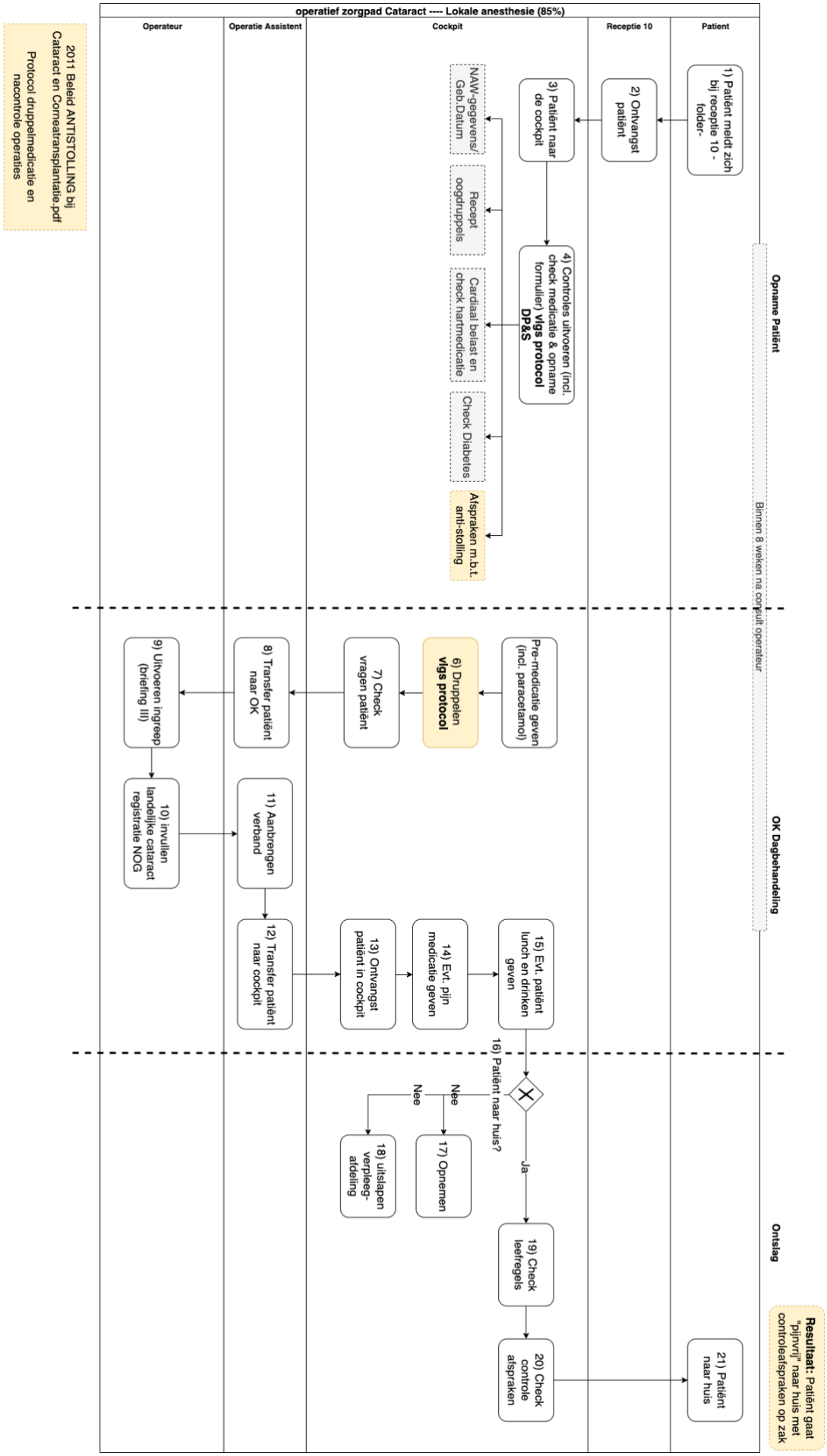
Postadres
Postbus 85500
3508 GA Utrecht

www.umcutrecht.nl
T. +31 (0)88 75 555 55

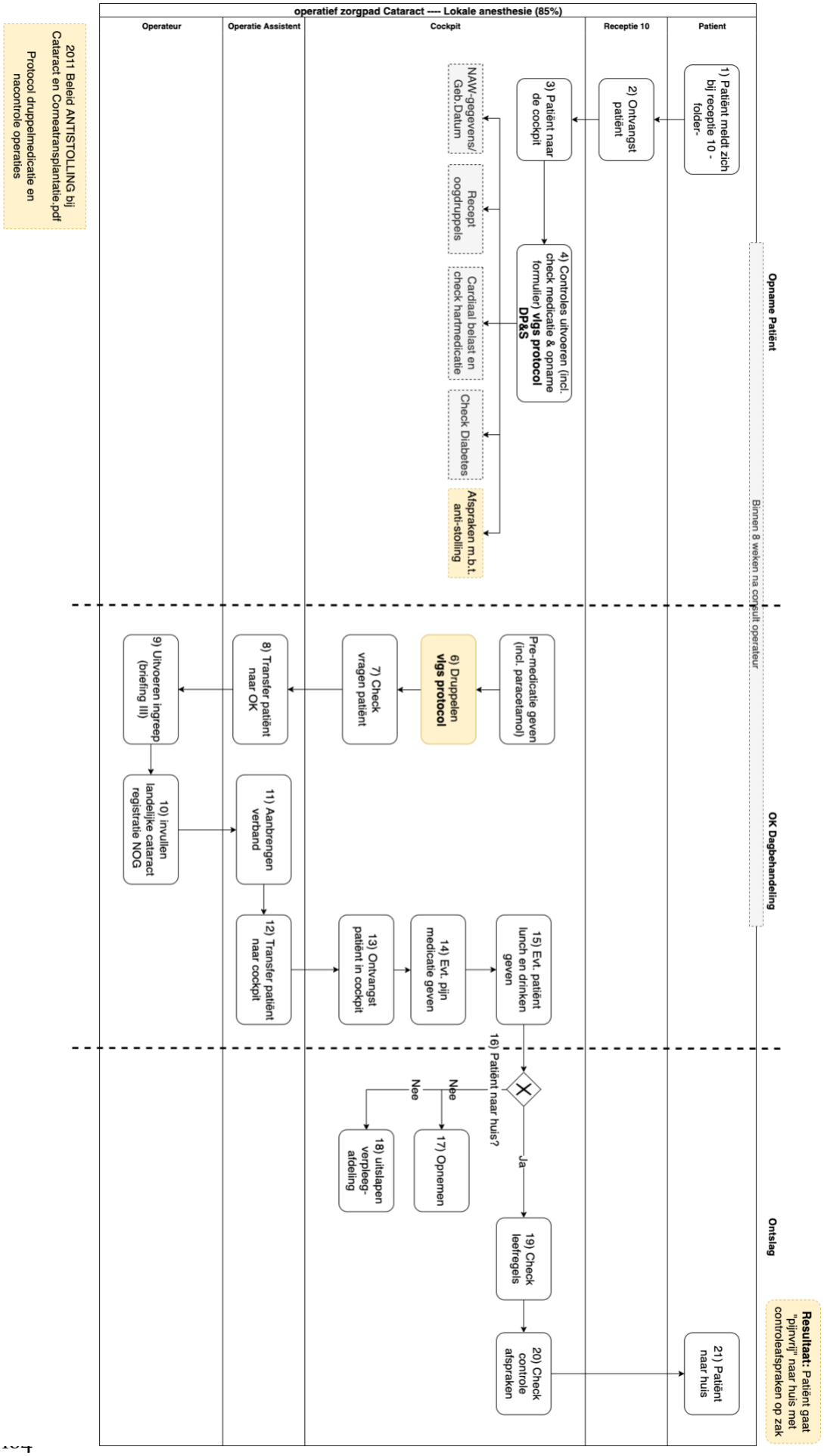
Appendix E: BPM current situation (Diagnosis)



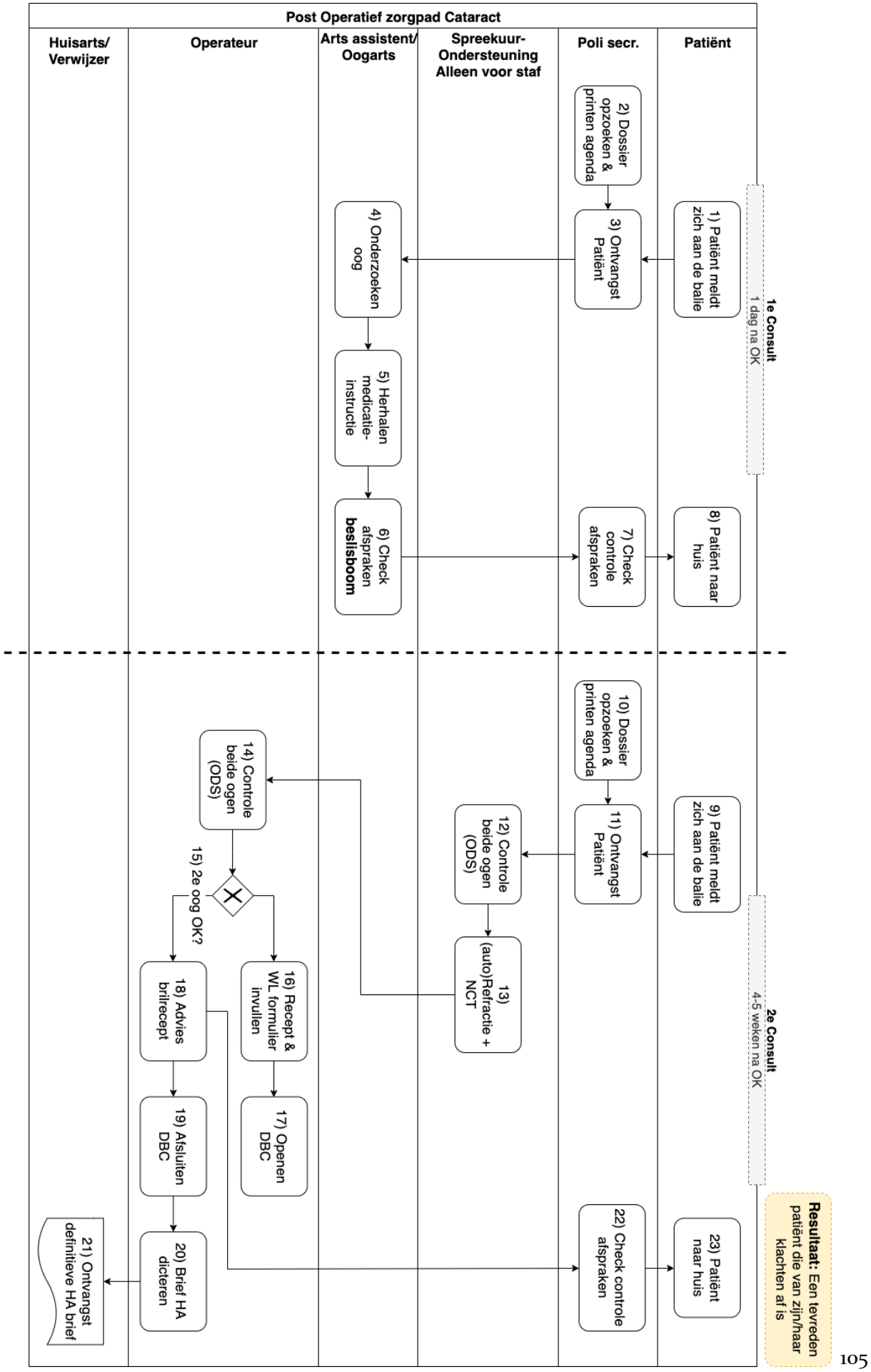
Appendix F: BPM current situation (Local Anesthesia)



