Use of subjective information from the COPD home-based device for improving provision of health care

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Summary

COPD stands for Chronic Obstructive Pulmonary Disease, which is defined as “a lung disease characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible” (WHO, 2009). In the Netherlands 2% of the population has COPD (328.000 individuals). Six thousand people die of COPD every year (4% of all deaths).

Novay is developing a home based device for COPD patients. It is a touch screen device which is placed at the patients’ home. On this device the patient answers questions about his health status daily, in the diary function, in which subjective information is emphasized. What other functions the device will have is not decided yet. The reasons to develop this home-based device are two issues in the current situation: “a lack of insight in the real daily activities of the patients and cross-organizational communication among the involved members and health professionals” (Novay, 2008).

The important elements in adoption and acceptance of an innovation (in this case a telehealth system) can be described in a flowchart. It starts with external variables which influence the perceived usefulness and the perceived ease of use. These last two elements can be divided in several factors.
Perceived usefulness consists of: relative advantage; compatibility/FITT; observability; and staff needs assessment, involvement and support.
Perceived ease of use consist of: complexity, trialability potential for reinvention, technical support, and staff changes required.
These two factors have effect on the behavioral intention of the perceived users: it determines whether he is a supporter or an opponent of the innovation. And this behavioral intention estimates if the perceived user will actually use the new system, which can be observed after implementation.

The main question of this study is: *How can the subjective information from the diary function of the home based device be utilized by health professionals in health care provision to COPD patients?*

The study is executed in Enschede. Eight health professionals (four pulmonologists, three physiotherapists and one nurse practitioner) are interviewed in order to map their expectations and views on the home-based device.

The following conclusions can be drawn from the interviews:

- The general view on the home-based device is moderately positive;
- The most important and most often mentioned advantage of the information from the home-based device is overview and insight on the patients health status;
- The information the health professionals need, give a complete view on how the patient is doing and how he feels about that (subjective information);
- The information should be displayed in a graph or pie chart (it gives a clear view in one glance);
- An action plan for the patient was identified as the most suitable solution to the possible problem of information overflow;
- A frequently expressed worry is that the patients should be able and be motivated to fill in the device every day.

The most important recommendations derived from the conclusions are the following:

- Demonstrate what the goal is of the home-based device to the health professionals and what advantages the collected information gives them;
- Include the overview-function in the application;
- Develop a long term plan for the post-pilot stages;
- Evaluate the definition of the target group;
- Further research is necessary on the improvement of the communication and cooperation between the pulmonologist and the general practitioner.

Preface

First of all I would like to thank my advisor Ton Spil and my second advisor Björn Kijl for their critical view and their feedback on my report.

I would also like to thank my company advisor Wout Slakhorst for his guidance and feedback in the second half of my master thesis, as well as Ellen Szwajcer who gave me the assignment and advised me in the first half of my assignment.

Furthermore I would like to thank the health professionals who cooperated in the interviews:
Paul van der Valk, Wendy van Beurden, Ruud Kotte, Paul Weltevreden, Nicolle Hekelaar,
Hayke Kotte, Ilonka van Veen and Clara van Ommeren. And researcher Job van der Palen who shared his view on the project.

And last but not least I would like to thank my family and friends for their support, and my fellow graduates at Novay.

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1. Introduction

In this chapter an introduction will be given to this study: the value and the background of the study will be described. First a short description of chronic obstructive pulmonary disease (COPD) is given. After that the COPE project and COPD.com project and their significance are described.
Within this part also the goal of the home-based device (the essence of the COPD.com project) is made clear. Then the goal of this study and the matching research questions are outlined.

1.1 COPD

COPD stands for Chronic Obstructive Pulmonary Disease, which is defined as "a lung disease characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible" (WHO, 2009). It is a combination of lung emphysema and chronic bronchitis. COPD cannot be cured; therefore the stabilization of the patients lung function is the goal of treatment and health provision. Only treatment of the symptoms is possible, which should also prevent a worsening of the patient's health status. The treatments during the different stages of the disease can be found in appendix one.

The seriousness of the disease varies among patients. Four stages can be distinguished, which are displayed in figure 1: mild (stage I), moderate (stage II), severe (stage III) and very severe (stage IV). By measuring the lung capacity (airflow limitations) of the patient, the severity of the disease can be measured and categorized in these four stages. The lung capacity is mainly expressed by two constructs:

- FVC which is short for Forced Vital Capacity. It is the volume change of the patients' lung between a full inhalation to the maximum lung capacity and a full exhalation to residual volume (SpirXpert, 2009). In other words: "the volume of air expelled by a forced maximal expiration from a position of full inspiration" (GP notebook, 2009).
- FEV_1 which stands for Forced Expiratory Volume in one second, is "the volume of air expelled in the first second of maximal forced expiration from a position of full inspiration" (GP notebook, 2009).

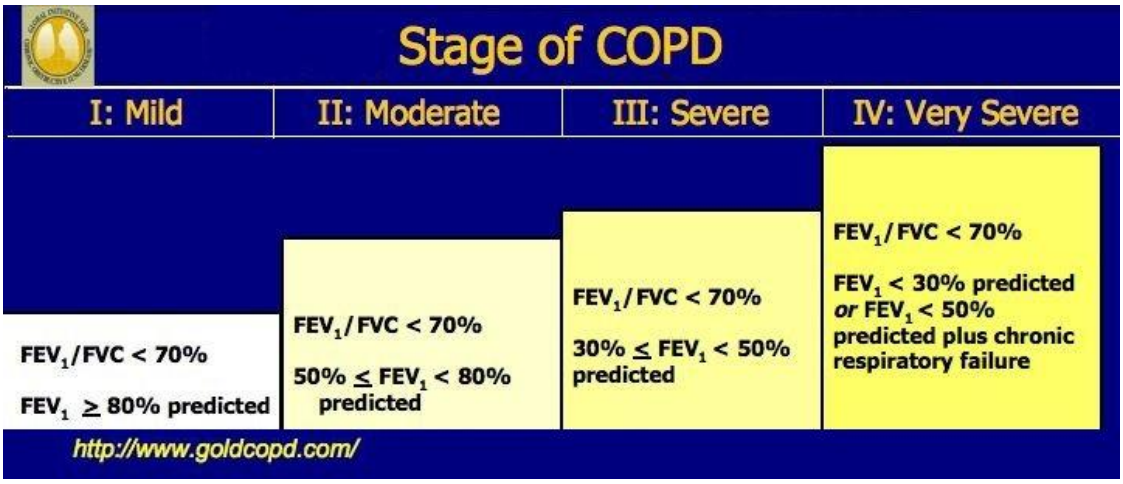

Figure 1: the severity of COPD categorized according to GOLD (GOLD, 2008).

