Design and evaluation of persuasive feedback-inhaler

Enhancing medication adherence among COPD patients

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Abstract

Background: Chronic lung patients often use inhalers incorrectly, which is a significant problem due to diminished therapeutic effects. Consequently, it can result in inflammations, exacerbations, hospitalization and a lower quality of life. Furthermore, it leads to high medical costs. Therefore, it is important to support patients in using inhalers properly. Current technological developments aimed at supporting inhaler use, mainly focus on measuring frequency of use, reminding patients to use the inhaler and monitoring of use in order to send data to healthcare professionals. These developments lack real time support of patients during inhalation.

Objective: The purpose of this study is the design and evaluation of a smart inhaler prototype, which integrates smart sensor technology and persuasive feedback in inhaler medication. The main objective is to define requirements and persuasive features that smart sensor technology needs to meet in order to provide reliable, valid and usable support for chronic lung patients as well as for the healthcare professionals. This study presents the outcomes of the user evaluation, among prospective users of the new smart inhaler and personalized portal, called the Feedback-Inhaler.

Methods: A holistic framework known as the CeHRes roadmap is applied as a guideline for the development of persuasive health technology. Within prior research the first contextual inquiry phase is conducted. In-depth interviews and contextual observations are carried out with twelve Dutch chronic lung patients to gain insights into the current practices and needs for smart sensor technology and inhaler medication. Persona's and use-case scenarios are developed based on the results of the contextual inquiry, as well as requirements and persuasive features within the value specification phase. After that, in the design phase, a first low-fidelity prototype of the smart inhaler and personalized portal is developed. The new *feedback-inhaler* provides real-time coaching during inhalation, as well as additional coaching via a portal. Within this study, a formative scenario-based user evaluation of the first prototype is carried out with chronic lung patients (age 41-78, eight male, six female) and healthcare professionals (four pulmonologists, one respiratory nurse and one medical microbiologist). Each participant received a short scenario-based introduction on the purpose of the study, as well as on how the new feedback-inhaler and patient portal for coaching works. Scenarios are based on medical inhalation protocols and are validated by a respiratory nurse. User evaluation sessions are video recorded and analysed.

Results: User evaluation results indicate that patients have a positive view towards the feedback-inhaler. The most important guidelines to improve the feedback-inhaler according to them are: a) the *type of real-time feedback modalities should be optional,* b) *guidelines to relax should be provided,* c) *the portal should be simplified,* and d) *notifications should be displayed via smartphone.* The healthcare professionals indicate that the new feedback-inhaler is clinically relevant. Guidelines for improvement according to them are: a) *patient data should be linked to hospital codes*; b) *patient data should be presented via one overview, and c*) *feedback should have a positive approach.*

Conclusions and Future Work: All participants are positive about the first feedback-inhaler prototype. In general for a feedback-inhaler to be succesful, it should be simple and provide praise and rewards. Furthermore, real-time feedback concering the proper maintenance of inhalers, the duration of the inhalation and guidelines to relax during inhalation should be added. The personalized portal for patients must enable users to self-monitor their inhalation technique. Via the personalized portal for healthcare professionals the data concerning the inhalation technique of patients must be available rapidly and presented in one clear overview. Healthcare profesionals have a positive attitude towards implementing the feedback-inhaler. Main conditions are that the technology must be available for all patients and type of inhalers and instructions about the technology must take place outside of the consultation room. Future work should aim at finetuning the feedback-inhaler. By means of a summative evaluation the effect of the technology should be examined.

Samenvatting

Achtergrond: Patiënten met chronische longaandoeningen gebruiken inhalatiemedicatie vaak niet op de juiste wijze. Dit is problematisch omdat het de therapeutische effecten vermindert. Hierdoor is er een grote kans op ontstekingen, exacerbaties, ziekenhuisopnames en een verminderde kwaliteit van leven. Daarnaast leidt dit tot hoge medische kosten. Het is van belang om patiënten te ondersteunen in het juist inhaleren. Huidige technologie die is gericht op het ondersteunen van het inhalatorgebruik focust zich met name op het meten van de frequentie van het inhaleren, herinneringen sturen naar patiënten om te inhaleren en het monitoren van het inhalatorgebruik om vervolgens deze informatie naar professionals in de gezondheidszorg te sturen. Deze ontwikkelingen missen 'real-time' ondersteuning aan patiënten tijdens het inhalatorgebruik.

Doel: Het doel van dit onderzoek is de design en evaluatie van een smart inhaler prototype, wat smart sensor technologie en persuasieve feedback integreert in inhalatiemedicatie. Hierbij is het belangrijk om de 'requirements' en 'persuasieve elementen' wat de smart sensor technologie moet bezitten in kaart te brengen. Dit zodat het betrouwbare, valide en bruikbare ondersteuning kan bieden aan zowel de patiënt als professional (e.g. longartsen en verpleegkundigen). Dit onderzoek presenteert de uitkomsenten van gebruikersevaluaties met potentiele gebruikers van de nieuwe technologie genaamd de Feedback-inhalator.

Methode: Een holistisch model, bekend als de CeHRes roadmap, is gebruikt voor de ontwikkeling van persuasieve eHealth technologie. De eerste fase van dit model, de 'Contextual Inquiry', is uitgevoerd tijdens een vooronderzoek. Diepte interviews en observaties zijn uitgevoerd met twaalf Nederlandse longpatiënten om inzicht te krijgen in het huidige inhalatorgebruik en de behoeftes voor smart sensors op inhalatie medicatie. Na deze fase zijn requirements en persuasieve elementen vastgesteld binnen de fase 'Value Specification' en zijn Personas en use-case scenarios ontwikkeld. Daarna, in de design fase, is een eerste low-fidelity prototype van de smart inhaler en een persoonlijk portaal ontwikkeld. Deze nieuwe 'feedback-inhalator' biedt real-time coaching tijdens het inhaleren en aanvullende begeleiding via het portaal, na het inhaleren. Gedurende dit onderzoek zijn gebruikersevaluaties van het eerste prototype uitgevoerd met patiënten met chronische longaandoeningen (41-78 jaar, acht mannen, zes vrouwen) en professionals (vier longartsen, één longverpleegkundige, één arts microbioloog). Elke participant heeft een korte introductie ontvangen over het doel van het onderzoek en over hoe de nieuwe feedback-inhalator werkt. Scenario's die hierbij gebruikt zijn, zijn gebaseerd op medische inhalatie protocollen en zijn gevalideerd door een longverpleegkundige.

Resultaten: De gebruikersevaluaties geven aan dat patiënten positief zijn over de feedback-inhalator. Belangrijke verbeteringen volgens hen zijn: a) *het type (real-time) feedback signaal moet optioneel zijn*, b) *richtlijnen om te ontspannen moeten worden toegevoegd, en* c) *het portaal moet worden vereenvoudigd.* De professionals geven aan dat de feedback-inhalator klinisch relevant is. De voornaamste aanbevelingen zijn: a) *data moet gelinkt worden aan ziekenhuiscodes*, b) *data moet gepresenteerd worden via één overzicht*, c) *feedback moet een positieve benadering hebben.*

Conclusie en aanbevelingen: Alle respondenten zijn positief over het eerste prototype van de feedback-inhalator. Volgens de respondenten is het van belang dat de feedback-inhalator simpel is en feedback geeft over het op de juiste wijze onderhouden van de inhalator en de duur van het inhaleren. Daarnaast moet de inhalator 'praise', 'rewards' en richtlijnen om te ontspannen bieden. Het portaal voor patiënten moet gebruikers in staat stellen om de inhalatietechniek te monitoren. Via het portaal voor professionals moeten de resultaten van patiënten omtrent het inhaleren worden weergegeven via één overzicht. Professionals hebben een positieve mening t.o.v. de implementatie van de technologie. Toekomstig werk moet zich richten op het 'fine tunen' van de feedback-inhalator. Doormiddel van een Summatieve evaluatie kan het effect van de technologie worden gemeten.

Preface

In front of you lies the result of my thesis research for obtaining the Master of Health Psychology. I experienced this period as very educational with ups and downs, but mostly ups! These ups are primarily due to the motivated and very friendly participants who took part in this study. I would like to thank a number of people here.

First of all I would like to thank all patients and healthcare professionals who participated in this study. You were all very friendly and motivated in having a contribution to this research. Not only by participating but also by pointing out others who would like to participate. Thank you so much (and also for the tea and cookies!)

I would also like to thank my supervisors from the University of Twente. Olga Kulyk, thank you for brainstorming with me and for sending multiple handy articles and examples via email. Also Lisette van Gemert-Pijnen, thank you for your time and for the email you sent me when I was insecure, telling me that I was doing a good job. Furthermore, I would also like to thank Nienke Beerlage-de Jong, for your trust in me doing this research for you. Also thank you for skyping with me about the status of the research and providing me reassurance in a moment of insecurity.

Finally, I would like to thank my father and Linda and my mother and big sister for the support during this period, and of course Jouwert thank you for your love, support (lay-out checks!) and attention.

Marieke Kingma
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Table of content

1. Introduction

In the Netherlands in 2011, 361.800 persons were diagnosed with Chronic Obstructive Pulmonary Disease (COPD). COPD concerns a deterioration of the elastic lung tissue and chronic constriction of the airways. The airway constriction is permanently present and largely irreversible (Boezen, Postma & Eysink, 2013; Boezen, Postma & Poos, 2013). COPD includes emphysema, chronic bronchitis and chronic narrowing of the small airways. Important symptoms of COPD are much mucus, chronic cough and (chronic) dyspnea. From an international perspective, the mortality rates of COPD are relatively high in the Netherlands (Boezen, Postma & Harbers 2013).

One possible consequence of COPD is the occurrence of exacerbations. Exacerbations are severe events. They are mostly defined as a disease state with an increase in symptoms of dyspnea, sputum purulence and sputum volume that is beyond normal day-to-day variations and is acute in onset (Bathoorn et al., 2008; Rabe et al., 2007 & Anthonisen et al., 1987). Exacerbations contribute to a decline in lung function (Donaldson et al., 2002), and are related to a low quality of life (Solem et al., 2013; Seemungal et al., 1998). Furthermore, exacerbations impair patients to undertake normal activities and the ability to be productive (Solem et al., 2013). 'Basic principles' regarding exacerbations, are: (a) past exacerbations are predictive of future exacerbations; (b) COPD exacerbations lead to hospitalization and therefore concerns a large cost factor; (c) reoccurring severe exacerbations are related to significantly higher mortality; and (d) COPD exacerbations are related to increased mortality (Gillissen, 2009).

In sum, COPD is a severe condition with a high prevalence and mortality rate in the Netherlands. It is important that chronic lung patients are able to self-manage their disease effectively to ensure good therapeutic effects and a high quality of life (Mesters & Hoving, 2010).

1.1 Treatment of COPD: Inhalation medication

For the treatment of COPD, patients receive inhalation medication aimed at preventing or reducing symptoms (e.g. coughing, dyspnea and sputum production), preventing exacerbations and preventing or slowing down a decline in lung function, complications and disabilities. The most important medications are bronchodilator and anti-inflammatories (Farmacotherapeutisch Kompas, 2006; Hesselink et al., 2001). Bronchodilators ensure that the airways become more spacious, and anti-inflammatories protect the lungs against inflammations and remedy inflammations that already exist (Boezen, Postma, & Poos, 2013). In short, the treatment of chronic lung patients concerns 'tertiary prevention'.

Inhalation medication can be categorized into dry powder inhalers (DPI) and metered dose inhalers (MDI). The DPI contains an inhalation powder, which can be inhaled in one or more in-respirations. The inhalations must be deep, fast and powerful to achieve a sufficient lung deposition, otherwise much of the medicine will remain in the mouth and oropharynx (Broekhuizen, Nijmeijer & ten Haven-Drenthen, 2014). Hence, DPIs are less suitable for patients who are not capable of inhaling powerfully. Examples of the DPI are the Handihaler® and Breezhaler® (Figure 1) (Broekhuizen et al., 2014).

Figure 1. Breezhaler® (Broekhuizen et al., 2014)

The MDI is a type of inhaler that delivers aerosolized medicine at high speed. In order to use the MDI correctly, the user needs to inhale the aerosol slowly and deeply (Broekhuizen et al., 2014). For many patients the MDI is difficult to use. The user needs to press the valve and inhale at the same time, which require good hand-lung coordination. A spacer device, such as the AeroChamber® (Figure 2) takes away the need to press the valve and inhale at the same time, and therefore is a good solution for patients who experience difficulties in using MDIs. Also a disadvantage for patients using the MDI is that most metered dose inhalers do not show when they are empty. The most reliable way to keep track of the dosages left in the MDI is for the patient to count the used dosages. Examples of the MDI are the Redihaler® and Autohaler ® (Figure 3) (Broekhuizen et al., 2014).

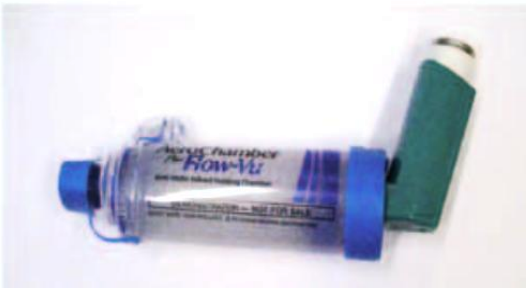

Figure 2. The Aerochamber® (Broekhuizen et al., 2014)

Figure 3. Autohaler® (Broekhuizen et al., 2014)

For effective management of COPD, the correct use of inhalers is crucial. Yet, chronic lung patients often use their inhalers incorrectly. Studies about the use of inhalers show that Dutch chronic lung patients (asthma and COPD) made significant mistakes while using their inhalers (Rootmensen, Keimpena, Jansen & de Haan, 2010; Hesselink et al., 2001). These findings are in line with the results of a systematic review from Lavorini et al. (2008) showing that between 4% and 94% of chronic lung patients do not use their inhaler(s) properly. The most common errors are: (a) *incorrect rotation sequence;* (b) *incorrect positioning* of the inhaler; (c) *failure* to *breath-hold after inhalation;* (d) *failure* to execute a *forceful and deep inhalation;* and (e) *failure* to *exhale before actuation.* Patients misusing their inhaler(s) are mostly: elderly patients, women and patients with emotional problems (Hesselink et al., 2001; Beerendonk et al., 1998; Goodman et al., 1994). Furthermore, there is a relationship between patients with low literacy skills and adherence (Twickler et al., 2009).

Misuse of inhalers is a significant problem. Mistakes can diminish therapeutic effects and result in little control over symptoms and inadequate disease management (Lavorini et al., 2008). Consequently, this may lead to inflammations, exacerbations, hospitalization, a low quality of life and high medical costs (Boezen & Postma, 2013; Solem et al., 2013; Suijkerbuijk, Poos, Bijenhof & Slobbe, 2013; Bathoorn et al., 2008; Seemungal et al., 1998). In the Netherlands COPD is one of the diseases with the highest healthcare costs (Panhuis-Plasmans, Poos & Gommer, 2013). The highest expenses are related to medication, followed by the costs for hospitalization and nursing care (Suijkerbuijk et al., 2013). Hence, it is of great importance to support patients in using inhalers properly. Not only for improving control over lung diseases, but also for reducing medical costs.

1.2 Technology to support medication adherence

There are several ways to support patients' inhaler use. To ensure correct inhaler use, it is essential to recheck the inhalation technique at each patient visit to clinicians (Rabe et al., 2007). Furthermore, patient education is a critical factor in the proper use of inhalation medication (Fink & Rubin, 2005). According to Fink and Rubin (2005) the primary responsibility for educating patients, rests with the pharmacists and prescribing clinician. Clinicians should demonstrate, teach and evaluate the patient's

technique and revaluate at following visits (Fink & Rubin, 2005). However, there are problems in patient education. One of the problems is that clinicians have limited time to teach patients how to use the inhaler properly (Fink & Rubin, 2005). Furthermore, although many chronic lung patients frequently visit clinicians, some do not and therefore might miss valuable repeating 'rechecks' concerning the inhaler use (Suijkerbuijk et al., 2013). Hence, patients might not get enough support due to these problems.

Technological support may be a good solution for increasing patient compliance to inhalation medication. Technology enables patients to receive support whenever they need it. Furthermore, in health care, technologies have already shown their potential. As described by Ossenbaard and Van Gemert-Pijnen (2013), technology contributes to the improvement of quality of care, the increase of efficiency of care and (cost-) effectiveness, the empowerment of consumers and in the long-term to a reduction of health care costs.

Currently, there are diverse technological developments aimed at supporting patients' inhaler use. Examples are: 1) the Novolizer®; 2) the Propeller sensor; 3) the Mag-Flo Inhaler Trainer, 4) the COPD Navigator App, and 5) the adHaler (Figure 4). However, these developments focus mainly on measuring frequency of use, reminding patients to use the inhaler and monitoring to send data to healthcare professionals, but lack real-time support and personal feedback on the patient's inhalation technique (BioTime, 2015; LifeMap, 2015; Propeller Health, 2014; Lavorini, et al., 2008; Kohler, 2004 & Evalan, n.d.). The adHaler for instance, is a device that records each moment that patients use their inhalers and enables remote monitoring of medication use in real-time. Furthermore, the adHaler can send text messages to patients to remind them to use their inhaler and can notify others when patients are forgetting to take the medication. Recorded data can be sent to a database wirelessly and is available to healthcare professionals. However, the adHaler does not provide real-time support during the inhaler use (Evalan, n.d.). Hence, it is important to design and evaluate a new technological device, which can support patient's inhalation technique and consequently enhance medication adherence. To the best of the author's knowledge, no such device is available as of yet.

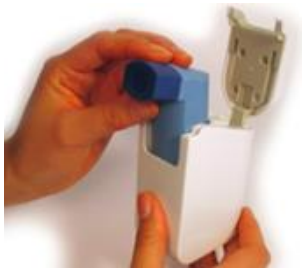

Figure 4. The adHaler. Evalan[1]

Within this study, a prototype of a new smart inhaler is designed and evaluated aiming at supporting patient's inhalation technique. This new smart inhaler is called the *'Feedback-inhaler'* and is developed based on findings of a previous conducted needs assessment among twelve Dutch chronic lung patients (Kingma, 2015). Long-term goals of this device are to increase the compliance to inhalation medication and consequently therapeutic effects and quality of life. Furthermore, the goal is to reduce exacerbations and hospitalization. This device is evaluated among chronic lung patients, pulmonologists, respiratory nurses and medical microbiologists because they are prospective users of the technology.

[1] https://real.evalan.com/adhaler last retrieved on 21-05-2015

1.3 INTERREG Va Health-i-Care project

This study is conducted as a prelude to the INTERREG Va Health-*i*-Care project, which stimulates and initiates innovations in health care, to ensure that the region around the Dutch-German border is becoming a dynamic and a secure health (economic) region. The Centre for eHealth & Wellbeing Research and the Department of Psychology, Health and Technology (PGT) of the Faculty of Behavioural, Management and Social Sciences (BMS) and the University of Twente (UT) is involved in the Health-*i* -Care project.

1.4 Research objective

The research objective of this study is to define user requirements and persuasive elements that smart sensor technology must comply with, so that it is reliable, valid and usable for chronic lung patients as well as for healthcare professionals. The aim of this study is to design innovative eHealth technology that enables chronic lung patients to self-manage their condition effectively and reaches good therapeutic effects. In this manner this study contributes to a secure health economic society.

1.5 Research questions

To achieve the objective of this study, the following main research question and sub questions are central: *"Which requirements (e.g. functional, non-functional etc.) and persuasive elements for smart sensor technology on inhalers are important, in order for it to be reliable, valid and usable for chronic lung patients as well as for the healthcare professionals, and how may smart sensor technology on inhalers be implemented in the care process?"*

1. Which requirements and persuasive features do smart sensors on inhalers need to possess according to chronic lung patients in order for it to be usable for them?
2. Which requirements and persuasive features do smart sensors on inhalers need to possess according to healthcare professionals in order for it to be usable for them?
3. What requirements are important so that the smart sensors on inhalers are clinically reliable and valid?
4. What are the criteria for successful implementation of smart sensor technology according to the healthcare professionals?

1.6 Structure of this report

The rest of the thesis is organized as follows: Chapter 2 presents the theoretical framework of this study and Chapter 3 describes the used research methods. Subsequently, Chapter 4 describes the results and Chapter 5 discusses the results and the research procedure. Chapter 6 concerns the final chapter of this thesis and regards the conclusion.

2. Theoretical framework

As described earlier, within this study a technological device aimed at supporting patients' inhaler use will be designed and evaluated. Technological support may be a good solution for increasing the adherence to inhalation medication among chronic lung patients. Technology that is used within health care and to support health is called 'eHealth technology' (Ossenbaard & Van Gemert-Pijnen, 2013). In this chapter the definition of eHealth technology and what it entails will shortly be described. Furthermore, the research model and a framework for persuasive system design, which will be used within this study to design and evaluate a prototype version of the technology, will be explained.

2.1 Persuasive eHealth technology

eHealth concerns different 'types' of technology that can be used to support health care and health. According to Ossenbaard and Van Gemert-Pijnen (2013), eHealth technology includes web-based technology, robotics, domotics, health sensors and mobile technology. A frequently quoted definition of eHealth, is formulated by Esyenbach (2001), and will also be used within this study:

> *"eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology". (pp. 13-14).*

Different users, like patients, health care providers or informal caregivers can benefit from eHealth technology. For instance via eHealth technology, patients can be supported in learning self-care management skills to manage their own disease and to use their medication properly (Van Gemert-Pijnen, 2013; Drossaert & Van Gemert-Pijnen, 2010). Consequently, this increases the success of treatment.

However, to increase the benefits and effects of eHealth technology, the technology and content should actually be used. The adherence to eHealth technology to date is low (Van Gemert-Pijnen, 2013). Hence, technology must contain 'persuasive elements' to motivate users to stick to the (technological) behavioral change program and continue using this (Van Gemert-Pijnen, 2013). 'Persuasive technology' offers insights about features that can be built into technology to make it more convincing without being coercive (Fogg, 2003). Oinas-Kukkonen and Harjuma (2009), describe persuasive technology as 'computerized software or information systems designed to change, shape or reinforce behaviors or attitudes or both without using deception or coercion. Persuasive technology focuses on how technology can be designed to empower and motivate users to realize their goals (Van Gemert-Pijnen, 2013). When developing eHealth technology it is important to use persuasive design techniques to modify the format and content of the technology while taking the users motivation, persuasion styles and ability to use the technology into account (Chatterjee & Price, 2009; Fogg, 2009). This ensures using the right triggers in the right format and at the right moment and consequently leads to an increase in adherence to the system (Van Gemert-Pijnen & Kelders, 2013). Oinas-Kukkonen and Harjuma (2009), propose various design principles for persuasive system content and functionality. These principles will be described in paragraph 2.3.

2.2 Research model

Within this study a holistic framework known as the CeHRes roadmap (Figure 5) is applied as a guideline for the development and evaluation of persuasive eHealth technology. This Roadmap concerns a holistic framework in which a fit between technology, humans and the context of usage in the development process is addressed (Van Gemert-Pijnen, 2013). It is important to use the CeHRes Roadmap because without a holistic approach, eHealth technologies run the risk of being ineffective to support healthy living (Van Gemert-Pijnen, 2013). As described by Van Gemert-Pijnen (2013), other frameworks regarding the development of eHealth technologies particularly have a 'design focus' based on software principles for information systems.

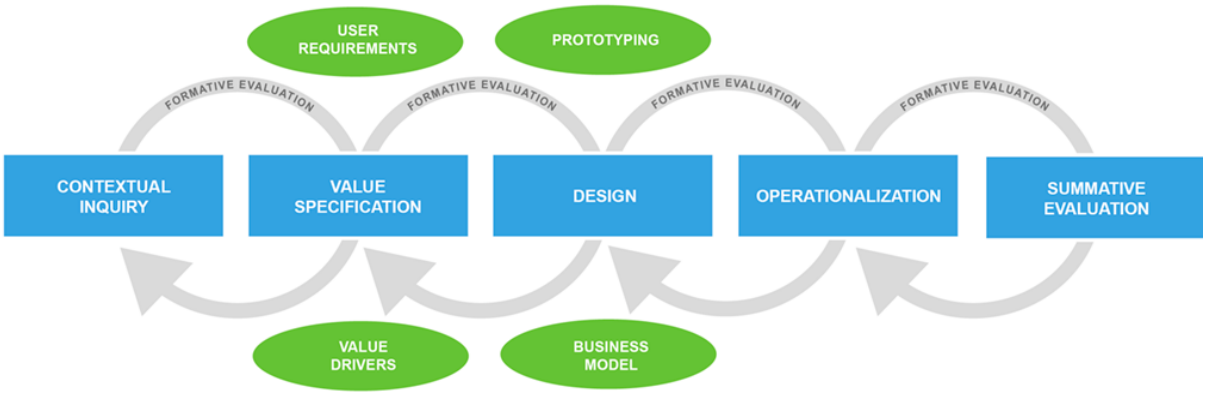

Figure 5. CeHRes Roadmap (Van Gemert-Pijnen, 2013)

The Roadmap is composed of five different phases and connecting cycles of activities (Van Gemert-Pijnen, 2013). The first step in the developmental process of new eHealth technology concerns the 'Contextual Inquiry'. This phase mainly concerns the identification of stakeholders' needs and problems and is aimed at figuring out whether and how technology can contribute to minimize problems (Van Gemert-Pijnen, 2013). Results from the contextual inquiry are input for the subsequent phase, namely the 'Value Specification'. As described by Van Limburg et al. (2011), within this phase values of stakeholders are determined and ranked based on their importance for solving the identified problem(s). Subsequently, requirements are defined to realize the values (Van Limburg et al., 2011). Together the contextual inquiry and value specification provide requirements and persuasive features for the design of the technology (Van Gemert-Pijnen, 2013). Within the 'Design' phase a first prototypal version of the technology will be developed and evaluated before a final design will be accomplished. The fourth step of the roadmap, namely 'Operationalization' refers to the arrangements for implementing the eHealth intervention (Van Gemert-Pijnen, 2013). During this phase, a business model for implementing the technology will be developed, which describes the capacities, resources and skills needed for implementation. Furthermore the expected cost-benefits will be described in this model (Van Gemert-Pijnen, 2013). The fifth and final phase of the roadmap concerns the 'Summative Evaluation'. Within this phase the effects of the technology are measured (Van Gemert-Pijnen, 2013).

Within this study the 'Value Specification', 'Design phase' and evaluation of the design are central. The 'Contextual Inquiry' is already conducted within earlier research performed by the department of PGT from the UT. During this previous research a needs assessment is conducted among twelve Dutch chronic lung patients. The results of this phase are used as input for this study.

2.3 Persuasive System Design Model

A framework for designing persuasive systems and that will be used within this study, concerns the Persuasive Systems Design (PSD) model from Oinas-Kukkonen and Harjumaa (2009) (Figure 6). This concerns a useful model that provides ideas and tools for designing technological interventions that are well described and persuasive (Oinas-Kukkonen & Harjumaa, 2009).

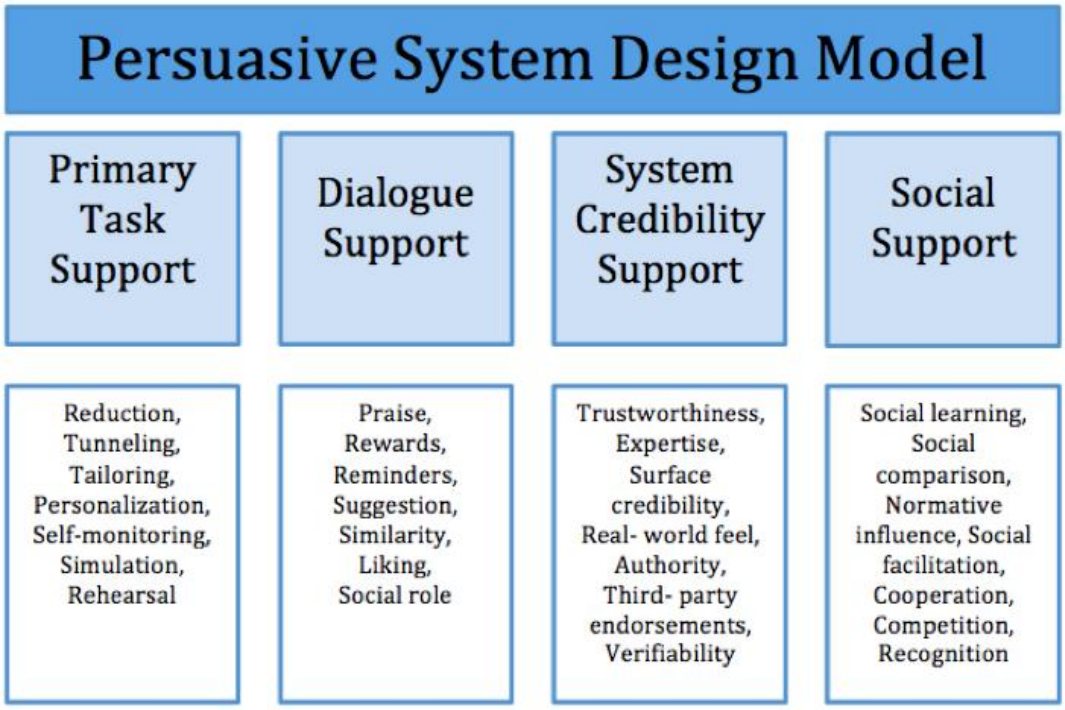

Figure 6. Persuasive System Design Model (Oinas-Kukkonen & Harjumaa, 2009)

The model describes persuasive features (design principles) in the categories of primary task support, dialogue support, system credibility support and social support. The category 'primary task support' contains design principles, which support the performance of the user's primary tasks and activities. Principles within the category 'dialogue support' refer to the human-computer dialogue and are techniques to achieve the aims set for using the technology (Van Gemert-Pijnen & Kelders, 2013; Oinas-Kukkonen & Harjumaa, 2013). The design principles from the category 'system credibility' relate to the trustworthiness of the system and the believability of the design. Lastly, the principles in the 'social support' category indicate how to design a system in order to motivate users by leveraging social influence (Van Gemert-Pijnen & Kelders, 2013; Oinas-Kukkonen & Harjumaa, 2009). Various principles, that are deemed to be important based on the contextual inquiry phase, will be used during this study for designing persuasive eHealth technology.

3. Methods

This study follows the Human-Centred Design approach (HCD). HCD concerns an approach in which the expectations, motivations, interests and needs of prospective users are taken as the focal point of design (Nijland, & Verhoeven, 2013; Gould & Lewis, 1985). As described earlier, within this study the results from the previous conducted Contextual Inquiry phase are used as input for the prototype. During this phase semi-structured interviews with twelve Dutch chronic lung patients took place to gain insights into the current practices and needs for smart sensor technology and inhaler medication. Using the input from prospective end-users and involving them in the design process is important because it leads to better user performance in health care environments, enhances user satisfaction and usage, and improves system acceptance (Nijland and Verhoeven, 2013). In sum, Human-Centred Design ensures technology success.

In this chapter the methods of this study will be explained. First the development of personas is described. After that, the methods of the value specification and design phase will be discussed. Lastly, the method of the user evaluations will be described.

3.1 Contextual inquiry

Within prior research this first phase of the CeHRes roadmap, namely the contextual inquiry is conducted and described in detail elsewhere. Persona's and use-case scenarios are developed based on the results of the contextual inquiry, as well as requirements and persuasive features within the value specification phase.

3.1.1 Personas

To provide clear input for the design process of the technology, Personas are made based on the results from the first contextual inquiry phase. Personas are abstract representations of distinctive user groups for a technology (Van Velsen et al., 2012; Pruitt & Grudin, 2008). As described by van Velsen et al. (2012), Personas can be convenient tools for designing usable and useful eHealth technology. Using Personas ensures making suitable decisions in the design process by taking the 'type of users' of the technology and how the technology will be used into account (Pruit & Gruding, 2008).

In order to develop Personas, the results from the earlier conducted research with twelve Dutch chronic lung patients are reviewed. Transcripts of the results are analysed and the quotes are translated into the categories of Personas, using the following classification: 'demographic', 'health care specifics' and 'technical specifics' (LeRouge, Ma, Sneha & Tolle, 2013). According to LeRouge et al. (2013), this classification may provide an adequate representation of considerations for technology. It captures the mental model of the user of health technology (LeRouge et al., 2013). Table 1 displays an example of excerpts of interview results, which are translated into Persona 2 (Johan Dekker).

By means of an overview of the responses of the twelve Dutch chronic lung patients, two distinctive groups are chosen as input for the personas. These groups are: (1) the one who is dedicated (Appendix 1), and (2) the one who is oblivious (Appendix 2).

Table 1

Example interview results translated to Persona 2: 'Johan, the one who is oblivious'

		Category: Health care specific	
Interview segment	**The one who is oblivious**	**Sample quote's**	**Translation to persona**
Know-ledge about how to use the inhaler	All participants received instructions regarding the use of inhalers and think they use their inhalers properly	"*I manage to carry out the steps regarding the use of my inhalers well"*	Thinks he uses his inhalers properly
Making errors with regard to the inhalation	Reasons for making errors: • Being in a hurry • Procrastination	*"If I am late or something then I do it sometimes while walking around. I am not sitting quietly or something. But for instance I walk through the house to pick up something that I need".* *"Then I just put it between my teeth and then I walk through the room"* *That is simply because I find it irritating to sit still for ten minutes. Since I am no longer full of mucus I should spend just more attention to this, but yes, I think when you sometimes take antibiotics for two weeks, then you are very meticulous… but if you need to inhale year after year, then you sometimes get a little tired of it.. "*	Sometimes he forgets to inhale or postpones the inhalation and consequently uses it in a hurry. He does not think this is a very severe problem.

3.2 Value specification

3.2.1 Requirement/persuasive feature analysis

Based on the results of the previously conducted interviews with chronic lung patients, requirements and persuasive features regarding inhaler medication with sensor technology are established. User expressions are translated into requirements or persuasive features when it captured something important in relation to the aims of the technology. Persuasive features are classified in: 1) *primary task support*, 2) *dialogue support*, 3) *system credibility support* and 4) *social support*. In addition, the requirements are classified within different requirement types, namely: 1) *functional requirements*, 2) *non-functional requirements*, and 3) *content requirements*. A functional requirement is a statement about what the sensor technology should do, what persuasive design features should be incorporated, how it should behave or what components it should have (Sutcliffe, 2002). A non-functional requirement concerns a statement of performance, quality and environment issues with which the sensor technology must comply. It regards a quality and performance criterion that is not directly implementable in software (Sutcliffe, 2002). Non-functional requirements can be subdivided into performance criteria and design-related criteria. Performance criteria regard achievements to which it must comply, such as reliability and response time. Design-related criteria refer to constraints such as security, maintainability or portability (Sutcliffe, 2002). Content requirements refer to the content that needs to be communicated via the technology (Van Velsen, Wentzel & Van Gemert-Pijnen, 2013).

The translation of raw data into requirements and persuasive features is based on a requirements development approach, which is described by Van Velsen et al. (2013). Within this approach three derivatives are determined, namely values, attributes and requirements. The value concerns an interest or ideal of an end user with regard to the technology, the attribute is a short summary of the wish or need that is expressed by the end user, and the requirement is a technical translation of an attribute (Van Velsen et al., 2013). This approach entails a systematic approach and forces to identify requirements and/or persuasive features in an empirical manner (Van Velsen et al., 2013). Table 2 displays a short overview of the requirement elicitation process.

Table 2

Example of the data analysis concerning the requirements

User expression	Value	Attribute(s)	Requirement(s)
Patient 2: *"It should provide information about the inhaler use. And preferably personal information about my inhalation use, so not in general"*	Personal feedback/ tailored feedback	Overview of specific information aimed at the user	The 'feedback-inhaler' provides tailored feedback about the specific inhalation technique of the individual. The 'feedback-inhaler' offers a personalized content and services to its users
Patient 8: *"Well look I am going to inhale and I will receive a red light for example.. oh I did it wrong… eh am I going to inhale again? Or did I still inhale some of the medication? Do I get too much inside when I inhale again? But what am I doing wrong exactly? So you are doing it wrong but then I need to receive information about how to do it right"*	Re-assurance	Advice about correcting mistakes	The 'feedback-inhaler' can provide reassurance by presenting clear and understandable information about which actions to carry out to resolve mistakes

After the elicitation process, the requirements and persuasive features are ranked based on importance. When an issue is frequently brought forward by the participants, it is assumed to be an important requirement and/or persuasive feature for the technology.