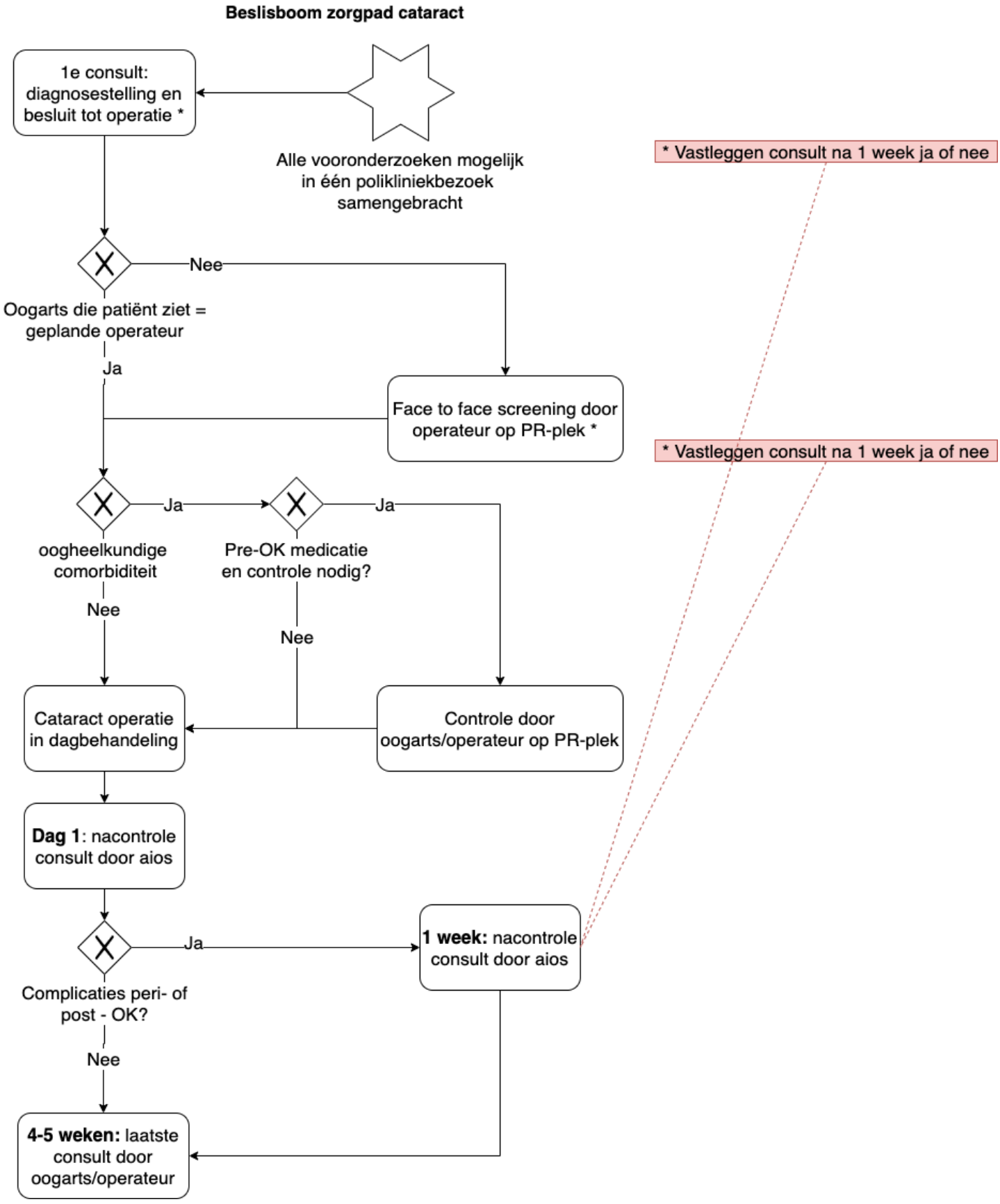
Appendix G: BPM current situation (Full Anesthesia)



Appendix H: BPM current situation (Post-op)



Appendix I: BPM Decision tree



Appendix J: PROM's questionnaire

Naam: Cataract PROMs

Auteur: Mats Lundström & Rotterdams oogheelkundig instituut (toestemming voor gebruik is verleend)

Locatie: Portaal

Opmerkingen:

- Deze vragenlijst wordt 4 keer uitgevraagd bij de patient. De data en score moet elke keer apart worden opgeslagen en moet identificeerbaar zijn aan welke van de 4 momenten dit is.
    - Voorbeeld registratie: 1.3.3 is vraag 3.3 van moment 1 en 4.3.3 is vraag 3.3 van moment 4.
- Per vraag de score registreren en de totaalscore registreren (optellen alle scores)

Introductie

Het doel van deze vragenlijst is vast te stellen welke moeilijkheden u in het dagelijks leven ondervindt als gevolg van uw verminderde gezichtsvermogen.

Om optimale zorg te kunnen ontwikkelen, verzoeken wij u de vragen in de vragenlijst zo eerlijk mogelijk te beantwoorden. De vragenlijst bevat vragen over de moeilijkheden die u ondervindt met bepaalde dagelijkse taken, als gevolg van uw verminderde gezichtsvermogen. Als u een bril voor veraf en/of dichtbij gebruikt, beantwoordt u de vragen alsof u deze draagt.

De vragen in deze vragenlijst (vragenlijst 1) hebben betrekking op uw situatie in de afgelopen 4 weken. Wij zullen u ongeveer 3 maanden na uw operatie vragen opnieuw een vragenlijst in te vullen (vragenlijst 2).

Bij het beantwoorden van de vragen op de volgende pagina moet u proberen alleen te denken aan de mogelijke moeilijkheden als gevolg van uw gezichtsvermogen. Wij begrijpen dat het moeilijk kan zijn te bepalen wat uw gezichtsvermogen voor u betekent als u ook nog andere problemen hebt, zoals gewrichtspijn of duizeligheid. Toch willen wij u vragen te antwoorden hoe belangrijk uw gezichtsvermogen volgens u is bij het uitvoeren van de volgende taken.

Wanneer u gevraagd wordt uw moeilijkheden te beschrijven, kunt u kiezen uit drie antwoorden, namelijk zeer grote moeilijkheden, grote moeilijkheden en enige moeilijkheden. Niet iedereen gebruikt dezelfde woorden om iets duidelijk te maken. Probeer de drie antwoordmogelijkheden te zien als drie gelijke delen van een schaal, die loopt van de grootste tot de minste moeilijkheden die u door uw gezichtsvermogen ondervindt bij het verrichten van verschillende activiteiten.

Hartelijk dank voor uw deelname.

1. Vindt u dat uw huidige gezichtsvermogen op een of andere manier moeilijkheden andere manier moeilijkheden veroorzaakt in uw dagelijks leven?

a. Ja, zeer grote moeilijkheden - Score: 4
b. Ja, grote moeilijkheden - Score: 3
c. Ja, enige moeilijkheden - Score: 2
d. Nee, geen moeilijkheden - Score: 1
e. Ik kan niet kiezen - Score: 0

2. Bent u tevreden of ontevreden over uw huidige gezichtsvermogen?

a. Zeer ontevreden - Score: 4
b. Tamelijk ontevreden - Score: 3
c. Tamelijk tevreden - Score: 2
d. Zeer tevreden - Score: 1
e. Ik kan niet kiezen - Score: 0

3. Hebt u moeite met de volgende activiteiten als gevolg van uw gezichtsvermogen? Zo ja, in welke mate? Zet in elke rij slechts één vinkje in het hokje dat volgens u het beste past bij uw situatie.

3.1 Krantenteksten lezen

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

3.2 Gezichten herkennen van mensen die u ontmoet

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

3.3 De prijzen van producten zien tijdens het winkelen

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

3.4 Zien waar u loopt op ongelijke ondergrond, bijvoorbeeld op straatkeien

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

3.5 Zien om te kunnen handwerken of houtbewerking etc.

a. Ja, zeer grote moeite - Score: 4

b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

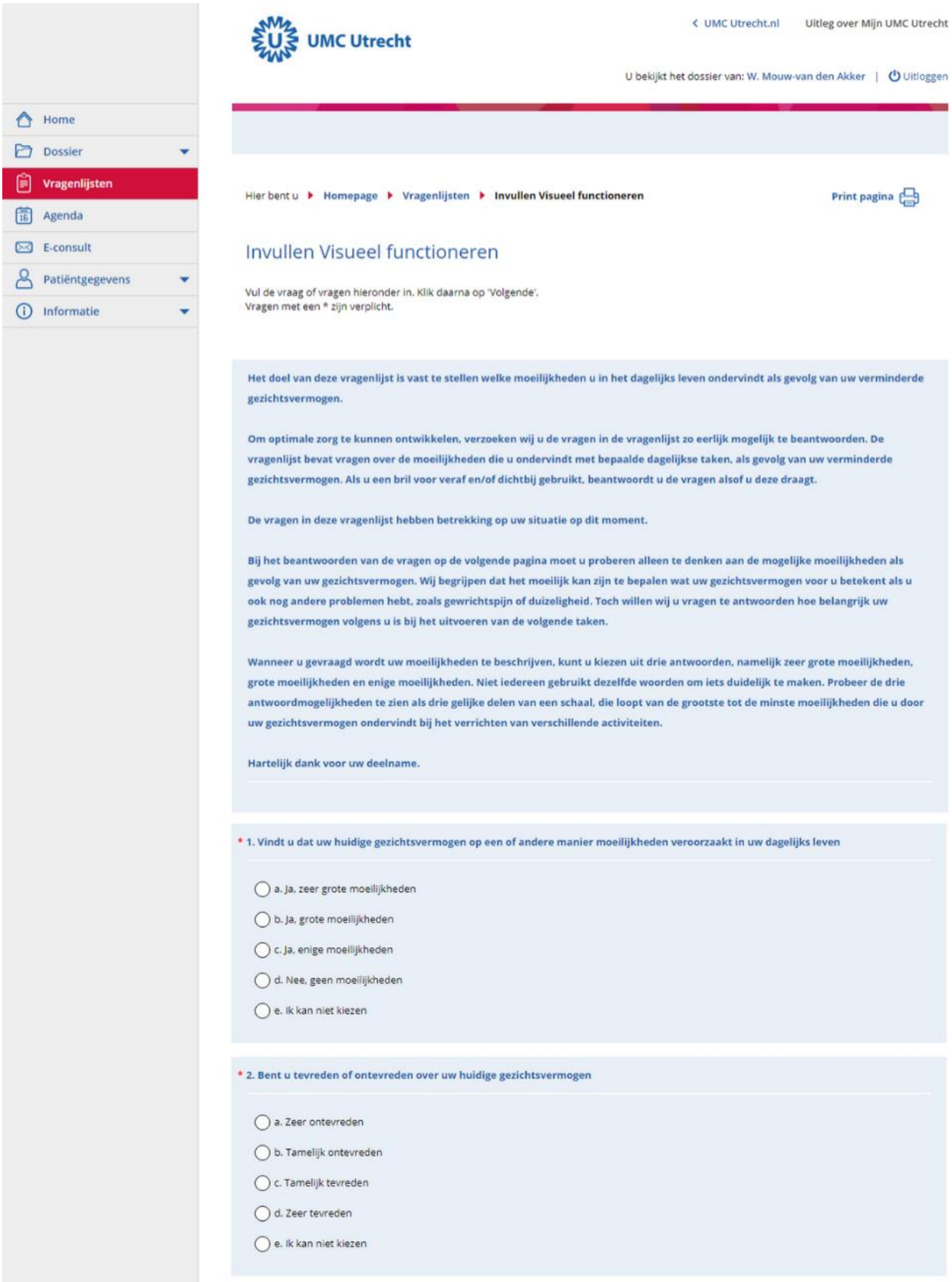
3.6 Ondertitels op TV lezen

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

3.7 Zien om te kunnen deelnemen aan een activiteit / hobby waar u zich voor interesseert

a. Ja, zeer grote moeite - Score: 4
b. Ja, grote moeite - Score: 3
c. Ja, enige moeite - Score: 2
d. Nee, geen moeite - Score: 1
e. Ik kan niet kiezen - Score: 0

Appendix K: PROM's questionnaire (portal)



3. Hebt u moeite met de volgende activiteiten als gevolg van uw gezichtsvermogen? Zo ja, in welke mate? Zet in elke rij slechts één vinkje in het hokje dat volgens u het beste past bij uw situatie.

*** 3.1 Krantenteksten lezen**

- ◯ a. Ja, zeer groote moeite
- ◯ b. Ja, grote moeite
- ◯ c. Ja, enige moeite
- ◯ d. Nee, geen moeite
- ◯ e. Ik kan niet kiezen

*** 3.2 Gezichten herkennen van mensen die u ontmoet**

- ◯ a. Ja, zeer groote moeite
- ◯ b. Ja, grote moeite
- ◯ c. Ja, enige moeite
- ◯ d. Nee, geen moeite
- ◯ e. Ik kan niet kiezen

*** 3.3 De prijzen van producten zien tijdens het winkelen**

- ◯ a. Ja, zeer groote moeite
- ◯ b. Ja, grote moeite
- ◯ c. Ja, enige moeite
- ◯ d. Nee, geen moeite
- ◯ e. Ik kan niet kiezen

* 3.4 Zien waar u loopt op ongelijke ondergrond, bijvoorbeeld op straatkeien

- a. Ja, zeer groote moeite
- b. Ja, grote moeite
- c. Ja, enige moeite
- d. Nee, geen moeite
- e. Ik kan niet kiezen

* 3.5 Zien om te kunnen handwerken of houtbewerking etc.

- a. Ja, zeer groote moeite
- b. Ja, grote moeite
- c. Ja, enige moeite
- d. Nee, geen moeite
- e. Ik kan niet kiezen

* 3.6 Ondertitels op TV lezen

- a. Ja, zeer groote moeite
- b. Ja, grote moeite
- c. Ja, enige moeite
- d. Nee, geen moeite
- e. Ik kan niet kiezen

* 3.7 Zien om te kunnen deelnemen aan een activiteit / hobby waar u zich voor interesseert

- a. Ja, zeer groote moeite
- b. Ja, grote moeite
- c. Ja, enige moeite
- d. Nee, geen moeite
- e. Ik kan niet kiezen

Appendix L: Triage questionnaire

Naam: Triage online oogmeting
Auteur: Robert Wisse
Locatie: Portaal

Beginscore:
A=0
B=0

Introductie
Deze vragenlijst is bedoeld om eventuele oogklachten te registreren en te beoordelen of u de online oogmeting kunt uitvoeren. De vragen uit deze vragenlijst zullen betrekking hebben op uw huidige situatie. Lees de vragen goed alvorens te antwoorden. Aan het einde van de vragenlijst zal worden aangegeven of u door kan gaan naar de online oogmeting.