Smoking is the most important cause of COPD. Other risk factors are: chronic exposure of the lungs to small, fine (damaging) particles (like crill); a low birth weight and premature calving; and a congenital enzyme deficit (NHG, 2007).

In order to depict the effect of smoking on the forced expiratory volume in one second (FEV1), the figure below is inserted. It compares the FEV1 from smokers (the purple line) to the FEV1 of non-smokers (the green line), as well as people who quit smoking on their fiftieth or sixtieth (dotted purple lines).

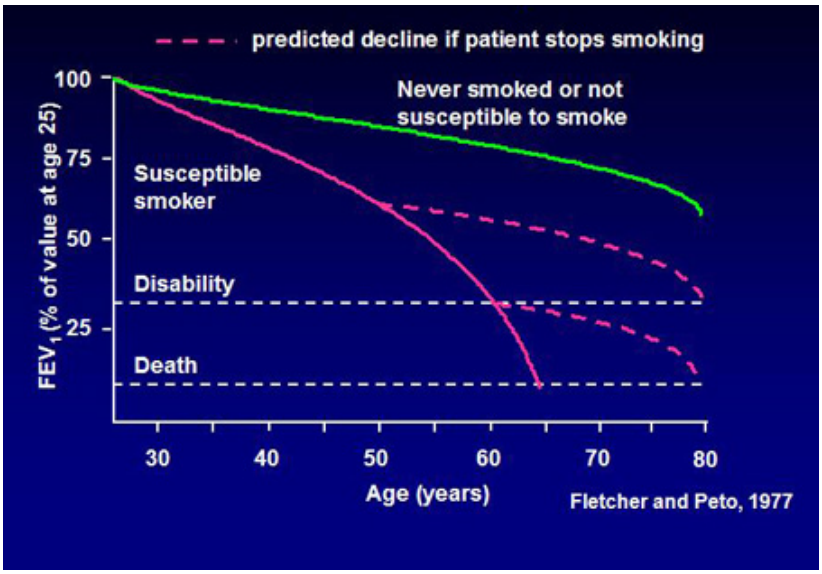

Figure 2: FEV1 of smokers and non-smokers compared (Fletcher & Peto, 1977).

Most COPD patients are over 40 and are smokers or people who smoked for a long period of time in the past. COPD occurs more often in people with lower education, also when corrected for a higher smoking prevalence (NHG, 2007).

In the Netherlands 2% of the population has COPD. From 16.4 million people this is 328.000 individuals. In the population of 80 years and older this is 17%, which comes down to approximately 104.600 individuals. Six thousand people die of COPD every year in the Netherlands. This is 4% of all deaths (RIVM, 2008; CBS Statline, 2009). Worldwide 210 million people are predicted to have COPD. Five percent of global deaths are caused by COPD in 2005, which comes down to three million people (WHO, 2008).

On average, patients have between one and three exacerbations a year (MST, 2009). An exacerbation is defined as “a sustained worsening of the patient’s condition, from the stable state and beyond normal day-to-day variations, that is acute in onset and necessitates a change in regular medication in a patient with underlying COPD” (Rodriguez-Roisin, 2000, p.399).

1.2 Health professionals

Many health professionals are involved with COPD patients. The following three disciplines are identified in the COPD.com project as the most important health professionals:

- Pulmonologist
- Nurse practitioner
- Physiotherapist

The most logical one is the pulmonologist. The pulmonologist checks the health status of the patient once a year during a consult or more frequent if the patient has more complaints. A nurse practitioner also has consults with COPD patients. The difference with the pulmonologist is that the nurse practitioner has twenty minutes time for one patient, the pulmonologist ten minutes. Additionally the nurse practitioner also gives instructions, counseling and psychosocial guidance. In general a patient sees a pulmonologist or nurse practitioner once or twice a year.
In order to keep in shape it is very important for COPD patients to do exercises. This can be done in groups, guided by a physiotherapist. Some physiotherapists are specialized in COPD patients. Most patients are advised to see the physiotherapist once or twice a week. Because of the peer pressure the chances of the patient doing his exercises when not feeling well or having dyspnoe are bigger, which is in their own interest.

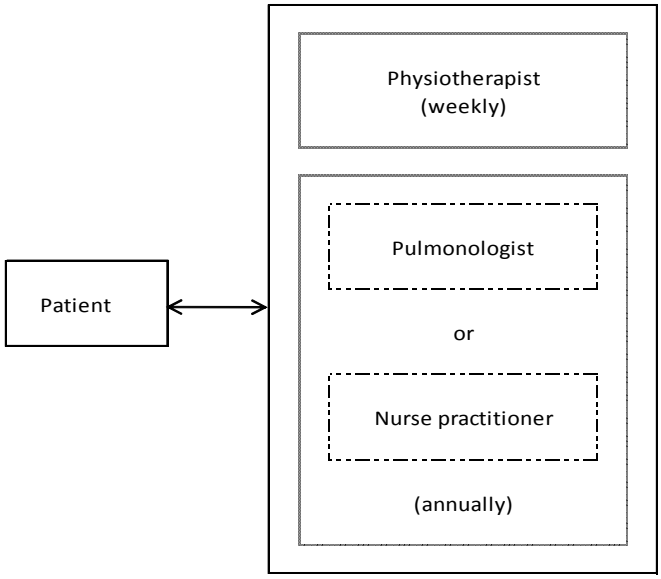

Figure 3: contact between the patient and three most important health professionals.