3.3 Design and Prototyping

To examine the usability of the technology, a low-fidelity prototype is developed, based on the outcomes of the contextual inquiry and value specification. Prototypes can be developed fully functioning in full detail (high-fidelity), or in more broad lines (low-fidelity) (Rettig, 1994). Within this study low-fi prototyping is chosen to create a simple design of the proposed technology. Sketches of the prototype are made with pencil and paper. Afterwards mock-ups (to create a real image) based on the sketches are made using Balsamiq and a scale model is made.

Low-fi prototyping is an effective and simple tool to create a prototype. In comparison to high-fi prototypes, low-fi prototypes are fast to develop and it allows trying more ideas (Rettig, 1994). In addition, low-fi prototyping is flexible, easily adaptable and quickly testable and it does not create high expectations among end-users (Rettig, 1994).

3.4 Evaluation

3.4.1 Target group

3.4.1.1 Patients

A broad target group is consulted within this study. This target group concerns Dutch chronic lung patients (asthma and COPD) aged 18 years and older and that are under the treatment of a lung specialist or receiving primary care. This broad target group will be approached because it consists of prospective users of the proposed technology and because of the explorative character of this study. Using a broad target group may lead to finding various results and consequently more input concerning the development of the technology.

3.4.1.2 Healthcare professionals

According to the holitic approach, it is important to include various stakeholders that have different roles in the development of eHealth technology (Van Gemert-Pijnen, 2013). Hence, healthcare professionals should also be included within this study. The technology is not only a helpful tool for chronic lung patients but might also be beneficial for healthcare professionals. In order to support patients in using inhalers properly, it may also be important to inform healthcare professionals about the status of the patients' inhaler technique via technology. This gives healthcare professionals more insight into the adherence of their patients and empowers them to make (successful) future decisions about treatments. Also results of prior research show that patients want their healthcare providers to be informed about their inhalation technique (Kingma, 2015). Therefore, it is important to include healthcare professionals to evaluate the usibility of the technology.

Hence, also Dutch pulmonologists, respiratory nurses and medical microbiologists are approached to participate within this study. They are experts among chronic lung conditions and prospective users of the technology.

3.4.2 Recruitment & participants

All participants are recruited by means of convenience sampling and snowball sampling. In other words, participants are asked to volunteer for participation in this study. Also participants are asked to invite others who possibly would like to participate in this study and meet the eligibility criteria (Crosby, DiClemente & Salazar, 2006). Participants are approached via the Dutch Lung Foundation, Dutch hospitals and via pharmacists.

Concerning the patients, fourteen Dutch chronic lung patients participated within this study (eight men and six women) with an age ranging from 41 till 78 years old. The mean age is 63 years. Table 3 shows the demographic and clinical characteristics of the patients. Inclusion criteria were: using one or more prescribed inhaler(s) for a chronic lung disease (e.g. asthma or COPD) and having an age of 18 years or older. Exclusion criteria were: only using a nebulizer device and an age younger than 18 years.

With regard to the healthcare professionals, four pulmonologists, one respiratory nurse and one medical microbiologist participated within this study (six men) with an age ranging from 38 till 64 and a mean age of 45 years (Table 4). The only inclusion criterion here was being a pulmonologist, respiratory nurse or medical microbiologist.

Table 3

Demographic and clinical characteristics of the participating patients (N=14)

Characteristic	n	%	M (SD)
Gender			
Male	8	57.14	
Female	6	42.86	
Age			63 (13.26)
Education			
High educated[a]	3	21.43	
Middle educated[b]	5	35.71	
Low educated[c]	6	42.86	
Diagnose			
COPD	10	71.43	
Asthma	3	21.43	
Bronchiectasis	1	7.14	
Type of inhalers			
Standard dosisaerosol with AeroChamber® users	11	47.83	
Genuair® users	1	4.35	
Autohaler® users	1	4.35	
Respimat® users	6	26.09	
Breezhaler® users	2	8.70	
Turbuhaler® users	1	4.35	
Dosisaerosol without AeroChamber® users	1	4.35	
Moment of inhaler use			
Spread during the day	2	14.29	
Morning and evening	12	85.71	
Receiving treatment from			
Pulmonologists	12	85.71	
General Practitioner	2	14.29	

Note. M = mean, SD= Standard deviation, [a]hbo, wo, doctor, [b]havo, vwo, mbo-2-4, [c]vmbo, mbo1, first three years of havo and vwo (Verweij, 2008).

Table 4

Characteristics healthcare professionals (N = 6)

Characteristic	n	%	M (SD)
Gender			
Male	6	100	
Female	-	-	
Age			45 (13.60)
Expertise			
Pulmonologist	4	66.67	
Respiratory nurse	1	16.67	
Medical microbiologist	1	16.67	

3.4.3 Procedure

Ethical committee approval was obtained before recruiting participants (nr. of approval ethical committee: 15368). Prior to the user evaluations, all participants received an informational letter (Appendix 3 & Appendix 4). This letter concerned an invitation and provided information about the aims and procedure of this study. Furthermore, participants signed an informed consent (Appendix 5). Each participant received a small reward after participation: a gift voucher of 15 euro.

The prototype of the proposed technology is evaluated by means of user evaluations. User evaluations are widely recognized as critical to the success of clinical information systems (Jaspers, 2009). Within this study interview questions about the usability of the prototype took place in combination with the method 'thinking aloud'. As described by Jaspers (2009) this method entails that users perform a series of tasks in interaction with the technology and at the same time are verbalizing their thoughts. This method will be used during this study because it enables prospective users to experience how the prototype of the technology works and how to use the technology. Furthermore, it leads to a rich source of data and insight about the experiences of the participants concerning the ease of use (Jaspers, 2009).

3.4.4 Materials

During the user evaluations a low-fi (hardcopy/paper) prototype of the technology and a model is presented to the participants (described in Chapter 4). The participants received both tasks and questions during the evaluation. The tasks were based on different scenarios about daily situations in which the technology could be used (Appendix 6 & 7). Scenarios are useful tools during user evaluations because they enable users to imaging the use situation and contexts of new or existing technology (Carroll, 2000). Furthermore, they capture the trade-offs and consequences of designs (Carroll, 2000). Within this study a respiratory nurse checked all scenarios to ensure that they are sufficiently realistic.

Three scenarios and three related tasks during the user evaluations with the chronic lung patients are used. The first scenario described a situation in which a patient received the technology (mouthpiece with sensor technology and portal) for the first time. The related task for the participant was to find out how the technology works by searching for the instructions in the portal and reading the instructions. The second scenario concerned a situation in which a patient received the real-time feedback that the inhalation was not executed properly. The related task was to search for the explanation of the real-time feedback concerning the mistakes in the patient portal. The third scenario was about the patient wanting to ask a random question. The related task here was to search for different places in the patient portal, where you can go to, to search for answers on a question.

After each scenario and related tasks the patients received post interview questions about the prototype (Appendix 6). A question for instance was: "What do you think of the real-time feedback feature of the sensor technology?" All questions are aimed at exploring the opinion of the patients concerning the prototype.

With regard to the user evaluations with the pulmonologists and respiratory nurse, one scenario and related task is used. The scenario was about a pulmonologist wanting to know the status concerning the inhaler use of one of his patients. The related task was to find the patient's information within the portal. Questions asked afterwards were aimed at exploring the opinion of the pulmonologists and respiratory nurse regarding the prototype and exploring their view on clinical relevance. This latter means the degree to which a professional is able to assess the adherence of the patient and make future decisions about the treatment of the patient based on the presented data in the portal. Examples of questions during the evaluations are: "What is your overall impression of the prototype?" and "To what extent is the patient data clinically relevant?" Concerning the evaluation

with the medical microbiologist, only questions about hygiene related aspects and the opinion of the medical microbiologist regarding the prototype of the technology are asked.

3.4.5 Data-analysis

The user evaluations are audio recorded with permission of the participants and transcribed verbatim. Every transcript consists of relevant quotes made by the participants.

With regard to the data from the user evaluations with patients, in total 52 codes are assigned. These codes are based on eight different categories, namely: 1) background information; 2) task performance; 3) opinion regarding the technology; 4) clearness regarding the technology; 5) expectations from the technology; 6) motivation to use the technology; 7) adjustments to the technology, and 8) other information. Appendix 8 presents an overview of the complete codebook.

Concerning the data from the user evaluations with healthcare professionals, in total 46 codes are assigned. These codes are based on nine different categories. These categories are: 1) background information; 2) opinion regarding the technology meant for the patients; 3) opinion regarding the technology meant for the healthcare providers; 4) expectations of the technology; 5) task performance; 6) adjustments to the technology; 7) clinical relevance; 8) motivation to use the technology, and 9) other information. Appendix 9 presents an overview of the complete codebook for the healthcare professionals. All codes are analysed by clustering them per code and summarized to answer the research questions.

Cohen's Kappa is calculated, to examine the reliability of the coding scheme. By means of the Cohen's Kappa, the consensus between two researchers rating the qualitative results of the same transcript of the interviews, based on the same codebook is measured. In short, Cohen's Kappa is a value that indicates the interrater reliability (Huizingh, 2012).

To calculate the Cohen's Kappa, two independent assessors coded five per cent of the excerpts from the user evaluations with patients. The Cohen's Kappa of these interview-coding scheme's was 0.511 and can be called moderate (Landis & Koch, 1977). Furthermore, two independent assessors rated five per cent of the excerpts from the user evaluations with the healthcare professionals. The Cohen's Kappa here was 0.575 and can be also be called moderate (Landis & Koch, 1977). All text excerpts are randomly selected.

4. Results

Within this chapter the results from this study will be described. First, the results of the value specification phase are described. Subsequently the results of the design phase will be presented, followed by the results of the user evaluations.

4.1 Value specification: requirements elicitation & Personas

4.1.1 Requirements and persuasive features smart sensor technology

Various requirements and persuasive features concerning the technology have been identified based on the results from the previously conducted research with Dutch chronic lung patients. All requirements (Table 5 & 6) and persuasive features (Table 7) are formulated with the sentence: "The sensor technology must…" Each requirement and persuasive feature is ranked to indicate the importance to the patients. The requirements are classified within the following categories: 'Functional requirements', 'Non-functional requirements' (e.g. Design- or Performance criteria) and 'Content requirements'. Furthermore, the persuasive features are classified in the categories: 'Primary task support', 'Dialogue support', 'System credibility support' and 'Social support'.

Table 5

Requirements regarding the Smart inhaler

Functional requirements	**Non-functional requirements**		**Content requirements**
	Design criteria	*Performance criteria*	
Provide information about amount of dosages	Be time efficient	-	Provide information regarding the degree of lung deposition
Sent information to healthcare providers	Give the opportunity to patients to be independent from care givers		

Table 6

Requirements regarding a website (portal)

Functional requirements	**Non-functional requirements**		**Content requirements**
	Design criteria	*Performance criteria*	
Provide peer support	Be clear and comprehensible	Provide links to other existing reliable sources of information	Provide information about correcting mistakes
Provide a forum to ask and answer questions		Be effective	Provide instructions concerning the use of regular inhalers

Table 7

Persuasive features regarding the feedback-inhaler

Primary Task Support	Dialogue Support	System Credibility Support	Social Support
Offer personalized information (Personalization)	Provide real-time feedback (Suggestion)	-	-
Provide a practice mode (Rehearsal)			

4.1.2 Personas

Two personas are created based on two distinctive groups of people (Appendix 1 and 2), based on the results from the previous conducted research with twelve Dutch chronic lung patients. The first Persona corresponds with the answers of five participants and the second Persona corresponds with the answers of seven participants. The Personas are called: (1) the one who is dedicated (Margriet Hamersma, Figure 7), and (2) the one who is oblivious (Johan Dekker, Figure 8).

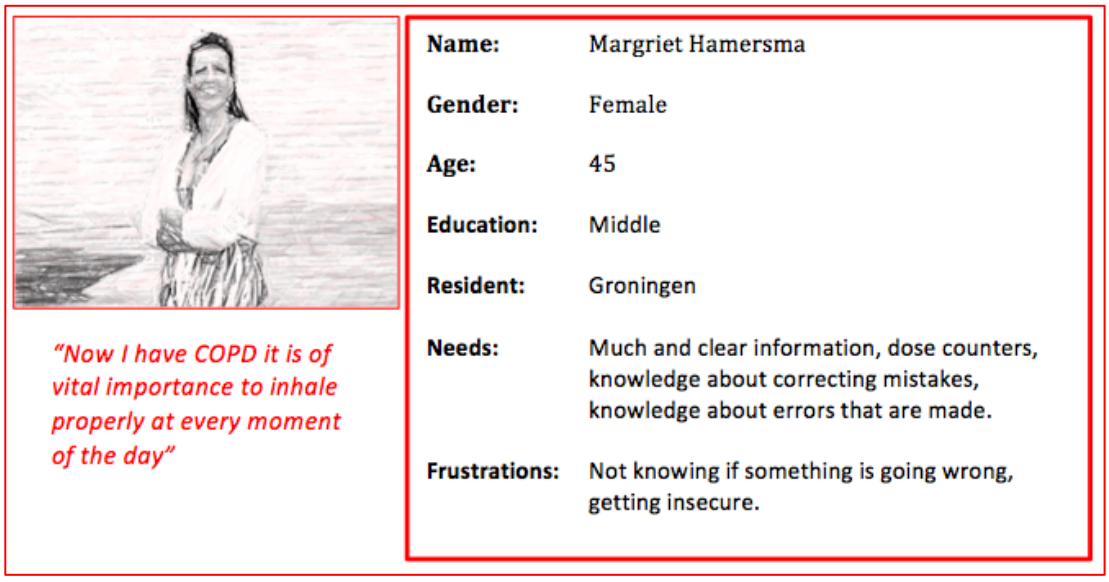

Figure 7. Persona 1 Margriet Hamersma: 'The one who is dedicated'

"Sometimes I have the tendency to do things at the same time. Then I just put the inhaler between my teeth and walk through the room"

Name:	Johan Dekker
Gender:	Male
Age:	65
Education:	Low
Resident:	Enschede
Needs:	Knowing if errors are being made, short and clear information.
Frustrations:	Frequent feedback, too much information, spending too much time on information or practicing the inhalation technique.

Figure 8. Persona 2 Johan Dekker: 'The one who is oblivious'

Persona 1 is about Margriet Hamersma. Margriet is very motivated to use inhalers correctly and would like to monitor the inhalation technique regularly. Hence, Margriet would like to receive feedback frequently about the inhalation technique. In addition, Margriet would like to receive information about correcting mistakes and the amount of dosages in each of her inhalers.

The second Persona, is about Johan Dekker. Johan is somewhat unaware of regular occurring mistakes while using inhalers and would not search for information about the inhaler use. Nevertheless, if Johan would notice something is wrong, he would like to know the problem. On occasion Johan would like to practice the inhalation technique if things are going wrong. However, Johan does not like to receive feedback frequently about the inhalation technique.

4.1.3 Use case scenarios

Two use case scenarios are developed to make it easy to understand how the future prototype will be used in daily context, namely (1) 'Margriet uses the mouthpiece' and (2) 'Margriet needs to find information about correcting mistakes'. By means of these scenarios it can be made clear what features the mouthpiece and portal of the feedback-inhaler needs to possess to influence behaviour.

Use case scenario 1: 'Margriet uses the mouthpiece'

It is Friday morning and Margriet needs to inhale a dose from the Spiriva Respimat®. Before inhaling a dose, she removes the protective cap of the regular inhaler and attaches it to the mouthpiece of the feedback-inhaler. Furthermore, Margriet waits for the checkmark sign, indicating that the inhaler is ready for use. When the checkmark appears, Margriet brings the whole device to her mouth and places the mouthpiece between her teeth. She pushes the grey button of the Respimat® to release a dose and begins to inhale. However, the mouthpiece starts to vibrate quickly, indicating that Margriet inhales to hard and that she needs to inhale slower. Margriet reacts immediately by slowing down her inhalation. Furthermore, Margriet receives the sign of an arrow pointing upwards, indicating that she does not adopt the proper posture and that she must put her head slightly up. When she notices the arrow she reacts by looking up. After the inhalation the mouthpiece presents a time bar which counts until ten. Margriet holds her breath until the time bar is full and disappears from the screen. Then she slowly exhales through the mouthpiece until she sees the sign of the exclamation mark, indicating that she is done and can remove the mouthpiece from her mouth. The exclamation mark also means that she did not use the inhaler properly.

Use case scenario 2: 'Margriet needs to find information about correcting mistakes'
After Margriet used the mouthpiece of the feedback-inhaler she received the symbol of an exclamation mark, which means she did not use the inhaler correctly. To find out what went wrong and how to correct mistakes, Margriet logs in to the personalized portal and clicks on the link 'status inhalation technique'. The subsequent page of the portal presents an overview of the inhalation technique of the current day. The page informs Margriet about the mistakes she made, namely that Margriet inhaled to forcefully while using the Spiriva Respimat® in the morning. The advice that is described on this page tells her to inhale less forcefully next time.

4.2 Design phase: Feedback-InHaler prototype

As described earlier in the Methods section, the prototype concerns a low-fi prototype, which is developed based on the results of the requirement/persuasive feature analysis, Personas and use-case scenarios. In addition, validated medical inhalation protocols and one expert were consulted during the iterative design phase: an expert in smart sensor hardware design was consulted on the subject of smart sensor types and state-of-the art technology suitable for real-time feedback on inhalation techniques. Below, the prototype is presented and design choices are explained.

The prototype consists of two main elements: (a) a mouthpiece with smart sensors attached to a dock station (Figure 9) and, (b) a personal portal (Figure 10). These two parts together concern one technological support system for chronic lung patients, and healthcare professionals, and is called the 'Feedback-InHaler'. Below the prototype and its features will be described and are linked to the requirements and persuasive elements that are established during the value specification.

Figure 9. Screenshot prototype: mouthpiece

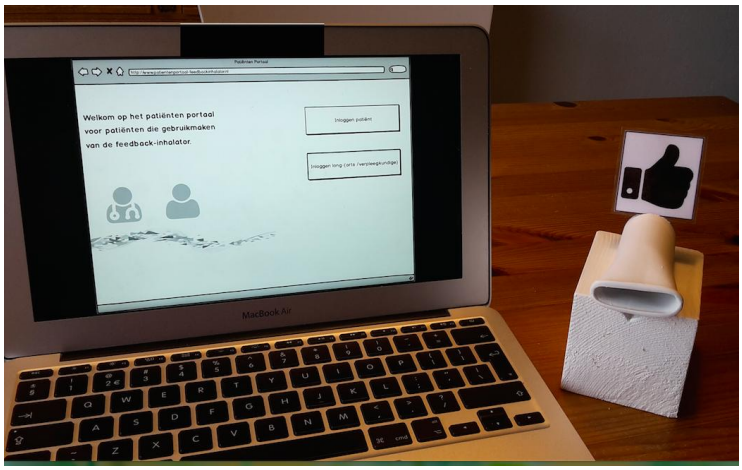

Figure 10. Screenshot prototype: patient portal and mouthpiece (e.g. Feedback-inhaler)

4.2.1 Mouthpiece with smart sensors

The prototype of the mouthpiece is made of a plastic tube and the prototype of the docking station is a wooden block (Figure 9). In short, it concerns a fictive model representing the technology. It proposes a universal device provided with various sensors. These sensors are flow sensors, motion sensors and pressure sensors, which are capable of measuring the important steps patients, need to perform properly to reach a sufficient lung deposition. The flow sensor measures the flow rate (e.g. inhalation strength). To use the MDI properly, the user needs to inhale the aerosol deeply and slowly and when using a DPI the user needs to inhale deeply and powerfully (Broekhuizen et al., 2014). The motion sensors measure whether or not the user has shaken the inhaler before use (only important if patients use an MDI) and if the user adopts the proper posture. According to the protocol of the Dutch Lung

Alliance (LAN)[2] these are important actions to perform. Shaking the inhaler ensures a good homogeneous distribution of the drug particles over the liquid of the MDI and adopting the proper posture (e.g. head slightly up) ensures a free access for the medication to reach the lungs. The pressure sensors measure the position of the mouthpiece in the mouth of the user. While using the inhaler it is important to keep the mouthpiece between the teeth (LAN). With regard to breath holding after inhalation, this is measured by means of the flow sensor and pressure sensor. These sensors together can measure if the user does not exhale before he/she breathes holds for ten seconds after inhaling a dose. Breath holding after inhalation for ten seconds or as long as possible is important because the drug particles have a required 'fall time' in order to reach the airway wall. If patients do not breath hold long enough, then a part of the dose will be exhaled again (Boer, 2015; Hoppentoch, 2015). Appendix 12 presents a specific overview of the different types of sensors and the important related actions they can measure. These actions are based on the protocols of the LAN.

The technology should fit all types of inhalers because chronic lung patients use different types of inhalers during the day. This enables them to attach the mouthpiece with sensors to DPIs or MDIs, and to receive support and tailored feedback from the feedback-inhaler. By providing tailored feedback, the information will be personalized because it only applies to the specific user. This is consistent with the persuasive feature: *'personalisation'*.

The mouthpiece recognizes the type of inhaler immediately when it is attached to the inhaler and only measures the specific operations associated with the relevant inhaler. As described earlier, while using a DPI the inhalation must be deep and powerful to receive a sufficient lung deposition. In contrast, when using an MDI, the inhalation should be deep and tranquil in order to receive a good lung deposition (Broekhuizen et al., 2014). Therefore, it is important that the smart mouthpiece can recognize the type of inhaler that is being used, to measure relevant operations concerning the inhalation technique.

By means of real-time feedback, the smart mouthpiece can coach patients immediately during inhaler use to support the correct inhalation technique. This feature corresponds to the persuasive design principle *'suggestion'*, because the mouthpiece offers fitting suggestions to carry out behaviours during the system use process (Oinas-Kukkonen & Harjumaa, 2009). Real-time feedback is presented in two different modalities, namely via (a) haptic, and (b) visual signals. These signals concern interrupted and uninterrupted vibrations and animated symbols (Figure 11).

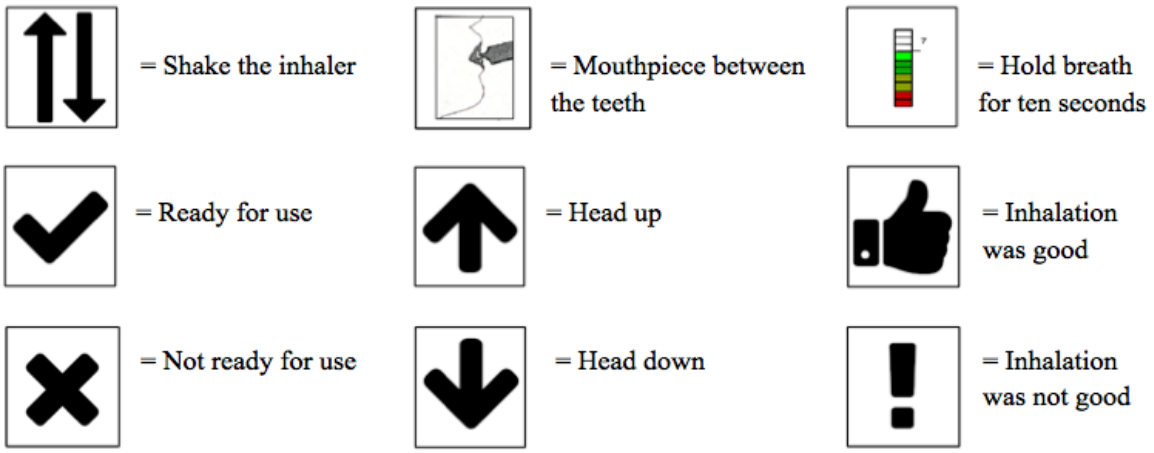

Figure 11. Screenshot: real-time feedback symbols

[2] http://inhalatorgebruik.nl/nl/home last retrieved on 10-03-2016

The signals indicate various operations concerning the inhalation. These operations are important to perform properly in order to achieve a sufficient lung deposition (LAN, n.d; Broekhuizen et al., 2014). For instance, when a user does not adopt the correct posture during inhalation (e.g. lowered head), the screen on the mouthpiece presents an arrow pointing upwards, indicating that the user must bring his/her head slightly up. As described earlier, by bringing the head up there is a clear passage for the medication to reach the lungs. Furthermore, when the patient should hold his breath after inhalation, a time bar will be presented which counts until ten.

The haptic feedback is integrated in the following way: when the user inhales to forcefully, the mouthpiece vibrates quickly and uninterrupted. However, when the user inhales to soft, the mouthpiece vibrates slowly and interrupted. When the user inhales properly, the feedback-inhaler is quiet. It is important for patients to inhale with an appropriate force. If the inhalation is not good, much of the medicine will remain in the oropharynx and mouth (Broekhuizen et al., 2014). Indirectly this haptic feedback *'provides information about the lung deposition'*, which is also one of the requirements for the prototype.

By means of ambient feedback, the dock station can give four different notifications (Figure 12).

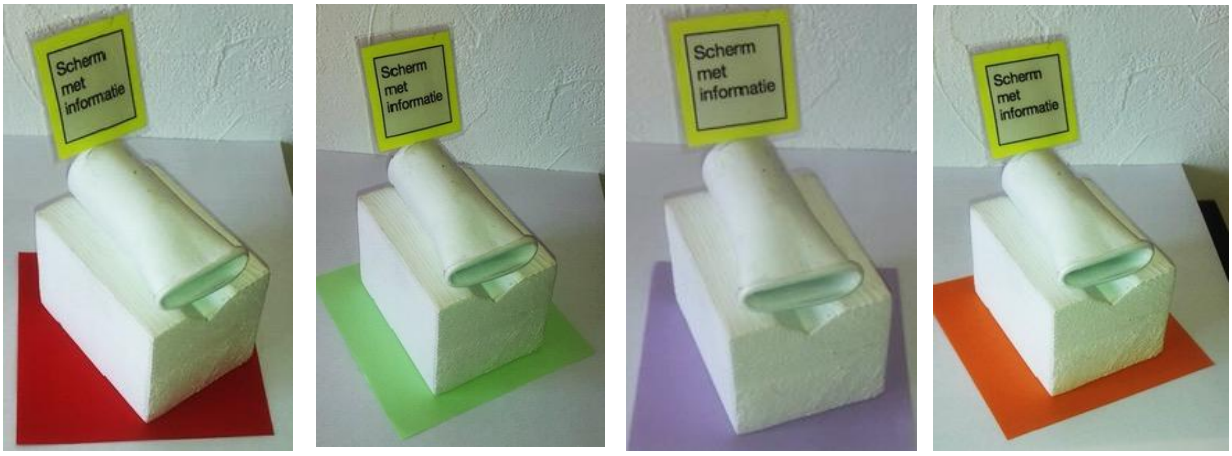

Figure 12. Screenshot mouthpiece: ambient feedback

Ambient feedback concerns different light signals, presented via the dock station in the colours green, red, purple and orange. These colours are randomly selected. By means of the user evaluations input can be obtained from the participants about these colours. When the dock system lights up and the colour green appear, this means that it is time to inhale. The colour red means that the patient has forgotten to inhale and the colour purple means that the mouthpiece must be cleaned. The colour orange means that the dose of the inhaler is running low and reminds users to order new medicine on time. This latter notification corresponds to the requirement *'Information about amount of dosages'*.

The mouthpiece can also be used to practice the inhalation technique. This corresponds to the persuasive feature *'rehearsal'*, because the practice mode enables users to rehearse the target behaviour (Oinas-Kukkonen & Harjumaa, 2009). When users want to practice they only need to use the mouthpiece without attaching it to their regular inhaler. This enables users to practice without inhaling a dose. During practice the feedback-inhaler can present the same signals to provide real-time feedback, as when the mouthpiece is attached to the inhaler.

4.2.2 Personalized Portal

The portal is a web-based platform both to support patients and healthcare professionals. The purpose of the portal for patients is (a) providing instructions about how to use the feedback-inhaler and (b)

providing educational support concerning inhaler use. For healthcare professionals the portal concerns a tool providing access to the history and the details of the inhalation technique of their patients.

4.2.2.1 Portal for patients

Information concerning the feedback-inhaler, inhalation medication and data about the inhaler use are available in the portal for patients. The instructions about the feedback-inhaler are presented stepwise and with illustrations (Figure 13), to make the information easy and quickly readable. This corresponds to the requirements to provide *'clear information'* and be *'time efficient'*.

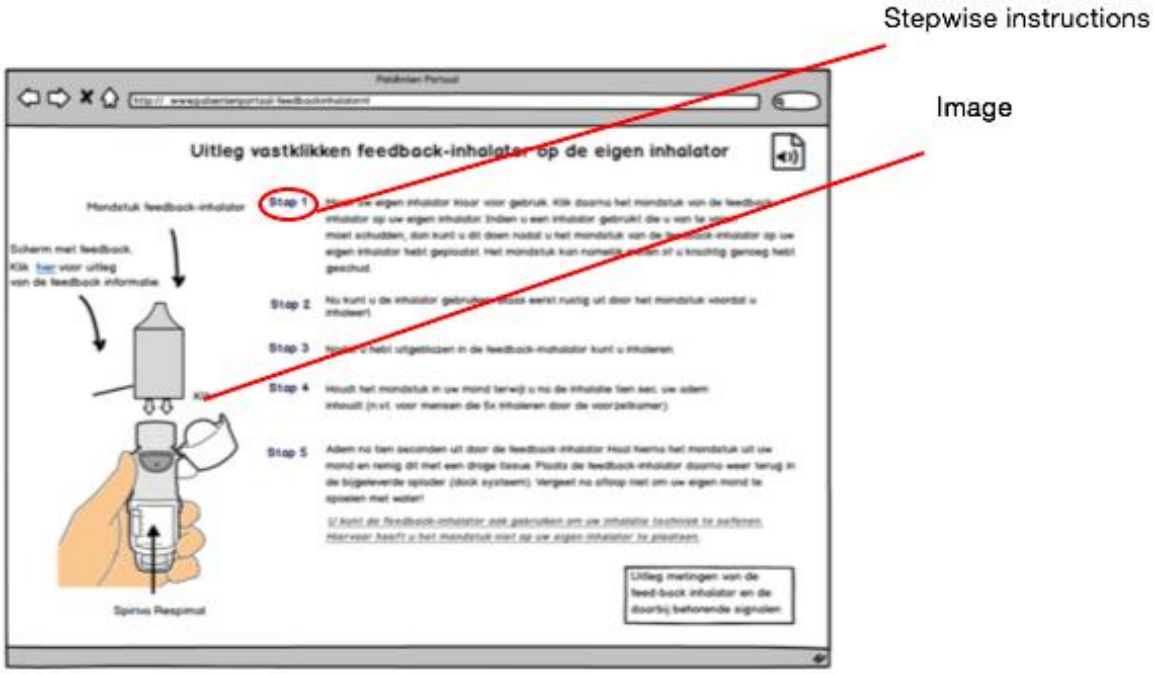

Figure 13. Screenshot portal: preview instructions

If the user is interested, he/she can look up the status concerning the inhalation technique. This information is only about the technique during the current day. Within the status, patients can find information about mistakes made during inhalation and an advice to correct them. This information meets the requirement *'information correcting mistakes'*. Also this information corresponds to the requirement *'independence from caregivers'*, because it provides direction to the patients without consulting a caregiver. Information about how to correct mistakes and instructions regarding the use of inhalers is based on information from the Dutch Lung Alliance. This to ensure the information is *'effective'*, which is also a requirement for the technology.

'Peer support' is also provided via a *'forum'* on the personalized portal. Patients can search for peer support by posting questions or support other peers by responding to questions (Figure 14). Patients can also consult the respiratory nurse via webcam or navigate to frequently asked questions within the portal for support.

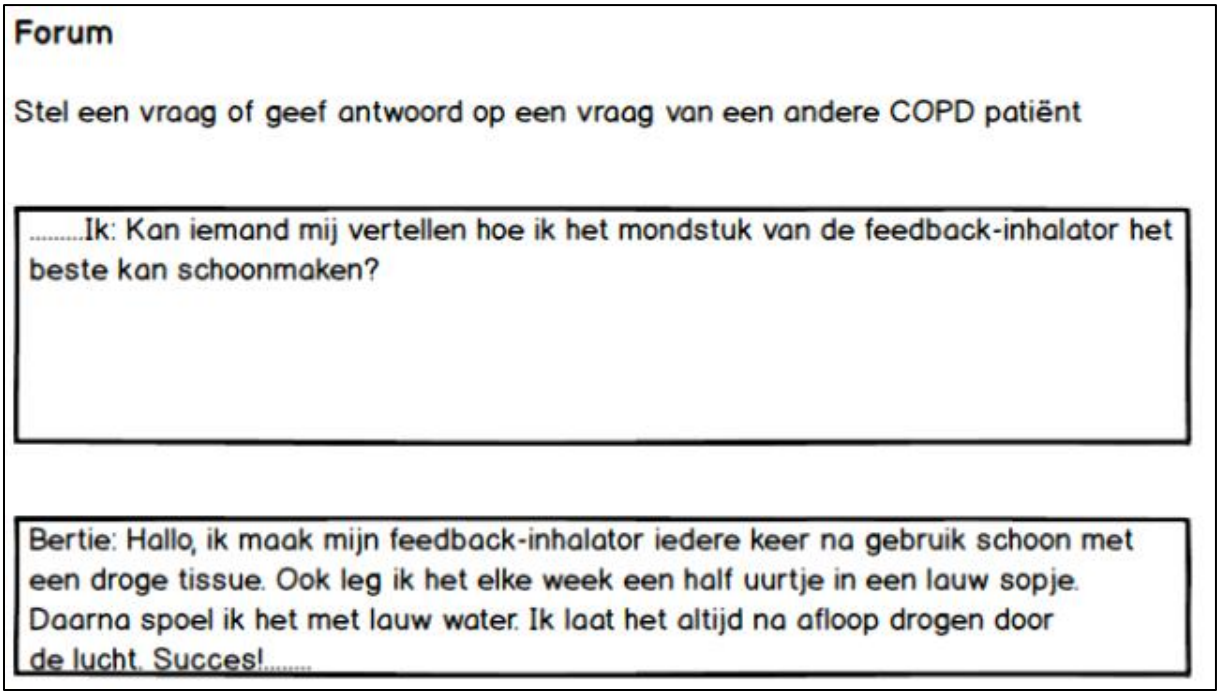

Figure 14. Screenshot: forum

'Instructions concerning the use of inhalers' are given by referring to the protocols of the LAN in the portal. When users are interested in the instructions of their type of inhaler(s), they can click on a link within the portal (Figure 15), which direct users to the website of the LAN (Figure 16). This corresponds to the requirement *'provide links and suggestions to other existing reliable sources of information'*. The website of the LAN concerns an existing human centered designed website with videos, pictures and written instructions of all types of inhalers. During user evaluations patients will not get to see this website but only the link they can click on.

Figure 15. Screenshot: link to website for further instructions on inhaler use

Figure 16. Screenshot: website instructions inhalation medication[3]

4.2.2.2 Portal for healthcare professionals

Data concerning diagnose, type of inhalation medication, history and the details of the inhalation technique of patients can be available for the treating pulmonologist and respiratory nurse. Only these healthcare professionals have access to the data of their patients, if the patient signed for informed consent. This corresponds to the requirement *'sending data to healthcare professionals'*. With the use of a secured code the pulmonologist and respiratory nurse can log into the portal. By entering the first- and surname of a patient (Figure 17), healthcare professionals can find the patient data (Figure 18). Only the data of patients that gave approval is available via the portal.

Figure 17. Screenshot: search patient data via portal

[3] http://inhalatorgebruik.nl/nl/home last retrieved on 10-03-2016

Figure 18. Screenshot: patient data

4.2.3 Using the prototype during the evaluations

During the user evaluations the prototype will be presented to the participants by means of a hardcopy paper version of the portal (Appendix 10 & 11). Furthermore, the researcher will present the mouthpiece attached to the docking station by brining the model of the plastic tube and block (Figure 9) (indicating the mouthpiece and docking station) to the evaluation and showing it to the participants. In addition, the researcher shows the different symbols and signals (Figure 11) via cards that can be inserted into the plastic tube.