10. Bent u al aan uw oog geopereerd?
   iii. Ja (Door naar vraag 2)
   iv. Nee (afbreken vragenlijst, score A=1)

11. Aan welk oog bent u geopereerd?
   iii. Links (Door naar vraag 3)
   iv. Rechts (Door naar vraag 3)

12. Heeft u het verband verwijderd?
   iii. Ja (Door naar vraag 4)
   iv. Nee (melding: Verwijder het verband en maak het oog voorzichtig schoon) (Door naar vraag 4)

13. Heeft u pijn gehad aan het oog?
   iii. Ja (geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10)
      i. >=8 (score B=1) (Door naar vraag 5)
      ii. <8 (Door naar vraag 5)
   iv. Nee (Door naar vraag 5)

14. Heeft u nu pijn aan het oog?
   iii. Ja (geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10)
      i. >=6 (Score B=1) (Door naar vraag 6)
      ii. <6 (Door naar vraag 6)
   iv. Nee (Door naar vraag 6)

15. Heeft u een zandkorrel gevoel in het oog?
   iii. Ja (Door naar vraag 7)
   iv. Nee (Door naar vraag 7)

16. Brandt het oog?
   iii. Ja (Door naar vraag 8)
   iv. Nee (Door naar vraag 8)

17. Jeukt het oog?
   iii. Ja (Door naar vraag 9)
   iv. Nee (Door naar vraag 9)

18. Heeft u een drukkend gevoel in uw oog?
   iii. Ja (Door naar vraag 10)
   iv. Nee (Door naar vraag 10)

10a. Dek uw <u>niet</u> geopereerde oog af. Kunt u uw vingers tellen met uw geopereerde oog?

i. Ja (door naar vraag 11)
ii. Nee (door naar vraag 10b)

10b. Dek uw <u>niet</u> geopereerde oog af. Kunt u handbewegingen zien met uw geopereerde oog?

i. Ja (afbreken vragenlijst en score A=2)
ii. Nee (door naar vraag 10c)

10c. Dek uw <u>niet</u> geopereerde oog af. Kunt u licht en donker zien met uw geopereerde oog?

i. Ja (afbreken vragenlijst en score A=2)
ii. Nee (afbreken vragenlijst en score A=2)

14. Is het oog gevoelig voor licht?

iii. Ja (Door naar vraag 12)
iv. Nee (Door naar vraag 12)

15. Ziet u bijzonderheden aan het geopereerde oog?

i. Ja, namelijk... (vrije tekst)
ii. Nee (Door naar vraag 13)

16. Heeft u andere klachten aan het geopereerde oog?

iii. Ja, namelijk... (vrije tekst)
iv. Nee

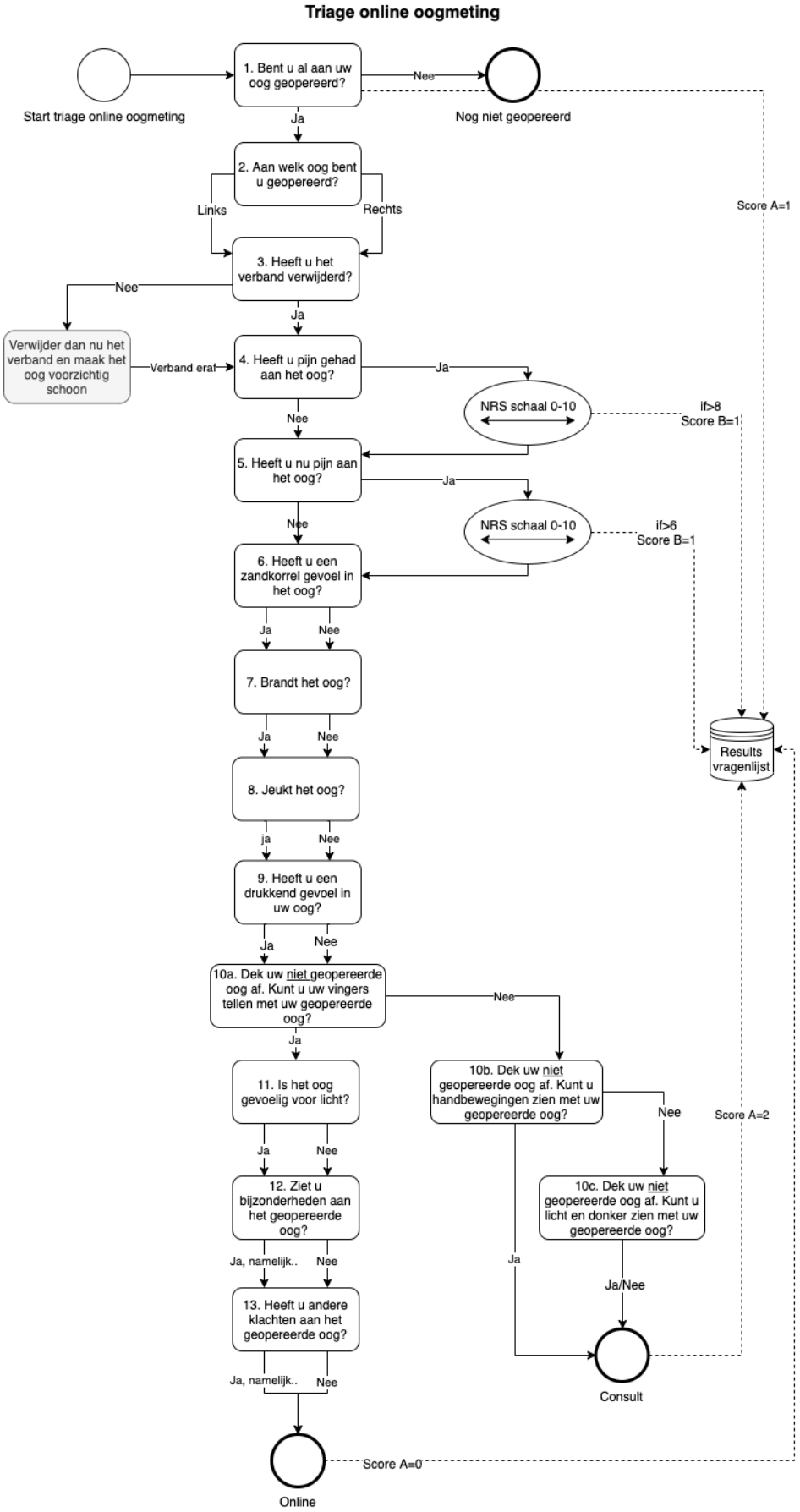
Samenvatting voor arts

De vraag met uitslag van de volgende vragen:
- 5, zo ja, pijnscore
- 6, alleen weergeven bij antwoord “ja”
- 7, alleen weergeven bij antwoord “ja”
- 8, alleen weergeven bij antwoord “ja”
- 9, alleen weergeven bij antwoord “ja”
- 10a (zo nee, ook uitslag b & c)
- 11, alleen weergeven bij antwoord “ja”
- 12, alleen weergeven bij antwoord “ja, namelijk...”
- 13, alleen weergeven bij antwoord “ja, namelijk...”
- scoreuitslag (alleen bij uitslag 3,4 of 5)

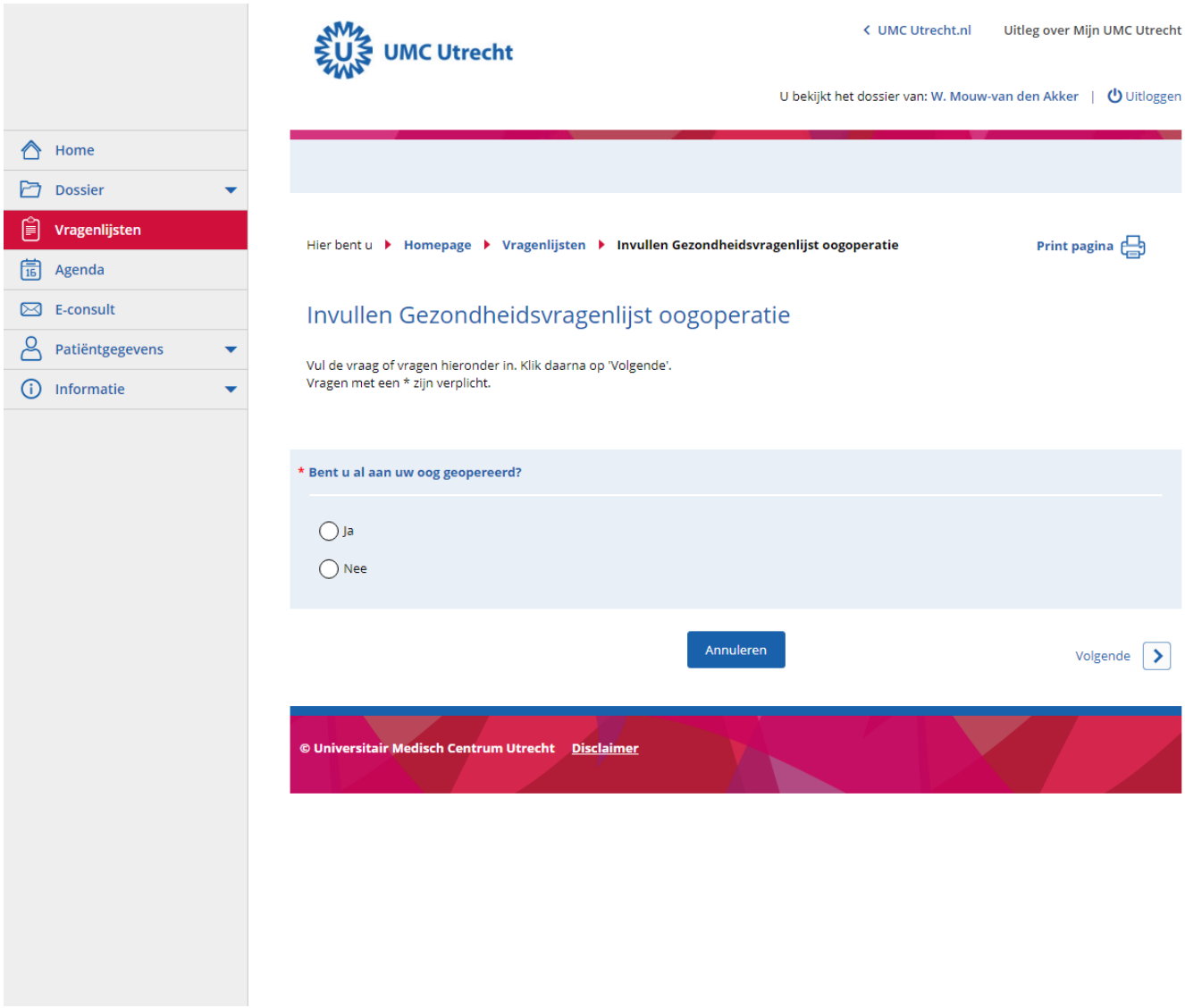
Scoreuitslag

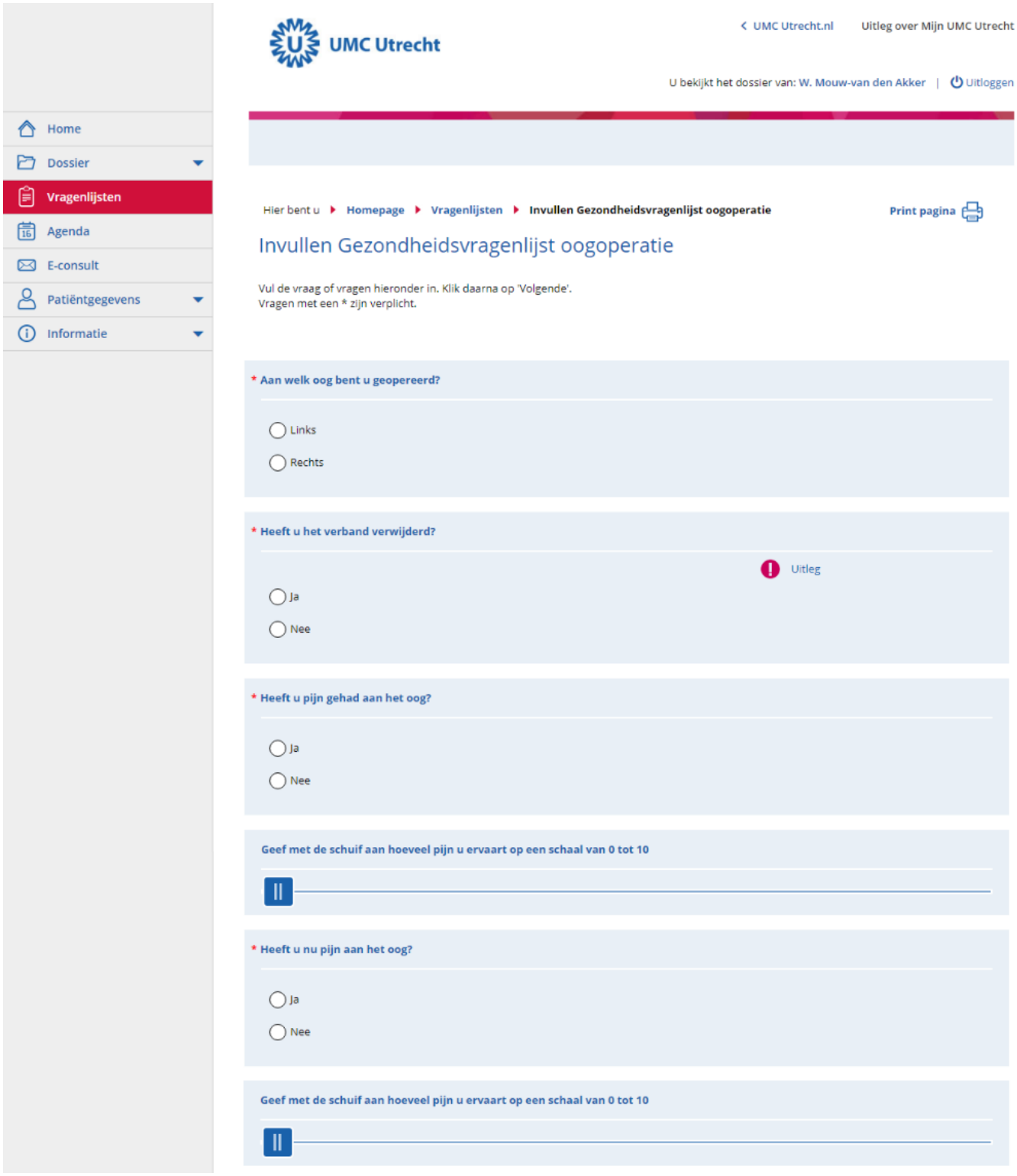
1. Score A=0 & B=0: Geschikt voor online test
2. Score A=1 & B=0: Nog niet geopereerd en geschikt voor online test
3. Score A=2 & B=0: Patient ziet niet voldoende voor online oogmeting
4. Score A=0 &B=1: Patient mag door met online test maar advies voor een consult vanwege pijn.
5. Score A=2 & B=1: Patient ziet niet voldoende voor online oogmeting en heeft pijn (gehad). Advies is een consult