This study focuses on the three health professionals named above. For the completeness the other professionals involved with COPD patients will also be named:
The general practitioner is engaged in the care of COPD patients. The general practitioner is the first person the patient sees when he or she is not feeling well, or for any intervening health complaints and complications.
The nutritionist is involved because the nutrition of a COPD patient is very important. He makes sure the patient eats healthy and doesn't lose weight.
The pharmacist is the supplier of the COPD patients' medication. This means the daily medication: the bronchodilators, which relax the muscles in the airway and makes it easier to breathe normally. But also the antibiotics and prednisolone when the patient has an exacerbation.
The pulmonary nurse will be involved if complaints are very heavy and an exacerbation results in hospital admittance. He is a nurse from the pulmonology department and he takes care of the patient during the stay in the hospital.

Other health professionals are involved if the patient has comorbidity. That is the presence of more diseases This is not necessarily for COPD related diseases or problems. For example, twenty-five percent of COPD patients also have heart failure and twenty-five percent of patients with heart failure also have COPD. In that case the cardiologist also plays a role in the provision of care to the patient. The complaints and condition resulting from the additional disease should be taken into account by the other health professionals involved.

1.3 COPE II

The COPE II project is executed as a predecessor of the COPD.com project. COPE stands for COPD Onderzoek afdeling Pneumonologie Enschede (COPD Research division Pulmonology Enschede). The COPE project, executed in the earlier mentioned MST hospital in Enschede, comprehended the development of a self management program for COPD patients. This self management program consisted of four elements:

- General guidelines for self treatment in case of an exacerbation;
- Self management training;
- An exercise program;
- When desired a referral to a nutritionist specialized in COPD patients.

The goal of this research was to investigate if the developed self management program results in a better quality of life for the involved COPD patients and less healthcare related costs.

A part of the guidelines for self management consisted of a questionnaire on the patients' health status. Daily they had to fill in the question if their health status has decreased in the last twenty-four hours compared to 'normal'. If the answer was no, they were finished with the questionnaire for that day. If they did have more complaints then normal the whole questionnaire, encompassing ten questions, had to be completed. Based on these answers (severity and number complaints) a 'plan of action' was derived for the patient: do nothing, start with antibiotics, start with prednisolone, start with both antibiotics and prednisolone or contact a health professional.

The study showed no significant difference between the treatment group that did participate in the self management program and the control group that did not receive the 'treatment'. In the following variables no differences were found between the two groups: hospital admissions, emergency room visits, days lost from work, and lung function (Monninkhof et al, 2003). However the study did show a (not proven) trend towards better quality of life for the COPD patients educated in the self management program. It is also stated that the existing Health Related Quality of Life measurements may not be able to capture the full experience COPD patients had while participating in the COPE study (Monninkhof et al, 2004).

1.4 COPD.com

The project COPD.com was started to create a new way of COPD disease management for COPD patients with GOLD status II or III. Participants are Novay, Roessingh Research & Development, and Medisch Spectrum Twente (the hospital in Enschede). Later on IZIT ('innovation for care with future') joined the project.
The project is part of the ZonMw program disease management of chronic illnesses. ZonMw is an organization which tries to improve prevention, care and health by stimulating and financing research, development and implementation (ZonMw, 2009).

This research project should result in a way of telemonitoring COPD patients with GOLD status II or III using four different technologies: the regional service platform (RSP), the hospital information system (ZIS), a body area network (BAN) and a home based device.

1. The regional service platform (RSP) is the integration of all information from hospital information systems from a region. Therefore it is like a regional electronic patient record. The programming and creation of this architecture is done by IZIT.
2. The hospital information system (ZIS) contains information about the patients: identification of the patient, as well as the medical information about the provision of health care to the patient (medical history, medication use etcetera). This medical file is now only available on paper. Only results (from the laboratory or lung-function tests) and medical imaging methods (x-ray images, Magnetic Resonance Imaging) are electronically documented. Sometimes the ZIS also has the possibility of making an invoice for the patient and the insurance company. The 'ZIS-part' of the project is executed by the Medisch Spectrum Twente.
3. The body area network (BAN) consists of sensors that should be attached to the body in order to measure certain values, like activity and heart rate. Factors concerning this body area network and the corresponding measurement data (the measurement process, the visualization of the data, and the interpretation of it) are worked at, by Roessingh Research & Development.
4. The home based device is developed by Novay. It is a touch screen device which is placed at the patients' home. On this device the patient answers questions about his health status daily. This is called the diary function of the device. This diary function contains the questionnaire used in the COPE II study. The first (multiple-choice) question is if there were any changes (negatively) in the health status of the patient in the last 24 hours. If there is no worsening in the patient's condition, the patient can touch the 'no-box' on the screen and he is finished for the day. This minimizes the effort for the patient and increases the likelihood of the patient willing to fill it in every day. If the patient's condition did worsen, the answer 'yes' should be given. Subsequently, the different aspects of the patient's health that could have worsened are questioned in a series of ten questions. These aspects are for example quantity and quality of mucus, shortness of breath, and coughing. For these (and more) complaints the patient can fill in if he suffered from these complaints 'a bit more than normally', 'clearly more than normally' or if they are 'normal'. One thing that also should be considered is how to establish what is 'normal' for a specific patient. Should it be determined together with a health professional or should it be defined by the patient himself. Also the question comes to mind what should be done with that baseline about what the normal situation is? Should it be included in the device in order to compare the current state of the patient with the normal state? Or should it just be kept in mind by the patient when he answers the questions?

The images below show a screenshot of the interface with one of the last mentioned multiple-choice questions displayed. These images are acquired from another master student graduating at Novay, who is developing the patient-friendly and motivating interface. The first one is the picture of the 'ordinary' interface; the second one is the picture with persuasive technologies applied to it. This persuasive technology should persuade and motivate the patient to fill in the diary every day.