Participants can use the prototype of the portal by clicking on the links with their forefinger. The researcher presents the subsequent pages after participants clicked on links. All data presented in the portal are fiction.

4.3 Evaluation

To gain insight in the usability of the feedback-inhaler, user evaluations are conducted. Results of these evaluations are presented in this subsection. First, the results from the user evaluations with patients are presented. Subsequently, the results from the user evaluations with the healthcare professionals are described.

4.3.1 Evaluation results with patients

4.3.1.1 Current use of technology

All participants indicate having experience using different types of technology. Technology, that they use for instance are the Internet, smartphone, I-pad, personal computers etc.

4.3.1.2 Using the feedback-inhaler prototype

During the user evaluations all patients received tasks to use the prototype of the feedback-inhaler. In general the majority of the participants were able to work with the prototype. However, some had difficulties fulfilling their tasks (Table 8). Below the results of the task performances are described.

Table 8

Task performance

		n	%
Task 1: Finding instructions about the feedback-inhaler	Correct route	6	42.86
	Detour	-	-
	Wrong route	8	57.14
Task 2: Searching for the status inhalation technique	Correct route	6	42.86
	Detour	2	14.29
	Wrong route	6	42.86
Task 3: Searching for options information support	Correct route	13	92.86
	Detour	-	-
	Wrong route	1	7.14

4.3.1.2.1 Task 1: Finding instructions about the feedback-inhaler

During the user evaluation, the first task for the participants was to find out how the feedback-inhaler works by searching for the instructions in the portal and reading the instructions. This was done by means of a paper prototype. Six participants managed to find the correct instructions immediately in the portal. The remaining eight participants struggled to find the correct route in the portal. These participants clicked on the instructions about the (regular) inhaler use instead of the ‘feedback-inhaler’ (Figure 19). One participant stated to name the instructions about the use of regular inhalers differently in the portal (e.g. ‘own medication’), to make the distinction between ‘instructions inhalers’ and

'instructions feedback-inhaler' more clear. A few participants needed some help from the researcher to find their way through the instructions. Some indicate that by giving the links colours in the portal, the path will be easier to find.

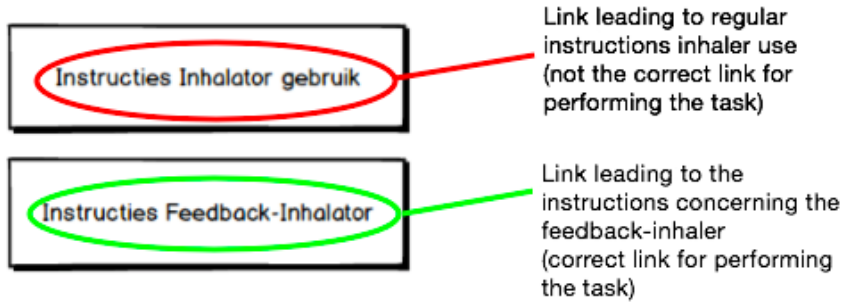

Figure 19. Screenshot: correct and incorrect link for performing task 1

4.3.1.2.2 Task 2: Searching for the status inhalation technique

The second task for the participants was to find out what went wrong during inhalation and how to correct these mistakes, after receiving the symbol of an exclamation mark. To find this information the participants needed to go to the status concerning the inhalation technique in the portal. Six participants found the information immediately and six participants couldn't find the information right away. Two participants used a detour. Figure 20 shows the different links that users clicked on trying to perform task 2.

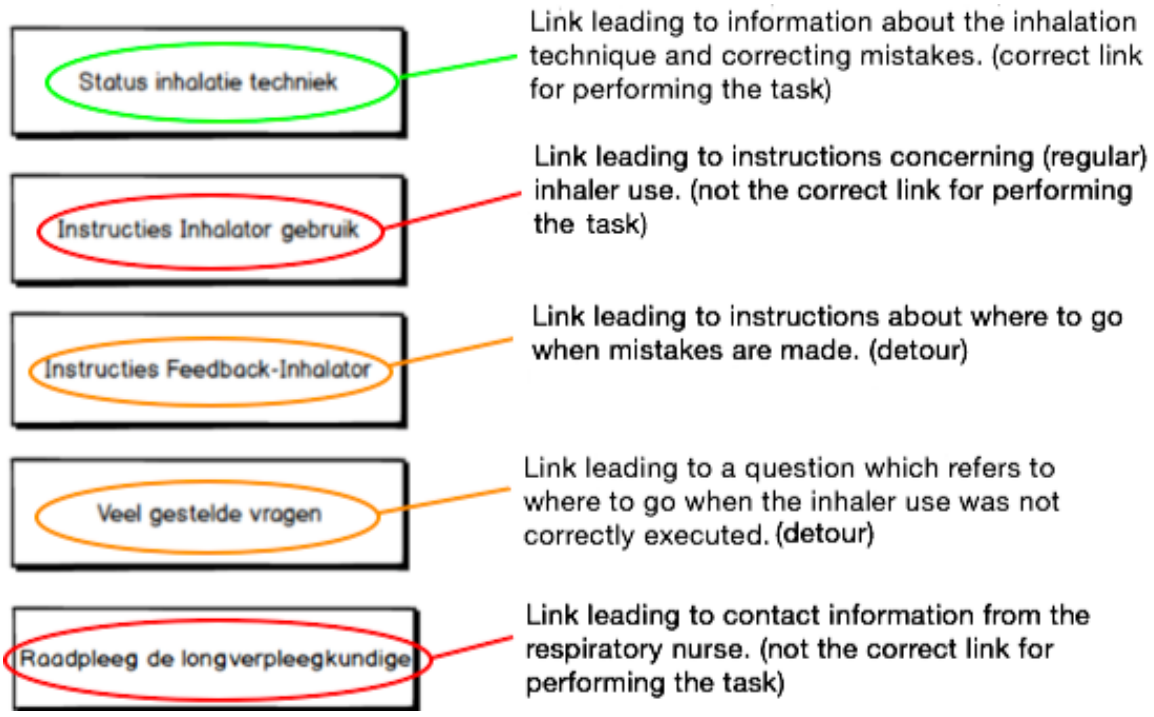

Figure 20. Screenshot: different links users clicked on to perform task 2

Three participants mention confusion about the name of the correct link called 'status inhalation technique', which leads to the information about the inhalation technique and correcting mistakes. According to them the words 'status' and 'technique' are confusing. To make this easier, eight participants mention adjustments. Seven participants indicate to rename the link, which lead to

the information, by using simple language and making the name more personal. Suggestions from participants are: “What went wrong”, “My status”, “What did I do wrong” or “Your inhalation technique”. One participant suggests using the symbol of the exclamation mark as a link in the menu of the portal to make the path in the portal clearer.

4.3.1.2.3 Task 3: Searching for options information support

The last task for the participants during the user evaluations was to look for the options in the portal to ask a random question. The technology offers three options where users can go to for questions, namely via: frequently asked questions (FAQ), consulting the respiratory nurse and a forum. Thirteen participants were able to find the correct route in the portal. One participant needed assistance from the researcher.

4.3.1.3 Overall impression concerning the feedback-inhaler

The majority of the patients gave their overall impression about the feedback-inhaler. Eight participants indicate to find it a useful system. Among those, two participants mention the system is convenient because it helps remembering using inhalers properly (Quote 1).

> *(Quote 1) “It is far too easy. You forget nothing and if you forget something you will be told immediately, it's a bit of a reminder. Think about this… think about that…” (Male, COPD patient)*

Another participant indicates the system being pleasant because it gives confirmation about whether or not the inhalation technique was good (Quote 2)

> *(Quote 2) “Well you receive a confirmation about whether you are doing well or not, and that I find pleasant... So it is nice to get confirmation about did I inhale properly”(Female, COPD patient)*

Two participants indicate the technology being cumbersome (Quote 3 & 4).

> *(Quote 3) “It is cumbersome. For some people it's good and convenient. There are probably many COPDers that might not have a job. However, my intention is to go back to work soon. So I'd rather use it to practice” (Female, Asthma patient).*

> *(Quote 4) “I feel that it is rather complicated... It presupposes already a few extra things... and that means that it becomes such a ritual. It becomes too much…” (Male, Bronchiectasis patient)*

Some participants mention questions, general adjustments and additions to the feedback-inhaler. One participant wonders how the system works when you are going away for a while and there is no Internet. The participant suggests Wi-Fi or Bluetooth as a good solution for this problem. Also two participants wonder about the battery runtime and one indicates preferring a runtime of at least a day. Furthermore one participant likes the mouthpiece to be compact and lightweight for traveling. The participant indicates to prefer a complete system that does not have to be assembled every time. This is in line with the opinion of another participant who mentions to like the technology build in to his AeroChamber® so that he does not have to do extra work. One participant would like a travel charger and two participants would like a charger with USB. In this way the device can be charged via smartphone, computer or in the car. One participant mentions that it is especially

important that the technology is universal and that it is applicable to all types of inhalers. Furthermore, one participant indicates the system must give a signal when there is a malfunction. Another participant mentions it is especially important that the screen on the mouthpiece is clearly visible because when he uses his inhalers in the morning he is not yet ready for the day. Lastly, concerning the hygiene of the system, one participant mentions she does not want to have the mouthpiece and docking station openly in her house because she thinks this is unclean. Because of dust she would like something to cover it up to keep it clean.

4.3.1.4 Motivation to use the feedback-inhaler

Participants are asked whether they would like to use the feedback-inhaler on daily basis. Thirteen of them indicate to want to use the feedback-inhaler to improve the inhalation technique. One participant indicates that after a few weeks he expects to stop using the device because he does not want to perform many operations on daily basis. Also three participants think they do not really need the feedback-inhaler to improve their inhaler use. One participant mentions to rather practice every once in a while instead of using the device every day (Quote 5)

> *(Quote 5) "I believe I would rather use it every once in a while to practice… when I speak for myself I do not think I will use it every time… because I am already spending lots of time on the inhalations … then I rather practice once or twice a week to check whether I am still doing a good job or not" (Female, Asthma patient)*

One participant mention to think the feedback-inhaler is especially useful when you get oblivious. Another participant thinks the device is handy when you are breathless so you can check to what extent you are doing fine. In contrast, another participant thinks the device would not be handy when you are short of breath. According to this participant the signals of the feedback-inhaler will make no difference when you are out of breath.

Ten participants indicate that they think that the feedback-inhaler is of added value to improve the inhalation technique. Seven participants name 'types of people' who might benefit most. According to three participants, patients who start with inhalation medication for the first time might benefit most. Also participants mention that, children, nervous patients, patients that are chaotic and patients who are forgetful might benefit most.

4.3.1.5 Features of the mouthpiece

4.3.1.5.1 Real-time feedback

All fourteen participants have a positive attitude towards the feature 'Real-time feedback'. Participants mention it to be very convenient. Eight participants indicate that they think the real-time feedback can improve their inhalation technique. One participant mentions it can help you concentrate during inhalation (Quote 6). Another participant argue it can correct mistakes and serves as a reference frame to talk about (for instance with the pulmonologist) (Quote 7).

> *(Quote 6) "That all will come on that thing, on this screen? Oh that's great, then you really learn to focus" (Female, Asthma patient)*

> *(Quote 7) "It can restore misuse and that's a positive thing. You want to receive your medicine properly. You should not say the doctor prescribed me the wrong medication… no I have to do it properly. And that is the point of the signals… It is a good help to know I'm doing*

well and if I should need other medications, then I have a reference frame to talk about" (Male, COPD patient)

One person thinks that it takes time getting used to the real-time feedback, but when you are used to it, it can be very handy. According to this participant, it is important to clearly inform whether you should inhale again when initially the inhalation went wrong (Quote 8).

(Quote 8) "If you do not do well… okay do I have to do it again? And what if I do it wrong three times in a row… what should you do then?" (Female, COPD patient)

4.3.1.5.1.1 Adjustments to improve the real-time feedback

Although all participants are positive towards the real-time feedback, many participants suggested adjustments to make this feature user-friendlier and the feedback signals (e.g. haptic and visual feedback) more clear. Six participants propose adaptations for the different visual signals, presented by the system (Table 9).

Table 9

Findings in relation to the visual signals

Symbol		n	%
Exclamation mark: inhalation was not good	Unclear	2	33.33
Check mark/cross: device is ready for use or not	Inefficient	2	33.33
Time bar: hold breath for ten seconds	Unclear	1	16.67
Two arrows: shake the inhaler	Unclear	1	16.67

Two participants indicate that the signal of the exclamation mark, which is presented when the inhalation technique is not properly executed, is unclear and that it can indicate something positive instead of something negative (Quote 9). Instead of the exclamation mark they rather see the screen turn to red or a symbol of a question mark.

(Quote 9) "An exclamation mark can also say excellent" (Male, COPD patient)

Furthermore, two participants mention adjustments for the symbols indicating whether or not the system is ready for use (Figure 21). One participant prefers to see an open circle to indicate the system is ready and a closed circle to indicate that it is not. The other participant prefers to only see the checkmark when the system is ready and to see nothing when the system is not. Therefore, the symbol of the cross can be excluded. Concerning the symbol of the time bar (Figure 22), one participant mentions to prefer a clock on the screen to indicate the amount of seconds to breath hold. According to her, this will be clearer. She indicates that the system could also use beeps to indicate the proper posture instead of arrows. Lastly, with regard to the 'shake sign' (Figure 23), one participant mentions to prefer to see the word 'shake' on the screen instead of the symbol, because he thinks the symbol is not clear.

Figure 21. Screenshot: ready for use symbols

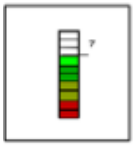

Figure 22. Screenshot: time bar indicating to breath hold

Figure 23. Screenshot: arrows indicating to shake the inhaler

With regard to the clarity of the visual signals, one participant mentions to make the symbols as broad as the screen and to give them colours. According to him, this makes it clearer and also visible when users inhale in the dark. Furthermore, this participant indicates to use animated symbols, to make them more noticeable. Lastly, this participant mentions the distance between the eyes and the screen being to close and this needs to be looked at, otherwise the feedback could be less visible.

Three participants indicate to prefer adjustment's concerning the haptic feedback. One participant indicates ambiguity between rapid vibrations and slow vibrations. Instead of haptic feedback, this participant prefers a symbol of a mouth and an arrow on the screen to indicate the degree of the inhalation strength. Another participant indicates that during inhalation, vibrations are probably irritating. According to him there must be an option to choose the desired signals to indicate the inhalation strength (e.g. vibrations or sounds). Lastly, one participant mentions the haptic feedback might be confusing. Currently when the user inhales to hard, the mouthpiece vibrates quickly and uninterrupted and when the user inhales to soft the mouthpiece vibrates slowly and interrupted. According to the participant this should be the other way around, because she thinks you will copy the speed. In other words, when it vibrates quickly, automatically you will also inhale quickly and when it vibrates slowly, you will also be inclined to inhale slowly.

A few participants name additions to the real-time feedback presented via the mouthpiece. One participant mentions it would be nice if the screen, with feedback were also visible for surrounding persons, to indicate they cannot disturb during inhalation (Quote 10).

> *(Quote 10) "Sometimes I use the inhaler in the train or in company…and when you hear the sound of the puff then people usually ask questions about what it is. And just in those ten seconds. And then for instance you can point it… Like look and wait a minute…" (Female, COPD patient)*

Another addition is to insert a blocking system into the mouthpiece. When the inhalation technique is not properly conducted, the system stops and there will be no dose release (Quote 11).

> *(Quote 11) "Actually there should be a blocking system on it. If you do not use the inhaler properly the thing stops. Otherwise if you have not done well and you have to start over then you probably get an overdose..." (Male, COPD patient)*

Two participants indicate that a signal should be added, pointing out the degree to which the inhaler is used sufficiently. In the current situation users only receive a signal indicating whether the inhaler was used properly or not (Figure 24). One participant suggests it would be good to give a percentage to indicate the degree to which the inhalation went well. According to him this will lead to people trying to do better.

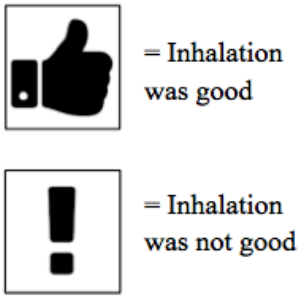

Figure 24. Screenshot: symbols indicating correct inhaler use

With regard to the action 'shaking the inhaler' before use; one participant mentions this is an operation he prefers to do before attaching the mouthpiece with sensors to the regular inhaler. Hence, the participant prefers a sign, which will be presented after the mouthpiece is attached to his own inhaler, saying: "Did you shake your inhaler?" instead of a feedback signal indicating, "Shake the inhaler". Also another participant mentions that if you have to shake the whole device (the mouthpiece with sensors and the inhaler) this might be inconvenient because it could fall of.

Concerning the feedback to breath hold for ten seconds after inhalation, four participants mention it to be hard sometimes to breath hold. According to these participants when you are out of breath, you are unable to hold the breath long enough. One participant indicates to wonder if five seconds is enough instead of ten, because this is what she initially learned. Another participant suggests inserting a button in the system, which you can press when you are out of breath. According to this participant, then you can inform the feedback-inhaler about your situation. Consequently, the system can take breathlessness into account (Quote 12).

> *(Quote 12) "Just a button with which you can indicate: then I was short out of breath and hence I couldn't manage it and it went wrong. So you see the error message after inhalation, however in text you also see: it is because you are out of breath and maybe it will go better next time" (Male, COPD patient)*

4.3.1.5.2 Notifications

The feature notifications concern four types of reminders presented via ambient feedback in the colours, green, red, purple and orange. These notifications support users to not forget using the inhaler on time, ordering new medication in time and cleaning the mouthpiece of the feedback-inhaler

regularly. Eight participants indicate to find the notifications helpful reminders. One participant mentions that the notification indicating you are late is especially helpful (Quote 13).

> *(Quote 13) "Sometimes I am not sure whether or not I used my inhaler, because it is an automatism. So I do not know…but then you can see it? Yes I think this is convenient" (Female, COPD patient)*

Five participants think some notifications are unneeded. According to four participants they do not forget to use the inhaler and because of that the notifications 'it is time to inhale' and 'you forgot to inhale' are unnecessary. Two participants indicate that they find the notification about the amount of dosages unneeded. One participant indicates that she finds the notification about cleaning the mouthpiece of the inhaler with smart sensors unneeded.

4.3.1.5.2.1 Adjustments to improve the notifications

Concerning the usability of the notifications, two participants indicate preferring to receive the notifications via an app on the smartphone. Also another participant indicates that it might be easier to have a scheme in the telephone in which you can set up the times you need to use the inhaler. One participant indicates to find it a hassle to log in to the portal and look up for the advice when you receive the notification that you forgot to inhale (the red notification) (Quote 14). Hence, she proposes the idea of developing an app to speed up the process.

> *(Quote 14) "Then it says you have to go to the portal… So then I have to go to the Internet… well off course this can be done quickly. However, I need to log in again and I would think what a hassle. Can't you develop an app instead of a portal purely to make the actions go faster?" (Female, Asthma patient)*

With regard to the signals of the notifications, one participant prefers different colours for the ambient feedback. According to this participant the colour green will not stand out and that is why he prefers bleu. Another participant prefers an alarm instead of ambient feedback. According to this participant, people who are demented could forget the meaning of the colours. One participant indicates to inhale in the morning and the evening and therefore he keeps his inhalation medication upstairs. Because of that he does not want ambient feedback and prefers the option to turn it off or to choose another type of alarm, for instance a short vibration or a beep. Furthermore, he likes to be able to turn off the notifications and choose which are important for him. One participant wonders whether the colours are also clear for persons suffering from colour-blindness. Therefore, this participant suggests using icons to make it easier.

Concerning the meaning of the notifications. One participant indicates to like the notification regarding the amount of dosages, but it is not specific enough for her. She would like to know precisely the amount of dosages left in her doses aerosol instead of an estimate of the maximum amount of dosages. One participant suggests using more colours to indicate that the inhaler is 'full', 'half full' or 'almost empty', to make it easier to order a new dose on time. Another participant mentions he liked to be notified about when to clean all his inhalers instead of only cleaning the mouthpiece with smart sensors.

4.3.1.5.3 Practice mode

The practice mode concerns a feature of the mouthpiece that enables users to practice the inhalation technique without inhaling a dose (i.e. placebo). Eleven participants indicate that this is a good feature. One participant mentioned this feature is convenient because you do not have to go to anybody else

for help and this might save money. Another participant mentions that the practice mode is especially handy when new medication is prescribed. Not everybody thinks a practice mode is necessary.

4.3.1.6 Features of the portal

4.3.1.6.1 Instructions feedback-inhaler

The portal describes instructions about the feedback-inhaler. Eight participants indicated that the instructions are clear. One participant mentions not knowing how the feedback-inhaler works after reading the instructions. Also three participants indicate to find the language confusing, like the words 'exhaling', 'feedback' and one of the links named: 'explanation attaching mouthpiece to regular inhaler'. Furthermore, one participant indicates not understanding the illustration presented via the portal, displaying the mouthpiece and dock station (Figure 25) (Quote 15).

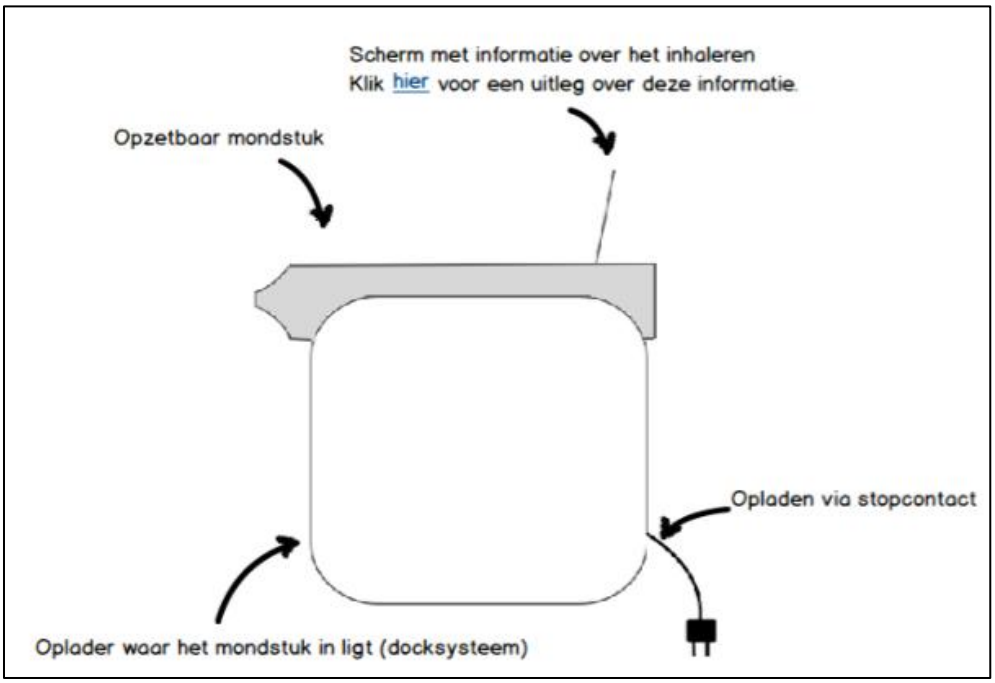

Figure 25. Screenshot: side view mouthpiece attached to the dock station

> *(Quote 15) "Based on the drawing I cannot see exactly what it is. It's probably some sort of holder, but it is not entirely clear yet" (Male, COPD patient)*

Five participants indicated the instructions were too long. One participant indicated to prefer it more simple and short (Quote 16). Also this participant wonders why the instructions are needed, while the system already displays whether or not the inhalation is correct.

> *(Quote 16) "Mamma mia... I totally do not look forward to this…I need to have it simple… (Female, COPD patient)*

Another participant indicated to not really mind it that the information is extensive, because you can always revert to it by logging into the portal (Quote 17).

> *(Quote 17) "Yes, I'm fine with that because you can go back any time. You can take the time as long as you want to actually ...(Female, COPD patient)*

4.3.1.6.1.1 Adjustments to improve the instructions about the feedback-inhaler

Six participants mention adjustments to the instructions about the feedback-inhaler, to make it clearer. Two participants indicated that they rather see a short video about the instructions and keep the written instructions as short as possible and stepwise. Also they mention to prefer the instructions being spread to multiple pages. For instance, one participant suggests that the explanation of the visual feedback (e.g. the symbols), the ambient feedback and the haptic feedback should be described on three different pages instead of one (Figure 26).

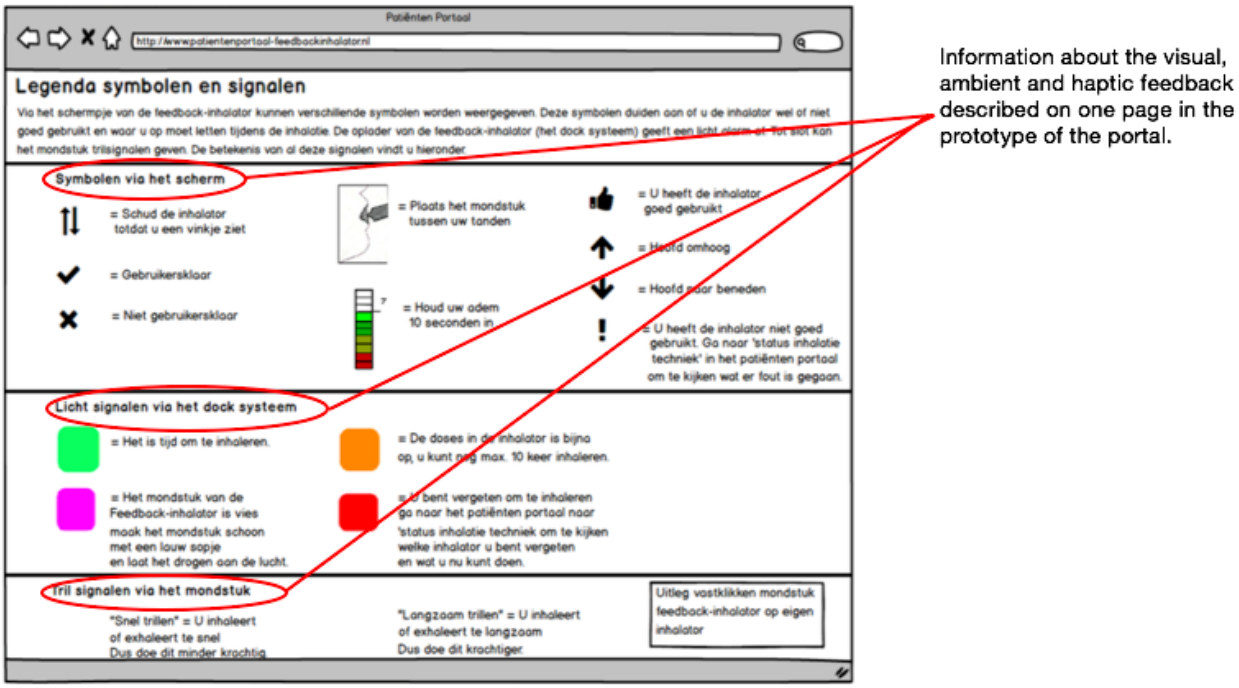

Figure 26. Screenshot: instructions real-time feedback and notifications

Two participants indicate to prefer more illustrations than text. According to one of them the illustrations should be 3D, and by means of words and colours the different components of the technology should be displayed. Another participant indicates to prefer the use of icons more. Furthermore, this participant would like to see icons of faces combined with the arrows that indicate whether the head must go up or down in the instructions to make it more clear. Lastly, one participant mentions to wish more consistency in the wording of the instructions.

4.3.1.6.2 Instructions regular inhaler use

The portal does not provide instructions about the regular use of inhalers. Instead, the portal refers to a link of an existing website with instructions about regular inhalers where users can go to when they feel the need to consult the instructions (Figure 15). Ten participants indicate to not mind being referred to another website with information. Two participants would like to find the information in the portal. One of them want's this information to be specific and only about the used inhalers. Another participant indicates always being in a hurry and because of that she prefers short information. Lastly, one participant wonders if there could be an app of these instructions.

4.3.1.6.2.1 Adjustments to improve the instructions about regular inhaler use

With regard to the way the link is presented in the portal, one participant mentions it would be a good addition to describe what people can expect on the website, otherwise users might think they will see a complex leaflet while in fact they will find clear videos about the instructions. Another participant mentions to find it important that the link also works on smartphone and tablet.

4.3.1.6.3 Information correcting mistakes

Information about the current day inhalation technique and possible mistakes is also available via the portal. All fourteen participants find this information clear. One participant thinks the way in which the information is presented is uncluttered. Thirteen participants indicate to find the information about what went wrong during inhalation a good feature. One participant only thinks this feature is important in a period of practice.

4.3.1.6.3.1 Adjustments to improve the information correcting mistakes

Participants are asked if the information in 'status inhalation' technique is enough in order to do better next time. Thirteen participants think the information is enough. Some participants named adjustments for the information concerning the inhalation technique. Three participants would like to see the information in less text and more icons. Furthermore, one participant would like to see explicitly whether the inhalation must be performed again. Instead of only receiving information about the technique of the current day, one participant would like to see the history of the inhalation technique presented in a graph, (Quote 18).

> *(Quote 18) "So you can look over time how well it goes. Is it going well? This also seems to be useful to me" (Male, Bronchiectasis patient)*

Another participant thinks it is good to also point out positive things concerning the inhalation technique instead of only summing up the negatives (e.g. the mistakes). According to her it is better to bring the information in a less negative way because some might not like hearing things that were not good. One participant thinks a short substantiation should be added about the importance of following the advice to improve the inhalation. Lastly, one participant indicates that it is important to add an extra reminder to use the inhaler properly next time (Quote 19).

> *(Quote 19) "When you pick up the device and switch it on you receive a reminder about what went wrong the last time. So you can see for instance that you need to keep your head up more this time" (Male, COPD patient).*

4.3.1.6.4 Personal details

Users can also find their personal details in the portal. This concerns information about their pulmonologist, diagnose, type of inhalers and dosage. Six participants indicate to have a positive attitude towards the information. One participant, mentions to dislike being confronted with her diagnose. Also another participant thinks it is unneeded to see the diagnoses in the portal. Two participants indicate to doubt whether they would use the information under 'my details'.

4.3.1.6.4.1 Adjustments to improve the personal details

Five participants indicate to like to see additional contact information of their pulmonologist and/or respiratory nurse. Two participants indicate that the history of the inhaler use should be presented here, to self-monitor the inhalation technique. Two participants mention they would like the ability to insert information about the medication use, their mood and personal goals. Furthermore, another

participant would like to see the personal hospital number and date of birth. Another participant would like to see the expiration date of the AeroChamber®, the date of usage of the inhalation medication and the initial number of doses per inhaler. One participant would like information about other ailments and related medication, and another participant would like information about the lung capacity. Lastly, one participant would like an explanation on the reason of using the specific types of inhalers and one participant would like to see the appointments with the pulmonologist and/or respiratory nurse.

4.3.1.6.5 Options for information support

The portal provides different options for information support. Options provided via the portal are a forum, frequently asked questions (FAQ) and the possibility to consult the respiratory nurse (e.g. via webcam). Six participants indicate to have a positive attitude towards the FAQ. Furthermore, nine participants have a positive attitude towards the feature 'consulting the respiratory nurse' (Quote 20, 21 & 22).

> *(Quote 20) "I think it is important and it should be an option that you can just ask a question directly or send a message describing this and that is going on…do I have to come and see you or can we fix it now?" (Male, COPD patient)*

> *(Quote 21) "It is quite nice to video chat via the webcam, if you are out of breath and you cannot go there or whatever" (Female, Asthma patient)*

> *(Quote 22) "Mostly they can see from your face that something is wrong. It is more personal" (Male, COPD patient)*

Six participants have a negative opinion about a forum. Most of them find it impersonal and dislike the negative stories posted on it by their peers. One participant finds it more pleasant having contact with peers she personally knows. One participant is not enthusiastic about the FAQ. Three participants do not have a positive attitude towards video chatting with the respiratory nurse, and one participant wonders whether this is feasible.

Concerning the use of the options for information support, the majority of the participants indicate that they want to use the FAQ and consult the respiratory nurse. Most participants indicate to want to use the forum the least.

4.3.1.6.5.1 Adjustments to improve information support

Two participants name adjustments to improve the options for information support. One participant mentions there is already a forum on the website of the lung fund. According to this participant it might be good to link this forum to the portal. Furthermore, this participant wonders whether a forum is necessary and whether providing a link to the manufacturer of the feedback-inhaler is more suitable, to enable users to find specific information related to the feedback-inhaler. Another participant also mentions to want to know more about the specifics of the feedback-inhaler, for instance, the battery life of the device. Furthermore, this participant would like the FAQ (Figure 27) categorised in main themes, to make a clear overview.

Figure 27. Screenshot: frequently asked questions

4.3.2 Evaluation results with healthcare professionals

4.3.2.1 Using the prototype of the portal for the healthcare professionals

4.3.2.1.1 Task: Finding the results of 'Johan Dekker'

During the user evaluation, the healthcare professionals received the task to search for patient data of a fictive patient called 'Johan Dekker' in the portal. All participants indicate that the data of the patient was easy to find. Four participants advocate that patients' data should be searched with a corresponding hospital code or date of birth instead of only the patient's name. One participant mentioned it is dangerous to search for patient data only by name.

4.3.2.2 Overall impression concerning the portal

With regard to the portal for the healthcare professionals, all participants have a positive impression. Four participants indicate to expect the portal to be useful for them. One participant mention to dislike to log in every time when using the portal. According to him the portal should be easy and quickly usable.

4.3.2.3 Clinical relevance of the portal

Participants are asked whether they can assess the adherence of their patients and make future decisions about treatments based on the information concerning the inhalation technique in the portal. All participants indicate that based on the presented information they are able to say something about the adherence of their patients. Furthermore, all participants indicate they can make decisions about the treatment of their patients based on the information.

4.3.2.4 Motivation to use the feedback-inhaler

All participants have a positive attitude towards the implementation of the feedback-inhaler. Some participants name conditions under which they like the technology to be implemented. One pulmonologist wants the feedback-inhaler to be usable and available for all patients and all types of inhalers. According to him if only half of his patients use the feedback-inhaler, it will be unhandy. In other words, it should be available and used by all of his patients or otherwise it should not be implemented. Another pulmonologist indicates explicitly that he does not want to arrange and explain things concerning the feedback-inhaler in his consultation room. According to him this should take place outside his consultation. Also another participant indicates that the respiratory nurse should give the instructions concerning the technology. One pulmonologist indicates to first want to participate in a pilot before deciding to implement the technology.

4.3.2.5 Features of the portal for the healthcare professionals

4.3.2.5.1 Patient data

Concerning the patient's status description, two participants indicate to find the status description too strict. The prototype shows that Johan's status concerning the inhalation technique is fair. Two participants indicated to find this too strict because Johan only made a few mistakes in the past. One pulmonologist does not think the strict manner of evaluation fits the current practice and this might set a high bar (Quote 1).

(Quote 1) "If you call this reasonable, then you set the bar too high and then you are going to

get this automatically. Then everyone is a worse pulmonologist and a worse patient. No one does it well" (Male, pulmonologist)

According to both participants when 70% of the inhaler use goes right, then this should be indicated as good. Between 50% and 70% should be rated fair and when it is fewer than 50% you should see whether this could be improved. Also another participant wonders what 'fair' means. He likes to know the starting point of the patient (Quote 2).

(Quote 2) "Status fair... So what do I have to do with it, what is good? What is the starting point? What did you taught him. Was he dumb or smart regarding the inhaler use?" (Male, Pulmonologist)

With regard to the data overview concerning the inhalation technique, three participants think the results are clearly presented. Two participants think the information is not clear. According to one pulmonologist the overview with results is terrible and too extensive (Quote 3).