Appendix M: Triage questionnaire model



Appendix N: Triage Questionnaire (portal)




UMC Utrecht
UMC Utrecht.nl
Uitleg over Mijn UMC Utrecht
U bekijkt het dossier van: W. Mouw-van den Akker | Uitloggen
Home
Dossier
Vragenlijsten
Agenda
E-consult
Patiëntgegevens
Informatie
Hier bent u Homepage Vragenlijsten Invullen Gezondheidsvragenlijst oogoperatie
Print pagina
Invullen Gezondheidsvragenlijst oogoperatie
Vul de vraag of vragen hieronder in. Klik daarna op 'Volgende'.
Vragen met een * zijn verplicht.
* Aan welk oog bent u geopereerd?
Links
Rechts
* Heeft u het verband verwijderd?
Uitleg
Ja
Nee
* Heeft u pijn gehad aan het oog?
Ja
Nee
Geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10
* Heeft u nu pijn aan het oog?
Ja
Nee
Geef met de schuif aan hoeveel pijn u ervaart op een schaal van 0 tot 10

* Heeft u een zandkorrel gevoel in het oog?

- ◯ Ja
- ◯ Nee

* Brandt het oog?

- ◯ Ja
- ◯ Nee

* Jeukt het oog?

- ◯ Ja
- ◯ Nee

* Heeft u een drukkend gevoel in uw oog?

- ◯ Ja
- ◯ Nee

* Dek uw niet geopereerde oog af. Kunt u uw vingers tellen met uw geopereerde oog?

- ◯ Ja
- ◯ Nee

Invullen Gezondheidsvragenlijst oogoperatie

Vul de vraag of vragen hieronder in. Klik daarna op 'Volgende'.
Vragen met een * zijn verplicht.

* Dek uw niet geopereerde oog af. Kunt u handbewegingen zien met uw geopereerde oog?

- ◯ Ja
- ◯ Nee

Vorige | Annuleren | Volgende

Invullen Gezondheidsvragenlijst oogoperatie

Vul de vraag of vragen hieronder in. Klik daarna op 'Volgende'.
Vragen met een * zijn verplicht.

*** Dek uw niet geopereerde oog af. Kunt u licht en donker zien met uw geopereerde oog?**

- ◯ Ja
- ◯ Nee

Vorige | Annuleren | Volgende

Invullen Gezondheidsvragenlijst oogoperatie

Vul de vraag of vragen hieronder in. Klik daarna op 'Volgende'.
Vragen met een * zijn verplicht.

*** Is het oog gevoelig voor licht?**

- ◯ Ja
- ◯ Nee

*** Ziet u bijzonderheden aan het geopereerde oog?**

- ◯ Ja
- ◯ Nee

Ja, namelijk

*** Heeft u andere klachten aan het geopereerde oog?**

- ◯ Ja
- ◯ Nee

Ja, namelijk

Vorige | Annuleren | Volgende

Appendix O: Results form

Naam vragenlijst voor arts: Resultaten online oogmeting
Naam vragenlijst patiënt (portaal): Online oogmeting
Auteur: Thomas Imhof
Locatie: Portaal

Introductie:
U gaat beginnen met de online oogmeting. Door op onderstaande link te klikken wordt u doorverwezen naar de website waar u de oogmeting kunt uitvoeren. Volg alle aanwijzingen goed op. Keer terug naar deze vragenlijst zodra u de meting heeft afgerond en vul de resultaten in op de volgende pagina door op volgende te klikken.

Ga naar de online oogmeting: https://www.easee.online/nl/umcu_core

Introductie volgende pagina:
Dit formulier kunt u gebruiken om de resultaten van de online oogmeting in te geven. De resultaten van de online oogmeting kunt u vinden op de resultatenpagina nadat u de test hebt afgerond. Ga bij elke vraag goed na of u het resultaat uit de online oogmeting goed hebt ingevuld.

Vraag 1: Welk oog heeft u gemeten? (dropdown of radio-button)
a. “Links” (label = OS)
b. “Rechts” (label = OD)

Vraag 2: Hoe heeft u de online oogmeting uitgevoerd?
a. “Met eigen bril” (Label = met eigen correctie)
b. “Zonder bril” (Label = zonder correctie)

Vraag 3: Visus
a. Open tekstveld (decimal 2.000=>x>0.001)

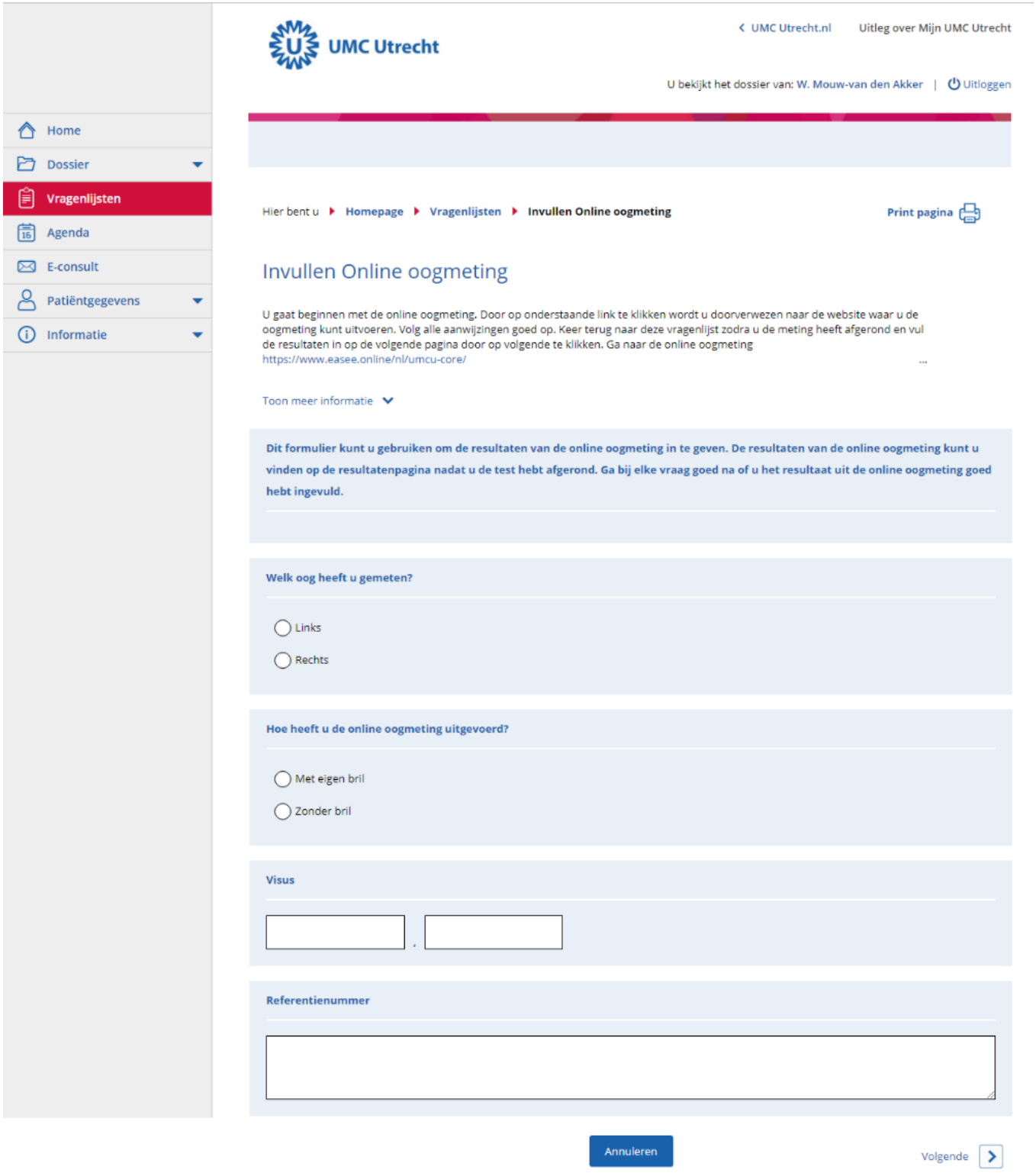
Vraag 4: Referentienummer
a. Open tekstveld (Alphanumeric)

Samenvatting voor de arts:
Uitslag online oogmeting: “Visus + “Label vraag 1” + “label vraag 2” “: ” + “(visuswaarde open tekstveld vraag 3)””

Voorbeeld:
Vraag 1: a. Links
Vraag 2: b. Zonder bril
Vraag 3: 0.6
Vraag 4: 379378

Samenvatting voor arts:
Uitslag online oogmeting: “Visus OS (zonder correctie): 0.6

Appendix P: Results form (portal)



Appendix Q: Requirements document

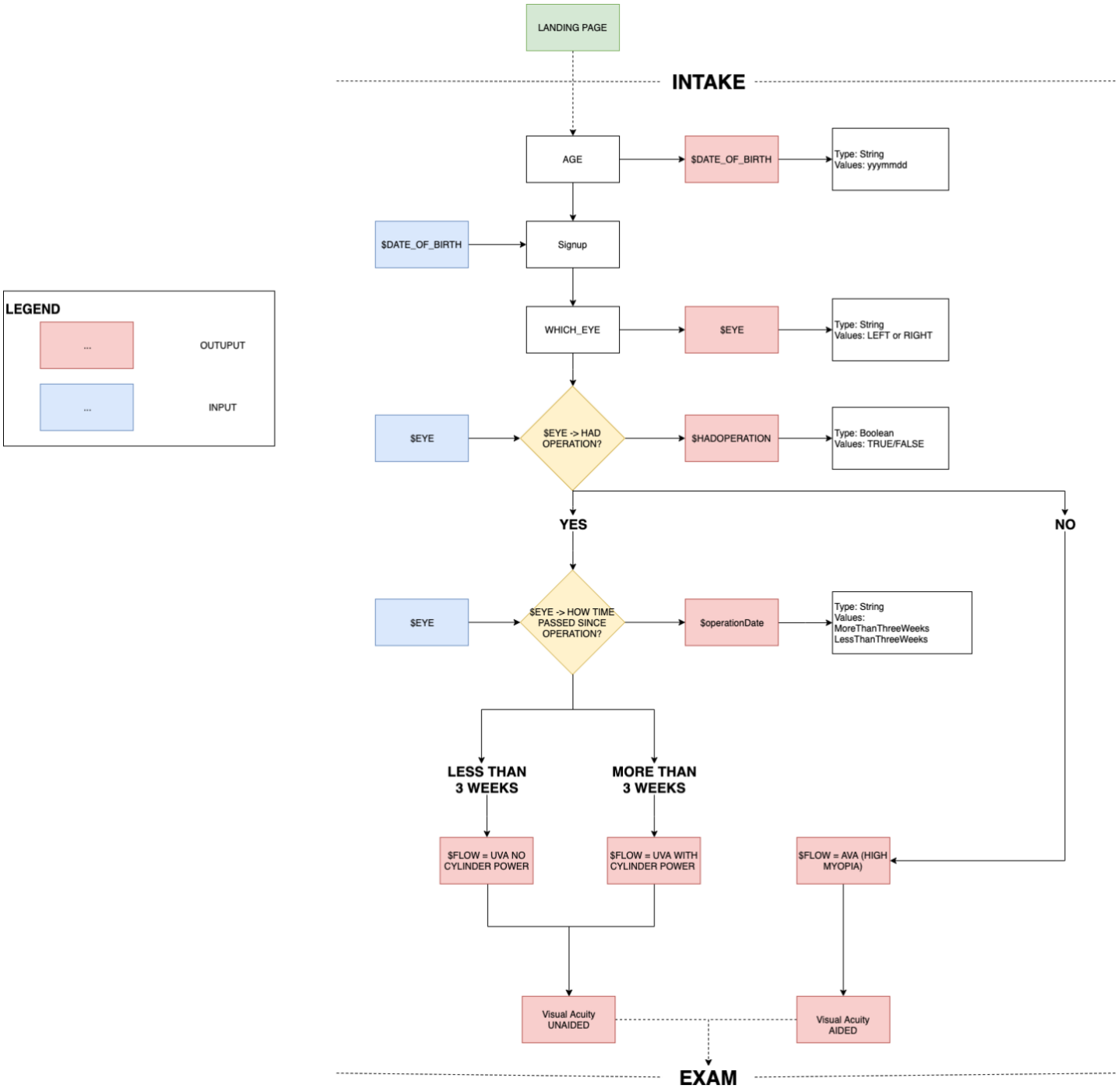
1	Issue	Scope	Priority	EDT (hours)	Required for testing	Comments
2	Need in house testing:Test with a 60+	UX	HIGH	?	TRUE	
3	Try the test with sph/cyl and scotch tape to reproduce cataract vision	UX	LOW	?	FALSE	
4	Uva all the time	UX	LOW	?	FALSE	
5	The exam is now meant for post operation visual acuity assessment	UX	MEDIUM	?	FALSE	The post-op test should be without any correction to the eye,
	We are investigating whether pre-operation testing needs to be implemented					the regular glasses of the patient will almost always need replacement
						because the lens changed and therefore the cylinder often changes as well.
6	Check if we can remove the age from the calculation	UX	LOW	?	FALSE	
7	The patients may be using scaling tools to magnify the elements on the screen, this will affect the test results	UX	HIGH	10.00	TRUE	The EDT is so long because this issue requires resarching magnifiyng tools
8	Change the bank card to generic card pass/id on the preprocess explanation and the card calibration	UX	HIGH	1.00	FALSE	
9	Shoe size - they will need a helper	Feature	HIGH	?	TRUE	Undefined EDT as we don't have a solution
10						
11	Create a landing page for the test	Feature	HIGH	10.00	TRUE	The EDT is long because we probably need a design session or someone has to come up with the design
12	Account:	Feature	HIGH	4.00	TRUE	
	Don't optimize account use Laravel signup					
	We should move the account page to the beginning or to the landing page					
13	If the test is done by umcu patients, then the health questionnaire should be skipped	Feature	MEDIUM	0.50		