Figure 4: the 'ordinary' interface of the diary function with the question: 'did you have complaints about shortness of breath?'

Figure 5: the 'persuasive technology' interface of the diary function with the question: 'did you have complaints about shortness of breath?'

The image below shows how the device looks: it is in fact a computer screen, with no additional technical features. A mouse and keyboard can be plugged in, but with these attributes it will look too much like a normal computer for the COPD patients. Therefore a touch screen is chosen: the mouse and keyboard are redundant.

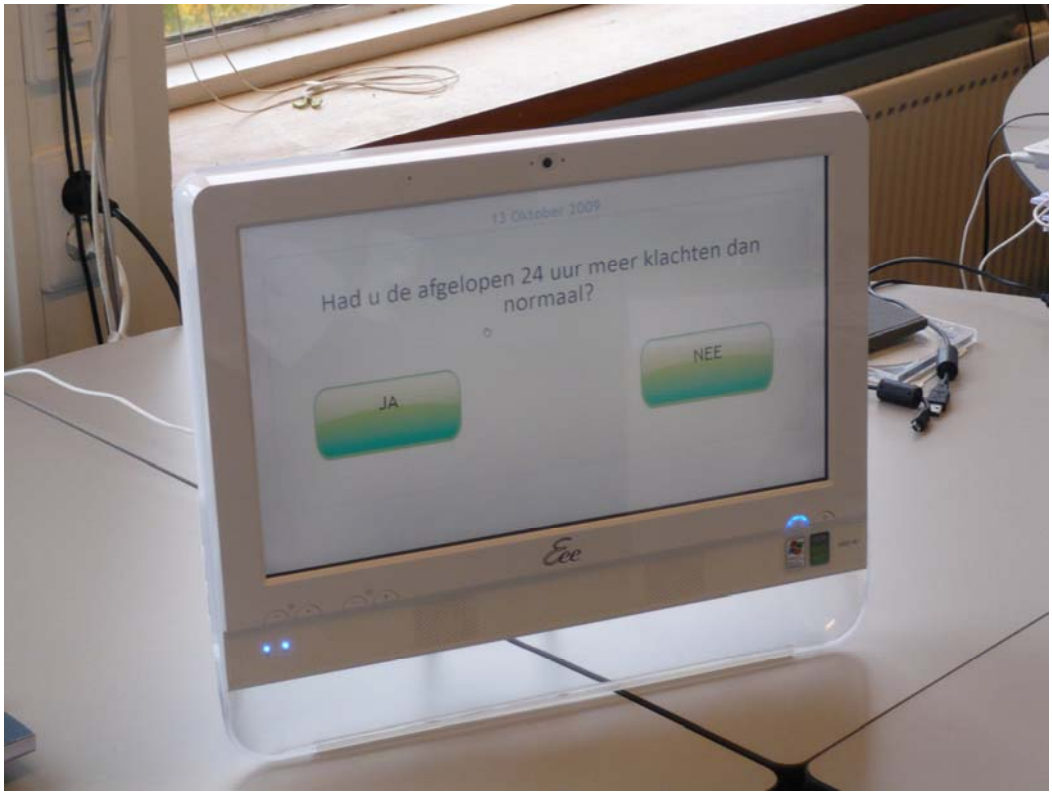

Figure 6: the touch screen home-based device, with the first question on the screen: 'did you have more complaints than normal in the last 24 hours?'

Next to this diary function there will probably be an exercise module included. This module will be like a coach in the patient's training: an assistant of the physiotherapist. The exercises for the patient are visualized and advice is given on how to perform these exercises the best they can. Other modules can also be included, but that is not determined yet. It should be kept in mind that the system should not become too complex.

Altogether the four aforementioned technologies could, when implemented, improve integrated care for COPD patients. They will have more knowledge about their own health status and therefore also be able to act in conformity with their health status: disease management by the patient himself.
The health professionals will also have more detailed information on the health status of the patient. Something to keep in mind is that the health professionals could have an overload of information. The information needs to be processed, preferably in an automated way, to meet the professionals' needs.

In this project the home based device is the point of interest for Novay, as stated before. The company has chosen to focus on the subjective information, gathered with the home based device. This means no objective information of variables measurable in numbers, like heart rate and lung capacity. Subjective information is how a person (in this case the patient) experiences something and the feelings he has about it. In this project it could be a question from the diary function on how the patient feels, for example about his lung capacity: it is a little or much better/worse than yesterday or last week. The subjective information from the device and the measurements from the body area network should give a thorough and integrated illustration of the health status of the patient.

The reasons to develop this home-based device are two issues in the current situation:

- "a lack of insight in the real daily activities of the patients
- cross-organizational communication among the involved members and health professionals" (Novay, 2008).

The target and the expected effects of the introduction of the device are:

- for the patient: the updating of their health status
- for the health professional:
  - the availability (and the processing) of (some of) the information on patients' health status and giving feedback based on this information
  - the cooperation (sharing information on patients' health status) with other health professionals

From the numeration above it can be derived that the patient and the health professionals are the customers for the innovation. Eventually the patient will most likely have higher importance as a customer. This study however focuses on the wishes and the expectations of the health professionals. Therefore in this study they are seen as the customer of the home-based device. The patients are the target group of the other graduate student at Novay who develops the interface.

1.5 Business model

An often seen scenario with information systems in telehealth is that after a very successful pilot the system falls into oblivion.
A decent business model could hopefully prevent that to happen, because the business model concept plays a role in exploiting business concepts (Kijl et al, 2005). Slywotzky (1996) defines the business design as follows: "the totality of how a company selects its customers, defines and differentiates its offerings, defines the tasks it will perform itself and those it will outsource, configures its resources, goes to market, creates utility for customers, and captures profit. It is the entire system for delivering utility to customers and earning a profit from that activity" (p. 4).