(Quote 3) "I am not waiting for all this kind of information. This is too much information. It is too extensive and I do not like this" (Male, pulmonologist)

4.3.2.5.1.1 Adjustments to improve the patients data

With regard to the patient information, one participant named some adjustments. According to him the gold stage should be described differently and the times to inhale a dose should be added. Furthermore, the dose and type of inhalers should be described in less text.

Four participants mention adjustments to make the overview concerning the patients inhalation technique more clear. Three participants indicate that the information should be reduced to a clearer overview. According to the medical microbiologist there should be a ready-made answer concerning the inhalation technique and a corresponding advice with one push on a button. Two other participants indicate that it might be convenient when there is a small report of the patient's inhalation technique that patients can bring to their respiratory nurse and pulmonologist. One pulmonologist indicates to like a compilation about the patient's inhalation technique presented in one flowchart or cobweb chart instead of searching for the results himself (Quote 4).

(Quote 4) "You want to spend your time on other things. So the question is whether the doctor should receive some sort of compilation of the patient's results instead of searching for it. It sounds silly but pulmonologists want to minimize time doing other things then sit and chat with patients. In a manner of speaking he wants to receive a cobweb chart or something. I would prefer this more than searching for all the data myself" (Male, pulmonologist)

According to one participant the monthly overview should contain symbols to indicate the kind of mistakes instead of only check marks or crosses to indicate whether the inhalation was properly executed (Figure 28) (Quote 5).

(Quote 5) "You do not want to check all the crosses. I do not have time to do that… it is useless" (Male, pulmonologist)

November, 2015

Spiriva Respimat | Seretide + voorzetkamer

Week	Maandag	Dinsdag	Woensdag	Donderdag	Vrijdag	Zaterdag	Zondag
44	26 1e puf ✓ 2e puf ✓	27 1e puf ✓ 2e puf ✓	28 1e puf ✓ 2e puf ✓	29 1e puf ✓ 2e puf ✓	30 1e puf ✓ 2e puf ✓	31 1e puf ✓ 2e puf ✓	1 1e puf ✓ 2e puf ✓
45	2 1e puf ✓ 2e puf ✓	3 1e puf ✓ 2e puf ✓	4 1e puf ✓ 2e puf ✓	5 1e puf ✓ 2e puf ✓	6 1e puf ✓ 2e puf ✓	7 1e puf ✓ 2e puf ✓	8 1e puf ✓ 2e puf ✓
46	9 1e puf ✓ 2e puf ✓	10 1e puf ✓ 2e puf ✓	11 1e puf ✓ 2e puf ✓	12 1e puf ✓ 2e puf ✓	13 1e puf ✓ 2e puf ✓	14 1e puf ✓ 2e puf ✓	15 1e puf ✓ 2e puf ✓
47	16 1e puf ✓ 2e puf ✓	17 1e puf ✓ 2e puf ✓	18 1e puf ✓ 2e puf ✓	19 1e puf ✗ 2e puf ✗	20 1e puf ✓ 2e puf ✓	21 1e puf ✓ 2e puf ✓	22 1e puf ✓ 2e puf ✓
48	23 1e puf ✓ 2e puf ✓	24 1e puf ✓ 2e puf ✓	25 1e puf ✓ 2e puf ✓	26 1e puf ✓ 2e puf ✓	27 1e puf ✓ 2e puf ✓	28 1e puf ✓ 2e puf ✓	29 1e puf ✓ 2e puf ✓
49	30 1e puf ✓ 2e puf ✓	1 1e puf ✓ 2e puf ✓	2 1e puf ✓ 2e puf ✓	3 1e puf ✓ 2e puf ✓	4 1e puf ✓ 2e puf ✓	5 1e puf ✓ 2e puf ✓	6 1e puf ✓ 2e puf ✓

Figure 28. Screenshot: patient data overview

According to this participant, this is more convenient because based on symbols you can see the inhalation technique at a glance, without searching for more specific data in the portal. Furthermore, this participant would like to see the data summarized over a timeline of half a year, because patients come to him once every year. The respiratory nurse wishes to see the prescribed dose of the patient on every overview with data concerning the inhalation technique.

With regard to the content of the information, two participants indicate that the flow rate is too high and should be around 30 and between two ranges. Furthermore, one participant indicates to not speak of inhalation strength but only about flow, because inhalers can have a high or a low resistance and this will influence the flow rate.

4.3.2.6 Overall impression concerning the feedback-inhaler

All healthcare professionals gave their overall impression about the feedback-inhaler. One pulmonologist mentions it is good to correct frequent mistakes from patients. However, according to him, because the technology measures many different things, it would probably be vulnerable for errors and this should be considered. The pulmonologist indicates that the feedback-inhaler would be a fantastic device, if the technology is functioning properly. Another pulmonologist indicates that the technology has good things and drawbacks. The pulmonologist indicates that the attachable mouthpiece with sensors will influence the long deposition (Quote 6) and this is an important disadvantage.

> *(Quote 6) "With the size you can change quite a lot of the dynamics… and guaranteed that this will bring problems concerning the deposition" (Male, pulmonologist)*

One pulmonologist thinks that the mouthpiece is not suitable for patients with false teeth. Also this pulmonologist does not think the docking station, presenting ambient feedback is a good idea. According to him it is more practical to link the system to a smartphone, partly because the mouthpiece must be compact for travelling. The respiratory nurse and the medical microbiologist both think the technology is good. According to the medical microbiologist it is useful to provide patients with feedback systematically.

With regard to the effectiveness of the technology, three participants think the technology can help improve the inhalation technique of their patients. One participant thinks it can help some patients but for others it will not help. Concerning the aims of the technology (e.g. enhancing therapeutic effects and quality of life, preventing exacerbations and hospitalization), five participants expect the technology (in theory) can be useful in reaching its goals. One participant does not believe that by improving the inhalation technique, exacerbations can be prevented. However, he does think the technology can enhance quality of life (Quote 7).

> *(Quote 7) "I wonder whether you can prevent exacerbations with it, but I think you can foster quality of life… I do not really believe that the inhalations can prevent exacerbations or that inhaling better can prevent exacerbations" (Male, pulmonologist)*

One participant indicates that the technology is not able to measure the most important thing, namely the lung deposition.

4.3.2.7 Features feedback-inhaler

4.3.2.7.1 Real-time feedback

With regard to the real-time feedback, one participant indicated ambiguities concerning the symbols. This pulmonologist indicates to not understand the symbol displaying placing the mouthpiece between the teeth (Figure 29). Furthermore, according to him patients could interpret the exclamation mark (meaning the inhaler use was not correct) as a positive sign instead of a negative sign.

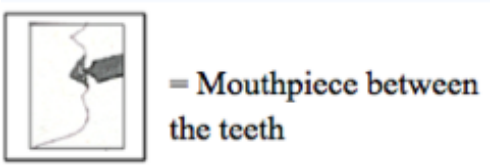

Figure 29. Screenshot: symbol indicating to place the mouthpiece between the teeth

Concerning the real-time feedback indicating the duration of breath holding (ten seconds), two participants mention the duration is too long for patients. In contrast, one participant thinks that most COPD patients should be able to breath hold for ten seconds when you instruct them well (Quote 8).

> *(Quote 8) "But actually most COPD patients and also Gold stage 4 patients… if you instruct them well then they are all capable of breath holding for ten seconds…Yes patients always receive my advice to sit while using the inhaler. When they use the inhaler while sitting in a rest position with their back against the seat and taking time. So do not do it between the acts, because that is not the right method" (Male, respiratory nurse)*

According to this participant, breath holding for ten seconds or as long as possible is important to have a sufficient lung deposition.

4.3.2.7.1.1 Adjustments to improve the real-time feedback

When users are shown the exclamation mark they need to go to the portal to see what they did wrong and how to improve. One pulmonologist thinks patients make frequent mistakes and are not motivated to log in the portal every time to search for the information about the mistakes. He suggests presenting information about the mistakes on the screen of the mouthpiece by means of the symbols.

According to the respiratory nurse it might be a good addition to measure the duration of the inhalation. This because a short and quick inhale might not bring the medication deep in the lungs (Quote 9).

> *(Quote 9) "Something could be added, a timeline for the duration of the inhalation. It is a bit debatable whether it has something to add. But someone who just does suuuuffff (portrays a short and rapid breathing) then it does not come far" (Male, respiratory nurse)*

One pulmonologist mentions, there should also be more attention to maintaining the inhaler properly. According to this pulmonologist some inhalers attract moisture. When patients do not close the inhaler with the protection cap, the inhaler can attract damp and then it does not function anymore. Furthermore, dust and other materials can get stuck in the inhaler when it is not maintained properly, and this can harm the patient (Quote 10).

> *(Quote 10) "Once I had a patient who had a paper wad in his pocket and the patient inhaled and got that wad in his airways. I needed to remove this from his airways with pliers. So he did not had a cap on his inhaler, and then dust from your jacket or pocket or other things can get into the inhaler. These are things that you should take into account" (Male, pulmonologist).*

Lastly, the medical microbiologist suggests inserting a peak flow. This helps patients to manage their medication use. According to the medical microbiologist, when the peak flow declines, patients could take an extra dose to prevent exacerbations (Quote 11).

> *(Quote 11) "When patients have an exacerbation, their lung function deteriorates. This can be measured with a peak flow. If this is detected at an early stage, then you can prevent this by taking extra inhalations" (Male, medical microbiologist)*

4.3.2.7.2 Notifications

The majority of the healthcare professionals indicate to think the notifications are useful. However, one participant mentions it is important to take into account colour blindness when choosing the colours for the ambient feedback. Another participant thinks the ambient feedback might be confusing for the patients.

With regard to the notification 'you forgot to inhale', four participants indicate that the moments to inhale are not very strict. According to the participants, when the patients need to inhale in the morning, then it does not really matter if it is at 7 or 9 am. Only when patients inhale three till four hours later than the initial appointed moment, this is latish and it might lead to patients getting hyper. Two participants indicate that it is not a big problem for patients to inhale the 'late dose'. However according to one of them whether it is safe depend on the type of inhaler.

Concerning, the notification 'cleaning the mouthpiece' of the feedback-inhaler, the medical microbiologist indicates that it is important to do this a couple of times every week. According to him it does not cause infections very quickly when you fail to clean the mouthpiece.

4.3.2.7.2.1 Adjustments to improve the notifications

The healthcare professionals suggest different adjustments for the notifications. According to one participant the notifications concerning the amount of doses and cleaning the mouthpiece could be presented as a symbol on the screen, and the notifications 'it is time to inhale' and 'you forgot to

inhale' can stay the same to make it clearer. Another participant indicates it is better to link the notifications to a smartphone. This participant mentions it is also good to be less strict with the notifications regarding 'you forgot to inhale' or 'it is time to inhale' and provide a more positive approach (Quote 12).

> *(Quote 12) "Yeah well it means you are on your way to forget. That is basically what you should say. You must not be too strict but say hey buddy… or a beep indicating: do you still think about it? So it is more a positive approach, than that it is a punishment. It should be more like please note… So give positive feedback instead of negative feedback" (Male, pulmonologist)*

4.3.2.7.3 Practice mode

Concerning the practice mode, five participants have a positive attitude towards it. However, one participant (a pulmonologist) does not think a practice mode is a good idea. According to him it is difficult to make patients familiar with the inhaler, and when there is time to help patients practice, it is important to do this with the real inhaler attached to the device. Another participant indicates it is important to take into account the internal resistance of inhalers when using the practice mode. In other words, the technology must be set to the type of inhaler with which you want to practice.

4.3.2.7.4 Information about correcting mistakes

Patients can find information about their inhalation technique when they made mistakes, and information about how to correct these mistakes in the personalized portal. Two healthcare professionals think this is a good feature. Two other participants think patients should not receive too much information about what they need to do differently. According to one of them, patients might forget the information when it is too extensive. The other participant thinks it is important to wonder which information is really relevant and to make a distinction between what are fatale mistakes and what is a tip to do better next time.

Four participants indicate that on occasion patients are allowed to inhale an extra dose when the previous inhalation was not optimal. However, two participants indicate that it depends on the extent, to which the inhalation went wrong. According to them it depends on the type of mistake and the lung deposition. If the latter is low, it should be good to inhale extra. Therefore, the participant indicates that in order to advice patients to inhale extra, the feedback-inhaler must be able to measure lung deposition.

Using the inhaler a second time when the initial dose has gone wrong is not without risks. According to one participant inhaling too often may lead to palpitations and a dry mouth. Furthermore, according to two participants a small part of the dose can get in the rest of the body and can lead to different side effects, like palpitations, fungal infections and urinary retention. The respiratory nurse indicates he prefers to play it safe and does not recommend taking an extra dose when the initial inhalation went wrong.

4.3.2.7.5 Video chatting with the respiratory nurse

Patients have the opportunity to video chat with their respiratory nurse via the portal. Two healthcare professionals think this is a good feature. According to one of them, this is medicine of the future. Three participants do not think this is a good feature. According to them, patients can also make a phone call and this should be sufficient. Via the telephone it should be quicker to talk to a professional. Furthermore, technical problems can occur during video chatting. Also one pulmonologist notes that although a respiratory nurse can tell something about the inhaler use, when there is a health related question, the respiratory nurse needs to send the patient to the pulmonologist and this can be a hassle.

Concerning the feasibility of integrating video chatting, all participants name difficulties, which play a role and should be taken into account. According to two participants the logistics of the hospital is not set to this. Others say the health insurance should agree because there should be paid for this. Also, the respiratory nurse should be available for this feature.

5. Discussion

In this chapter the research questions are answered in the following subsections. Practical recommendations for the improvement and further development of the smart inhaler prototype will be described. Also the research procedure will be discussed in this chapter and the relevance of this study will be described.

5.1 Research question 1: important requirements and/ or persuasive features according to patients

User evaluation results indicate that the majority of the participating patients have a positive attitude towards the first prototype version of the feedback-inhaler. Furthermore, the majority of the patients are motivated to use the technology. Various guidelines to improve the feedback-inhaler are brought forward by the patients. Below, recommended requirements and persuasive features for improving the prototype of the feedback-inhaler are described.

5.1.1 Guidelines to improve the mouthpiece and docking station

According to the patients, fourteen guidelines are important to improve the mouthpiece and docking station. In Table 10 these guidelines are summarized. Thereafter, each guideline will be explained.

Table 10

Guidelines to improve the mouthpiece and docking station

Guidelines	
Mouthpiece	**Docking station**
- Real-time feedback should be more clear - The mouthpiece should provide options to choose feedback modalities - Guidelines to 'relax' should be provided - The mouthpiece should be compact and light weight - Real-time feedback should be visible to others - The mouthpiece should be able to block a dose - The mouthpiece should indicate second attempts - The mouthpiece should provide extra reminders about correcting previous mistakes - The mouthpiece should be usable in the dark - The mouthpiece should provide praise	- The docking station should provide options to choose the type of notification - Notifications should be presented via smartphone - Dose counter should be specific - The docking station should notify to clean regular inhalers - Notifications should not be optional

5.1.1.1 Real-time feedback should be more clear

Symbols presenting the real-time feedback should be clearer. The real-time feedback symbols indicating the inhalation technique is incorrect (exclamation mark), the duration of breath holding (time bar), and shaking the inhaler (arrow up and down) were not clear for some participants. Hence, they should be replaced with other symbols. Suggestions from the participants are to replace the exclamation mark with a question mark or red sign. Furthermore, using a clock instead of a time bar and using the word 'shake' instead of arrows pointing up and down might be clearer.

5.1.1.2 The mouthpiece and docking station should provide options to choose feedback modalities and notification signals

The type of real-time feedback modalities should be optional. Some participants do not like the haptic feedback and prefer more visual feedback or beeps. Because of different opinions about the preferred type of signals and the different settings in which users use their inhaler, it may be a good addition that users can choose the preferred modalities (e.g. beeps instead or vibrations etc.).

With regard to the different colours of the ambient feedback (i.e. red, green, orange and purple), one participant wonders if these are clear for users suffering from colour blindness and mentions this should be considered. Different types of colour blindness can be distinguished. Consequently, the colours that people may or may not see might be different (Prins, 2014). The most common form of colour blindness makes it impossible for humans to make a distinction between red and green (Prins, 2014). Hence, other colours should replace the ambient feedback colours red and green that currently are used within the first prototypal version of the feedback-inhaler. Furthermore, it might be convenient to insert options to choose a preferred type of alarm for the notifications (e.g. haptic feedback or beeps) to ensure notifications being notified.

5.1.1.3 Guidelines to 'relax' should be provided

Some participants mentioned having difficulties using the inhaler when they experience breathlessness, and that in these situations the support of real-time feedback would not make any difference. For instance, when experiencing breathlessness, breath holding for ten seconds is difficult for patients. It might be helpful to insert feedback/guidelines telling patients to sit on a chair while using the inhaler and trying to relax. It is assumed this might help patients using their inhaler as good as possible during breathlessness. Participants mentioned to insert a 'bypass button', which lead to ignoring feedback concerning breath holding for ten seconds when experiencing breathlessness. However, this is no solution to the problem.

5.1.1.4 Notifications should be presented via smartphone

The notifications should not only be presented with ambient feedback signals via the docking station, but also via smartphone. When users are not at home and do not see the docking station, they do not notice the notification. Also an explanation of the notification should be presented via smartphone to make it efficient because users do not like to log into the web-based portal for information every time because this is time consuming.

5.1.1.5 The mouthpiece should be compact and light weight

The mouthpiece should be designed for traveling. Participants would like it to be compact and light weighted and that it has a travel charger with USB. This enables users to charge the mouthpiece with docking station at multiple locations (e.g. in the car).

5.1.1.6 Real-time feedback should be visible to others

The screen on the mouthpiece presenting the real-time feedback should also be visible for surrounding people. A participant mentioned that some people disturb the inhaler use, and making others aware of the inhalation process might rectify this. Therefore, the real-time feedback screen should be visible for others to inform them to not disturb during the inhalation process.

5.1.1.7 The mouthpiece should be able to block a dose

A blocking system should be provided on the mouthpiece to block a dose when the inhaler is not correctly used. According to one participant this could prevent inhaling a dose of which most of it will not deposit in the lungs due to the improper inhalation technique. However, the incorrect use of

inhalers might be due to patients experiencing breathlessness. 'Punishing' patients by inserting a blocking system when the inhaler use is not properly executed due to breathlessness might not be a good solution here. Dyspnea is one of the most important symptoms of COPD (Boezen, Postma & Eysink, 2013) and according to a few participants this could make it difficult to use their inhaler(s) properly. Fortunately, physical capabilities of chronic lung patient are considered while determining a suitable type of inhaler (Broekhuizen et al., 2014). Despite these choices, all chronic lung patients could experience breathlessness and consequently difficulties using the inhaler. When patients experience breathlessness the inspiratory flow rate might not be optimal, which lead to a lower degree of lung deposition. However, even though the deposition is not high, this might be better than no deposition at all and therefore blocking a dose does not seem to be a good idea. In contrast, when the inhaler is not correctly prepared for usage (e.g. shaking the inhaler) or when the users do not adopt the proper posture might be good indications to block a dose.

5.1.1.8 The mouthpiece should indicate second attempts

The mouthpiece should indicate whether or not patients must inhale again when mistakes are made. In current state users only get to see if the inhalation technique was correct. When the inhalation was not good, users would like to see if it is necessary to inhale again to ensure a sufficient lung deposition. This corresponds to the Persona Margriet, who also likes to know how to correct mistakes. However, to be able to advice users to make a second attempt, the technology should be able to measure lung deposition, because when patients inhale too much medication, this could lead to side effects (Farmacotherapeutisch Kompas, 2016)

To the best of the author's knowledge, the lung deposition cannot be measured by means of smart sensors. There is a device described in one study, which is able to measure the deposition of the drug particles, namely the 'cascade impactor' (Dekhuijzen, 1998). However, this concerns a device through witch air will be sucked inside, but it does not measure lung deposition 'in vitro'. By using radiolabeling techniques and pharmacokinetic methods the lung deposition can be measured in vitro, but these manners are rather difficult and therefore assumed to be unachievable (Dekhuijzen, 1998). Hence, the feedback-inhaler cannot specifically indicate the lung deposition. However, it can indirectly say something about the deposition, because if the inhaler is not used properly and the inhalation was not good, much of the medicine will remain in the oropharynx and mouth (Broekhuizen et al., 2014). Indirectly these signals indicate that the deposition is not complete. In future research it is important to examine whether measuring the lung deposition indirectly is a reliable method to say something about the safety of making second attempts to inhale.

5.1.1.9 The mouthpiece should provide extra reminders about correcting previous mistakes

The mouthpiece should provide an extra reminder about previous mistakes and how to prevent them during current inhaler use. Reminding users extra beforehand might enable them to be more alert during inhaler use.

5.1.1.10 Dose counter should be specific

The mouthpiece should be more specific in counting the amount of dosages. Currently, it only tells users that the inhaler is almost empty. Some participants would like this to be more specific. However, this might be difficult because the mouthpiece can only count the amount of times the user uses the inhaler when the mouthpiece is attached to the regular inhaler. In other words, when the regular inhaler is used without the mouthpiece, the sensor technology cannot count the dosages being used and consequently cannot provide information about the exact amount of dosages left in the inhaler. A solution to this problem could be to make users aware of this issue, to stimulate them to constantly use the mouthpiece and consequently count every inhaled dose. Also the Persona Margriet (the one who is

dedicated) likes to be reminded of the exact amount of dosages left in het inhalers, allowing her to keep track of the amount of dosages left.

5.1.1.11 The mouthpiece should be usable in the dark

The real-time feedback presented by the mouthpiece should be visible in the dark. Most patients use their inhalers in the morning and in the evening. One participant explicitly mentioned this to be important.

5.1.1.12 The docking station should notify to clean regular inhalers

The docking station should also notify users to clean their regular inhalers. In current state the docking station only notifies to clean the mouthpiece with smart sensors, but not to clean regular inhalers.

5.1.1.13 Notifications should not be optional

Some participants indicate that the notifications 'it is time to inhale', 'you forgot to inhale', 'the inhaler is almost empty' and 'you must clean the mouthpiece of the feedback-inhaler' are unneeded. In stead, they would like the notifications to be optional. However, some participants might not be aware of the ways they misuse their inhalers. This corresponds for instance to the persona 'Johan' who is oblivious. Hence, it may not be a good idea to let users choose the type of notifications they would like to receive.

5.1.2 Persuasive features

5.1.2.1 The mouthpiece should provide praise

The mouthpiece should provide information about the degree to which users used their inhalers properly. In current situation the mouthpiece only informs users whether the technique was correct or not. According to one participant, by indicating the degree to which the inhaler use was properly executed people might be motivated trying to do better. This corresponds to the persuasive design principle 'praise'. By means of images indicating the degree to which the inhalation use was properly executed users might get persuaded to do better next time (Figure 30) (Oinas-Kukkonen & Harjumaa, 2009).

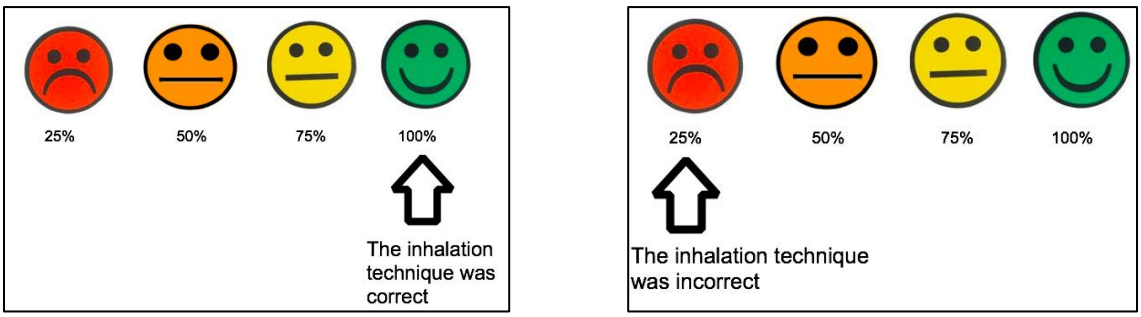

Figure 30. Example of using praise

5.1.3 Guidelines to improve the portal

With regard to the personalized portal, according to the patients seven guidelines are deemed to be important for improving this part of the feedback-inhaler. In Table 11 these guidelines are summarized. Thereafter, each guideline will be explained.

Table 11

Guidelines to improves the personalized portal

Guidelines
Personalized portal
- The portal should be simplified
- The portal should make it easy to navigate
- The portal should provide more personal details
- The portal should provide information about technical specifications
- The portal should provide instructions about regular inhalers
- The portal should provide rewards
- The portal should enable self-monitoring

5.1.3.1 The portal should be simplified

The portal should be simplified and consequently more time efficient. Some participants feel that the first prototypal version of the web based portal is not efficient enough but rather cumbersome. A preferred addition is developing an app about the portal so users do not have to log in every time and use their personal computers.

Also, information in the portal should be reduced to make it more simple, time efficient and clear. Participants indicated that the information about the instructions concerning the feedback-inhaler was too long and some did not understand how the technology works after reading the information in the portal. Participants would like to see less text and more icons and videos. This corresponds to the Persona of Johan (the one who is oblivious) that likes short and clear information.

5.1.3.2 The portal should make it easy to navigate

The portal should make navigating through it easier. A lot of the participants did not find the correct path within the portal and some needed assistance from the researcher while working with the portal to fulfil their tasks. Also a few took a detour in the portal to fulfil a task (e.g. find the information correcting mistakes). In short, navigating through the portal was not easy and took unnecessary time.

Suggestions according to the participants to make navigating through the portal quick, easier and clearer, are: giving the links colours and using symbols/icons for links. Furthermore, renaming links into simple language. For instance, renaming the link to the instructions about the use of regular inhalers into ‘own medication’, or renaming the link to the status concerning the inhalation technique into ‘your inhalation technique’.

5.1.3.3 The portal should provide more personal details

The portal must provide more information about the personal details of the patients. Patients would like to see their personal hospital numbers, date of birth, information about the expiration date of the AeroChamber®, the date of usage of the inhalation medication and number of doses per inhaler. Furthermore, patients would like to see information about other ailments and related medication, information about the lung capacity, substantiation about the choice for the specific types of inhalers, a

substantiation of the advice concerning correcting mistakes and information about scheduled appointments with the pulmonologist and/or respiratory nurse.

5.1.3.4 The portal should provide information about technical specifications

The portal should provide information about the technical specifications. Participants would like to know the battery runtime and life duration of the feedback-inhaler. Some participants would like to find a link referring to the manufacturer of the feedback-inhaler. This enables users to find specific answers for questions related to the technological specifications.

5.1.3.5 The portal should provide instructions about regular inhalers

With regard to the instructions concerning the use of regular inhalers, information should be presented via the portal. Consulting this information should not take to much time. This corresponds to the Persona Johan who does not like to spend too much time on information. Therefore, the information should be specific to the type of inhalers patients use.

5.1.4 Persuasive features

5.1.4.1 The portal should provide rewards

Patients mentioned that the data in the portal about the inhalation technique should not only point out negative things but also positive things. Pointing out positive things might motivate users to use the feedback-inhaler and consequently use inhalers properly. Indicating positive things by means of the technology corresponds to one of the several described design principles by Oinas-Kukkonen and Harjumaa (2009), namely ‘rewards’. A system that reward target behaviors may have great persuasive powers (Oinas-Kukonen and & Harjumaa, 2009). Currently the technology only points out the mistakes that are made but does not describe what went well and does not ‘reward’ users for this. Therefore, in a second version of the feedback-inhaler it might be valuable to reward users by inserting credits for performing target behaviors.

5.1.4.2 The portal should enable self-monitoring

The portal must track the inhaler use or status of the inhalation technique over a longer period of time. In other words, a history of data should be available for users. According to one participant this is useful and gives insight into how it is going over time. This is inline with the persuasive design principle ‘self-monitoring’, which helps users achieve their goals (Oinas-Kukkonen & Harjumaa 2009). The Persona Margriet (the one who is dedicated) also likes the ability to monitor the inhalation technique.

5.2 Research question 2: important requirements and/or persuasive features according to healthcare professionals

User evaluation results indicate that the majority of the participating healthcare professionals have a positive view on the first prototypal version of the feedback-inhaler. The majority thinks the feedback-inhaler is a good innovation to help patients use inhalers properly. Most participants believe the features of the feedback-inhaler can improve the inhalation technique and consequently are useful in reaching its goals (e.g. enhancing therapeutic effects and quality of life, preventing exacerbations and hospitalization). However, one participant does not believe that improving the inhalation technique can prevent exacerbations.

Preventing exacerbations fully does indeed seem impossible because of the deterioration of the lung function and the increase of symptoms, which are important characteristics of COPD (Szafranski

et al., 2003). As described by Szafranski et al. (2003) and Seemungal et al. (1998), acute exacerbations among COPD patients are common particularly in later stages. Hence, it seems inevitable that exacerbations do occur and that although the use of inhalers is executed properly, this cannot fully prevent exacerbations. However, reducing (unnecessary) exacerbations seems feasible. Diverse studies show that inhaler therapy could decrease exacerbations (Calverley et al., 2003; Szfranski et al., 2003; Casaburi et al., 2002). Logically, when using inhalers properly this increases the likelihood in influencing exacerbation frequency.

Concerning the part of the portal that is meant for the healthcare professionals, all participants were able to work with the portal and had no difficulties in searching for patient data. However, participants did suggest various recommendations to improve the part of the portal that is meant for them. Also they made suggestions to improve the mouthpiece of the feedback-inhaler and the personalized portal meant for the patients. Below recommended guidelines for improving the prototype of the feedback-inhaler are described.

5.2.1 Guidelines to improve the portal for healthcare professionals

According to the healthcare professionals three guidelines are important to improve the personalized portal. In Table 12 these guidelines are summarized. Thereafter, these guidelines will be explained.

Table 12

Guidelines to improve the personalized portal

Guidelines
Personalized portal
- Patient data should be searched by hospital code - The portal should be less time consuming - The inhaler use should not be assessed to strict

5.2.1.1 Patient data should be searched by hospital code

A crucial addition is a corresponding hospital code or patient number when searching for patient data. Currently users can only search for patient data by inserting their names. However, according to the healthcare professionals only searching by names can be dangerous because patients might have the same name. Consequently, patient data might get mixed up.

5.2.1.2 The portal should be less time consuming

The first prototypal version of the portal is considered to be time consuming. The healthcare professionals mentioned not liking to log in and search for patient data every time. They rather receive one clear visual overview concerning the inhalation technique of their patients over a period of half a year, or find a clear overview by ‘a push on a button’.

5.2.1.3 The inhaler use should not be assessed too strict

Some healthcare professionals indicate that the inhaler use among chronic lung patients should not be assessed too strictly. According to them this does not fit the current practice in which many chronic lung patients make frequent mistakes while using their inhalers. One participant thinks that by setting a high bar, no one does it well. Currently in the portal the status of the fictive person ‘Johan’ was fair. Participants indicated this to be too strict because Johan only made a few mistakes. In future research

it is important to study what can be defined as a good, fair, moderate and an insufficient inhalation technique.

5.2.2 Guidelines to improve the feedback-inhaler

According to the healthcare professionals eight guidelines are important for improving the mouthpiece, docking station and personalized portal intended for patients. These guidelines are summarized in table 13.

Table 13

Guidelines to improve the mouthpiece, docking station and patient portal

Guidelines		
Mouthpiece	**Docking station**	**Patient portal**
- The mouthpiece should provide information about second attempts - The mouthpiece should provide feedback about the maintenance of inhalers - The mouthpiece should measure the duration of the inhalation - The mouthpiece should provide guidelines to relax - The mouthpiece should be able to measure exacerbations at an early stage	- Notifications should be less strict - Notifications should be presented via smartphone and symbols	- The portal should provide short and clear information

5.2.2.1 The mouthpiece should provide information about second attempts

The healthcare professionals indicated that on occasion patients are allowed to inhale extra when the previous inhalation is not executed properly. However, in order to give the advice to inhale extra, the feedback-inhaler must be able to provide information about the degree of lung deposition because an overdose may lead to side effects (Farmacotherapeutisch Kompas, 2016). For instance, when a patient uses the inhaler while in fact the inhaler is not yet ready for use, no dose will be released and logically the patient is allowed to ‘inhale’ again. However, when a patient did not succeed in breath holding for ten seconds (but for five), there will be a lung deposition but probably not a sufficient deposition. Consequently, using the inhaler again might lead to an overdose and side effects and this should be taken into account. In other words the advice to inhale again should depend on the type of mistakes because they might indirectly say something about the degree of lung deposition and might prevent an overdose.

5.2.2.2 Notifications should be less strict

A few participants think some notifications do not have to be very strict and think it is good to have a more positive than negative approach when reminding patients to not forget to use their inhalers. According to them the moments to inhale or not very strict and for instance failing to clean the mouthpiece does not directly lead to infections.

5.2.2.3 The mouthpiece should provide feedback about the maintenance of inhalers

An important addition to the real-time feedback is providing feedback about the proper maintenance of inhalers. According to one participant when the inhalers are not maintained properly, it can lead to health problems. Information concerning the maintenance of the inhaler is described by the protocols of the Dutch Lung Alliance (LAN)[4]. Hence, these tips and advices are deemed to be important and the feedback-inhaler should be improved by adding reminders concerning proper maintenance of inhalers (e.g. putting the protective cap back on the inhaler, or keeping the inhaler at room temperature).

5.2.2.4 The mouthpiece should measure the duration of the inhalation

According to one of the healthcare professionals, an addition that is important for the real-time feedback is measuring the duration of the inhalation. This participant indicates that if a patient only inhales briefly and rapidly, the medication does not enter the lungs sufficiently. Currently the technology only measures the inhalation strength but does not measure the duration or completeness of the inhalation. The emission time releasing a dose depends on multiple factors, namely: the type of inhaler, inhalation manoeuvre and drug formula (LAN). Due to these factors, the inhalation time can be different per type of inhaler and should be considered. As described by the LAN, it is important to inhale as deeply and completely as possible in all cases. Therefore, the mouthpiece should take the duration into account, and encourage users to inhale completely.

5.2.2.5 The mouthpiece should provide guidelines to relax

With regard to the feedback to breath hold for ten seconds, some healthcare professionals think this is too long for their patients. However, the protocols of the LAN advice patients to breath hold for ten seconds or as long as possible to make sure there is a sufficient lung deposition. Breath holding is important because it stimulates targeting lung regions. Heyder (2004) indicates that breath holding has two advantages: “It allows targeting of sub regions of the alveolar region and, at the same time, increases the dose delivered to the alveolar sub region…” (p.320). Inhaled drug particles have a required ‘fall time’ in order to reach the airway wall. If the breath is held insufficiently, then a part of the inhaled dose will be exhaled again (Boer, 2015; Hoppentocht, 2015). One participant thinks if you well instruct patients (e.g. sit on a chair while using the inhaler, try to relax, take time etc.), it is possible to breath hold long enough. It may be a good addition to provide these instructions via the mouthpiece, in order to empower patients to breath hold long enough.

5.2.2.6 The mouthpiece should be able to measure exacerbations at an early stage

According to one of the healthcare professionals, another requirement is to insert a peak flow meter to detect possible exacerbations at an early stage. The participant indicated that if patients have an exacerbation, the lung function will decline and this can be measured by means of a peak flow meter. According to him taking an extra dose of the inhalation medication can possibly prevent the exacerbation. However, no studies are found of using a peak flow meter to self-manage and detect (early) exacerbations among COPD patients. Furthermore, as described by the Dutch Farmacotherapeutisch Kompas (2016), a peak flow meter is often not suitable for measuring the obstruction of COPD patients. This because patients with COPD especially have obstruction in the small airways, which hardly influence the peak flow measurement (Farmacotherapeutisch Kompas, 2016). There are studies in which asthma patients use a peak flow meter to monitor and self-manage their condition. Findings from Ignacio-Garcia and Gonzalez-Santos (1995) show that personal use of an objective measure of lung function can lead to improvement in the condition of the asthma patient. This in association with a medication self-management plan (Ignacio-Garcia & Gonzalez-Santos,

[4] http://inhalatorgebruik.nl/nl/home last retrieved on 10-03-2016

1995). In contrast, findings from Kotses, Harver and Humphries (2006) show that the strength of the association between symptoms and peak flow is low to moderate. Furthermore, they found that the advantages of peak flow monitoring provide, no more than a small increase in effectiveness beyond that yield by symptom monitoring in asthma self-management (Kotses et al., 2006). With regard to symptom monitoring among COPD patients, research shows that individualized action plans help patients anticipate to exacerbations. However, these action plans do not seem to have influence on the frequency of exacerbations, quality of life and care consumption, but they do reduce the impact of exacerbations on health status, the intensity and accelerates the recovery of both the symptoms and health status (Trappenburg et al., 2012). In other words, early detection of exacerbations can be helpful but does not seem to reduce the amount of exacerbations and need for care. Nevertheless, integrating a solid action plan to the technology to support patients in recognizing and dealing with exacerbations early might be a good addition.