14	Simplify the brightness setting component - we are using too many names to specify the device (laptop, desktop,m computer, tablet)	Feature	MEDIUM	0.50	TRUE	
15	Calibrate screen v2.0	Feature	HIGH	0.50	TRUE	The component already exits, we need to update the flow and release it
16	Instruct to get help if cannot see phone	Feature	MEDIUM	?	FALSE	
17	Font size selector	Feature	MEDIUM	?	FALSE	
18	We need a component to instruct the patient to remove the eyewear	Feature	MEDIUM	0.50	FALSE	Not required if the rest of the instructions are updated
19	Arrange tri and hex on a diamond grid	Feature	LOW	8.00	FALSE	
20	Same arm component - it may be painful to do the test with always the same arm risen up	Feature	MEDIUM	0.50	FALSE	
21	Take a break component / add a sit/ rest component	Feature	MEDIUM	0.50	FALSE	
22	Use the split screen duochrome	Feature	HIGH	0.50	TRUE	
23	Update the Cataract Health Questions	Feature	HIGH	0.50	TRUE	EDT assuming we already have the questions
24	remove fine angle astigmatism	Feature	HIGH	0.50	TRUE	
25	fix result page, save #id, send email, need screenshot of form form Thomas	Feature	HIGH	1.50	TRUE	
26						
27	Simplify the card calibration component - instructions are too long - the component is hard to use is the hands are shaking	UX-Instructions	MEDIUM	0.50	TRUE	Would be nice if all the instructions were clear for testing
28	Ask if the patient is supervised during the examination	UX-Instructions	HIGH	0.50	FALSE	
29	If users are assisted we can show advanced instructions	UX-Instructions	LOW	?	FALSE	
30	The font size is too small for the elderlies to read (as they cannot accommodate)	UX-Instructions	HIGH	1.00	TRUE	

31	The eye selector component should ask which eye was operated	UX-Instructions	HIGH	0.50	TRUE	
32	Explicitly say that the patient should press next after selecting the eye	UX-Instructions	HIGH	0.50	TRUE	
33	In the instruction we should never use "je", they should use formal "u" instead - this is a big issue as all of our text/audio instructions need to change	UX-Instructions	MEDIUM	?	FALSE	
34	We can adjust the formality of the instructions based on age	UX-Instructions	LOW	?	FALSE	
35	Replay button, slower reading speed	UX-Instrusctions	MEDIUM	4.00	FALSE	Slowing the instructions will be very important, the replay button would be handy but it may take longer to implement
36	Simplify the brightness setting component - we are using too many names to specify the device (laptop, desktop,m computer, tablet)	UX-Instrusctions	MEDIUM	1.50	FALSE	
37	Clean up instruction - left eye tumbling E says "again"	UX-Instrusctions	HIGH	0.50	TRUE	
38	Text instructions should always be dark text on white background	UX-Instrusctions	HIGH	1.50	FALSE	
39	sit down to take the test	UX-Instrusctions	MEDIUM	?	FALSE	
40						
41	Change od/os to right/left on the result page	Improvements	HIGH	0.50	FALSE	
42	Visus should be in decimals	Improvements	HIGH	0.50	FALSE	
43	The 6 digit number should be marked as important	Improvements	HIGH	0.50	FALSE	
44	Send an email with the results	Improvements	MEDIUM	?	TRUE	Would be nice to have it for testing
45	Webcam should check which eye they are testing, and if they are using eyewear	Improvements	LOW	?	FALSE	
46	Need a repeat instruction button	Improvements	MEDIUM	?	FALSE	Unknown delivery time

47	Some myopic patients decide to remain myopic - we could add a Remote VA test at ~40cm (-2.5 D)	Improvements	LOW	?	FALSE	
48	the audio instructions should be played from the phone - patients with hearing impairments can use earphones	Improvements	MEDIUM	?	FALSE	Very imporntant important improvement, even though not quite necessary for testing purposes
49	Pause button	Improvements	MEDIUM	?	FALSE	Very imporntant important improvement, even though not quite necessary for testing purposes
50	Remove current prescription input	Feature	HIGH	0.5	TRUE	Removal of feature
51	Remove health assessment	Feature	HIGH	0.5	TRUE	Removal of feature
52	Only measure one eye	Feature	HIGH	5.0	TRUE	Removal of feature
53	Generate reference ID for results	Feature	HIGH	5.0	TRUE	
54	No need for validation by optometrist	Feature	HIGH	0.5	TRUE	Removal of feature
55	No user feedback on refractive error	UX	HIGH	1.0	TRUE	
56	Design an exit/results page without affiliates and advertisements	UX	MEDIUM	3.0	TRUE	
57	Remove payment	Feature	HIGH	0.5	TRUE	Removal of feature

Appendix R: Easee exam flow



Appendix S: Survey in English

Variable	Items used in survey	Author(s)
Behavioural Intention		
Bi1	Overall, I am highly willing to use the eHealth service	[28], [29]
Bi2	I intend to use the eHealth service to monitor my health.	[50]
Bi3	I'm curious about using the eHealth service to monitor my health.	[50]
Bi4	I find it would be good to use a eHealth service to monitor my health.	[50]
Bi5	I would like to try the eHealth service.	[44]
Performance Expectancy		
PE1	I would find the eHealth service useful	[20], [50], [47], [43], [45]
PE2	Using the eHealth service increases my productivity.	[20], [45]
PE3	Using eHealth service increases my effectiveness in monitoring my health.	[50]
PE4	Using eHealth service increases my performance in monitoring my health.	[50]
PE5	Using eHealth service increases the facility in monitoring my health.	[50]
PE6	The eHealth service enables me to live independently for longer	[42]
Effort Expectancy		
EE1	My interaction with the eHealth service would be/is clear and understandable.	[20], [50], [47], [43], [45]
EE2	It would be easy for me to become skillful at using the eHealth service	[20], [50], [47], [43], [45]
EE3	I would find the eHealth service easy to use/operate	[20], [50], [47], [43], [45]
EE4	Overall, I find that using the eHealth service would be convenient	[41]
EE5	Using the eHealth service does not require me much effort	[50],
EE6	Learning to operate the eHealth service is easy for me	[20], [50], [47], [43], [45], [41], [42]
Social Influence		
Si1	People who influence my behavior think that I should use the eHealth service.	[20], [50], [47], [41], [43], [45]
Si2	People who are important to me think/agree that I should use the eHealth service.	[20], [50], [47], [41], [43], [45]
Si3	People whose opinions that I value prefer that I use the eHealth service.	[50], [47], [43], [45]
Si4	People I trust believe that I should use the eHealth service.	[50],
Si5	People close to me would approve the use of the eHealth service	[44]
Facilitating Conditions		
FC1	I have the resources necessary to use the eHealth service.	[20], [50], [47], [43], [45]
FC2	I have the knowledge necessary to use the eHealth service.	[20], [50], [47], [43], [44], [45]
FC3	I believe specific persons (or a group) is available for assistance with system difficulties (a call center)	[20], [41],
FC4	I have no problems to use the eHealth service.	[50],
FC5	I believe specialized instructions concerning the use of the eHealth service will be available to me	[41],
Technology Anxiety		
TA1	I feel apprehensive about using the eHealth service.	[20]
TA2	I hesitate to use a computer for fear of making mistakes	[20], [41],
TA3	The eHealth service is somewhat intimidating to me.	[20],
TA4	Using the eHealth service make me worried.	[45]
TA5	Using the eHealth services may make me feel uncomfortable	[45]
Hedonic Motivation		
HM1	Using eHealth service applications is fun	[50], [43]
HM2	Using eHealth service applications is enjoyable.	[50], [43]
HM3	Using eHealth service applications is entertaining.	[50], [43]
HM4	Using eHealth service applications gives me pleasure.	[50],
HM5	Using eHealth service applications is exciting.	[50],
Self-efficacy	I could complete a job or task using the eHealth service …	

SE1	If there was no one around to tell me what to do as I go.	[20]
SE2	If I could call someone for help if I got stuck.	[20]
SE3	If I had a lot of time to complete the task.	[20]
Trust/reliability		
TR01	I can rely on the eHealth service	
TR02	I trust in the data protection and privacy	
TR03	I trust in the eHealth service provided by my trusted healthcare provider	[47]
TR04	I obtain accurate and error-free services from eHealth service providers.	[47]
Doctors opinion		
DOC01	I trust my doctor's judgment	[41]
DOC02	The doctors' expertise makes him/her more likely to be right	[41]
DOC03	The doctor has a lot of experience and usually knows best	[41]
DOC04	The doctor's knowledge usually makes him/her right	[41]
DOC05	I trust my doctor's judgment about the use of the eHealth service	[41]
DOC06	Doctors are intelligent	[41]

Appendix T: Survey in Dutch

Variable	Items used in survey
Behavioural Intention	
Bi1	Ik zou graag de eHealth dienst willen gebruiken
Bi2	Ik ben van plan de service te gebruiken voor het monitoren van mijn gezondheid
Bi3	Ik ben nieuwsgierig naar het gebruik van de eHealth dienst voor het monitoren van mijn gezondheid
Bi4	Ik denk dat het goed is om de eHealth dienst te gebruiken voor het monitoren van mijn gezondheid
Bi5	Ik zou graag de eHealth dienst willen proberen
Performance Expectancy	
PE1	Ik vind de eHealth dienst nuttig
PE2	Het gebruik van de eHealth dienst verhoogt mijn productiviteit
PE3	Het gebruik van de eHealth dienst verhoogt mijn effectiviteit in het monitoren van mijn gezondheid
PE4	Het gebruik van de eHealth dienst verhoogt mijn prestatie in het monitoren van mijn gezondheid
PE5	Het gebruik van de eHealth dienst vergroot de mogelijkheden voor het monitoren van mijn gezondheid
PE6	Het gebruik van de eHealth dienst stelt me in staat om langer onafhankelijk te leven/wonen
Effort Expectancy	
EE1	Mijn interacties met de eHealth dienst zijn duidelijk en begrijpelijk
EE2	Het is voor mij makkelijk om behendig te worden met het gebruik van de eHealth dienst
EE3	Ik vind de eHealth dienst makkelijk in gebruik
EE4	Ik vind het gebruik van de eHealth dienst handig
EE5	Het gebruik van de eHealth dienst kost me niet veel inspanning en moeite
EE6	Leren om te gaan met de eHealth dienst is makkelijk voor me
Social Influence	
Si1	Mensen die mijn gedrag kunnen beinvloeden denken dat ik de eHealth dienst moet gebruiken
Si2	Mensen die belangrijk voor me zijn denken dat ik de eHealth dienstmoet gebruiken
Si3	Mensen wier mening ik waardeer, vinden dat ik de eHealth dienst moet gebruiken
Si4	Mensen die ik vertrouw geloven dat ik de eHealth dienst moet gebruiken
Si5	Mensen dicht bij mij zouden het goedkeuren als ik de eHealth dienst gebruik
Facilitating Conditions	
FC1	Ik heb de benodigde middelen voor het gebruik van de eHealth dienst
FC2	Ik heb de benodigde kennis voor het gebruik van de eHealth dienst
FC3	Ik geloof dat er een bepaalde persoon of groep beschikbaar is voor assistentie voor moeilijkheden die ik ondervindt tijdens gebruik van de eHealth dienst
FC4	Ik heb geen problemen met het gebruik van de eHealth dienst
FC5	Ik geloof dat er speciale instructies beschikbaar zijn voor het gebruik van de eHealth dienst
Technology Anxiety	
TA1	I feel apprehensive about using the system.
TA2	Ik twijfel met het gebruik van een computer vanwege de angst om fouten te maken
TA3	Ik vind de eHealth dienst intimiderend
TA4	Het gebruik van de eHealth dienst maakt me bezorgt
TA5	Het gebruik van de eHealth dienst voelt voor mij ongemakkelijk
Hedonic Motivation	
HM1	Het gebruik van de eHealth dienst is leuk
HM2	Het gebruik van de eHealth dienst is prettig/aangenaam
HM3	Het gebruik van de eHealth dienst is vermakelijk
HM4	Het gebruik van de eHealth dienst geeft me genoegen
HM5	Het gebruik van de eHealth dienst is opwindend/spannend
Self efficacy	Ik zou de eHealth dienst kunnen gebruiken als…