As an extension to that, Faber et al (2003) see the business model as the way *a group of companies* aim to generate and capture value from the application of technical opportunities. There will be more companies involved in the project because Novay is not going to produce the home-based device itself. The *group of companies* as emphasized by Faber et al (2003) is applicable here. Despite the lack of consensus on a definition of the business model, there are four common components, which together are called the STOF-model (Faber et al, 2003; Bouwman et al, 2005):

1. Service design, which is the description of the added value of the new service and the division of the market at which the service is aimed.
   For the home based device the target market is 'COPD patients with GOLD status II or III'. The added value for the health professional should be the availability of information as well as the cooperation with other health professionals, sharing the information;

2. Technology design, referred to as "a description of the technical functionality required to realize the service" (Bouwman et al, 2005, p. 3).
   In this project that should be the technical specifications of the home-based device for the patient, including the storage of data and the way the health professionals can access the information;

3. Organization design is the description of the whole process needed to create and deliver the service. It encompasses the actors needed plus the role each actor plays, clarifying how the group of companies creates the value for the end-users.
   First of all the development should be finished, there should be a manufacturer who produces it, a party that installs the diary function on it, as well as a company that installs the devices at the patients homes and explains how to use it, and technical support (in the form of a helpdesk for example);

4. Finance design is "a description of how a value network intends to capture monetary value from a particular service offering and how risks, investments and revenues are divided over the different actors of a value network" (Faber et al, 2003, p. 3). Each flow of money concerning the home-based device and its' segmentation should be mapped.

The COPD.com project, as stated above, is executed by several parties who are all involved in doing research and not necessarily exploiting the 'products they invent'. This is what Chesbrough calls 'open innovation': it is the paradigm that assumes "firms can and should use external as well as internal ideas, and internal and external paths to market as they look to advance in their technology" (Chesbrough, 2004, p. 23). In this case the idea is developed internally and the path to the market is external. Therefore it is crucial to find a company willing to take care of the production and distribution of the home-based device.
However, the focus of this study is on the point of view of the health professionals. It may be possible to do some recommendations about the business model at the end of the study.

1.6 Research questions

From the introduction above the research goal of this study can be derived:
To identify how health professionals within different disciplines expect to utilize the subjective part of the diary function of the home-based device in the provision of health care to the COPD patients.

In order to reach the above stated research goal the following questions are formulated:

- How can the subjective information from the diary function of the home based device be utilized by health professionals in health care provision to COPD patients?
  - According to the health professionals, what subjective information should be included in the diary function of the device, serving what purpose?
  - Which health care professionals are interested in which information (within the diary function) during the patients' consultation?
  - How often and in what way do the healthcare professionals want to provide feedback to the COPD patient or intervene?

In order to answer these research questions, some 'what-questions' should be answered as well:

- What is the home based device?
- What is the diary function?
- What is subjective information?
- Which health professionals are involved in providing care to COPD patients?
- What is diffusion?
- What is acceptance?

The first four 'what-questions' are already answered in this introductory chapter. The other questions will be answered in the coming chapters.
The answers to the 'what-questions' will not be explicitly given in the conclusion because they are part of the three sub questions of the main question.

1.7 Outline

The research questions will be answered using the theories of Rogers (1983), Greenhalgh (2004), Gustafson (2003), Venkatesh & Davis (2000) and Ammenwerth, Iller & Mahler (2006).
These theories will be described and explained in chapter two.
Additionally, health professionals who work with COPD patients were interviewed: pulmonologists, nurse practitioners, and physiotherapist. The information on the interviews can be found in the method-section (chapter three).
After that, in chapter four, the results of the interviews will be discussed.
Finally conclusions will be drawn and recommendations will be given in chapter five.

2. Theoretical framework

In order to answer the research questions mentioned in paragraph 1.6 and to make an interview framework the following theories will be used: 'the diffusion model' by Rogers (1983), 'rate of adoption' by Greenhalgh (2004), 'the organizational change manager' by Gustafson (2003), the theory acceptance model by Venkatesh & Davis (2000), and the FITT framework by Ammenwerth, Iller & Mahler (2006).
These theories are chosen because together they cover several different areas related to innovations: the (properties of the) innovation itself, the process of innovation, the acceptance of the new system, and the fit between different aspect of, and surrounding the innovation.

After illustrating these theories, they will be applied to the case of the home-based device. Questions are brought up which are relevant for adoption, from the perspective of the health professionals. Finally the theories will be merged into one model in paragraph 2.6.

2.1 Diffusion of innovation

First of all, Rogers is one of the most cited writers on diffusion of innovations. He defines diffusion of innovations as: the innovation (the new idea) that is "communicated through certain channels over time among the members of a social system" (Rogers, 1976, p. 292).
Additionally Rogers (1983) invented a list of attributes to describe innovations. The rate of adoption from the innovation can be predicted by how the attributes are perceived by individuals. This theory is aimed at the end user of the innovation, which in this case are the health professional and the patient.

Rogers (1983) distinguishes five attributes. After describing each attribute, the case of the home based device will be discussed in the perspective of Rogers' theory.
This will raise questions that will be answered later in the study, using the answers given by the health professionals during the interviews.

1. Relative advantage is "the degree to which an innovation is perceived as being better than the idea it supersedes" (p.213). It is expressed in different ways, but economic profitability is mostly used. The kind of advantage also depends on what the adopters want. If they consider social advantage important, this should be taken into account. The relative advantage of the adoption of a certain innovation can also be an incentive promised by the distributor of the new product. The prospect of a reward could persuade consumers to adopt the innovation. In health care the relative advantage should improve any aspect of the process of providing health care: time required, money, efficiency, effectiveness, ease, etcetera.
   A logical assumption is that the advantage of the home-based device compared to the current situation is the existence of a 'database' where different health professionals from different health care organizations can collect information on a patient. Currently there is no such thing. For that reason it now is very complicated for a health professional to gather information on the health status of a patient. The other professionals working with the patients have to be contacted (by phone, by email or otherwise) in order to request the information.