5.2.2.7 Notifications should be presented via smartphone and symbols

Most Healthcare professionals have a positive attitude towards the notifications. However, some think the notifications could be more users friendly by linking the notifications to a smartphone instead of a docking station, and be clearer by using symbols instead of ambient feedback.

5.2.2.8 The portal should provide short and clear information

Some healthcare professionals think patients should not receive too much information via the portal. According to the healthcare professionals patients might have difficulties remembering information. Hence, the information should be short and clear.

5.3 Research question 3: extent to which the technology is clinically relevant

All healthcare professionals indicated that they are able to assess the adherence of patients based on the information about the inhalation technique presented in the portal. Furthermore, participants indicated to be able to make future decisions about the treatment of their patients by means of the information in the portal. Some participants suggested recommendations concerning the clinical relevance.

5.3.1 Guidelines concerning clinical relevance

Two guidelines are important according to the healthcare professionals to increase the degree to which the feedback-inhaler is clinically relevant (Table 14).

Table 14

Guidelines concerning clinical relevance

Clinical relevance
- The flow rate should be presented between two ranges
- The term ‘inhalation strength’ should not be used in the portal

5.3.1.1 The flow rate should be presented between two ranges

With regard to the content of the information presented via the portal, a few participants indicated that the flow rate should be presented between two ranges. Furthermore, they indicated that the currently presented flow rate in the portal is too high and should be around 30. As described by Al-Showair et al. (2007), there is a lot of discussion about the optimal inhalation flow that have to be reached when a patient uses an inhaler. In general it is accepted that a DPI should be used with an inhalation flow of more than 30 L min^{-1} and when using an MDI, the inhalation flow should be less than 90 L min^{-1} (Al-Showair et al., 2007). If patients inhale too fast or too slow, the drug will most likely deposit in the mouth and throat instead of into the lungs (Broekhuizen et al., 2014).

5.3.1.2 The term 'inhalation strength' should not be used in the portal

One participant indicates to prefer not speaking of inhalation strength ('inhalatie kracht') in the portal but only about the flow rate ('stroom snelheid'). According to him inhalers can have a high or a low resistance and this will influence the flow rate. Among the diverse types of inhalers there are indeed differences in terms of resistance (Al-Showair et al., 2007), and the resistance determines the required inhalation strength to receive a sufficient flow rate. Thus, it is important to only speak of the inspiratory flow rate in the portal instead of the inhalation strength because it is clearer and better interpretable.

5.4 Research question 4: conditions for implementation

All healthcare professionals have a positive attitude towards the implementation of the feedback-inhaler. Conditions, under which the smart inhaler technology should be implemented are: (a) *the smart inhaler technology must be available for all patients and all types of inhalers*; (b) *the arrangement and explanation concerning the feedback-inhaler must take place outside the consultation room;* (c) *the respiratory nurse should give the instructions concerning the feedback-inhaler;* and (d) *an implementation pilot in real health care practice should be conducted prior to implementing the smart inhaler technology in the field.*

5.5 Reflection on the research procedure

Within this study, a first low-fidelity prototype is developed based on various requirements and persuasive features. By means of formative scenario-based user evaluations, the first prototypal version of the technology is evaluated among chronic lung patients and healthcare professionals.

The aim of the user evaluations was to define requirements and persuasive elements (guidelines) that smart sensor technology must comply with, so that it is reliable, valid and usable for chronic lung patients as well as for the healthcare professionals. One of the strengths of this study is that the low-fi prototype is evaluated with the target group; in order to ensure the timely input from prospective users and to make sure the prototype meets user needs and requirements. The prototype is designed based on the various established requirements and persuasive features that are derived from the earlier conducted in-depth interviews with twelve Dutch chronic lung patients. Most requirements and persuasive features could be evaluated during this study. By letting the participants accomplish 'real world' tasks by using the prototype, user experiences, instead of merely expectations could be evaluated. This concerns strength of this study because the experiences of the prospective users can improve the technology. However, one part of the prototype, namely the mouthpiece, is not 'used' during the evaluations by the participants. Due to hygienic reasons, the participants did not use the mouthpiece in any way. Consequently, one drawback is that participants did not experience the real feel of using the mouthpiece. This might have lead to a lack of key input concerning the mouthpiece.

Future research could provide the opportunity for participants to use the mouthpiece. However, precautions should be taken into account to ensure hygiene to secure participants.

Some initial requirements for designing the first prototypal version of the feedback-inhaler could not be examined during this study. These requirements are: 'being effective', 'provide information about the degree of lung deposition' and 'sent information to health care providers'.

The requirement 'being effective', means the degree to which the feedback-inhaler 'works'. In other words the feedback-inhaler should be effective in reaching its goals due to the information it presents. The effectiveness of the technology is an aspect that may be difficult to examine during formative evaluations. However, by means of a summative evaluation the impact (and therefore the effect) can be measured. When talking about the impact of the technology, this means the degree to which the intended objectives of the technology are being realized (van Gemert-Pijnen et al., 2011).

Because the feedback-inhaler does not specifically indicate the degree of lung deposition, also the requirement 'providing information about the degree of lung deposition' could not be evaluated. The technology does not inform users about the lung deposition because as far as the author knows this cannot be measured by means of smart sensors. As described earlier the technology cannot specifically indicate the lung deposition, but it can indirectly say something about the deposition, because if the inhaler is not used properly and the inhalation was not good, much of the medicine will remain in the oropharynx and mouth (Broekhuizen et al., 2014). Indirectly these signals indicate that the deposition is not complete.

During user evaluations also the requirement 'sent information to healthcare providers' is not evaluated. This because in order to support patients in using inhalers properly, it may be important to inform healthcare professionals about their status concerning the inhaler use. For instance, when patients have lasting difficulties using their inhaler, or when (even do they use their inhalers properly) they have a lot of symptoms, healthcare professionals should be informed to be able to make future decisions about the treatment of their patients. Hence, the requirements 'sending information to healthcare professionals' might concern an unalterable requirement for the technology and therefore no questions are asked about the patient's opinion concerning this aspect of the technology. However, a downside is that there are no findings about whether patients feel comfortable having their data transparent to their pulmonologist and respiratory nurse(s). Some patients might feel that this is an invasion of their privacy and consequently will not be motivated to use the feedback-inhaler.

5.6 Relevance and next steps

The results of this study are an important step towards increasing a secure health (economic) society. By means of eHealth technology COPD patients can be supported in proper inhaler use, which consequently could lead to good therapeutic effects and a reduction in medical costs. To reach this aim there should be a fit between users and eHealth technology to ensure usable and user-friendly technology and a high adherence and usage of the technology (Nijland & Verhoeven, 2013). The findings of this study provide valuable input to ensure this fit, and reduce the risk of developing technology that will not be used (Nijland & Verhoeven, 2013). Based on the results of this study, a first 'working' prototype of the smart inhaler technology can be created and evaluated. Subsequently the next steps of the CeHRes Roadmap, can be followed, namely operationalization and summative evaluation.

6. Conclusion

This study presents the results of user evaluations with prospective users of the new smart inhaler technology and portal called the feedback-inhaler. The results indicate that the majority of the participants are positive about the first feedback-inhaler prototype. Findings indicate that in general for a feedback-inhaler to be successful, it should be simple. Furthermore, the mouthpiece of the feedback-inhaler should be usable in different settings (e.g. during traveling, in the dark or in public), by making it compact and light weight and by presenting notifications about the inhaler via smartphone. Also, by informing surrounding others to not disturb patients while using the inhaler.

To increase the ability to use inhalers properly the mouthpiece must present guidelines to relax while using the inhaler and a short reminder about previous mistakes and how to deal with them during current inhalation. Furthermore, the mouthpiece should provide feedback about maintaining inhalers properly and about the duration of the inhalation. In order, to make the feedback modalities (e.g. audio, visual, ambient or haptic feedback) of the mouthpiece and docking station user friendly and personalized, the users should be able to choose the type of feedback modality. When mistakes are made the mouthpiece should indicate if users should make a second attempt. By means of praise and rewards users can be motivated trying to use their inhaler properly at each time.

The personalized portal for patients should be simple. Instructions about the technology and regular inhalers must be short and described via easy language, icons, videos and/or symbols. Technical specifications of the feedback-inhaler should also be presented via the portal. Furthermore, the portal should provide more positive information about the personal inhalation technique and must enable users to self-monitor their inhalation technique by presenting a history of data concerning the inhaler use and extra personal details.

The personalized portal for healthcare professionals should enable finding patient data via hospital code. Furthermore, the data concerning the inhalation technique must be available rapidly by one click on a link and presented via one clear overview. The flow rate should be presented in patient's data and described between two ranges in order for it to be clinically relevant.

The healthcare professionals have a positive attitude towards implementing the feedback-inhaler. Main conditions are that the technology must be available for all patients and type of inhalers and instructions about the technology must take place outside of the consultation room.

Future work should focus on fine-tuning the feedback-inhaler. Moreover, the effects of the further developed smart inhaler prototype should be evaluated by means of a summative evaluation.

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Appendix 1: Persona 'The one who is dedicated'

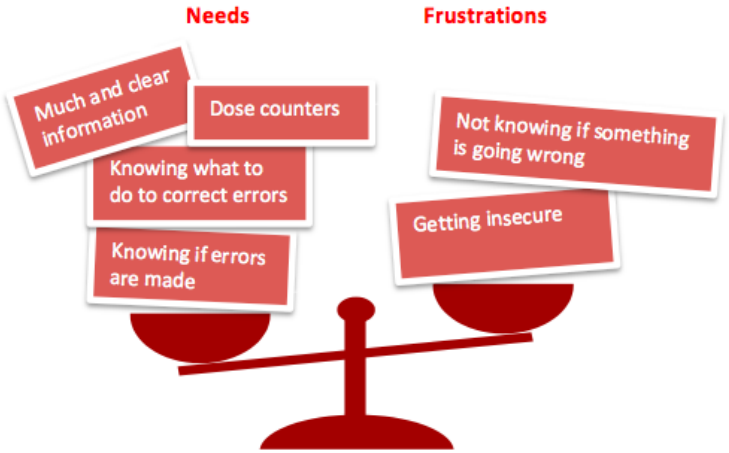
Margriet Hamersma

"Now I have COPD it is of vital importance to inhale properly at every moment of the day"

Margriet is 45 years old and middle educated. Margriet is married to Tim and together they have two children (20 and 18 years old). Currently Margriet is disapproved to work because of her condition. Margriets hobbies are reading books and yoga.

Since her childhood Margriet suffers from Asthma. Recently she is also diagnosed with COPD. Margriet uses three types of inhalers aimed at keeping her condition stable. These inhalers are: the Respimat®, a standard dose aerosol with AeroChamber® and a RediHaler®. In the past Margriet sometimes made mistakes while using her inhalers. Since she knows she suffers from COPD, she is very motivated to inhale properly. Therefore, she likes to monitor her inhalation technique on regular basis and receive frequent feedback concerning her inhalation technique. Also Margriet likes to know how to handle when making mistakes. Margriet likes to be reminded of the amount of medicine left in her inhalers. Margriet experienced severe dyspnea once but her inhaler turned out to be empty. Ever since she is interested in counters on each of her inhalers, which allows her to keep track of the amount of dosages left.

Margriet believes she can work well with new technology. She really likes to use her IPhone 5g for several applications and she likes to search on the Internet. Margriet always pays a lot of time at her computer to check her email and social media accounts. Recently she discovered Twitter and really likes to place Tweets. Margriet likes to search information about the use of inhalers and about her condition on the Internet. She uses an online medical dictionary to find the translation of medical jargon.



Name:	Margriet Hamersma
Gender:	Female
Age:	45
Education:	Middle
Resident:	Groningen

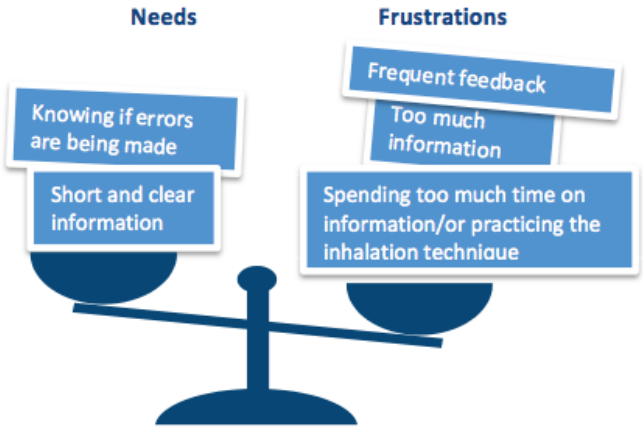
Appendix 2: Persona 'The one who is oblivious'

Johan Dekker

Johan is 65 years old, low educated and old gardener. Johan is married for 49 years with his wife Anne. Johan's hobbies are drawing and going for a swim.

For almost ten years Johan suffers from COPD. Johan uses two types of inhalers aimed at keeping his condition stable. He uses the Respimat® twice in the morning and a standard dose aerosol with AeroChamber® once in the evening. Johan believes he uses his inhalers properly. However, sometimes Johan postpones the use of his inhalers. According to Johan, postponing the use of his inhaler is not a problem because he does not notice any side effects. Furthermore, sometimes Johan is in a hurry. Consequently, this leads to not adopting the correct posture during inhalation and forgetting to exhale gently before and after inhalation.

Johan thinks he can work with computers and mobile phones very well and he enjoys using them. Johan uses the Internet for searching information about the nature, for online banking and for checking his email. Johan only uses his smart phone for calling or sending text messages. Johan likes to be standby all the time and therefore always carries his Samsung s5 mini with him. Johan is someone who will not search for information about the use of inhalers on the Internet, because he believes he is experienced enough and therefore does not need the extra information. Johan will only search for information about the use of inhalers if he notices something is going wrong. Johan does not like to frequently receive real-time feedback about his inhalation technique because Johan thinks this is time consuming. However, he would like to practice his inhalation technique every once in a while if he notices something is going wrong.



"Sometimes I have the tendency to do things at the same time. Then I just put the inhaler between my teeth and walk through the room"

Name:	Johan Dekker
Gender:	Male
Age:	65
Education:	Low
Resident:	Enschede

Appendix 3: Informational letter for the health care providers

Enschede, 2015

Beste meneer/mevrouw

Mijn naam is Marieke Kingma en ik ben student Gezondheidspsychologie aan de Universiteit Twente. Vanuit de vakgroep Psychologie, Gezondheid en Technologie voer ik mijn masterthesis uit gericht op de toepassing van smart sensor technologie op inhalatiemedicatie. Dit omdat blijkt dat voor veel COPD patiënten het lastig is om iedere keer op de juiste manier gebruik te maken van de inhalator.

Smart sensor technologie biedt de mogelijkheid voor patiënten om dagelijks op de juiste wijze de inhalator te gebruiken. Doormiddel van smart sensoren kan de inhalatietechniek van de patiënt gemeten worden en er real time feedback worden gegeven aan de patiënt. Deze feedback geeft patiënten de gelegenheid aanpassingen te maken wanneer nodig en daardoor het inhalator gebruik succesvol uit te voeren. Voor longartsen en longverpleegkundigen wordt met smart sensor technologie de mogelijkheid gecreëerd om inzicht te krijgen in het inhalatorgebruik van de patiënt en daardoor in te grijpen wanneer nodig. Alle gegevens van de patiënt met betrekking tot het inhalator gebruik worden bewaard en in kaart gebracht via een patiënten portaal. Vanuit dit portaal kunnen de specifieke gegevens (e.g. frequentie inhalator gebruik, inhalatie kracht, postuur etc.) van de patiënt worden bekeken. Het doel van smart sensor technologie is om exacerbaties te reduceren en het aantal ziekenhuisopnames van COPD patiënten terug te dringen.

Om te onderzoeken waaraan smart sensors op inhalatiemedicatie moet voldoen zodat het klinische relevante en betrouwbare informatie weergeeft willen wij graag hierover met u in gesprek gaan. Bent u bereid mee te werken aan ons onderzoek? Het onderzoek loopt nog tot 22 januari. We zullen tijdens een interview een aantal vragen aan u stellen over een lo-fidelity prototype van de smart sensor technologie en het patiënten portaal.

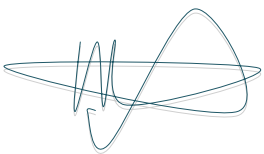
Het onderzoek zal ongeveer 40 minuten duren en kan plaatsvinden op een locatie die voor u handig is. Als u er geen bezwaar tegen hebt, zouden we graag het interview met u willen filmen. Op die manier kunnen we de analyse zo goed mogelijk doen. De gegevens worden alleen voor dit onderzoek gebruikt, bovendien zullen alle gegevens vertrouwelijk en anoniem behandeld worden. Hiervoor ondertekent u een toestemmingsverklaringsformulier.

Wanneer u interesse hebt voor deelname kunt u uw contactgegevens doorsturen naar het volgende email adres: m.kingma-1@student.utwente.nl wij zullen daarna met u contact opnemen om een afspraak in te plannen. **Als bedankje voor uw deelname ontvangt u van ons een vvv-bon.**

Bij voorbaat dank voor uw medewerking!

Hartelijke groeten,
Onderzoeksteam Universiteit Twente

Marieke Kingma



m.kingma-1@student.utwente.nl

Prof. Dr. Lisette van Gemert-Pijnen

j.vangemert-pijnen@utwente.nl

Appendix 4: Informational letter for the patients

Enschede, 2015

Beste meneer/mevrouw,

Mijn naam is Marieke Kingma en ik ben student Gezondheidspsychologie aan de Universiteit Twente. Binnen mijn afstudeeropdracht ben ik bezig met een onderzoek naar het gebruik van inhalatoren door COPD patiënten.

Voor optimale behandeling van COPD, is het van groot belang dat de inhalator goed wordt gebruikt. Toch blijkt dat dit voor sommige COPD patiënten best lastig is. Daarom zijn wij, de afdeling Psychologie, Gezondheid en Technologie van de Universiteit Twente, gestart met een onderzoek naar de toepassing van sensor technologie op inhalatoren. Het doel van deze toepassing is patiënten te ondersteunen bij het inhalator gebruik, door ze van feedback te voorzien over de eigen inhalatie techniek.

Om de gebruiksvriendelijkheid van sensor technologie op inhalatoren te kunnen onderzoeken, hebben wij een prototype ontwikkeld. Dit prototype is gebaseerd op de wensen en behoeftes van twaalf COPD patiënten die naar voren zijn gekomen tijdens eerder uitgevoerde interviews. Het prototype betreft een concept van een inhalator met sensoren die kan meten in hoeverre u op de juiste wijze gebruik hebt gemaakt van de inhalator. Daarnaast kan dit prototype informatie aan u bieden over uw inhalatie techniek.

Graag willen wij uw hulp vragen bij dit onderzoek. Bent u bereid mee te werken aan ons onderzoek tussen 16 november en 18 december op een maandag, dinsdag, woensdag of donderdag? We vragen deelnemers tijdens een interview om het prototype te gebruiken (hierbij vindt geen daadwerkelijke inhalatie van medicatie plaats) en hardop te vertellen wat ze van het prototype vinden. Daarnaast zullen wij een aantal vragen stellen over het prototype. Hierbij zijn geen verkeerde antwoorden mogelijk en u kunt niets fout doen. We zijn alleen geïnteresseerd in uw mening.

Het onderzoek zal ongeveer een uur duren. Het kan, in overleg met de onderzoeker, plaats vinden op een locatie die voor u handig is, bijvoorbeeld bij u thuis.

Als u er geen bezwaar tegen hebt, zouden we graag het interview met u willen filmen. Op die manier kunnen we de analyses zo goed mogelijk doen. De gegevens worden alleen voor dit onderzoek gebruikt, bovendien zullen alle gegevens vertrouwelijk en anoniem behandeld worden.

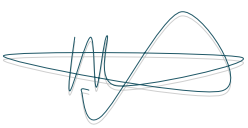
Wanneer u interesse hebt voor deelname kunt u uw contactgegevens doorsturen naar het volgende email adres: m.kingma-1@student.utwente.nl. Wij zullen daarna met u contact opnemen om een afspraak in te plannen. Kent u trouwens nog andere geïnteresseerden voor dit onderzoek? Dan horen wij dit ook graag en kunnen wij ook diegene uitnodigen voor deelname! **Voor deelname ontvangt u van ons een vvv-bon als bedankje.**

Bij voorbaat dank voor uw medewerking!

Hartelijke groeten,

Onderzoeksteam Universiteit Twente

Marieke Kingma



m.kingma-1@student.utwente.nl

Prof. Dr. Lisette van Gemert-Pijnen

j.vangemert-pijnen@utwente.nl

Appendix 5: Informed consent

Titel onderzoek: *"Persuasieve feedback en coaching van COPD patiënten via smart inhalatoren"*

Verantwoordelijke onderzoeker: ……...

In te vullen door de deelnemer

Ik verklaar hiermee dat ik op een voor mij duidelijke wijze, mondeling en schriftelijk ben ingelicht over de aard, methode en doel van dit onderzoek. Mijn vragen zijn naar tevredenheid beantwoord. De schriftelijke informatie, die behoort bij deze verklaring is aan mij overhandigd. Ik stem geheel vrijwillig in met deelname aan dit onderzoek. Ik behoud me daarbij het recht voor om op elk moment zonder opgaaf van redenen mijn deelname aan dit onderzoek te beëindigen.

Ik weet dat de gegevens en resultaten van het onderzoek alleen anoniem en vertrouwelijk aan derden bekend gemaakt zullen worden. Ik begrijp dat videomateriaal of bewerking daarvan uitsluitend voor analyse zal worden gebruikt.

Naam deelnemer: .....

Datum: .....

Handtekening deelnemer: .....

In te vullen door de uitvoerende onderzoeker

Ik heb een mondelinge en schriftelijke toelichting gegeven op het onderzoek. Ik zal resterende vragen over het onderzoek naar vermogen beantwoorden. De deelnemer zal van een eventuele voortijdige beëindiging van deelname aan dit onderzoek geen nadelige gevolgen ondervinden.

Naam onderzoeker: .....

Datum: .....

Handtekening onderzoeker: .....

Appendix 6: Script user evaluation patients

Script user evaluations patients

Voorbereiding:
Van de participanten wordt verwacht dat zij:

- ervaring hebben met het gebruiken van een inhalator;
- tijdens de gebruikerstest hardop nadenken.

Van de onderzoeker wordt verwacht dat zij:

- vooraf heldere instructies geeft over het interview;
- vooraf vraagt aan de participant of alles helder is;
- een toestemming verklaringsformulier (Informed Consent) laat tekenen door de participant.

Introductie:

Voorstellen
Student Gezondheidspsychologie aan de Universiteit Twente.

Doel onderzoek
(Kortgezegd: inzicht krijgen in de gebruiksvriendelijkheid van de feedback-inhalator en het patiënten portaal en welke eisen (requirements en persuasieve elementen) toegevoegd moeten worden.

Uitleggen procedure van het onderzoek
Uitleg: Tijdens dit interview leg ik een concept prototype aan u voor van een mondstuk met smart sensors genaamd de feedback-inhalator en een patiënten portaal om te kijken wat u hiervan vindt. Het gaat dus vooral om het idee en daarom is het nog niet helemaal uitgewerkt. Ik zal u hier een aantal vragen over stellen. Dit interview duurt ongeveer 60 minuten. Tijdens dit interview kunt u niks fout doen en er zijn dan ook geen foute antwoorden mogelijk. Wanneer u een pauze nodig hebt dan houden we een pauze. Het gesprek wordt opgenomen met een camera zodat het gesprek kan worden geanalyseerd. Alleen personen die direct betrokken zijn bij dit onderzoek kunnen de video bekijken. Verder wordt dit materiaal niet verspreid en het blijft dus vertrouwelijk.
Let op! Tijdens dit interview mag het mondstuk niet in uw mond worden geplaatst en u mag er ook niet doorheen ademen!

Mogelijkheid voor vragen
Als er dingen tijdens het interview onduidelijk zijn dan mag u hier gewoon een vraag over stellen.

Toestemmingsverklaringsformulier laten tekenen

Demografische gegevens:

- Leeftijd
- Opleidingsniveau
- Kunt u vertellen binnen welk stadium van COPD u zit/van welke longaandoening u last heeft?
- Kunt u vertellen of u onder de behandeling van de huisarts staat of de longarts vanuit het ziekenhuis?
- Welke type inhalatoren gebruikt u?
- Op welke momenten van de dag gebruikt u de inhalator? (Hoeveel doses?)

Technisch gebruik:

- Maakt u weleens gebruik van nieuwe technologie, zoals het internet en mobiele telefoons?
  Doorvragen: Zo ja, waar gebruikt u dit voor? Wat doet u bijvoorbeeld allemaal op het internet? En met uw mobiele telefoon? Zo niet, waarom maakt u hier geen gebruik van?

- Weet u wat een smart Phone is?
  Doorvragen: Heeft u ook een smart Phone? Zo ja, heeft u deze altijd bij u?

Scenario 1

Johan/Margriet heeft COPD (stadium III) en gebruikt daarom twee typen inhalatoren, de Spiriva Respimat en de Alvesco met voorzetkamer. Johan/Margriet vindt het soms lastig om de tijd te nemen om rustig gebruik te maken van zijn/haar inhalatoren, omdat hij/zij wel eens wat gehaast is. Daarnaast weet hij/zij niet altijd zeker of hij/zij op de goede manier zijn/haar inhalatoren gebruikt.

Op advies van de longarts gebruikt Johan/Margriet daarom vanaf vandaag de Feedback-inhalator en het daarbij behorende patiënten portaal (een website) ter ondersteuning van het inhalator gebruik. Johan/Margriet wil graag informatie vinden over de manier waarop de feedback-inhalator werkt. Daarom gaat hij/zij naar het patiënten portaal toe en logt zich in met zijn/haar persoonlijke inloggegevens om de gebruiksaanwijzing van de feedback-inhalator op te zoeken.

Taak: Ga naar het patiënten portaal, log in en zoek informatie op over het gebruik van de feedback-inhalator. Wilt u hierbij hardop vertellen wat uw gedachtes zijn en wat u allemaal ziet?

1. Was de gebruiksaanwijzing voor u makkelijk te vinden in dit patiënten portaal?
   A. Zo niet:
   - Waar ligt dit volgens u aan?
   - Hoe zou dit gemakkelijker voor u kunnen worden gemaakt?
     (Als meneer of mevrouw het niet heeft gevonden, ga er dan eerst samen naar toe voordat de volgende vragen worden behandeld)

2. Wat vindt u van de gebruiksaanwijzing over de feedback-inhalator in het patiënten portaal die u zojuist hebt doorgenomen?
   - Is dit verhaal helder voor u? (Kunt u bijv. op basis van deze uitleg vertellen hoe het werkt?)

- Zo niet, waar ligt dit aan?
- Wat moet er veranderd worden om het duidelijker te maken?

3. **Alle functies bij langs gaan en daarbij de volgende vraag stellen:** Wat vindt u van alle functies van de feedback-inhalator?

- real time feedback;
- na afloop feedback;
- oefen functie;
- notificatie aantal dosissen;
- notificatie dat er moet worden geïnhaleerd;
- notificatie vergeten te inhaleren;
- notificatie schoonmaak;

4. In hoeverre zijn alle verschillende signalen die de feedback-inhalator aan u kan geven duidelijk voor u? (dus de symbolen, trillingen en ambient feedback)
   A. Niet duidelijk, welke zijn onduidelijk?
      - Waar ligt dit aan?
      - Wanneer zou het wel duidelijk zijn?

5. Denkt u dat u door deze feedback signalen iedere keer de inhalator goed weet te gebruiken?
   A. Zo niet, waarom niet?
      - Wat moet er nog toegevoegd of veranderd worden zodat u dit wel kunt?
      - Zijn er nog extra dingen die de feedback-inhalator volgens u nog moet kunnen doen om het inhalator gebruik makkelijker te maken?
      - Zo ja welke en waarom?

6. Via het patiënten portaal kunt u ook klikken op de knop ‘instructies inhalator gebruik’ als u daar naartoe gaat wordt u doorverwezen naar een andere website die met afbeeldingen en video’s per type inhalator aan u uitlegt hoe de inhalator te gebruiken. Wat vindt u ervan dat wij u naar een andere bestaande website doorverwijzen?

Scenario 2

Nadat Johan/Margriet de feedback-inhalator heeft gebruikt ontvangt hij/zij het signaal van een uitroepteken wat betekent dat het inhalator gebruik niet helemaal goed is gegaan. Daarom moet hij/zij naar het patiënten portaal om te kijken wat er mis is gegaan.

Taak: Leg het mondstuk terug in het dock systeem en ga in het patiënten portaal op zoek naar informatie die aan u uitlegt wat er precies is misgegaan. Vertel hierbij hardop wat u waarneemt.

7. Was deze informatie makkelijk voor u om te vinden?
   A. Zo niet:
   - Waar ligt dit volgens u aan?
   - Hoe zou dit gemakkelijker voor u kunnen worden gemaakt?
     (Als meneer of mevrouw het niet heeft gevonden, ga er dan eerst samen naartoe voordat de volgende vragen worden behandeld)

8. Wat vindt u van de manier waarop de informatie (die u dus krijgt wanneer het inhaleren niet goed is gegaan) aan u is gepresenteerd?

9. Kunt u op basis van deze informatie vertellen wat er mis is gegaan?
   (laat de patiënt dit ook vertellen ter controle)
   A. Zo niet:
   - Waar ligt dit volgens u aan?
   - Hoe zou dit gemakkelijker voor u kunnen worden gemaakt?

10. Denkt u dat u door middel van deze informatie erin slaagt om de inhalator de volgende keer beter te gebruiken?
    (vraag ter controle wat er volgens de patiënt dan de volgende keer anders moet)
    - Zo niet, waar ligt dit aan?
    - Wat moet er veranderd/toegevoegd worden zodat u hier wel in slaagt?

11. Naast de informatie van wat er fout is gegaan, ziet u dat u op het patiënten portaal informatie kunt vinden onder ‘mijn gegevens’ (wijs aan). Welke informatie verwacht u hier te zien?

(Ga er daarna samen naartoe)

12. Wat vindt u van deze informatie?
    - Is dit volledig voor u?
    - Zo niet, wat mist er nog?

Scenario 3

Nadat Johan/Margriet de feedback-inhalator heeft gebruikt en zijn/haar status van het inhaleren heeft gelezen, wil hij/zij graag aan iemand een vraag stellen. Via het patiënten portaal zoekt hij/zij naar de verschillende manieren om een antwoord te vinden op zijn/haar vraag.

Taak: Zoek via het patiënten portaal naar de verschillende mogelijkheden waar u met uw vraag terecht kunt. Denk hierbij hardop en vertel wat u ziet en wat volgens u de mogelijkheden zijn die door het portaal worden geboden.

13. Was het gemakkelijk voor u om mogelijkheden te vinden waar u met uw vragen terecht kan?
    A. Zo ja, welke mogelijkheden heeft u gevonden?
    B. Zo niet:
        - Waar ligt dit volgens u aan?
        - Hoe zou dit gemakkelijker voor u kunnen worden gemaakt?
          (Als meneer of mevrouw het niet heeft gevonden, ga er dan eerst samen naar toe voordat de volgende vragen worden behandeld)

14. Wat vindt u van de verschillende manieren waarop u een antwoord kan vinden op uw vraag?
    - Forum
    - Via longverpleegkundige (webcam/mail)
    - Via 'veel gestelde vragen'

15. Denkt u dat u gebruik zou willen maken van deze mogelijkheden?
    A. Zo ja, welke wel en welke niet?
        - Waarom wilt u niet van deze gebruik maken?
        - Als meneer of mevrouw geen een van de mogelijkheden wil gebruiken dan vragen → Op welke manier zou u dan een antwoord willen vinden op uw eventuele toekomstige vragen?

Afsluitende vragen:

16. In hoeverre denkt u dat u met behulp van de feedback-inhalator en het patiënten portaal dagelijks uw inhalatoren goed kunt gebruiken?
    A. Als u denkt dat dit u niet lukt, waar ligt dit dan aan?
        - Wat moet er nog veranderen zodat u dat wel kunt?

17. Zou u de feedback-inhalator en het patiënten portaal ook dagelijks willen gebruiken?
    A. Zo niet, waarom niet?
        - Waaraan moet het nog meer voldoen zodat u het wel dagelijks wilt gebruiken?
        - Wat kan u nog meer motiveren om de feedback-inhalator en het patiënten portaal te gebruiken?

    B. Heeft u nog andere tips/ideeën met betrekking tot de feedback-inhalator en het patiënten portaal?
        - Veranderingen
        - Toevoegingen

        Etc.

<u>Afsluiten en bedanken</u>

- Sluit het interview af en vraag of de deelnemer nog een laatste toevoeging wil geven of een vraag wil stellen over het onderzoek.
- Bedank de deelnemer voor deelname aan het onderzoek.
- Vraag of de deelnemer nog interesse heeft in de onderzoeksresultaten.
- **<u>Geef een vvv bon aan de deelnemer na afloop van het interview en laat de deelnemer een handtekening zetten voor ontvangst van de vvv bon.</u>**

Appendix 7: Script user evaluation healthcare professionals

Script user evaluation healthcare professionals

Voorbereiding:

Van de Longarts/Longverpleegkundige wordt verwacht dat hij/zij:

- tijdens de gebruikerstest hardop nadenkt.

Van de onderzoeker wordt verwacht dat zij:

- vooraf heldere instructies geeft over het interview;
- vooraf vraagt aan de participant of alles helder is;
- een camera meeneemt;
- een toestemming verklaringsformulier (Informed Consent) laat tekenen door de participant.

Introductie:

Voorstellen

Master student Gezondheidspsychologie aan de Universiteit Twente. Doel onderzoek: Op dit moment ben ik voor mijn afstudeer onderzoek aan het kijken naar de gebruiksvriendelijkheid van het prototype en de eisen waaraan het prototype moet voldoen zodat het o.a. betrouwbaar en klinisch relevant is.

Uitleggen onderzoek:

Er is een prototype ontwikkeld van een mondstuk met sensoren genaamd de feedback-inhalator en een daarbij behorend patiënten portaal. Het doel van deze technologie is om goede therapeutische effecten, minder exacerbaties, minder ziekenhuis opnames en een hoge kwaliteit van leven te bereiken. Het prototype is ontwikkeld om het tijdens dit onderzoek te kunnen evalueren d.m.v. gebruikers testen.

Doel gesprek:

Het doel van dit gesprek is dus om te kijken naar de mate waarin de huidige functies van de smart sensor technologie en het patiënten portaal volgens u waardevol zijn in het bereiken van het gezondheidsdoel. Daarnaast om te bespreken in hoeverre er volgens u nog toevoegingen/veranderingen gemaakt moeten worden.

Dit gesprek duurt maximaal 60 minuten. Deelname is volledig vrijwillig en u mag op elke moment stoppen met het interview. Het gesprek wordt opgenomen (audio) zodat het gesprek na afloop kan worden geanalyseerd. Alle data worden anoniem verwerkt alleen voor het onderzoeksdoeleinde. Alleen personen die direct betrokken zijn bij dit onderzoek kunnen de video bekijken. Verder wordt dit materiaal niet verspreid en het blijft dus vertrouwelijk.

Toestemmingsverklaringsformulier laten tekenen

Demografische gegevens/achtergrond informatie:

- Specifieke functie/expertise/specialisme
- Vanuit welke organisatie of werkplek?
- Hoeveel jaar ervaring in het vak?
- Leeftijd?
- Man/vrouw
- Ervaring met technologie: internet/mobiele apps/sesoren/….