SE1	Er niemand om mij heen aanwezig is die me zou vertellen wat ik moet doen
SE2	Ik iemand zou kunnen bellen als ik vast zou lopen
SE3	Ik veel tijd zou hebben om de taak uit te voeren
Trust/reliability	
TR01	Ik kan vertrouwen op de eHealth dienst
TR02	Ik vertrouw erop dat de eHealth dienst goed omgaat met mijn gegevens en privacy
TR03	Ik vertrouw op de eHealth dienst omdat hij aangeboden wordt door mijn vertrouwde zorgleverancier
TR04	ik verkrijg accurate en foutvrije diensten van mijn zorgleverancier
Doctors opinion	
DOC01	Ik vertrouw op het oordeel van mijn arts
DOC02	De ervaring van de arts maakt het waarschijnlijker dat hij gelijk heeft
DOC03	De arts heeft veel ervaring en weet het meestal het beste
DOC04	De kennis van de arts maakt dat hij meestal gelijk heeft
DOC05	Ik vertrouw mijn arts zijn/haar oordeel over de eHealth dienst
DOC06	Artsen zijn intelligent

Appendix U: Final Survey (Dutch)

Wat vragen wij van u?

De afdeling oogheelkunde van het UMC Utrecht onderzoekt de mogelijke toepassing, verwachtingen en acceptatie van digitale gezondheidsdiensten. In het bijzonder onderzoeken we het gebruik van een online oogmeting voor het vervangen van een nacontrole van een oogoperatie. Deze online meting is getest bij gezonde proefpersonen, maar nog niet bij patiënten met een oogziekte. Wij vragen u deze vragenlijst in te vullen in de gedachte dat de online oogmeting u aangeboden wordt als nacontrole van een oogoperatie.

Wat houdt de online oogmeting in?

De online oogmeting kan thuis worden uitgevoerd met behulp van uw computer en smartphone, hierbij mag u hulp gebruiken van familie, vrienden of zorgverleners.

- U kunt de oogmeting uitvoeren via het patiënten portaal van het UMC.
- Voor de oogmeting zijn een computer, smartphone en 3 meter ruimte benodigd.
- U kunt de oogmeting zo vaak uitvoeren als u wilt.
- De online oogmeting zou een nacontrole van een oogoperatie kunnen vervangen.
- De online oogmeting duurt ongeveer 25 minuten.
- Uw arts heeft direct toegang tot uw resultaten.
- De kwaliteit van de online test is bewezen in wetenschappelijk onderzoek. (https://www.jmir.org/preprint/14808)

De vragenlijst bestaat uit twee delen en duurt ongeveer 15 minuten. De vragen in het tweede deel staan in een willekeurige volgorde. Met de vragenlijst willen we meten wat u vindt van online oogmetingen. De verkregen gegevens worden gebruikt voor de evaluatie van ons zorgproces en geanonimiseerd verwerkt en opgeslagen.

Hartelijk bedankt voor uw medewerking.

Begin van de vragenlijst

1. **Wat is uw leeftijd?**

---

2. **Wat zijn de eerste 4 cijfers van uw postcode?**

---

3. **Wat is uw geslacht?**
   - Man
   - Vrouw

4. **Wat is uw hoogst behaalde opleiding?**
- Basisonderwijs
- Middelbaar onderwijs
- MBO
- HBO
- Universitair

5. **Heeft u een oogoperatie gehad?**
- Ja, korter dan 5 jaar geleden
- Ja, langer dan 5 jaar geleden
- Nee, nooit
- Nee, maar ik onderga binnenkort een oogoperatie

6. **Heeft u wel eens gebruik gemaakt van het patiënten portaal van het UMC Utrecht?**
- Ja
- Nee
- Nee, ik ben geen patiënt bij het UMC Utrecht

7. **Heeft u thuis wel eens gebruik gemaakt van een digitale gezondheidsdienst? (Bijvoorbeeld een hartslagmeter, smartwatch, glucosemeter, bloeddrukmeter)**
- Ja
- Nee

8. **Bent u in het bezit van een smartphone?**
- Ja
- Nee

9. **Bent u in het bezit van een computer of laptop?**
- Ja
- Nee

10. **Hoe vaak gebruikt u een smartphone?**
- Meerdere keren per dag
- één keer per dag
- Een paar keer per week
- Een paar keer per maand

11. **Hoe vaak gebruikt u een computer of laptop?**
- Meerdere keren per dag
- één keer per dag
- Een paar keer per week
- Een paar keer per maand

Deel 2 van de vragenlijst
Vul hieronder uw mening in over de onderstaande stellingen. Zet een kruisje (x) in het vakje die uw mening het beste omschrijft. De antwoordmogelijkheden staan hieronder:

1 = Helemaal oneens
2 = oneens
3 = neutraal
4 = eens
5 = helemaal mee eens

#	**Vraag**	**1**	**2**	**3**	**4**	**5**
1	Het gebruik van een online oogmeting voelt voor mij ongemakkelijk					
2	Mensen die ik vertrouw vinden dat ik een online oogmeting moet/zou moeten gebruiken					
3	Ik heb de benodigde middelen voor het gebruik van een online oogmeting (smartphone, computer & 3 meter ruimte)					
4	Artsen zijn intelligent					
5	Ik vertrouw erop dat de aanbieder goed omgaat met mijn gegevens en privacy					
6	Ik denk dat de online oogmeting goed presteert/zal presteren					
7	Ik denk dat het gebruik van de online oogmeting duidelijk en begrijpelijk is/zal zijn					
8	Ik denk dat het gebruik van een online oogmeting mijn productiviteit in het dagelijkse leven verhoogt/zal verhogen					
9	Ik vertrouw op de uitkomst van online oogmeting					
10	Ik denk dat leren om te gaan met een online oogmeting makkelijk voor me is					
11	Ik ben nieuwsgierig naar het gebruik van de online oogmeting voor het controleren van de gezondheid van mijn ogen					
12	De arts heeft veel ervaring en weet het meestal het beste					
13	Ik ben van plan de online oogmeting te gebruiken voor het controleren van de gezondheid van mijn ogen					
14	Ik zou graag de online oogmeting willen gebruiken voor het controleren van de gezondheid van mijn ogen.					
15	De kennis van de arts maakt dat hij/zij meestal gelijk heeft					

1 = Helemaal oneens 2 = oneens 3 = neutraal 4 = eens 5 = helemaal mee eens

#	**Vraag**	**1**	**2**	**3**	**4**	**5**
16	Ik denk dat het gebruik van een online oogmeting prettig/aangenaam is					
17	Ik denk dat het gebruik van een online oogmeting vermakelijk is					
18	Mensen in mijn omgeving zouden het accepteren als ik een online oogmeting gebruik					
19	Ik vertrouw op het oordeel van mijn arts					
20	Ik vind een online oogmeting intimiderend					
21	Mensen van wie ik zijn/haar mening waardeer, vinden dat ik een online oogmeting moet gebruiken					
22	Ik denk dat een online oogmeting nuttig is					
23	Ik denk dat het gebruik van een online oogmeting handig is					
24	Ik denk dat het gebruik van een online oogmeting effectief is					
25	Mensen in mijn omgeving zouden het gebruik van een online oogmeting aanmoedigen.					
26	Ik denk dat het gebruik van een online oogmeting me in staat stelt om langer zelfstandig te leven/wonen					
27	Ik denk dat het gebruik van een online oogmeting de mogelijkheden verbreed voor het controleren van de gezondheid van mijn ogen.					
28	Mijn vertrouwen in de online oogmeting wordt vergroot doordat hij wordt aangeboden door mijn ziekenhuis.					
29	Het gebruik van een online oogmeting maakt me bezorgd					
30	Ik denk dat een online oogmeting makkelijk in gebruik is					
31	Ik zou een online oogmeting kunnen gebruiken als er niemand om mij heen aanwezig is die me zou vertellen wat ik moet doen					
32	Ik denk dat het gebruik van een online oogmeting me weinig inspanning en moeite kost					
33	Ik vind het eng om een online oogmeting te gebruiken					
34	Ik denk dat er voldoende instructies te krijgen zijn voor het gebruik van de online oogmeting					
35	Mensen die mijn gedrag kunnen beïnvloeden denken dat ik een online oogmeting moet gebruiken					

1 = Helemaal oneens 2 = oneens 3 = neutraal 4 = eens 5 = helemaal mee eens

#	**Vraag**	**1**	**2**	**3**	**4**	**5**
36	Ik geloof dat er mensen beschikbaar zijn voor hulp met moeilijkheden die ik ondervind tijdens gebruik van een online oogmeting					
37	Mensen die belangrijk voor me zijn denken dat ik een online oogmeting moet/zou moeten gebruiken					
38	Ik heb vertrouwen in de zorg die mij wordt aangeboden					
39	Ik denk dat ik in staat ben om een online oogmeting te gebruiken.					
40	Ik denk dat het gebruik van een online oogmeting opwindend/spannend is					
41	Ik vertrouw mijn arts zijn/haar oordeel over de online oogmeting					
42	Ik zou graag de online oogmeting willen gebruiken					
43	Ik twijfel een computer te gebruiken vanwege de angst om fouten te maken					
44	Ik denk dat het goed is om de online oogmeting te gebruiken voor het controleren van de gezondheid van mijn ogen.					
45	Ik hecht waarde aan de ervaring van mijn arts					
46	Ik zou een online oogmeting kunnen gebruiken als ik iemand zou kunnen bellen als ik vast zou lopen					
47	Ik denk dat het gebruik van een online oogmeting leuk is					
48	Ik zou een online oogmeting kunnen gebruiken als ik veel tijd zou hebben om de online oogmeting uit te voeren					

Appendix V: Usability test report (patient-portal)

Date	October 9, 2019
Usability Test Date	October 3, 2019
Scope	UMCU patient portal cataract questionnaires in conjunction with Cataract Flow Easee
Employees or Associates Present	Thomas Imhof, Mason Morrow, Krisztina Kovari, Busra Sara
Patient portal	https://zorgpppoc-intern.umcutrecht.nl/
Patientnummer Wachtwoord	2215882 [redacted]
Q1	Visueel functioneren (Cataract PROMs)
Q2	Gezondheidsvragenlijst oogoperatie
Q3	Online oogmeting
Easee exam version	1.6.109
Exam type	Cataract

User Flow

This usability test was conducted to test the patient experience completing the easee online eye exam in the context of cataract surgery conducted through the University Medical Center Utrecht (UMCU). The outline of the patient journey is as follows:

1. Reading instruction letter
2. Logging in to the patient portal
3. Finding the questionnaires
4. Finishing the questionnaires according to the instruction letter
5. Begin the easee online eye exam for cataracts from a link provided by one of the questionnaires.
6. Complete easee exam & save the results.
7. Fill in the exam results into one of the questionnaires in the patient portal of the UMCU.

Exam Observations

Available Phases: **LOGIN**, **LANDING, Q1, Q2, Q3.**
Catastrophic: defined as a usability problem that compromises ability to give accurate results, excluding abnormal use of the product (YES / NO)

Catastrophic Outcomes

Below is the occurrence of catastrophic outcomes across the set of tests.