The other professional has to look it up, read it to the requesting professional, or send it. For both of the professionals this is a very cumbersome manner of sharing information.

Relevant questions to be asked here are: what information do the health professionals need from other health professionals? Is it mostly objective information, subjective information, or a combination of those two? In what way do the health professionals want the information to be available? Do the health professionals need to be able to make a comparison of the health status of the COPD patient over time (improvement or worsening)? And how do the health professionals want to compare the information, do they want numbers, a graph, or another way of displaying the data?

2. Compatibility is "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p.223). For an innovation it is preferable to be more compatible. Anderson (1997) applied the concept of compatibility to health care. He states that clinical information systems are not likely to be accepted by health professionals when it gets in the way of traditional practice routines (is incompatible with those routines). Additionally Paré et al (2008) state that clinical information systems must support the care process and thus be compatible with it.
   An innovation can be (in)compatible in three fields:
   a. Values and beliefs. A consumer will never adopt an innovation that is in contradiction with his beliefs or values.
      It is difficult to come up with an objection against working with the home-based device from the perspective of the health professional. It is very improbable that it is against a health professionals values and beliefs to work with a database with information which is filled in by the patient. The question raised here is: which values and beliefs of the health professionals are incompatible with the utilization of the home-based device?
   b. Previously introduced ideas. These can influence the adoption of an innovation in two ways: if an innovation is completely incompatible with previous products (in health care this can be an existing electronic medical record for example) it will probably be adopted by a small number of people. However, if it is completely compatible with current practices, it is not very innovative, and there is no reason to adopt the innovation. Therefore the golden mean between those two should be found. Markus & Tanis (1999) also state a form of compatibility as an important factor in the diffusion of an innovation: the extent to which systems for different business processes can be integrated (data warehousing). Not all companies want that, but the presence of the possibility could be considered an advantage.
      In the case of the home-based device, it should be possible to integrate the data inserted by the patient, with the data in the electronic medical record filled in by the health professional, if present.
      Therefore the relevant questions are: do the health professionals have electronic patient records? If this is the case, is this data compatible and can the data collected with the home-based device be integrated with the patient records?

   c. Needs. If an innovation is not compatible with the needs of the consumer a slower rate of adoption occurs, or no adoption at all.

This case is viewed from the perspective of the health professional. Therefore his needs are important. The need for information about the patient is probably most relevant, because the health professionals base their decisions on what the patient tells and feels plus the information about the medical history of the patient. Consequently the following questions should be kept in mind: do the health professionals currently feel that they need information they don't have? If they do not miss information, the innovation can make them aware of the fact that they miss information. Could the information from the home-based device solve this need?

3. Complexity is "the degree to which an innovation is perceived as relatively difficult to understand and use" (p. 230). If an innovation is too complex for a potential adopter to understand, he will not be able to work with it and therefore will not adopt it.
   The process of requesting patient information by the health professionals should be an easy process. The more complex it will be, the less it will be utilized in the provision of health care. It should be considered that it must also be easy for health professionals who are not used to working with computers. Additionally health professionals in general are not fond of electronics that are not directly used in providing care, like medical records. Evidence for this computer resistance among physicians is given in several studies (Paré et al, 2008; Lapointe & Rivard, 2006; Spil et al, 2004). The complexity of hardware and software is also considered a critical risk factor in information systems in health care (Paré et al, 2008). If the process of using it is complex they will resist even more. All health professionals treating COPD patients should be able to work with it.

   This factor of complexity raises the following questions: Are the health professionals able to work with computers? What requirements should be met for the design? Should information within the database be linked? (This will also make it more complex.)

4. Trialability is "the degree to which an innovation may be experimented with on a limited basis" (p.231). If an innovation is experimented with and the consequences are clear, a potential adopter knows what can be expected of the innovation and will adopt it more rapidly. This is especially important in health care, because people's health is at stake. If something is not tested and consequently does not function properly, a patient can become very sick.
   With the home-based device, an experiment in a limited group is very feasible. An experiment can be executed with the COPD patients from one hospital and their treating health professionals. Even a selection of the COPD patients from one hospital is possible. The size of the experiment depends on its' goal and the stage in which the innovation is.

   Questions flowing from the description of the trialability are: how big should the experiment be? What is demanded from the participating patients? Should they be a certain age? Should they be a certain gender? Should their dyspnoe be of a certain level? In what stage of the development should the device be tested? Should the device be tested as a whole, or just a few parts of it? What health professionals will be involved in the trial? What should they be able to do with the prototype?

5. Observability is “the degree to which the results of an innovation are visible to others” (p.232). The more visible the innovation itself or the result of the innovation is, the faster the rate of adoption is (if the visible result is considered to be advantageous).

The home-based device itself is off course observable for the patient using it. The device and the results are less commonsense for the health professionals; it generates the following questions: How will it change their way of working? Will it change the health professionals’ need for information? Will it save time in the provision of health care? Will it change (improve) the cooperation between the different health care professionals?

In summary: according to Rogers (1983) there are five attributes to describe innovations and their diffusion: relative advantage, compatibility, complexity, trialability and observability.

2.2 The rate of adoption

In addition to Rogers’ five factors influencing diffusion of innovations, Greenhalgh (2004) came up with six factors, which are in her opinion complementary to those of Rogers in influencing the rate of adoption of the innovation:

1. Potential for reinvention. This encompasses the possibility for potential adopters to adapt, refine or modify the innovation to meet their own requirements. The more flexible an innovation is in modification, the more easily it will be adopted.

   In the case of the home-based device it could be that flexibility is limited. Customization of the (display of) information from the device for every health professional would be far-fetched. A different kind of flexibility could be adapting the system for usage for different illnesses, like diabetes type 2.
   Apparently the question here is; how far should the customization be carried through? Is it performable? And does it have additional value?