Uitleggen feedback-inhalator en patiënten portaal door het presenteren van het prototype. (Paper prototype patiënten portaal en het prototype van de 'feedback-inhalator').

1. Wat is uw algemene indruk over het prototype?

2. In hoeverre zou deze technologie volgens u een bijdrage kunnen leveren in het verbeteren van therapeutische effecten, het verminderen van exacerbaties en uiteindelijk het terugdringen van ziekenhuis opnames en het verhogen van de kwaliteit van leven?
    - Als u denkt dat dit doel door deze technologie niet bereikt kan worden. Waar ligt dit dan aan?
    - Wanneer zou dit doel wel bereikt kunnen worden?

3. Wat vindt u van alle functies van de feedback-inhalator?

- real time feedback ***(Hierna vraag 4)***
- na afloop feedback;
- oefen functie;
- notificatie aantal dosissen;
- notificatie dat er moet worden geïnhaleerd;
- notificatie vergeten te inhaleren;
- notificatie schoonmaak;

4. Denkt u dat doormiddel van de verschillende aspecten die de feedback-inhalator meet er op een betrouwbare manier gezegd kan worden of de inhalatietechniek goed/fout was en er dus een goede longdepositie is?
    - Zo niet, wat moet er nog extra gemeten worden zodat dit wel kan?

5. Denkt u dat patiënten met behulp van dit hulpmiddel dagelijks erin slagen om op de juiste wijze de inhalator te kunnen gebruiken?
    A. Zo niet, waarom niet?
    - Wat zou er moeten veranderen zodat dit wel lukt?/Welke feedback zou de feedback-inhalator nog meer moeten geven aan patiënten zodat ze dit volgens u wel zou kunnen?

6. Sommige patiënten hebben aangegeven graag te willen weten in hoeverre ze de inhalatie van een doses opnieuw moeten uitvoeren als is gebleken dat het inhaleren niet helemaal goed is gegaan. Wanneer is het verantwoord om nog een extra dosis te nemen?
    - Is hier sprake van een bepaald omslag punt?

7. De feedback-inhalator geeft een rood licht alarm af wanneer een patiënt is vergeten om te inhaleren. Na hoeveel tijd kan er gezegd worden dat de inhalatie te laat is?
    - Via het patiënten portaal willen wij graag de patiënt kunnen informeren wat hij/zij op dat moment moet doen om dit te herstellen. Wat is normaliter het advies aan een patiënt die is vergeten om een dosis in te nemen?

Scenario 1

Dokter Jan Veenstra behandelt veel verschillende COPD patiënten. Jan heeft al een tijdje niks van een van zijn patiënten, Johan Dekker gehoord. De afgelopen twee afspraken die gepland stonden met Johan zijn allebei niet doorgegaan. Nu is Dokter Jan Veenstra erg benieuwd naar hoe het met Johan gaat. Omdat Johan gebruik maakt van de feedback-inhalator worden al zijn gegevens rondom het inhalator gebruik gemeten en opgeslagen in het patiënten portaal. Dokter Jan Veenstra wil daarom via dit portaal opzoek gaan naar de gegevens van het inhalator gebruik van Johan.

Taak: Ga naar het patiënten portaal en log in. Ga op zoek naar de gegevens van uw patiënt Johan Dekker. Denk hierbij hardop gedurende het proces en vertel wat u allemaal ziet.

1. Zijn de patiënten gegevens van Johan Dekker gemakkelijk voor u om te vinden?
   A. Zo niet:
      - Waar ligt dit volgens u aan?
      - Hoe zou dit gemakkelijker voor u kunnen worden gemaakt?

   (Als meneer of mevrouw het niet heeft gevonden, ga er dan eerst samen naar toe voordat de volgende vragen worden behandeld)

2. Wat is uw algemene indruk over dit deel van het prototype? Is het potentieel nuttig voor u?
   - Zo niet, waarom niet?

3. Zijn de gegevens die u kunt inzien voor u klinisch relevant?
   - Dus kunt u op basis van deze gegevens controleren of de patiënt therapietrouw is?
     A. Zo niet, wat moet er nog extra toegevoegd worden qua informatie?
   - Kunt u ook op basis van deze gegevens beslissingen/keuzes maken over de behandeling van uw patiënt?
     A. Zo niet, wat moet er nog extra toegevoegd worden qua informatie?

4. Wat vindt u van de wijze waarop de gegevens m.b.t. het inhalator gebruik van Johan Dekker aan uw wordt gepresenteerd?
   A. Is de weergave van gegevens helder voor u?
      - Zo niet, waarom niet?
      - Wat zou u graag anders willen zodat dit wel helder is?

Ga samen met de arts naar de pagina waarop patiënten een vraag kunnen stellen aan de longverpleegkundige via de mail of webcam. Stel vervolgens de volgende vraag:

1. Wat vindt u ervan als een patiënt via de mail of webcam een vraag aan u of de longverpleegkundige stelt over het inhalator gebruik of de gezondheid?
   A. In hoeverre is dit haalbaar?
   B. Zou u hieraan mee willen werken?
   C. Zo niet, waarom niet?

Afsluitende vragen:

1. Stel u wilt dit systeem integreren in uw werk, hoe zou u dat dan aanpakken?

2. Wat zou u ervan vinden als dit systeem in de toekomst wordt geïmplementeerd binnen het zorgproces van COPD patiënten (of andere chronische longpatiënten)?

3. Zou u zelf gebruik willen maken van het patiënten portaal en dus ook uw patiënten aan willen raden om de feedback-inhalator te gebruiken?
   A. Zo niet, waarom niet?
      - Wat zou er veranderd of toegevoegd moeten worden zodat u hier wel gebruik van zou willen maken?

<u>Afsluiten en bedanken</u>

- Sluit het interview af en vraag of de deelnemer nog een laatste toevoeging wil geven of een vraag wil stellen over het onderzoek.
- Bedank de deelnemer voor deelname aan het onderzoek.
- Vraag of de deelnemer nog interesse heeft in de onderzoeksresultaten.
- Geef een vvv bon aan de deelnemer na afloop van het interview en laat de deelnemer een handtekening zetten voor ontvangst van de vvv bon.

Script evaluations medical microbiologist

Voorbereiding:

Van de onderzoeker wordt verwacht dat zij:

- vooraf heldere instructies geeft over het interview;
- een toestemming verklaringsformulier (Informed Consent) laat tekenen door de participant;
- geluidsopname apparatuur meeneemt en extra batterijen.

Introductie:

Voorstellen

Master student Gezondheidspsychologie aan de Universiteit Twente. Doel onderzoek: Op dit moment ben ik voor mijn afstudeer onderzoek aan het kijken naar de gebruiksvriendelijkheid van het prototype en de eisen waaraan het prototype moet voldoen zodat het o.a. betrouwbaar en klinisch relevant is.

Uitleggen onderzoek:

Er is een prototype ontwikkeld van een mondstuk met sensoren genaamd de feedback-inhalator en een daarbij behorend patiënten portaal. Het doel van deze technologie is om goede therapeutische effecten, minder exacerbaties, minder ziekenhuis opnames en een hoge kwaliteit van leven te bereiken. Het prototype is ontwikkeld om het tijdens dit onderzoek te kunnen evalueren d.m.v. gebruikers testen.

Doel gesprek:

Het doel van dit gesprek is dus om te kijken naar de mate waarin de huidige functies van de smart sensor technologie en het patiënten portaal volgens u waardevol zijn in het bereiken van het gezondheidsdoel. Daarnaast om te bespreken op welke manier er op een hygiënische verantwoorde wijze gebruik kan worden gemaakt van de feedback-inhalator. Tot slot in hoeverre er volgens u nog toevoegingen/veranderingen gemaakt moeten worden.

Dit gesprek duurt maximaal 60 minuten. Deelname is volledig vrijwillig en u mag op elke moment stoppen met het interview. Het gesprek wordt opgenomen (audio) zodat het gesprek na afloop kan worden geanalyseerd. Alle data worden anoniem verwerkt alleen voor het onderzoeksdoeleinde. Alleen personen die direct betrokken zijn bij dit onderzoek kunnen de video bekijken. Verder wordt dit materiaal niet verspreid en het blijft dus vertrouwelijk.

Toestemmingsverklaringsformulier laten tekenen

Demografische gegevens/ achtergrond informatie:

- Specifieke functie/expertise/specialisme:
- Organisatie (werkplek):
- Hoeveel jaar ervaring in het vak
- Leeftijd
- Man/vrouw
- Ervaring met technologie: internet / mobiele apps / sensoren /….

Uitleggen feedback-inhalator en patiënten portaal door het te laten zien.

1. Wat is uw algemene indruk van het prototype?

2. In hoeverre zou deze technologie volgens u een bijdrage kunnen leveren in het verbeteren van therapeutische effecten, het verminderen van exacerbaties en uiteindelijk het terugdringen van ziekenhuis opnames en het verhogen van de kwaliteit van leven?
    - Als u denkt dat dit doel door deze technologie niet bereikt kan worden. Waar ligt dit dan aan?
    - Wanneer zou dit doel wel bereikt kunnen worden?

3. Wat vindt u van alle functies van de feedback-inhalator?

- real time feedback;
- na afloop feedback;
- oefen functie;
- notificatie aantal dosissen;
- notificatie dat er moet worden geïnhaleerd;
- notificatie vergeten te inhaleren;
- notificatie schoonmaak;

4. Zijn er extra dingen waar volgens u op gelet moet worden of functies die toegevoegd zouden moeten worden om het doel (goede therapeutische effecten, minder exacerbaties, minder ziekenhuis opnames en een hoge kwaliteit van leven) te kunnen bereiken?

5. Op welke wijze en hoe frequent zou zo'n mondstuk met sensoren volgens u schoon gemaakt moeten worden om exacerbaties te voorkomen?

6. Welke stappen zijn hierin essentieel?

7. Zijn er nog extra zaken van belang waarmee rekening moet worden gehouden om exacerbaties bij COPD patiënten te voorkomen?

8. Heeft u nog aanvullende suggesties/opmerkingen/vragen?

Informatie laten zien die longartsen en longverpleegkundigen te zien krijgen wanneer zij zich inloggen in het patiënten portaal.

9. Wat is u algemene indruk over dit deel van het prototype? Is het potentieel nuttig/niet?

10. Wat vindt u van het overzicht van de gegevens m.b.t. het inhalator gebruik die longartsen en longverpleegkundigen kunnen inzien?

- Zijn de gegevens die longartsen en longverpleegkundigen kunnen inzien volgens u klinisch relevant? (Dat wil zeggen: kunnen zij op basis van deze gegevens een inschatting maken van

de mate waarin de patiënt therapietrouw[1] is en beslissingen nemen over de behandeling van de patiënt?)

- Zo niet, wat moet er volgens u nog extra toegevoegd worden qua informatie?
- Heeft u nog aanvullende suggesties/opmerkingen/vragen?

Afsluiten en bedanken

- Sluit het interview af en vraag of de deelnemer nog een laatste toevoeging wil geven of een vraag wil stellen over het onderzoek.
- Bedank de deelnemer voor deelname aan het onderzoek.
- Vraag of de deelnemer nog interesse heeft in een samenvatting van de onderzoeksresultaten.
- **Geef een vvv bon aan de deelnemer na afloop van het interview en laat de deelnemer een handtekening zetten voor ontvangst van de vvv bon.**

Appendix 8: Coding scheme patients (in Dutch)

1. Achtergrond informatie	
AD	De respondent benoemt het type longaandoening waar hij/zij last van heeft.
BH	De respondent benoemt zijn/haar behandelaar.
TI	De respondent benoemt welk(e) type inhalator(en) hij/zij gebruikt.
MI	De respondent benoemt op welke momenten hij/zij gebruik maakt van de inhalator(en).
TG	De respondent benoemt van welke technologie hij/zij gebruik maakt.
2. Uitvoeren taak	
WPT (taak nr.)	De respondent weet/gaat naar waar hij/zij wezen moet in het portaal om taak 1, 2 of 3 uit te voeren.
OMW (taak nr.)	De respondent neemt een omweg om taak 1, 2 of 3 uit te voeren.
WNT (taak nr.)	De respondent weet niet/gaat niet naar waar hij/zij wezen moet in het portaal om taak 1, 2 of 3 uit te voeren.
WV (taak nr.)	De respondent benoemt in hoeverre het makkelijk is om de weg te vinden in het portaal om taak 1, 2 of 3 uit te voeren.
OHW (taak nr.)	De onderzoeker moet de respondent helpen om de weg te vinden in het portaal om taak 1, 2 of 3 uit te voeren.
WP	De respondent benoemt op welke wijze hij/zij graag te werk gaat in het portaal, of wanneer hij/zij nieuwe technologie gebruikt.
3. Mening t.o.v. de technologie	
MHS	De respondent benoemt wat zijn/haar algemene indruk is van de technologie of wat hij/zij van de gehele technologie in zijn algemeenheid vindt.
MRT	De respondent benoemt wat hij/zij van de functie real-time feedback vindt.
MAF	De respondent benoemt wat hij/zij ervan vindt dat er feedback via het portaal wordt gegeven wanneer het inhaleren fout is gegaan.
MOF	De respondent benoemt wat hij/zij vindt van de functie om de inhalatie techniek te kunnen oefenen met het mondstuk, zonder het vrijkomen van een dosis.
MN	De respondent benoemt wat hij/zij van de functie notificaties vindt.
WS	De respondent benoemt wat hij/zij van de verschillende feedback signalen vindt (symbolen, haptische en ambient feedback).
MVW	De respondent benoemt wat hij/zij ervan vindt dat er via het portaal wordt verwezen naar een andere bestaande website over de ‘instructies inhalatorgebruik’
IH	De respondent benoemt dat hij/zij de instructies over het inhalator gebruik niet nodig vindt.
MVV	De respondent benoemt wat hij/zij van de optie ‘veel gestelde vragen’ vindt.
MRL	De respondent benoemt wat hij/zij van de optie ‘raadpleeg de longverpleegkundige’ via, mail/ webcam of telefoon vindt.
MF	De respondent benoemt wat hij/zij van de optie ‘forum’ vindt.
MMV	De respondent benoemt wat hij/zij in het algemeen vindt van de verschillende manieren waarop er via het portaal een antwoord kan worden gevonden op een vraag.
WIM	De respondent benoemt wat hij/zij van de informatie onder ‘mijn gegevens’ vindt.
4. Helderheid van de technologie	
MIF	De respondent benoemt wat hij/zij van de instructies over de feedback-inhalator vindt.
HIF	De respondent benoemt de mate waarin hij/zij de instructies over de feedback-inhalator helder vindt/of kan benoemen hoe het systeem werkt.
VTG	De respondent benoemt dat er verwarring is door taalgebruik.
BW	Mate waarin de respondent begrijpt hoe het portaal werkt.
VR	De respondent benoemt iets wat hij/zij zich afvraagt m.b.t. de technologie.
HS	De respondent benoemt de mate waarin hij/zij de verschillende feedback signalen (symbolen, haptische en ambient feedback) helder/duidelijk vindt/kan vertellen wat een signaal betekent.
MISI	De respondent benoemt wat hij/zij vindt van de manier waarop de informatie is gepresenteerd in ‘status inhalatie techniek’
HIS	De respondent benoemt de mate waarin hij/zij de feedback in ‘status inhalatie techniek’ helder vindt/kan op basis van de informatie opnoemen wat de feedback is.

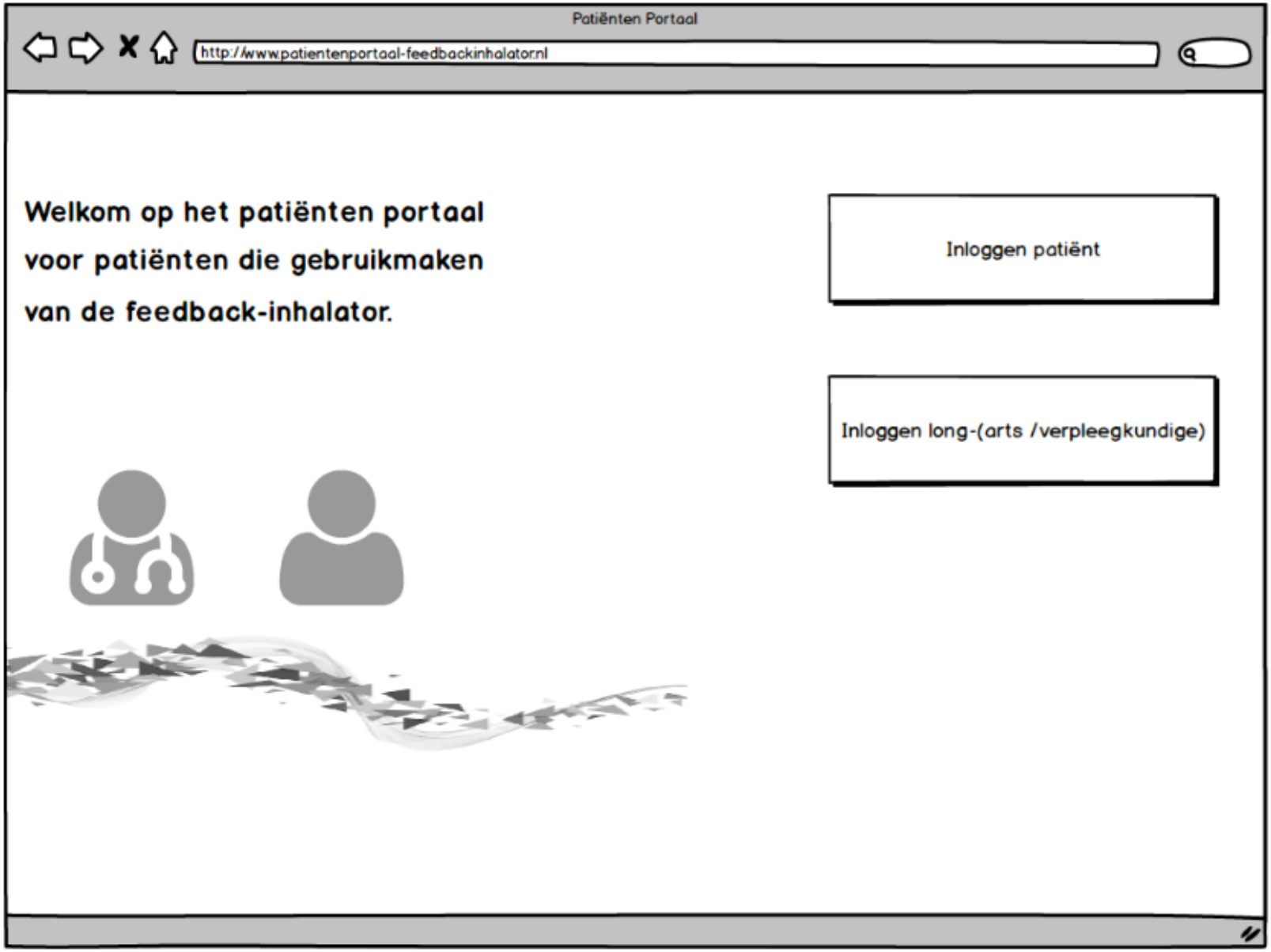
5. Verwachtingen van de technologie	
IV	De respondent benoemt de mate waarin hij/zij denkt dat de functie ‘real-time feedback’ zijn/haar inhalatorgebruik kan verbeteren.
ISG	De respondent benoemt de mate waarin hij/zij denkt dat de informatie in ‘status inhalatie techniek’ het inhalator gebruik voor de volgende keer kan verbeteren.
FEI	De respondent benoemt de mate waarin hij/zij denkt dat de gehele technologie voor hem/haar effectief /van toegevoegde waarde is.
VIM	De respondent benoemt welke informatie hij/zij verwacht te zien onder de knop ‘mijn gegevens’.
BT	De respondent benoemt welke personen volgens hem/haar baat hebben bij de technologie.
TWN	De respondent benoemt een situatie waarin hij/zij verwacht dat de technologie voor hem/haar niet werkt.
SGS	De respondent benoemt een situatie waarin hij/zij denkt dat het systeem nuttig is om te gebruiken.
6. Motivatie om de technologie te gebruiken	
MGG	De respondent benoemt de mate waarin hij/zij de informatie onder ‘mijn gegevens’ wil gebruiken.
GGM	De respondent benoemt de mate waarin hij/zij gebruik wil maken van de verschillende (‘veel gestelde vragen’, ‘raadpleeg de longverpleegkundige’ en het ‘forum’) opties om een antwoord te vinden op een vraag.
WDG	De respondent benoemt in hoeverre hij/zij de technologie wil gebruiken.
TN	De respondent benoemt de mate waarin hij/zij denkt de technologie nodig te hebben.
7. Aanpassingen technologie	
ET	De respondent noemt aanbevelingen/ideeën/suggesties/veranderingen en/of eisen m.b.t. de technologie.
NT	De respondent benoemt dat er geen wijzigingen aangebracht hoeven te worden in (een bepaald onderdeel van) de technologie.
8. Overige informatie	
FI	De respondent benoemt wanneer/waarom het inhaleren wel eens mis gaat.
DF	De respondent benoemt wat hij/zij doet wanneer het inhaleren fout is gegaan.
SI	De respondent benoemt wat hij/zij van het schoonmaken van de inhalator vindt.
BAD	De respondent benoemt op welke wijze hij/zij gewend is om het aantal dosissen bij te houden.
MAI	De respondent benoemt soms moeite te hebben met het inhouden van de adem na het inhaleren, of dat anderen hier moeite mee kunnen hebben.
PP	De respondent geeft aan het prettig te vinden om af en toe met een professional te praten, of geeft aan wanneer hij/zij het belangrijk vindt om met een ‘professional’ te praten.
OV	Overige informatie

Appendix 9: Coding scheme health care professionals (In Dutch)

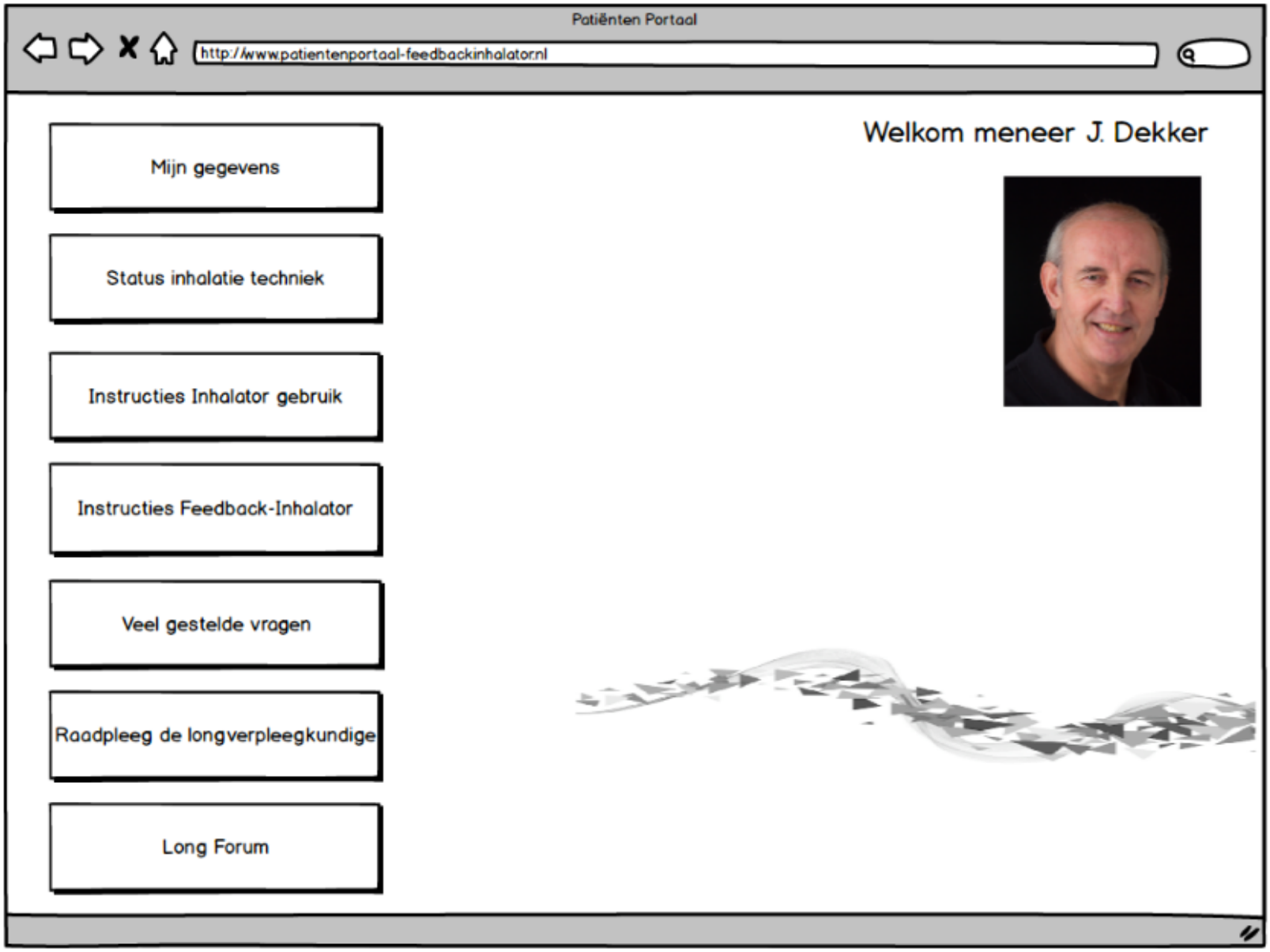
1. Achtergrond informatie	
EX	Specifieke functie/expertise/specialisme.
TG	Technisch gebruik/ervaring met technologie.
OIG	De respondent benoemt op welke wijze patiënten momenteel ondersteund worden in het inhalator gebruik.
2. Mening t.o.v. de technologie wat voor de patiënt is bedoeld	
AGP	De respondent benoemt zijn algemene indruk/mening van de technologie wat voor de patiënt bedoeld is.
MOF	De respondent benoemt wat hij van een oefenfunctie vindt.
MAF	De respondent benoemt wat hij ervan vindt dat de patiënt in het portaal feedback kan vinden wanneer het inhaleren niet goed is gegaan.
MN	De respondent benoemt wat hij van de functie notificaties vindt.
WS	De respondent benoemt wat hij van de verschillende feedback signalen vindt (symbolen, haptische en ambient feedback).
VUI	De respondent benoemt wat hij van het ventiel in het mondstuk vindt, waarmee de uitademing kan worden gemeten.
MVB	De respondent benoemt wat hij ervan vindt als patiënten via het portaal kunnen videobellen met een longverpleegkundige.
3. Mening t.o.v. de technologie wat voor de longarts/longverpleegkundige is bedoeld	
AGL	De respondent benoemt zijn algemene indruk/mening van de technologie wat voor de longarts/longverpleegkundige bedoeld is.
MO	De respondent benoemt wat hij van de manier vindt waarop de resultaten m.b.t. de inhalatie techniek van ‘Johan Dekker’ wordt gepresenteerd in het portaal.
MGP	De respondent benoemt wat hij van de type gegevens vindt (e.g. persoonlijke gegevens, type inhalator, inhalatie techniek etc.) die het portaal van de patiënt weergeeft.
DON	De respondent benoemt in hoeverre hij het dag overzicht nuttig vindt.
MIL	De respondent benoemt wat hij ervan vindt om zich te moeten inloggen.
SF	De respondent benoemt wat hij van de status van Johan Dekker vindt.
4. Verwachtingen van de technologie	
TBL	De respondent benoemt in hoeverre hij denkt dat de technologie een bijdrage kan leveren in het verbeteren van therapeutische effecten, het vergroten van de kwaliteit van leven, het voorkomen van exacerbaties en het verminderen van ziekenhuisopnames.
TIV	De respondent benoemt in hoeverre hij denkt dat de technologie de inhalatie techniek van de patiënt kan verbeteren.
PN	De respondent benoemt in hoeverre hij verwacht dat de technologie voor hem potentieel nuttig is.
HVB	De respondent benoemt in hoeverre hij verwacht dat videobellen met de longverpleegkundige haalbaar is (in de toekomst).
5. Uitvoeren van de taak	
WV	De respondent geeft aan dat het makkelijk is om de gegevens van ‘Johan Dekker’ op te zoeken via het portaal.
WPT	De acties die de respondent uitvoert in het portaal om de taak uit te voeren.
OSH	De onderzoeker ondersteunt de respondent in het portaal om naar een specifiek onderdeel toe te gaan.

6. Aanpassingen /aanbevelingen voor de technologie	
ET	De respondent noemt aanbevelingen/ideeën/suggesties/veranderingen en/of eisen m.b.t. de technologie.
SOT	De respondent doet een suggestie voor het onderzoeken van de effecten van de technologie of suggesties voor de uitvoering van dit huidige onderzoek.
GRS	De respondent benoemt wat hij onder goed, redelijk en slecht verstaat wanneer het gaat om de status inhalatie techniek.
HLI	De respondent benoemt in hoeverre de technologie de belangrijke handelingen omtrent de inhalatie techniek meet of dat er nog extra handelingen gemeten moeten worden.
7. Klinische relevantie	
BTT	De respondent benoemt in welke mate hij met behulp van de technologie kan beoordelen of de patiënt therapietrouw is.
TT	De respondent geeft aan in hoeverre er nog iets toegevoegd moet worden aan de technologie om de therapietrouwheid te kunnen beoordelen.
BB	De respondent benoemt in welke mate hij met behulp van de technologie beslissingen kan maken over de behandeling van zijn patiënt.
8. Motivatie om de technologie te gebruiken	
MIT	De respondent geeft aan wat hij ervan vindt als de technologie wordt geïmplementeerd.
VIT	De respondent geeft aan op welke wijze en/of onder welke voorwaarden de technologie geïmplementeerd mag worden.
TTG	De respondent geeft aan in hoeverre hij de technologie in de toekomst wil gebruiken.
9. Overige informatie	
GED	De respondent benoemt wat de gevolgen kunnen zijn van het nemen van een extra dosis.
VED	De respondent benoemt in welke mate het volgens hem verantwoord is om een nieuwe dosis te nemen nadat het inhaleren fout is gegaan.
NST	De respondent benoemt in hoeverre er op vaste tijdstippen moet worden geïnhaleerd.
DNL	De respondent benoemt in hoeverre het verantwoord is om een dosis ‘in te halen’ wanneer de patiënt de inhalatie aanvankelijk is vergeten.
IL	De respondent benoemt wanneer het inhaleren te laat is.
AI	De respondent benoemt de mate waarin patiënten de adem tien seconden kunnen inhouden.
AIN	De respondent benoemt hoelang de adem ingehouden moet worden na het inhaleren.
MEV	De respondent legt uit wat er op dit moment gedaan wordt om exacerbaties te voorkomen.
KP	De respondent benoemt wat voor karakteristieken COPD patiënten hebben.
IMS	De respondent benoemt in hoeverre een inhalator moet worden schoongemaakt
FR	De respondent geeft aan wat hij van de flow-rate vindt, en/of legt uit wat flow-rate inhoudt.
VR	De respondent benoemt iets wat hij zich afvraagt in het algemeen, m.b.t. de technologie of andere dingen die nog onduidelijk zijn.
OV	Overige informatie

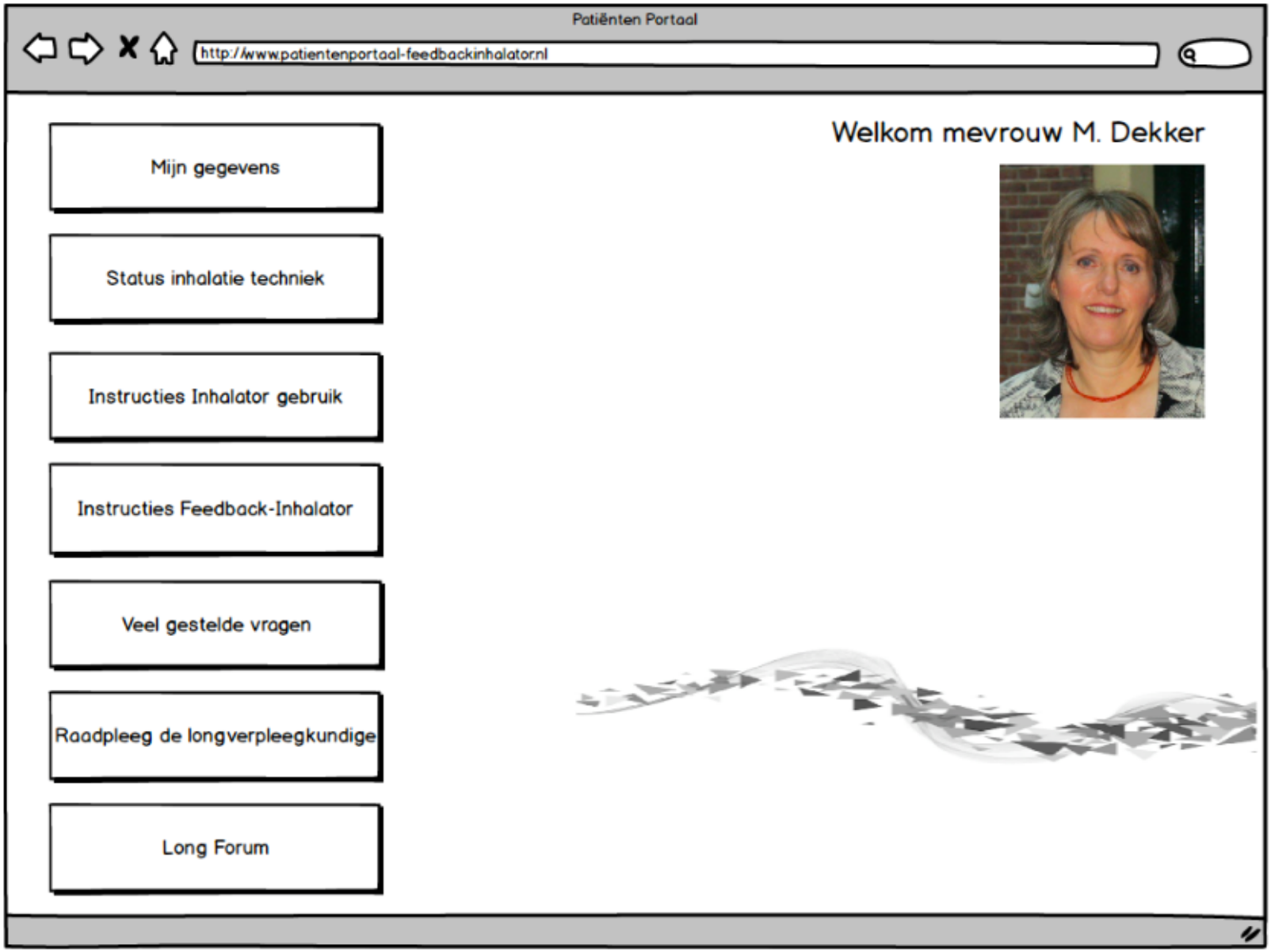
Appendix 10: Patient Portal



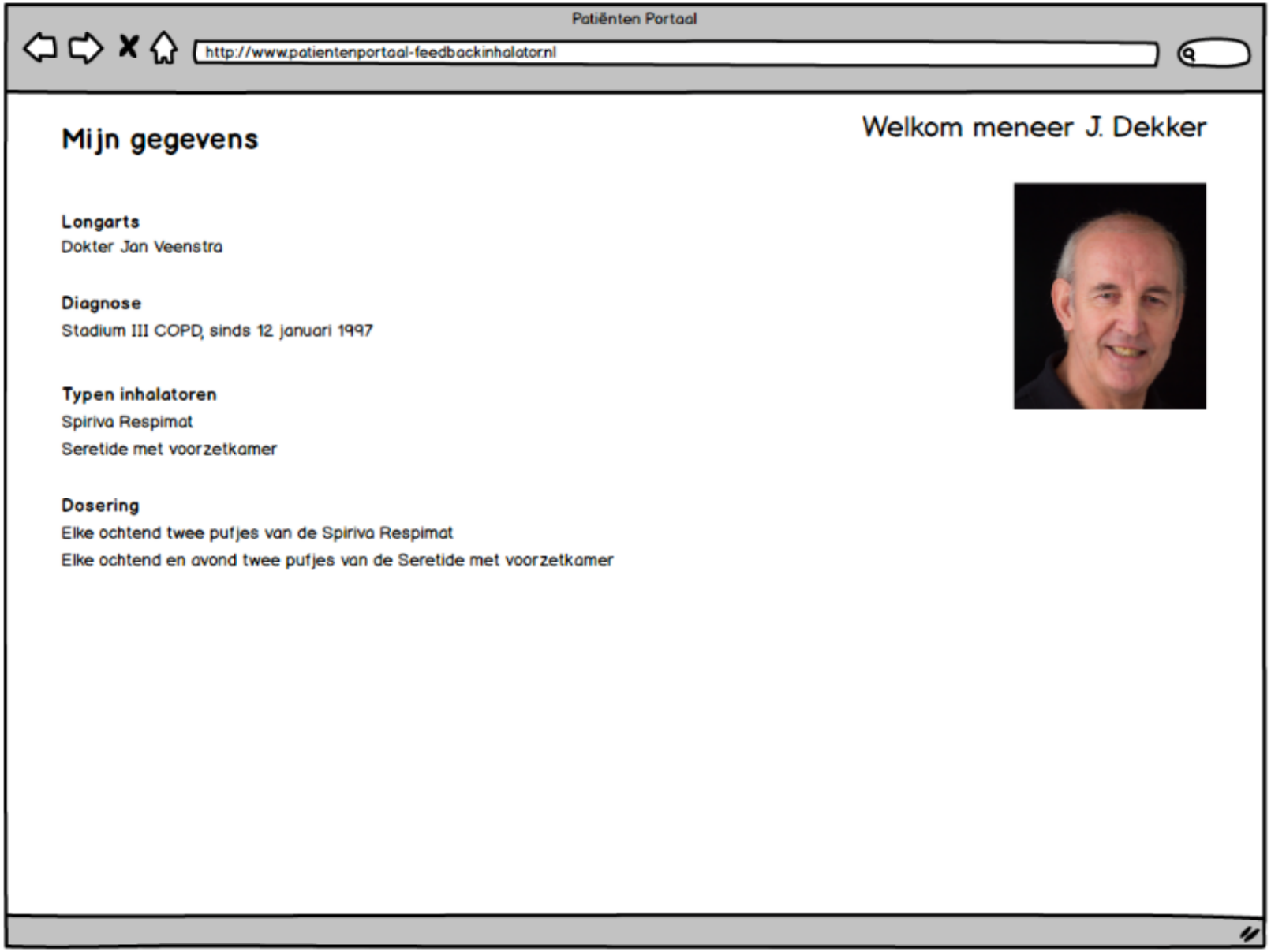
Page: Menu (after user logs in)