No	Catastrophic Event	Number (Out of 5)
1.1	Pressed “tussentijds opslaan” instead of continuing with the questionnaire	5
1.2	Stuck at URL clicking or copy/paste	5
1.3	Cannot find questionnaires	4
1.4	Does not know which questionnaires to make	3
1.5	Decimal after comma is only 1 digit	2

Other Outcomes

No	Non-Catastrophic Event	Number (Out of 5)
2.1	Comment: No indication of end questionnaire	5
2.2	Scroll speed is very fast, misses questions	4
2.3	Does not read instructions carefully	4
2.4	Enters Q2 multiple times because only 1 question	3
2.5	Font-size too small or unreadable contrast	3
2.6	Clicks information icon instead of edit button	3
2.7	Comment: Questionnaires not in correct order	3
2.8	Comment: Only one question in questionnaire	3
2.9	Start filling out Q3 without actual results	2
2.10	Comment: ingewikkeld	2
2.11	Cannot find the first questionnaire	2
2.12	Comment Q1: Can be different depending on with or without glasses	1

Appendix W: Usability test report (easee.online)

Date	October 8, 2019
Usability Test Date	October 3, 2019
Scope	Cataract Flow in conjunction with UMCU patient portal questionnaires
Employees or Associates Present	Mason Morrow, Krisztina Kovari, Busra Saral, Thomas Imhof
Easee exam version	1.6.109
Exam type	Cataract

User Flow

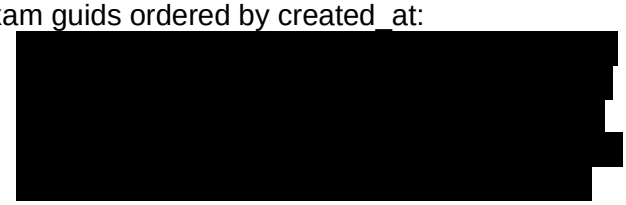
This usability test was conducted to test the patient experience completing the easee online eye exam in the context of cataract surgery conducted through the University Medical Center Utrecht (UMCU). The outline of the patient journey is as follows:

1. Complete multiple questionnaires in the patient portal available through the UMCU.
2. Begin the easee online eye exam for cataracts from a link provided by one of the questionnaires.
3. Complete the exam and save the results.
4. Fill in the exam results into one of the questionnaires in the patient portal of the UMCU.

Exam Observations

Available Phases: **LANDING, INTAKE, SETUP, EXAM, RESULTS**
Catastrophic: defined as a usability problem that compromises ability to give accurate results, excluding abnormal use of the product (YES / NO)

Exam guids ordered by created_at:



Can review by visiting https://easee.online/patients/exams/ <guid>

Exam 1

Subject: mid-80's man

Phase	Observation	Catastrophic
Landing	Cookies form covers half of screen, and obscures information about exam.	NO

Setup	Had to go find phone at Pre Exam Status	NO
Setup	Audio on shoe size says to remove your shoes, although it is not necessary until later	NO
Setup	Asked if taking off shoes was necessary	NO
Setup	Asked what object he should use	NO
Setup	Was physically challenged by walking heel to toe as shown in the animation (wobbling), while holding his phone and keeping his glasses in his mouth	NO
Exam	Used phone in landscape mode as remote	NO
Exam	Was reluctant to use “I don’t know” as response	NO
Exam	Astig Scale - attempted to use the feedback display as a slider, instead of the + / - buttons	NO
Exam	Astig Scale - seemed confused about the scaling function, probably because of the attempted manipulation of the feedback display instead of the buttons	NO
Exam	Use of chair enabled him to lay the phone in his lap, but required a lot of effort to look up / down for every input	NO

General Comments

Time spent on the forms and completing the exam: **28 minutes**
He performed the exam perfectly and encountered no catastrophic events. His background in IT perhaps influenced his enthusiasm or ability to follow detailed written instructions.
He didn’t ask for help even though this was offered on the landing page (might be because of our presence.)
He used his reading glasses for the desktop. It may have been challenging for him to see the mobile phone screen without his glasses.
He said getting an object was confusing.

Exam 2

Subject: mid-80's woman

Phase	Observation	Catastrophic
Landing / Intake	Struggled with the UMCU intake questionnaire, which biased her to think she was incapable.	NO
Setup	Had to go elsewhere to get what she needed	NO
Setup	Screen size warning show up, preventing continuing. It was before calibrate screen step.	YES
Setup	Needed help with Calibrate Screen, was not sure how to resize. Also, it requires a lot of hand / eye coordination.	NO
Setup	Calibrate Screen: the next button was not visible on the screen after calibration (probably because of the zooming). She had to scroll down to see it.	NO
Setup	Asked if she really had to take off her shoes?	NO
Setup	She was wobbly with heel to toe steps.	NO
Exam	Did not start exam wearing glasses, although she was asked	
Exam	She was asked to walk 1.5 meters closer but the chair is not mentioned, so she keeps standing.	NO
Exam	Had difficulty with Android / Samsung because of the positioning of the back button at the lower right of the phone itself. She would accidentally close the remote web page. The QR code would appear, but it was unclear what to do as there are no instructions, and she had used the SMS pairing mode.	YES
Exam	Thought she had to aim the phone to the laptop screen. Caused fatigue and also reduced ability to operate the phone properly	NO
Results	Got an error page	YES

General Comments

Time spent on the forms and completing the exam: **33 minutes**
She wanted to get at a distance from the laptop before starting to interact with the exam.
She didn't ask for help even though this should be an option as indicated on the landing page.
She struggled to input the answers on the phone with one hand on the eye.
Problem with "remote stuck on waiting".
Samsung device opens the link in a Samsung browser when pairing.

Exam 3

Subject: mid-70's woman

Phase	Observation	Catastrophic
Setup	Process Explanation: fetched an object, and placed it at 3 meters before continuing. Later affected the X steps forward.	YES
Setup	Webcam: she doesn't know if the webcam is enabled (this was done within the browser already, so no action was required on her behalf). In context, she was just asked to adjust the brightness / volume, but webcam doesn't have a feature to control it like brightness / volume.	NO
Setup	Take X Steps Forward: Instead of heel to toe steps she makes 3x1 meter long steps and then the heel to toe steps, so she's too far from the screen.	YES
Setup	Now you are at 3 meters: She stands behind the chair instead of sitting down.	NO
Exam	She looks at the hexagon with both eyes because she's not instructed clearly which eye to cover.	YES
Exam	Avoids using "I don't know" and tries very hard on very small optotypes	NO
Exam	First Part Done, may be confusing that the exam is over	NO

General Comments

Time spent on the forms and completing the exam: **35 minutes**
She wears reading glasses.
Used Fullscreen toggle mode successfully when she accidentally dragged browser window and it resized down

Exam 4

Subject: mid-70's man

Phase	Observation	Catastrophic
Setup	Walk to 3 meters: did not start from edge of table, but near	NO
Setup	Fullscreen: it seemed like because there was no audio, he skipped this step	NO
Setup	Chair, instead of placing chair at 3m, put chair sideways "in line" between himself and 3m, but the chair was blocking the computer screen and had to be moved by an associate	YES
Exam	Wanted to go back while using the remote, because wasn't sure about answers/directions, but could not find a way. Had to ask help about how to go back.	NO

Exam	Did not understand triangles remote layout ‘1, 2, 3, 4’ -> followed tumbling e remote ui	NO
Exam	Hexagons & Triangles, both eyes were open	YES

General Comments

Time spent on the forms and completing the exam: **20 minutes**
He wears reading glasses.
People tend to be embarrassed by having to take their shoes off (this may not be an issue when they do the exam alone).
Volume on the desktop was not loud enough even though put on max.

Exam 5

Subject: late 60’s man and woman

Phase	Observation	Catastrophic
Setup	Set Brightness: They spent some time but were not able to adjust brightness. They just clicked “Next”.	NO
Setup	Calibrate Screen: Clicking instead of dragging on the <> icon. Had difficulty for several minutes	NO
Setup	Click on shoe size before gender (Also occurred on at least one other exam)	NO
Setup	Pair SMS - tried only clicking on the flag, as the placeholder seemed it wasn’t able to fill in phone number	NO
Setup	Had difficulty with minimalist buttons on SMS pair (Send SMS). Was hesitant to press	NO
Setup	Next button often hidden below the fold, did not always scroll down immediately	NO
Setup	Take X Steps: didn’t start from edge of table, but near	NO
Setup	Chair: put chair “in line” with the computer, blocking the screen again	YES
Exam	Remote is stuck on waiting, and did not self-correct	YES

General Comments

Time spent on the forms and completing the exam: **?**
Patient wearing reading glasses (normally).
Helper should sit next to patient when doing the exam.
1234 buttons help with the partner
Mentioned volume was a bit low, but seemed better on the louder Google voice
Chair is a great idea, if properly implemented.

Overall Observations

1. The group tested all used the SMS pairing method (except for second person)
2. The Calibrate Screen was complicated, as it takes both arms, and a dragging motion, which was not clear. (Could be aided by an animation or slider appearance)
3. Chair was a good idea for those that understood where to place it, otherwise, the wording of the directions and illustration caused catastrophic outcomes.
4. Partnering seemed like a good idea, especially because it reduces effort for the person taking the exam. However, the landing page prompting to “get help” was not enough for those tested to seek out a partner.
5. The screen size warning was appearing even though the device was supported. This is because the warning was from media queries, instead of the card calibration component. The media queries are affected by the zoom setting of a browser, which is very likely to be set higher for those of an older age / those who experience difficulty seeing.
6. We should incorporate the print screen on the results page.
7. The “start test” button in the footer of the landing page goes to the regular exam
8. Cylinder test should only be done according to the cataract-flow-diagram
9. Instruction on the results page to go back to the portal and enter the results is missing.
10. URL is different from the one we have agreed on; https://www.easee.online/nl/umcu_core
11. Google voice should be slowed down, especially for long texts.

R&D Investigate

1. Ensure that everyone gets a results page, even if Poor Vision / Out of Acuity
2. Health questionnaire is not included
3. After surgery = should not ask for eyewear (need to remove if wearing)

Catastrophic Outcomes

Below is the occurrence of catastrophic outcomes across the set of tests.

Catastrophic Event	**Number (Out of 5)**
Screen size warning before calibrate screen, with no available corrective action	1
Phone unpairs and no instructions about re-pairing	1
No results - error page	1
Take X Steps / Process Explanation (Object & 3M problem)	1
Takes hexagon test with both eyes	3
Places chair in front of computer screen	2
Remote was stuck on waiting / loading, without quick self-correction	1

Other Outcomes

Non-Catastrophic Event	**Number (Out of 5)**
Does not start X steps from table, but near	4
Calibrate Screen Difficulty	3
Shoe size selection - select size before gender	4
Take shoes off at shoe size screen audio - “remove your shoes”, instead of just asking for size. Later repeats on remote.	4
Leave exam to find necessary items at Process Explanation	4
Heel-to-toe walking difficulty (balance challenge)	3
Confusion / error about what kind object to take	3
Astig scale feedback UI used as slider	3
Avoids using “I don’t know” button	3
Webcam was unintuitive in context of previous setup screens	3
Necessity to scroll was not always obvious	2
Cookies bar is very obstructive and not intuitive	2

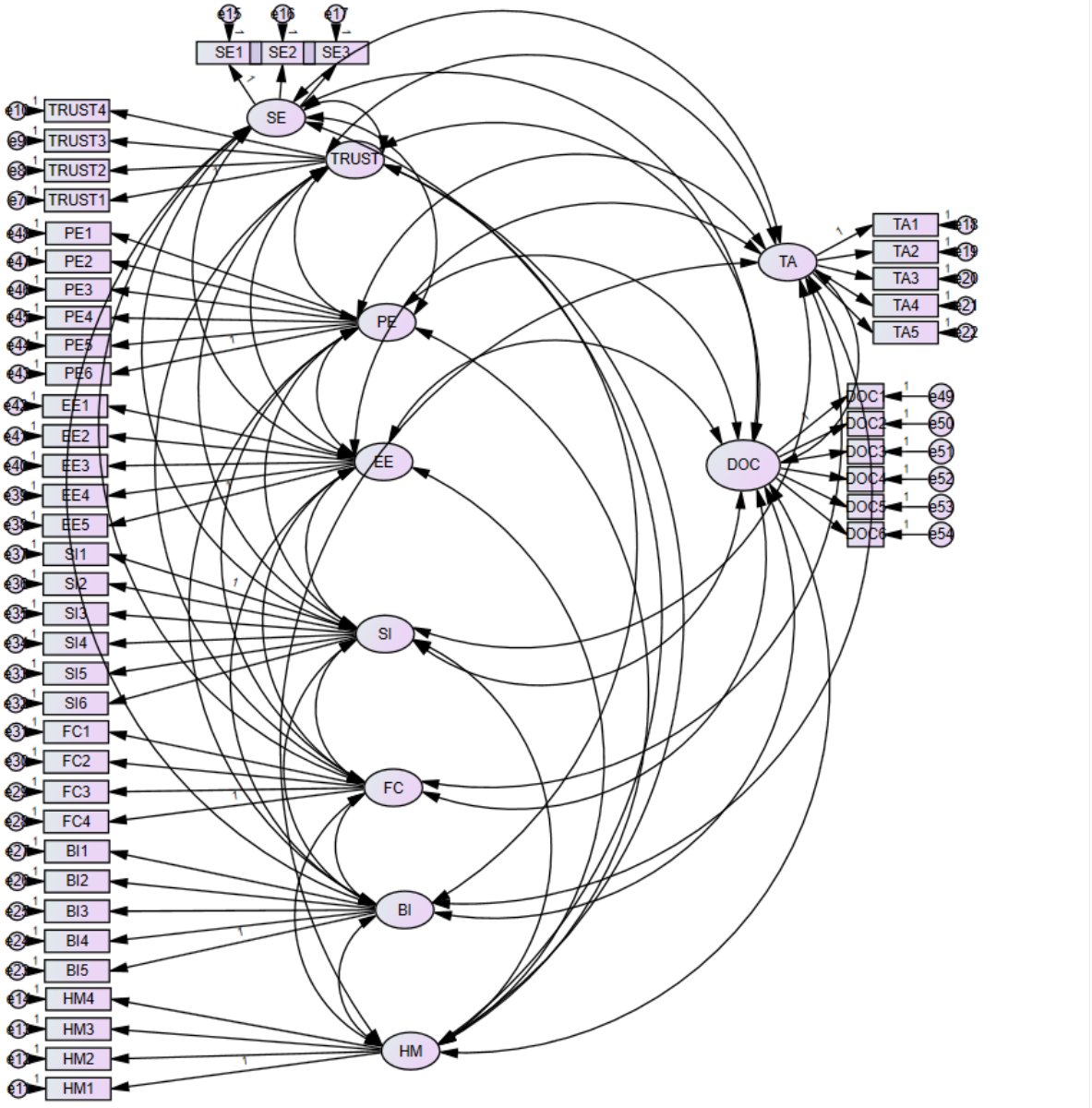
Action Points

1. Critically review instructions, taking into account eyewear, cover eye, which eye, audio and text.
2. Include illustration (including computer, phone, chair, footsteps etc) for setup to 3 meters
3. Improve word press page with setup instructions, split screen for “helper” or “no helper”
4. Include fullscreen audio
5. Review cataract exam flow diagram
6. The cylinder power test is only tested if patient had surgery more than 3 weeks ago
7. Exit page, improve usability

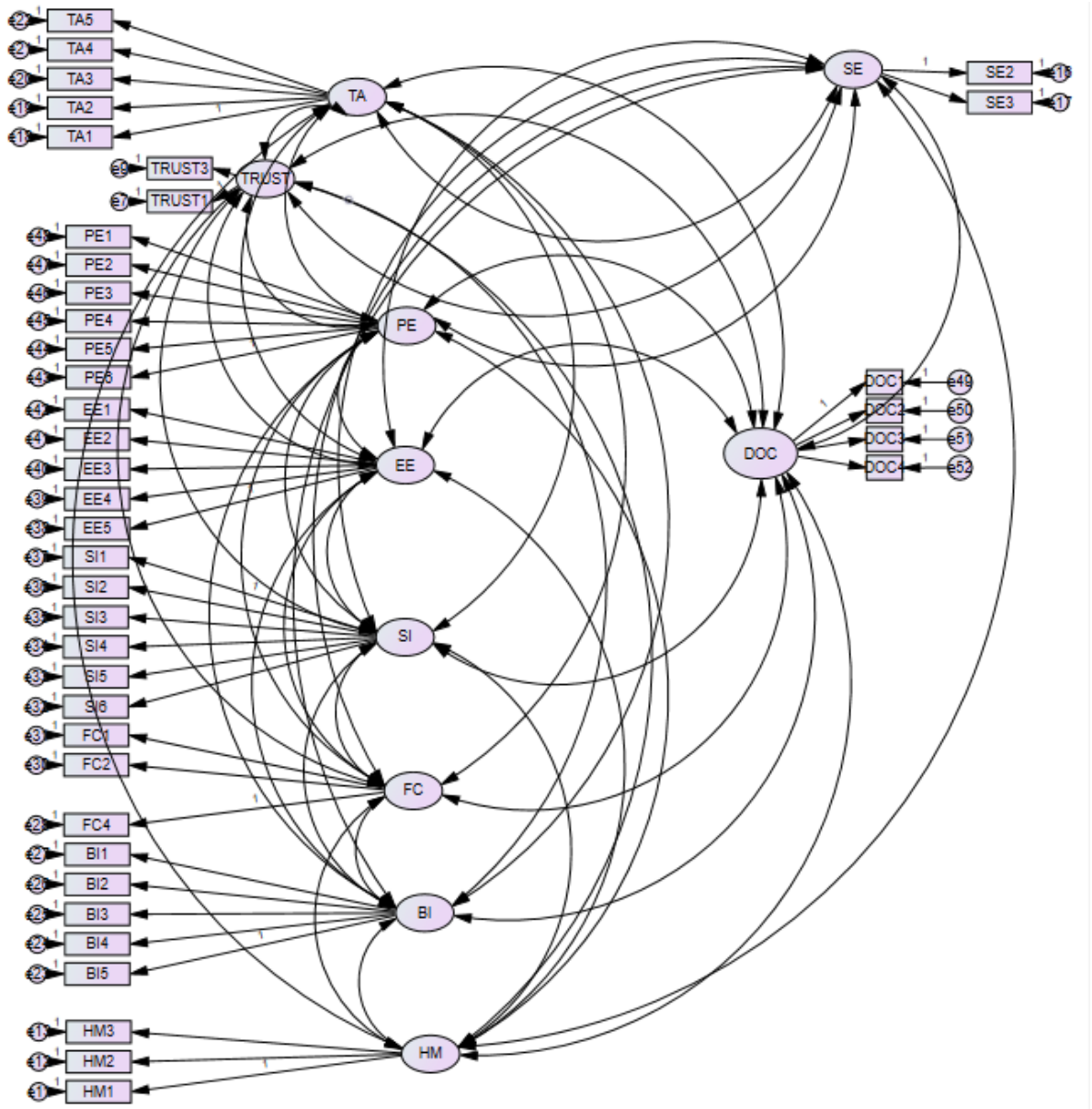
Stretch Action Points

1. Display results in exit page
2. Set-up video
3. Add intonations to audio
4. Partner instructions inside exam, at least sit next to partner at 3 meters, shoe size of helper/test subject
5. Add pairing instructions if phone unpairs during exam (next to QR code, or on main page).
6. Aligning chair instructions
7. 1.5 meter chair
8. Card calibration instruction (video)
9. 3 meter instructions - self measure or use shoe size / steps / steps gif
10. Include measuring tape / calibration card

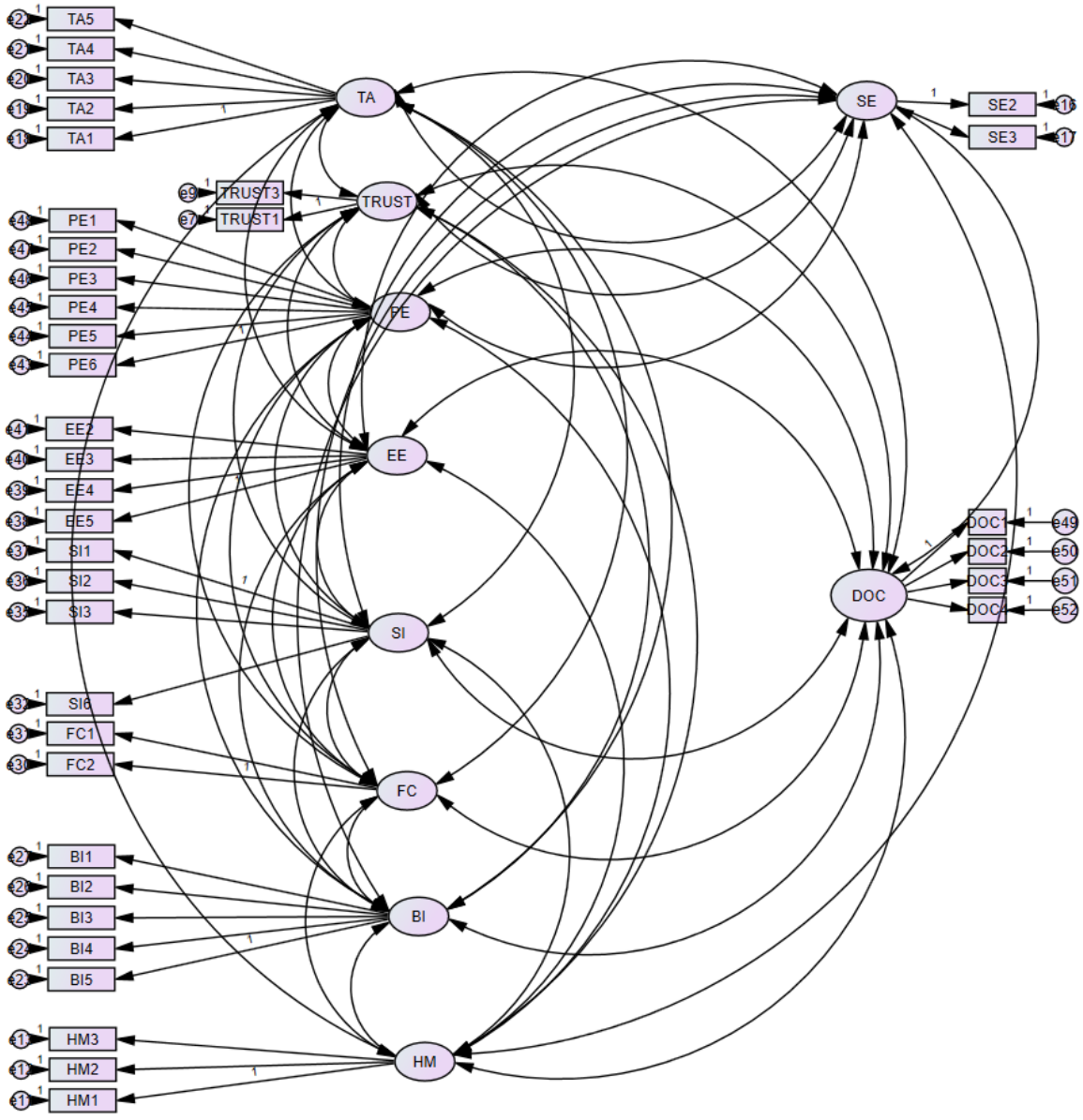
Appendix X: CFA model 1



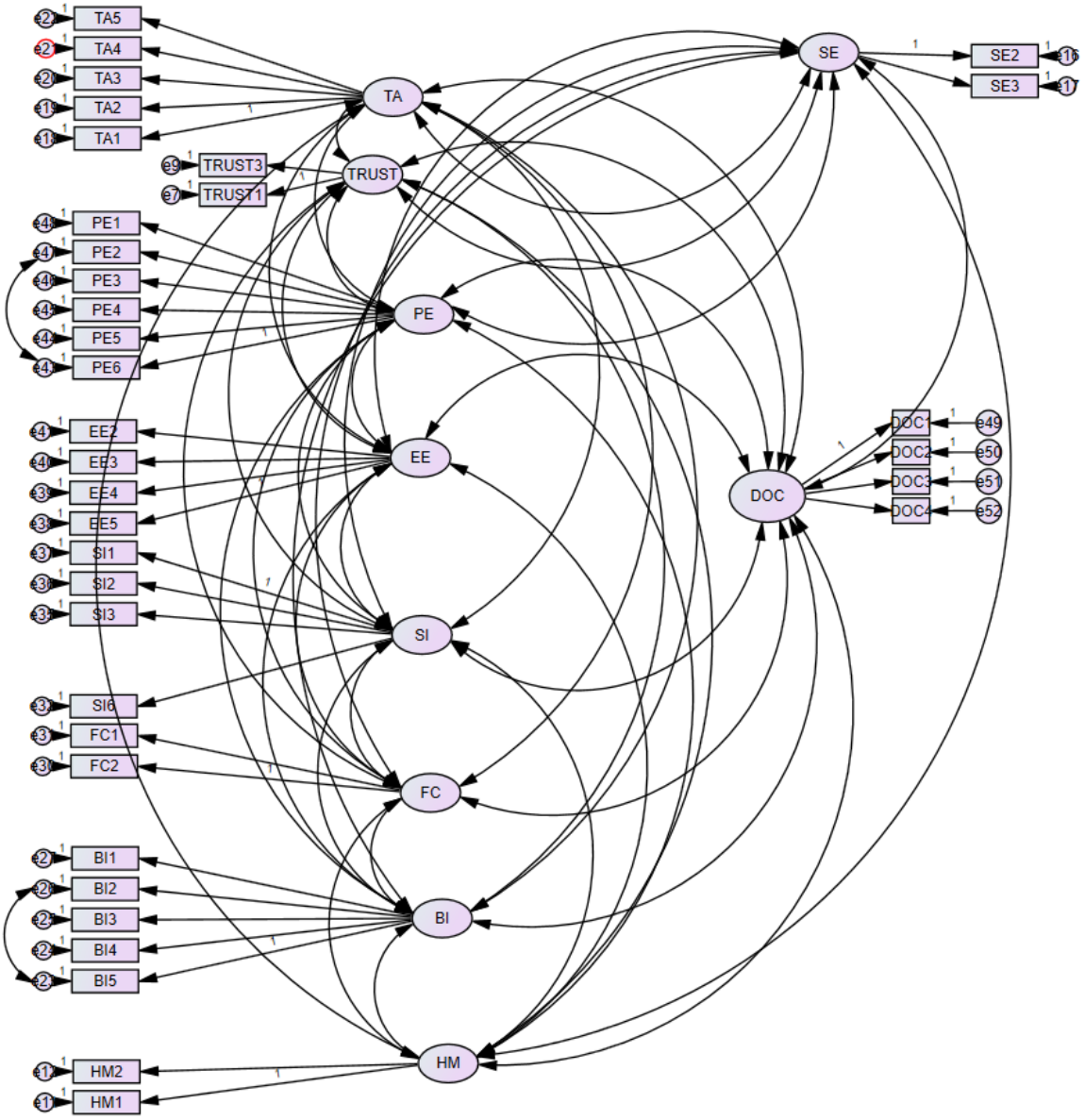
Appendix Y: CFA model 2



Appendix Z: CFA model 3



Appendix AA: CFA model 4



Appendix BB: Structural model