Page: Menu (after user logs in)

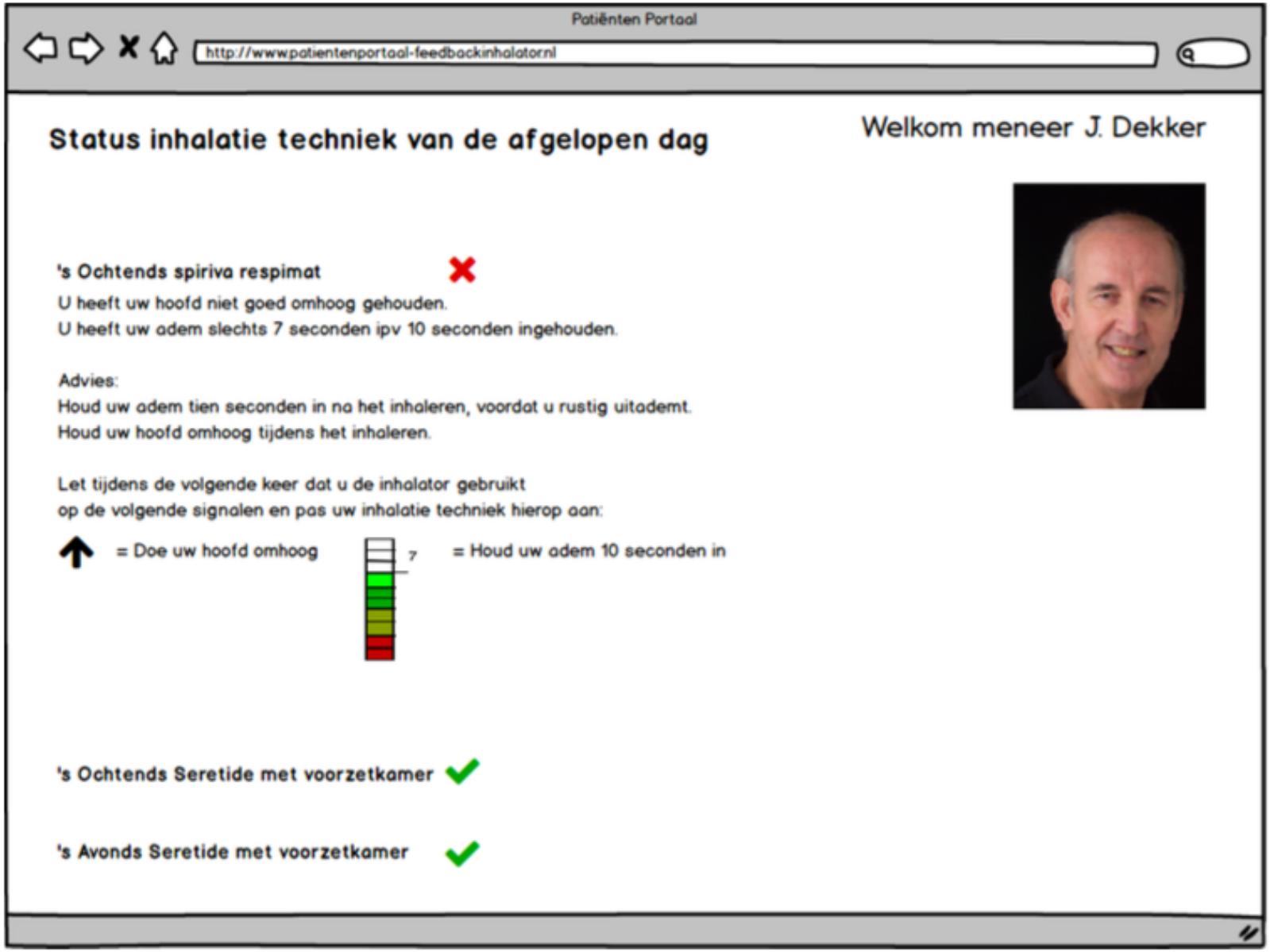


Page: My details (after clicking on ‘Mijn gegevens’)

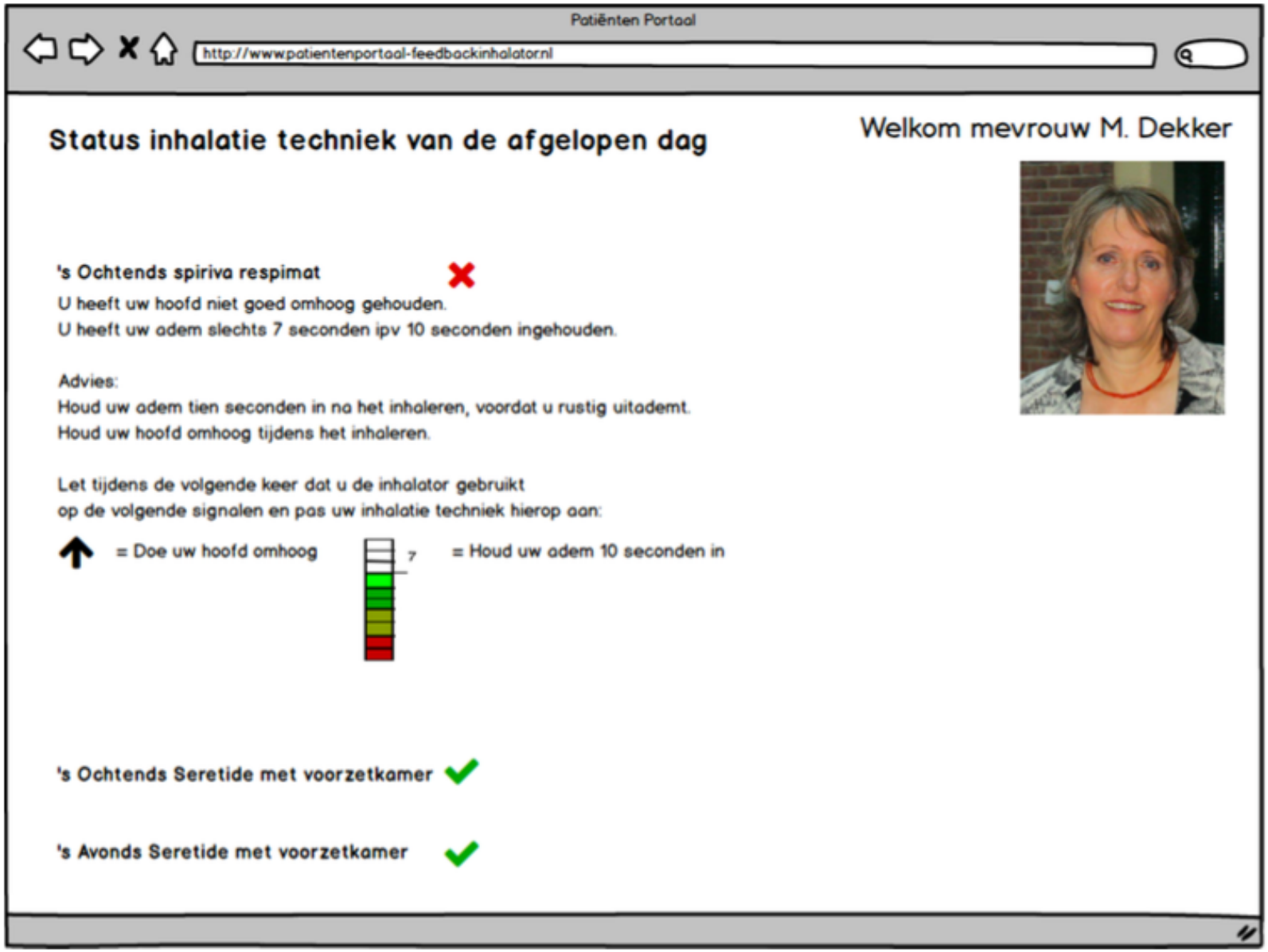


Page: My details (after clicking on ‘Mijn gegevens’)

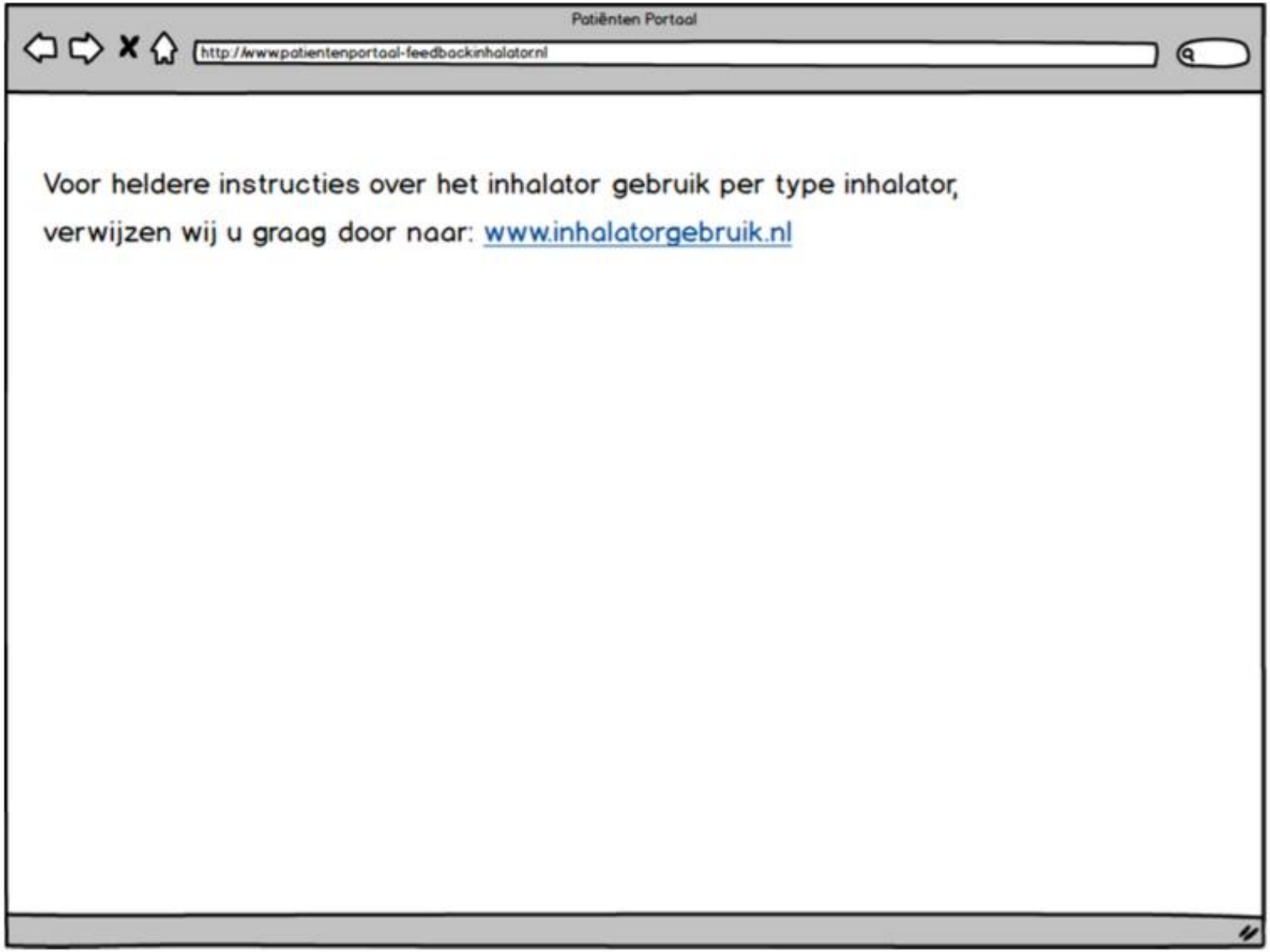
Page: Status inhalation technique (after clinking on ‘Status inhalatie techniek)



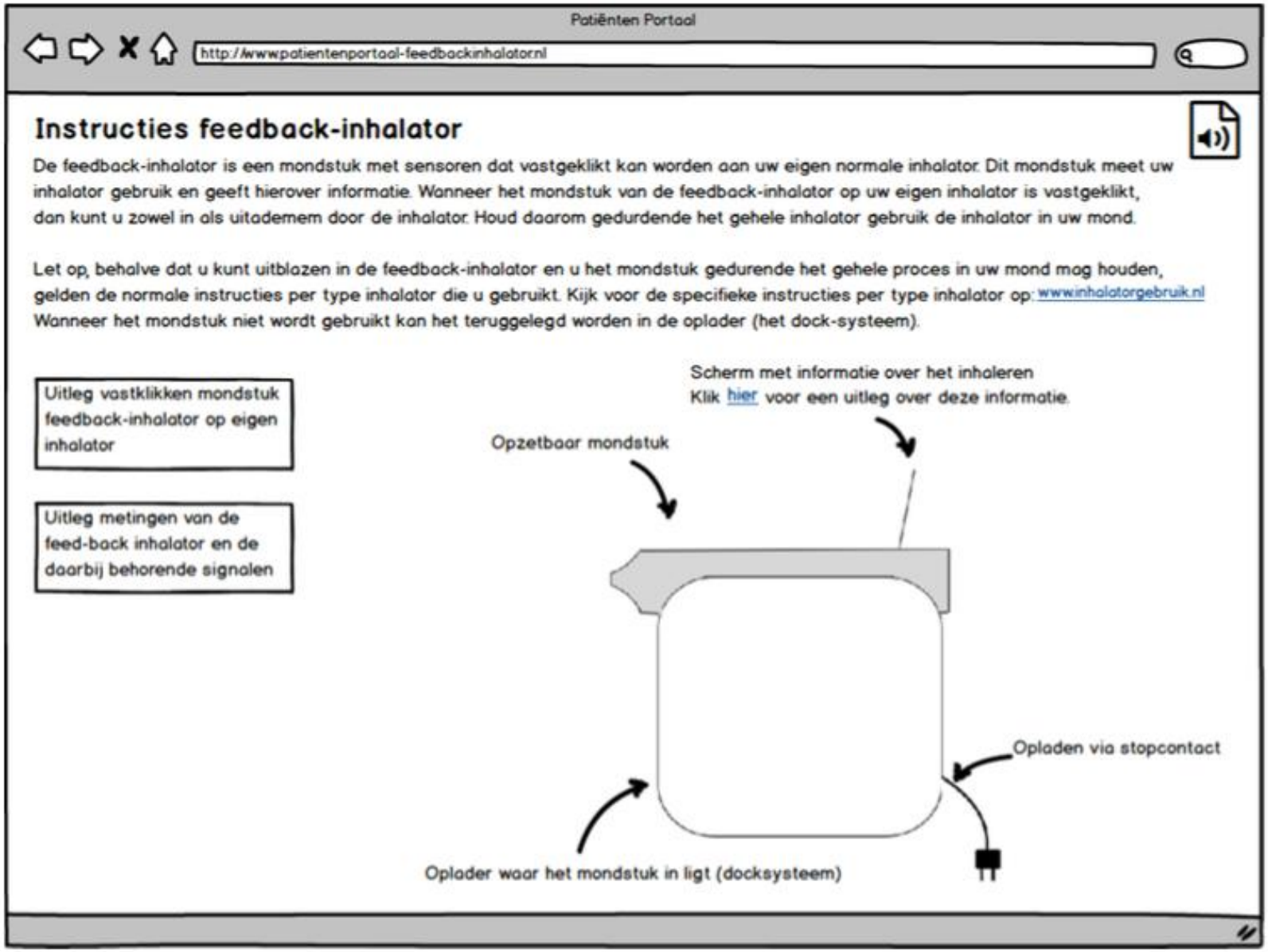
Page: Status inhalation technique (after clinking on ‘Status inhalatie techniek)



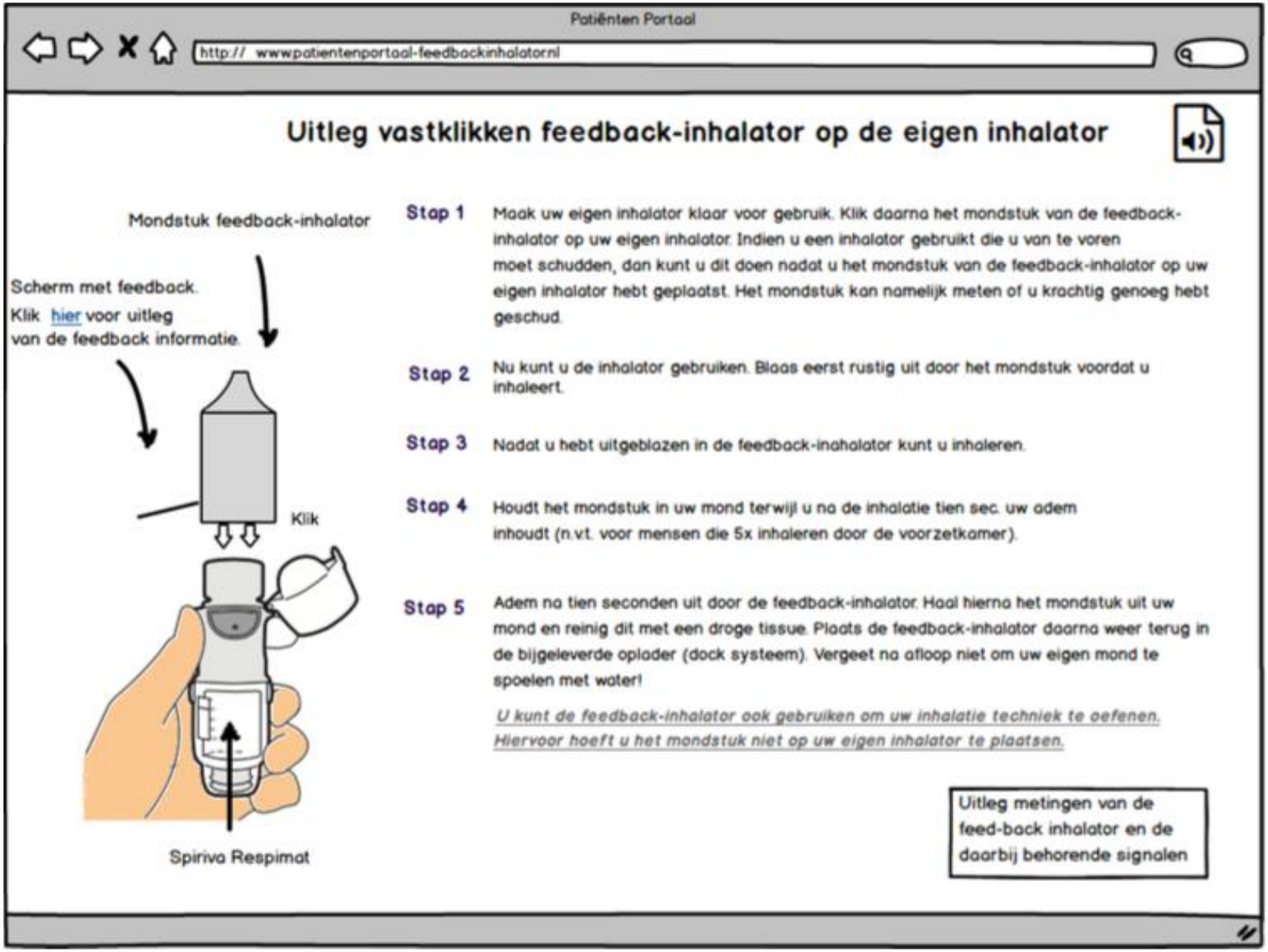
Page: Instructions inhaler use (after clicking on ‘instructies inhalator gebruik’)



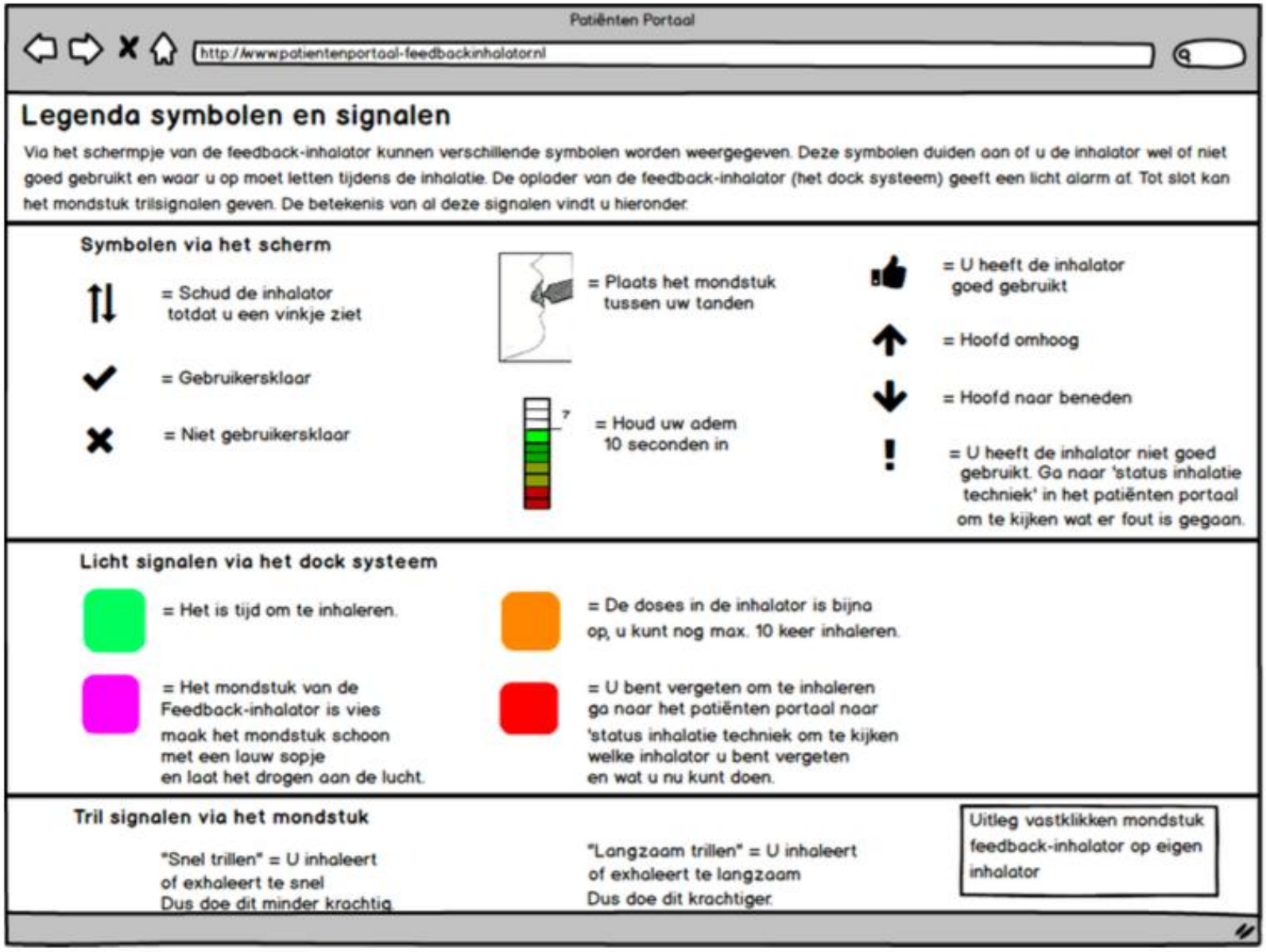
Page: Instructions Feedback-inhaler (after clicking on ‘Instructies feedback-inhalator’)



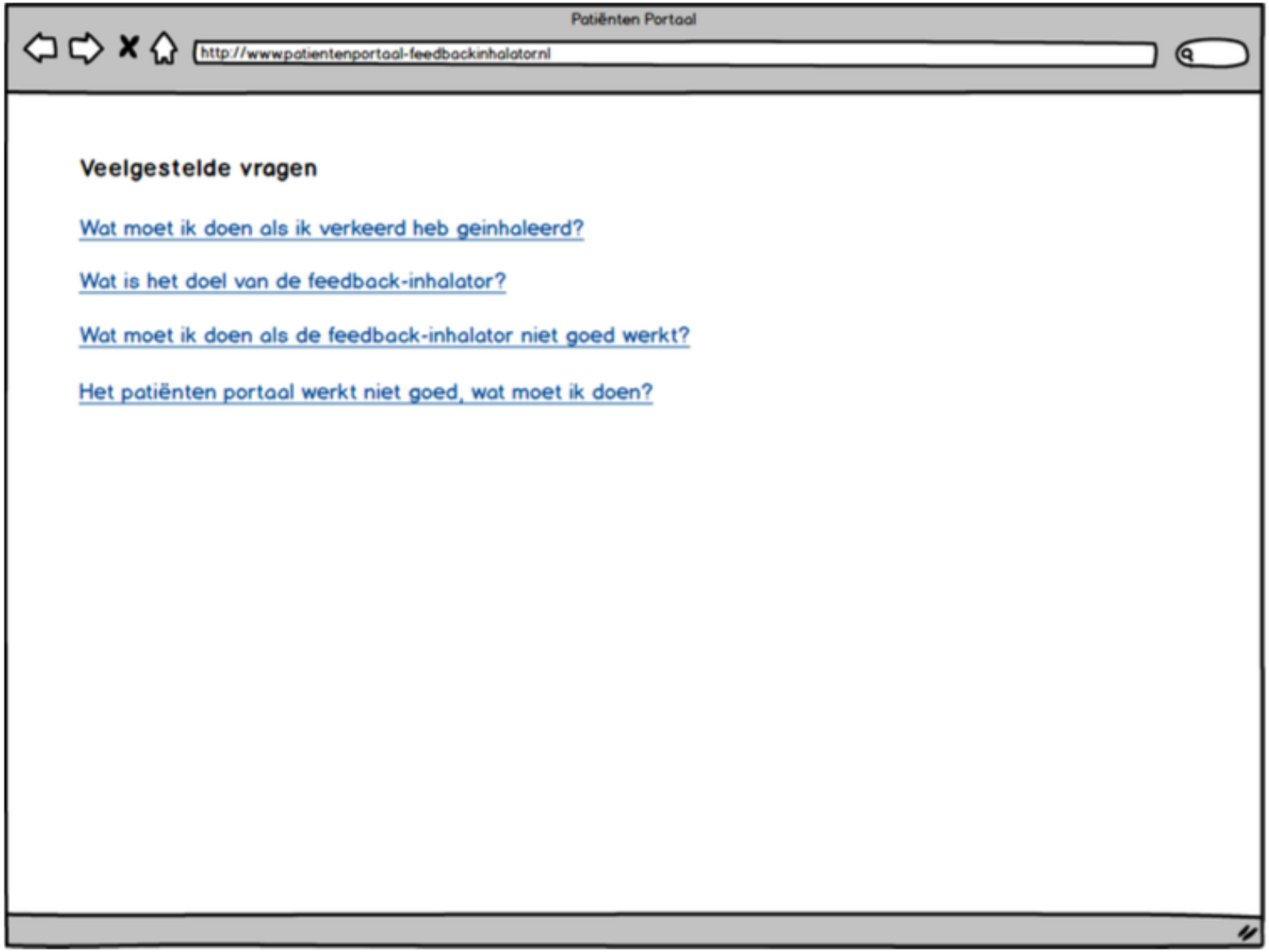
Page: Instructions attaching mouthpiece with smart sensors to own inhaler (after clicking on 'Uitleg vastklikken feedback-inhalator op de eigen inhalator')



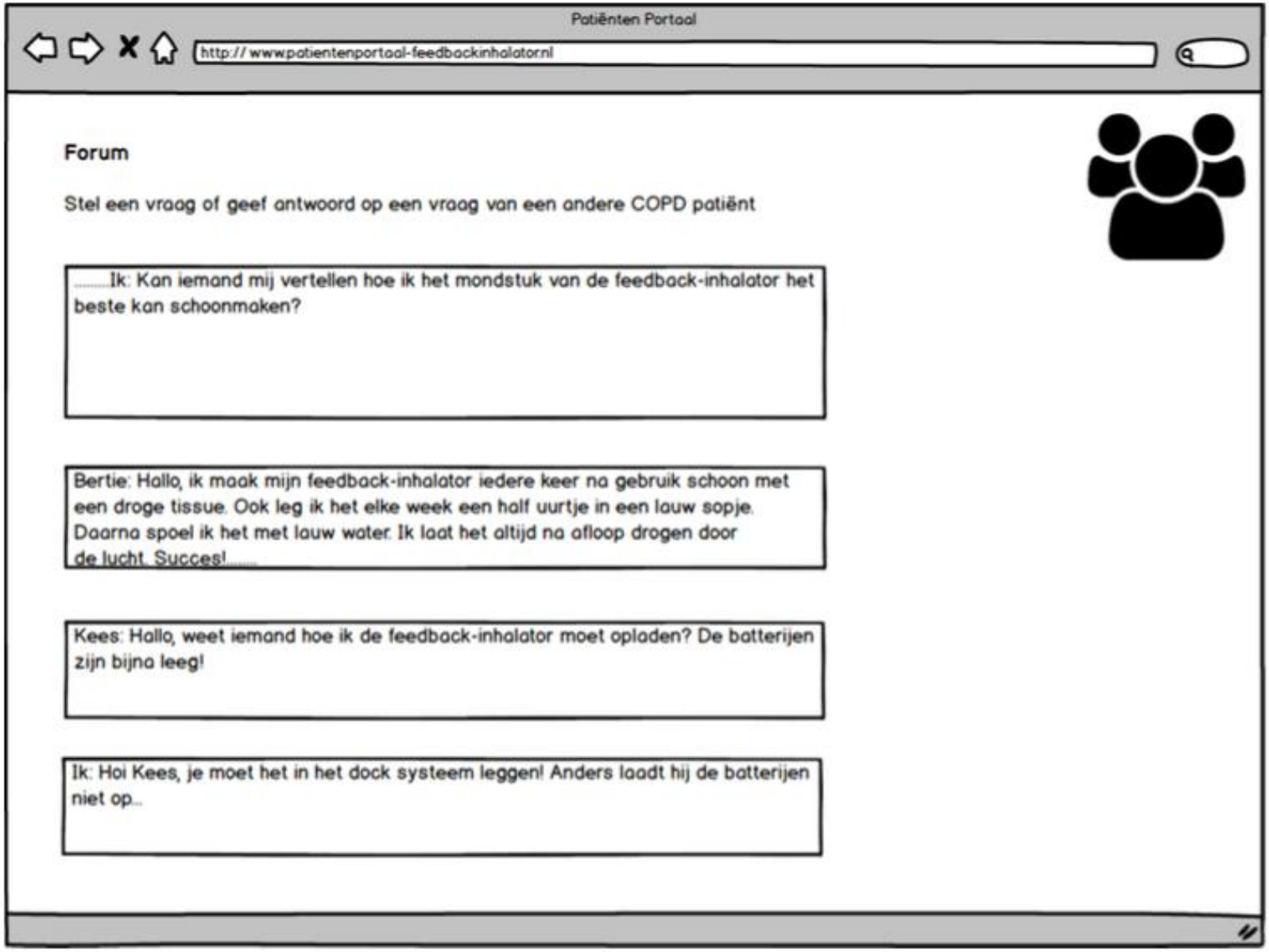
Page: Information feedback symbols and signals (after clicking on ‘uitleg feedback signalen en de daarbij behorende symbolen’)



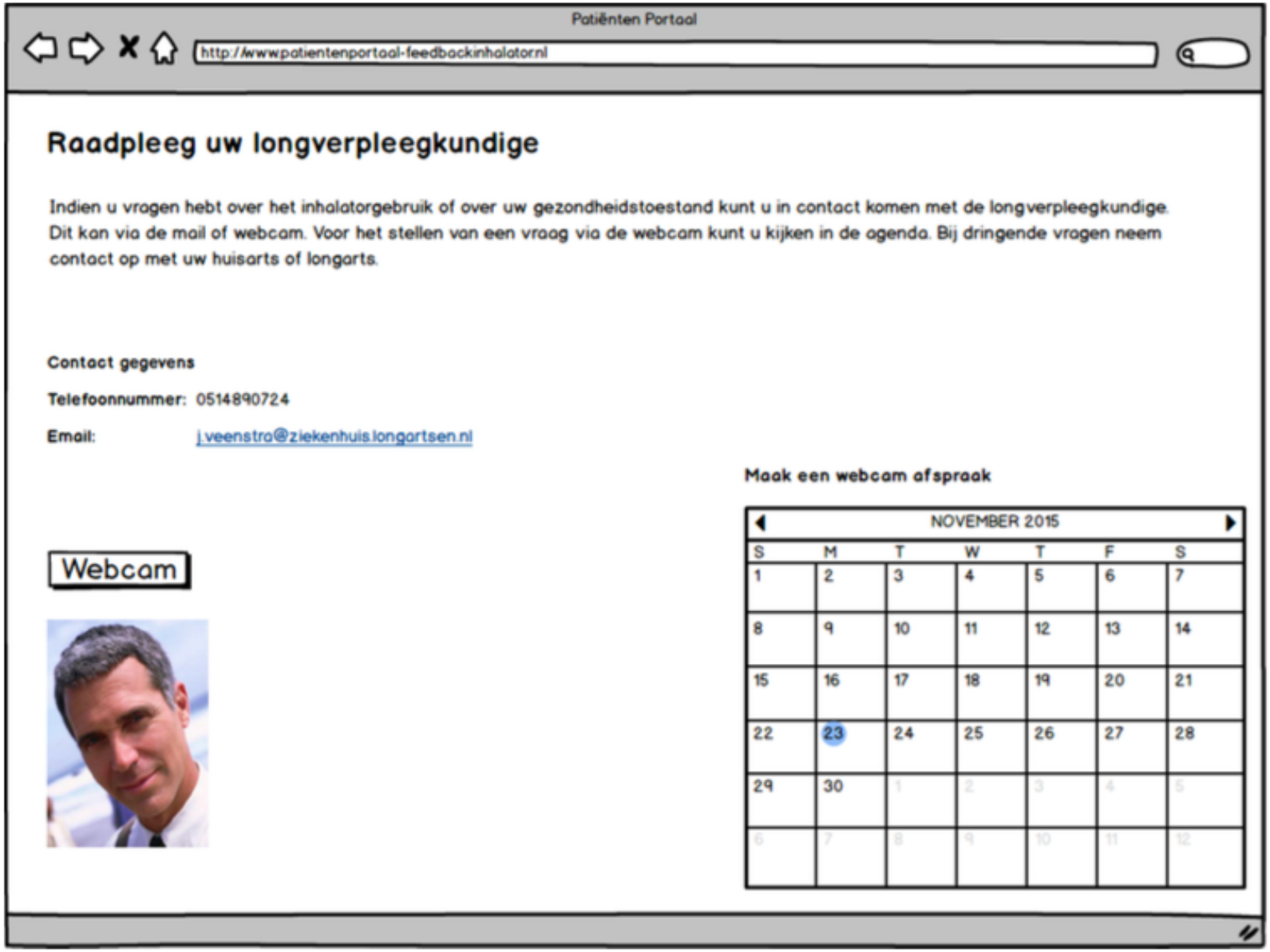
Page: Frequently asked questions (after clinking on ‘veel gestelde vragen’)



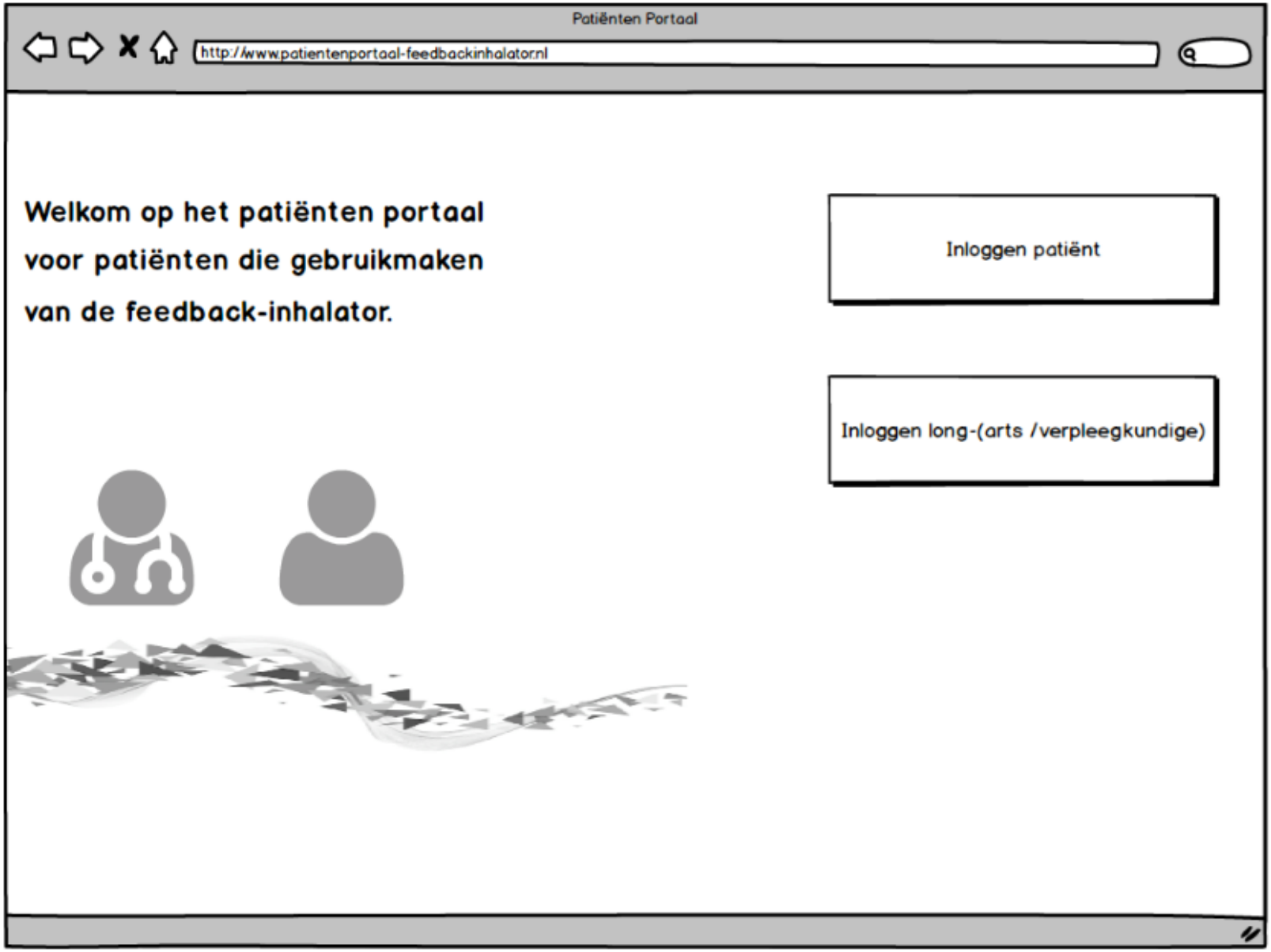
Page: Forum (after clicking on ‘forum’)



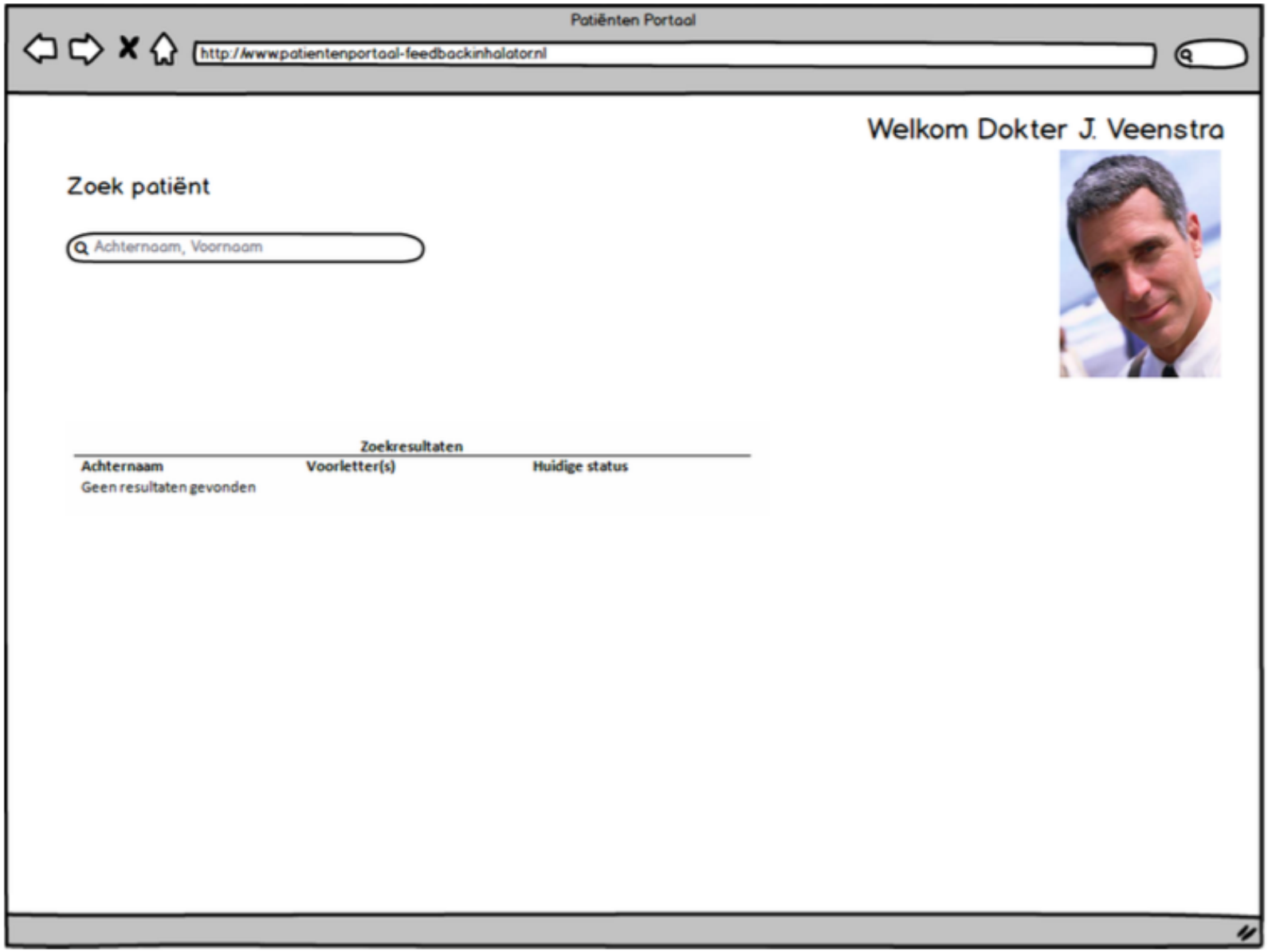
Page: Consult the respiratory nurse (after clicking on ‘raadpleeg de longverpleegkundige’)



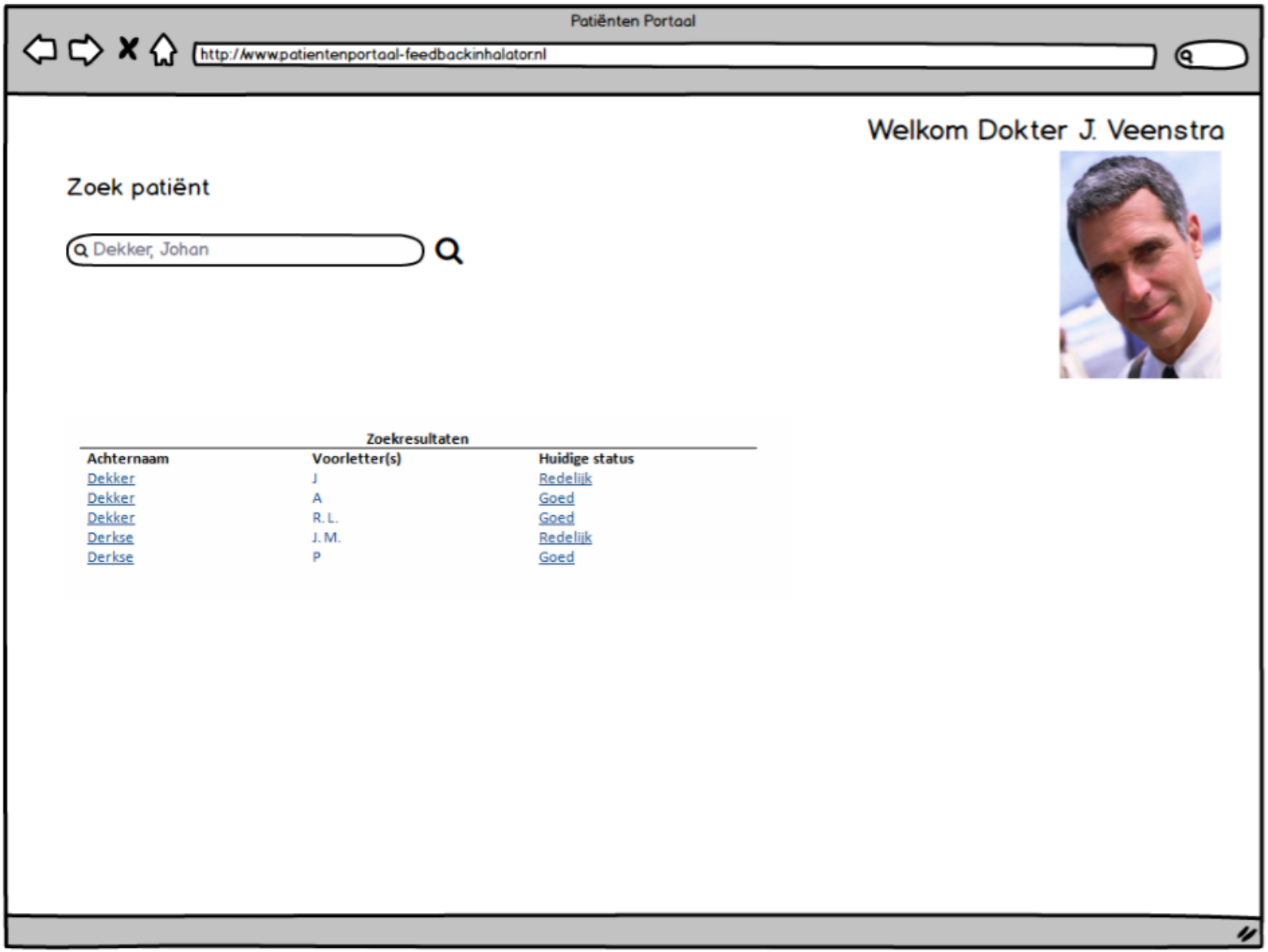
Appendix 11: Portal for the healthcare professional



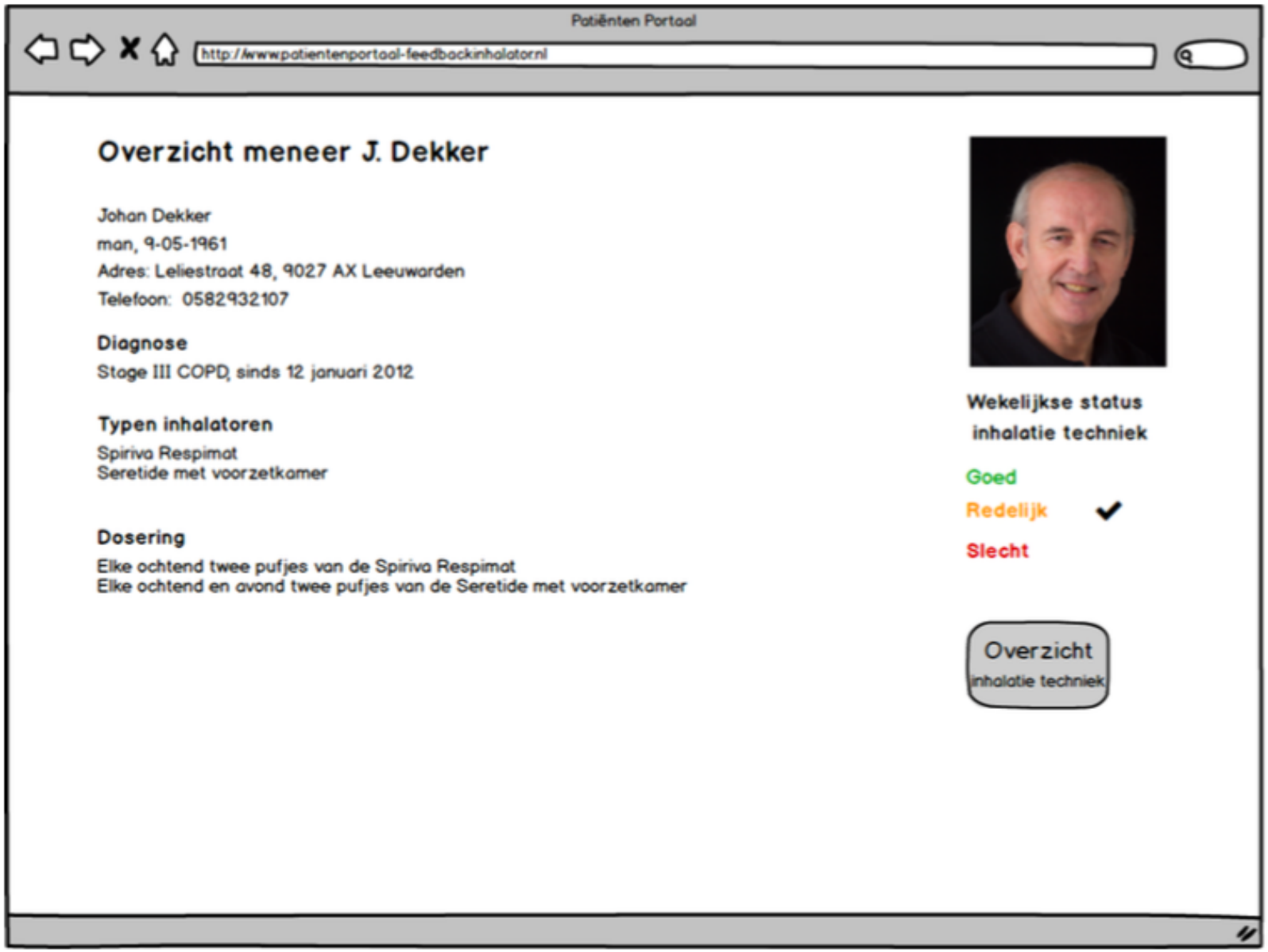
Page: Search for patient data page (after user logs in)



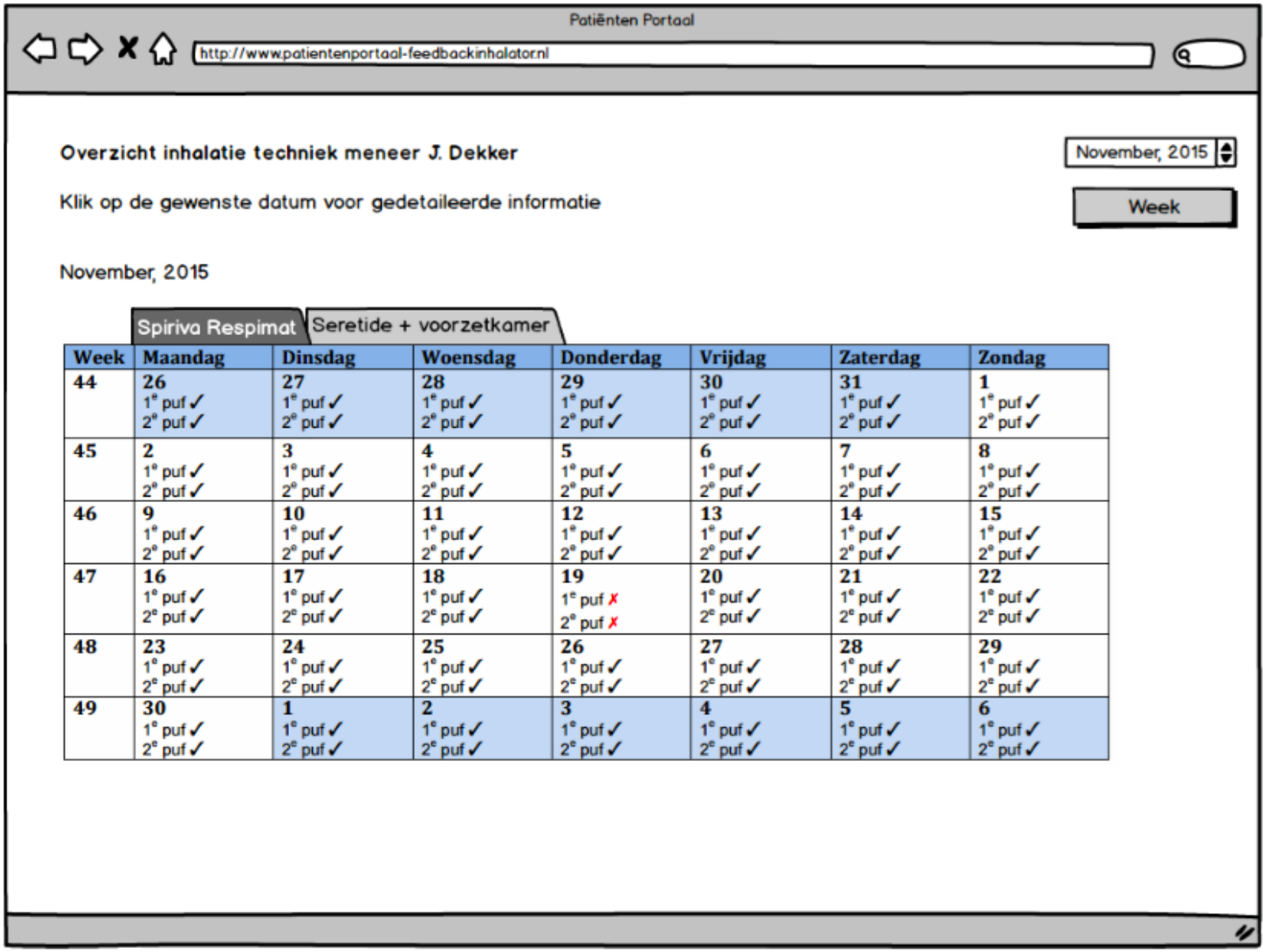
Page: Search for patient data (after user inserts voornaam en achternaam)



Page: Overview Johan Dekker (after clicking on ‘Dekker J’)

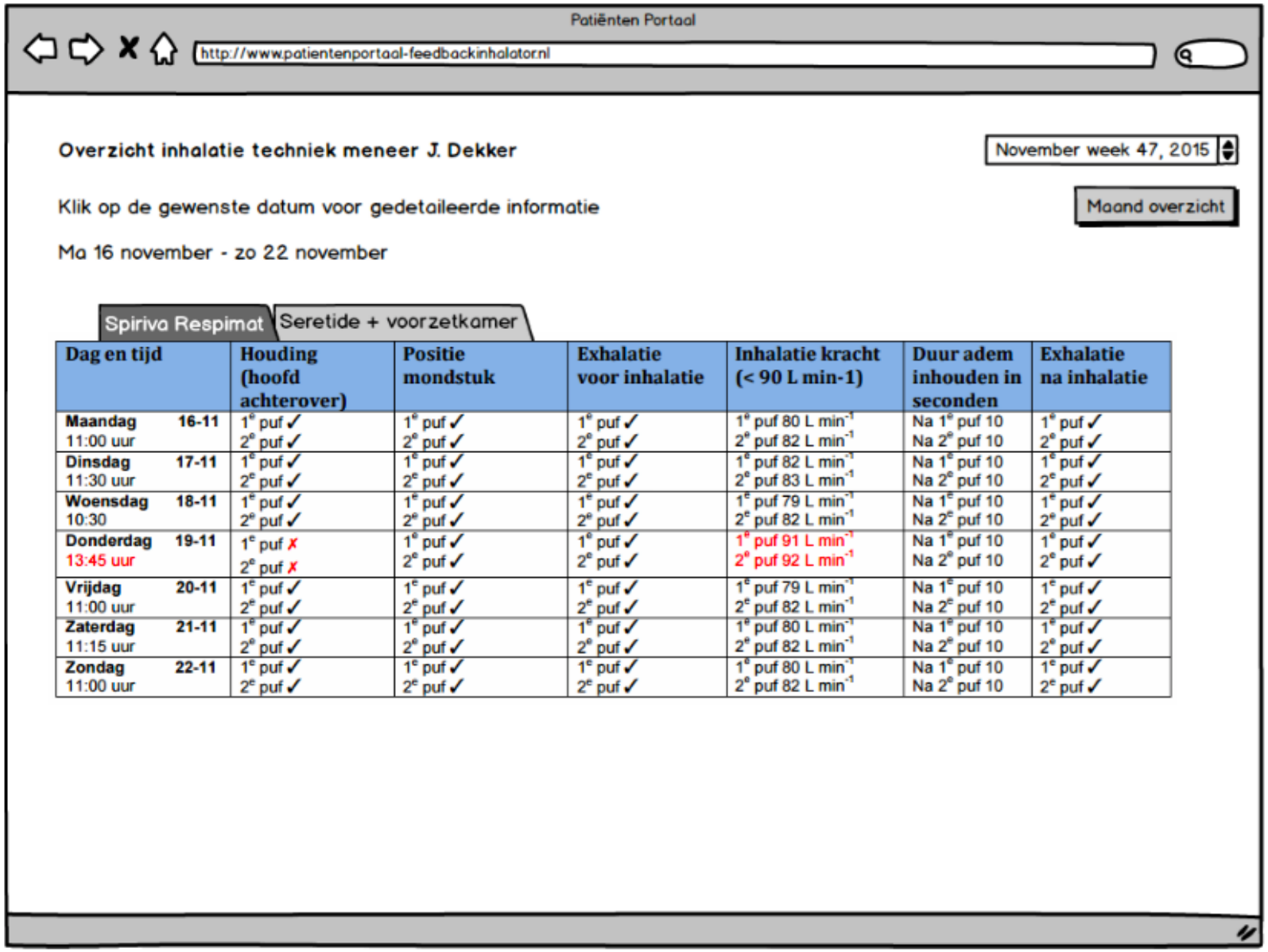


Page: Monthly overview Spiriva Respimat® (after clicking on 'Overzicht inhalatie techniek')



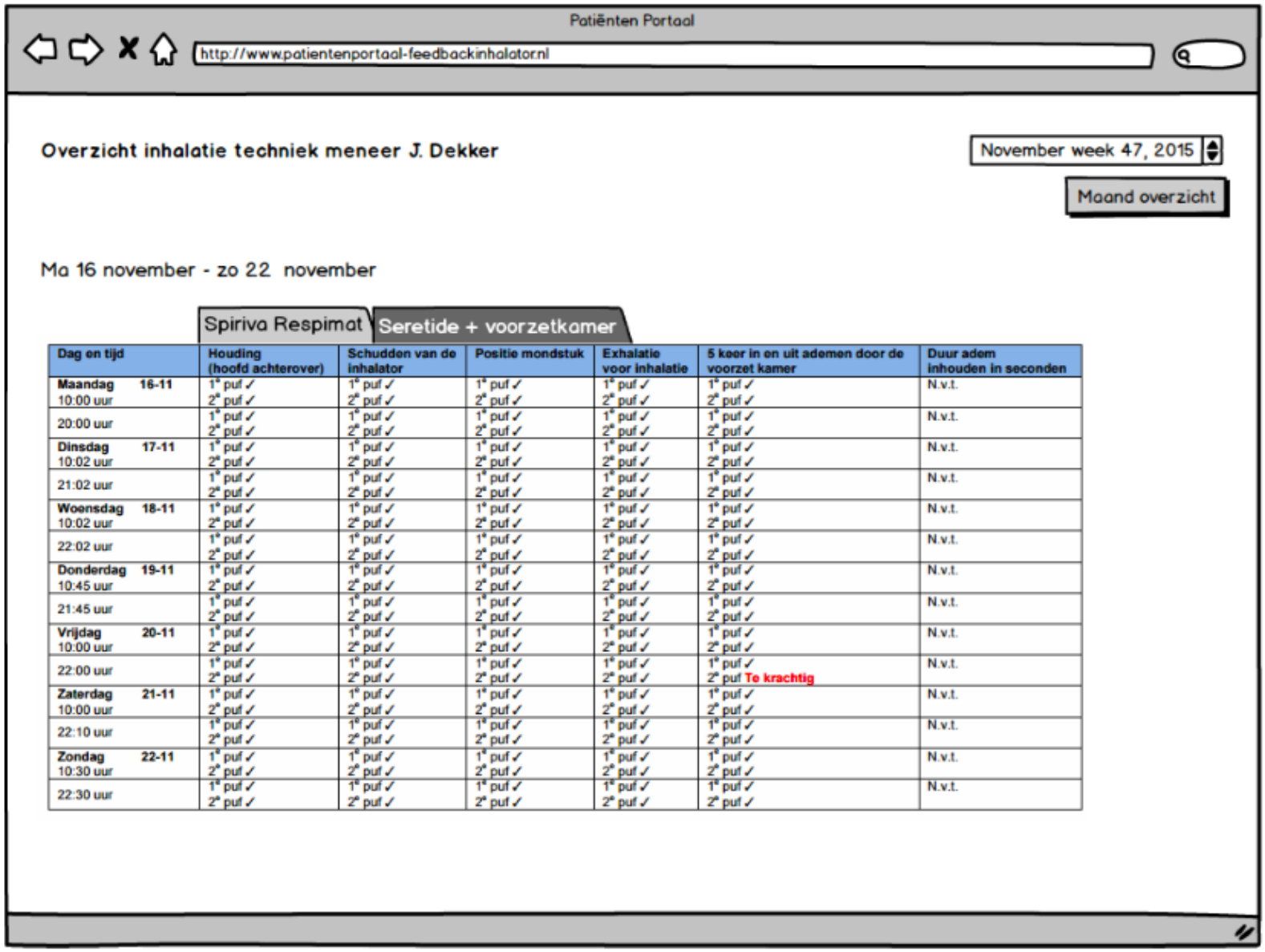
Week	Maandag	Dinsdag	Woensdag	Donderdag	Vrijdag	Zaterdag	Zondag
44	26 1e puf ✓ 2e puf ✓	27 1e puf ✓ 2e puf ✓	28 1e puf ✓ 2e puf ✓	29 1e puf ✓ 2e puf ✓	30 1e puf ✓ 2e puf ✓	31 1e puf ✓ 2e puf ✓	1 1e puf ✓ 2e puf ✓
45	2 1e puf ✓ 2e puf ✓	3 1e puf ✓ 2e puf ✓	4 1e puf ✓ 2e puf ✓	5 1e puf ✓ 2e puf ✓	6 1e puf ✓ 2e puf ✓	7 1e puf ✓ 2e puf ✓	8 1e puf ✓ 2e puf ✓
46	9 1e puf ✓ 2e puf ✓	10 1e puf ✓ 2e puf ✓	11 1e puf ✓ 2e puf ✓	12 1e puf ✓ 2e puf ✓	13 1e puf ✓ 2e puf ✓	14 1e puf ✓ 2e puf ✓	15 1e puf ✓ 2e puf ✓
47	16 1e puf ✓ 2e puf ✓	17 1e puf ✓ 2e puf ✓	18 1e puf ✓ 2e puf ✓	19 1e puf ✗ 2e puf ✗	20 1e puf ✓ 2e puf ✓	21 1e puf ✓ 2e puf ✓	22 1e puf ✓ 2e puf ✓
48	23 1e puf ✓ 2e puf ✓	24 1e puf ✓ 2e puf ✓	25 1e puf ✓ 2e puf ✓	26 1e puf ✓ 2e puf ✓	27 1e puf ✓ 2e puf ✓	28 1e puf ✓ 2e puf ✓	29 1e puf ✓ 2e puf ✓
49	30 1e puf ✓ 2e puf ✓	1 1e puf ✓ 2e puf ✓	2 1e puf ✓ 2e puf ✓	3 1e puf ✓ 2e puf ✓	4 1e puf ✓ 2e puf ✓	5 1e puf ✓ 2e puf ✓	6 1e puf ✓ 2e puf ✓

Page: Weekly overview Spiriva Respimat® (after clicking on 'week')



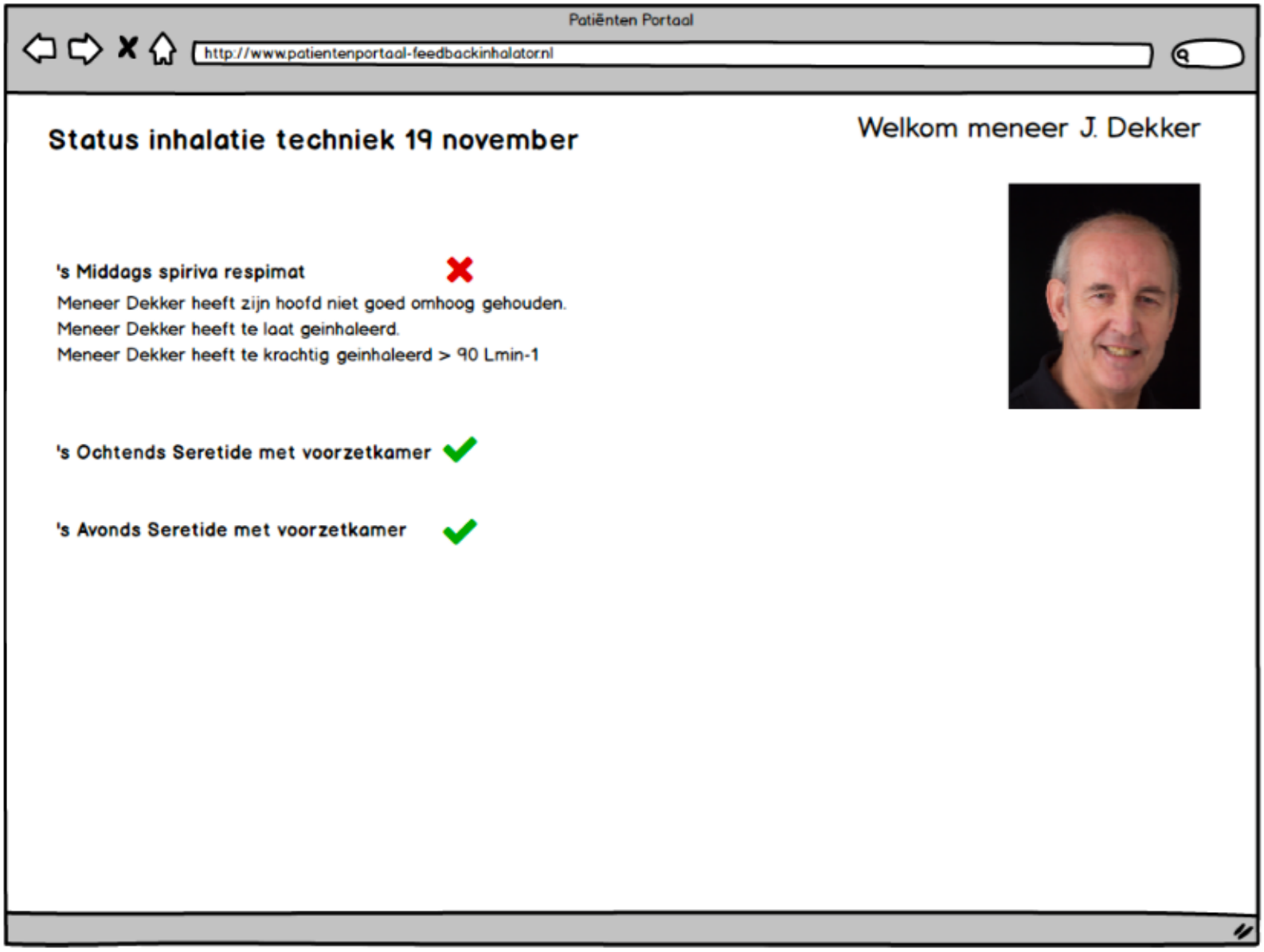
Dag en tijd	Houding (hoofd achterover)	Positie mondstuk	Exhalatie voor inhalatie	Inhalatie kracht (< 90 L min-1)	Duur adem inhouden in seconden	Exhalatie na inhalatie
Maandag 16-11 11:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 80 L min-1 2e puf 82 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Dinsdag 17-11 11:30 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 82 L min-1 2e puf 83 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Woensdag 18-11 10:30	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 79 L min-1 2e puf 82 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Donderdag 19-11 13:45 uur	1e puf ✗ 2e puf ✗	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 91 L min-1 2e puf 92 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Vrijdag 20-11 11:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 79 L min-1 2e puf 82 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Zaterdag 21-11 11:15 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 80 L min-1 2e puf 82 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓
Zondag 22-11 11:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf 80 L min-1 2e puf 82 L min-1	Na 1e puf 10 Na 2e puf 10	1e puf ✓ 2e puf ✓

Page: Weekly overview Seretide® + AeroChamber ® (after clicking on 'seretide + voorzetkamer')



Dag en tijd	Houding (hoofd achterover)	Schudden van de inhalator	Positie mondstuk	Exhalatie voor inhalatie	5 keer in en uit ademen door de voorzet kamer	Duur adem inhouden in seconden
Maandag 16-11 10:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
20:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
Dinsdag 17-11 10:02 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
21:02 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
Woensdag 18-11 10:02 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
22:02 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
Donderdag 19-11 10:45 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
21:45 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
Vrijdag 20-11 10:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
22:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf **Te krachtig**	N.v.t.
Zaterdag 21-11 10:00 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
22:10 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
Zondag 22-11 10:30 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.
22:30 uur	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	1e puf ✓ 2e puf ✓	N.v.t.

Page: Status inhalation technique on a specific day (after clicking on ‘19 november’)



Appendix 12: Sensor technology