2. Fuzzy boundaries. The concept of fuzzy boundaries is linked with the before mentioned potential for reinvention. Complex innovations are said to have a ‘hard core’, which is an inevitable and unchangeable part of the innovation. The ‘soft periphery’ however, is adaptable to the organization. It can be stated that the soft periphery has a high potential for reinvention.

   As stated above it would not be reasonable to customize the information for each health professional, the way it can be done with software for desktop computers for ‘normal use’.

3. Risk. If the potential adopter considers the outcome uncertain or risky to his situation, it is less likely to be adopted. This factor can be linked to the observability from Rogers (1983). If the observability is high, the outcomes and risks of the innovation are clear. Consequently the potential adopter can determine whether the risks are applicable to his situation. Visibility of risks will have a negative influence on the adoption of an innovation.

If Rogers' observability only brings positive outcomes the health professionals do not expect the innovation to result in risks. Questions that can be asked here are: do the health professionals expect any risks after implementing the home-based device? If yes, what risks, and how can the effect of these risks be mitigated?

4. Task issues. The innovation can help the potential adopter in his current tasks in his work, and improve performance or efficiency. If this is the case, the innovation is more likely to be adopted. This factor is comparable with Rogers' relative advantage. Only this factor further specifies the area in which the relative advantage should take place.

   Because the task issues are comparable with relative advantage, mostly the same questions can be asked. Most important in this factor is: does the information from the home-based device help the health professional in the provision of health care, and make it better and more efficient?

5. Nature of knowledge required. To be able to use the innovation, a certain level or kind of knowledge is required. If this knowledge can be codified and converted to any type of company, it will be more likely to be adopted. This factor of Greenhalgh can be linked to Rogers' complexity: The more complex an innovation is to work with, the more knowledge is required to be able to work with it. It will probably be like a database with the data the patient filled in from which information can be retrieved and displayed. Therefore it is an advantage if health professionals are used to working with a computer. Additionally the user of the information system must have knowledge about the used medical terms to be able to interpret the data. As the users are health professionals the medical terms are already part of their knowledge.

   The most relevant questions for this factor are: do the health professionals experience difficulties in working with computers? What additional knowledge (next to knowledge about computers) is needed to be able to work with the information from the home-based device?

6. Technical support. This can be described as additional services. For example the availability of a telephonic helpdesk in addition to a software package. This will encourage potential adopters to choose for the innovation. The presence of technical support is also studied in a clinical environment. From the study by Jarvis-Selinger et al (2008) it can be concluded that technical support staff is necessary in order to minimize the troubleshooting done by physicians. Consequently the health professionals can concentrate on their clinical duties. In the study by Liddy et al (2008) the manufacturer also provided technical support.

   This factor applied to the home-based device results in the following questions: what possibilities are there for additional services to the home-based device? Is there demand for these extra services? If yes, what kind of extra services?

These six factors plus those of Rogers (eleven in total) are in the 'innovation-section' in the "conceptual model for considering the determinants of diffusion, dissemination, and implementation of innovations in health service delivery and organization, based on a systematic review of empirical research studies" by Greenhalgh (2004, p. 595). The rest of this model (which is included in appendix 2) is not used in this study, because it is very complex and the remaining elements are irrelevant for this study.

The six factors by Greenhalgh seem to be aimed at change management. Rogers' factors are aimed at the end user of the innovation. Therefore the compatibility of the two models is questionable.

In summary, Greenhalgh proposes six factors complementary to those of Rogers (1983) in the diffusion of innovations, namely: potential for reinvention, fuzzy boundaries, risk, task issues, nature of knowledge required and technical support.

2.3 Health care change

Gustafson (2003) invented an 'organizational change manager' (OCM). This model is focused on the change process, whereas Rogers and Greenhalgh are focused on the innovation. The goal of the Gustafson model is to "predict the potential for successful implementation of a health system change and to explain (identify) the factors that mitigate for and against success in that particular change" (p. 751). A change agent is responsible for causing the process improvement. This model will help the change agent to identify potential barriers and improve the chances for successful implementation. The factors in this model are mostly occurring prior to the implementation of the change. This is consistent with the point of view of this study.

The Gustafson model consists of eighteen factors influencing the success of a change process. The complete list and an extensive description of the eighteen factors is in appendix 3.
A flowchart is used to compare and integrate this model with the other theories. For that purpose the eighteen factors are grouped in time sequence and can be placed in a flowchart with arrows indicating relationships which are presumably causal: the different factors influence each other.

The figure below shows the timeline converted into a flowchart:

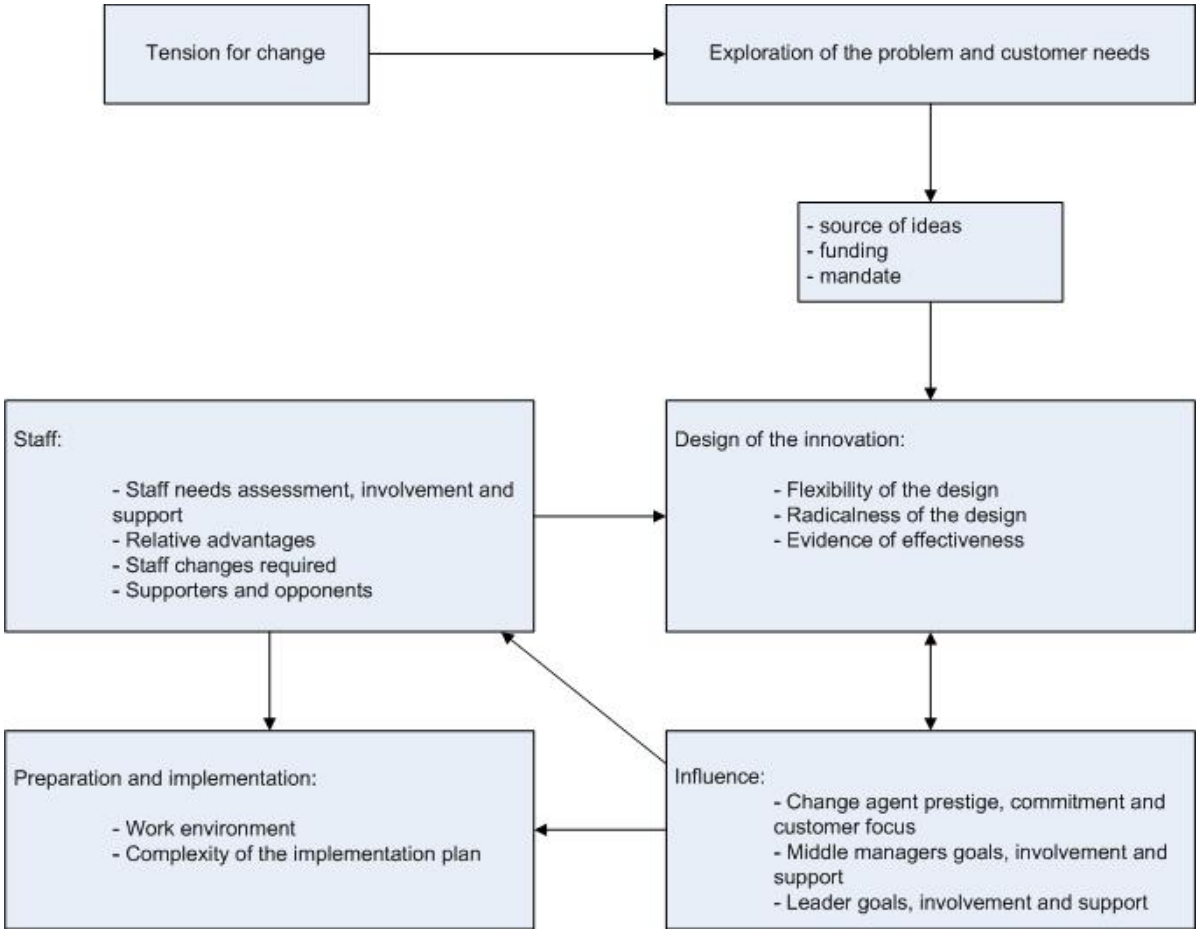

Figure 7: Gustafson's organizational change model (2003), converted into a flowchart

The 'staff box' in the above flowchart is most important for this study because the research questions concern the health professionals (staff) and the changes caused by the subjective information collected by the home-based device in their process of health care provision. The rest of the model is outside the scope of this study. Therefore only the elements from the 'staff box' will be clarified.

The following factors are part of the staff box (Gustafson, 2003):

- 'Staff needs assessment, involvement and support': personnel is more likely to co-operate and support a change if they will benefit. User involvement is named as one of the most critical variables in determining success or failure in user response and acceptance to an information system (Ginzberg, 1981; Smith & Carayon, 1995) as well as enhancing motivation (Smith & Carayon, 1995). In other literature it is also shown that many system failures are an effect of user dissatisfaction with the goal of the system, the scope of the system or the system's general orientation to the business problem (Evan & Black, 1967; Harvey, 1970; and Dearden & Lastavica, 1970). Additionally all departments affected by the change should be involved (Lawler, 1986). Therefore needs of the staff should be identified and the plan of action should prove that the change is in the best interest and is matching the goals of the employees. To accomplish that, first the working process of an employee (or employees in general) should be discerned.

Subsequently the most inefficient, the most impractical and least challenging parts can be identified. For those parts a better solution should be designed.
Questions flowing from this reasoning are: what do the health professionals consider to be the least efficient or practical part of their working process? Do they consider the information facility part of it? How do they think it should be improved? How do they want to be involved in the process? How do they expect to support the change?

- 'Relative advantages': Employees preferring the new situation in comparison to the old situation are more likely to co-operate in the change process. People are more likely to accept when they understand the implications of the change and perceive that they will gain more than it will cost them (Kotter & Schlesinger, 1979). This 'relative advantage' is exactly the same as the one from Rogers (1983). Therefore the same questions are relevant, as mentioned above in the section about relative advantages from Rogers' theory.
- 'Staff changes required': refers to the degree of complexity of the skills required from the affected employees. As Lorenzi & Riley (2000) state it: "any significant organizational change involves changing habits, that is, changing the way we actually work" (p.120). The chance of resistance is lower if the amount of new skills is low and level of complexity fits available skills (Kotter & Schlesinger, 1979). This factor can be linked to the complexity and compatibility from Rogers' theory: the more complex the innovation is, the more changes required (unless the previously introduced idea was already very complex). And the less compatible the new idea is, the more adoption is necessary to be able to work with the totally different innovation. Consequently the same questions can be posed as stated in the section about complexity and compatibility by Rogers.
- Supporters and opponents are always present in the process. An employee is more likely to support the change, if more relevant fellow workers also support the change. This factor is more or less the result of all five factors of Rogers. Based on their opinion on Rogers' factors, the potential adopters shape their opinion on the innovation and consequently choose to be a supporter or opponent.
  Relevant questions concerning supporters and opponents are: what are the most important reasons for employees to be an opponent/supporter? What are the consequences of being an opponent on the process change if the innovation is implemented anyway?

In summary: Gustafson came up with several factors concerning the staff that should be kept in mind when an organizational change is conducted, namely: staff needs assessment, involvement and support; relative advantages; staff changes required; and supporters and opponents.

2.4 Technology acceptance

Next to the previous theories concerning diffusion of innovation and change, there are also theories in which the acceptance of innovations is the most important point discussed. Acceptance is defined as follows: "Acceptance of an innovation or technology describes the positive adoption decision of users – in contrast to the rejection of an innovation or technology" (Simon, 2001, p.87). There are still some dimness's about acceptance. Some studies use the date of first use as the measure of acceptance (Ryan & Gross, 1943). Others however state that first use may not always lead to continued use and therefore the distinction between 'trial' and 'adoption' should be made (Katz et al, 1963).

The article by Hu et al (1999) shows what makes the acceptance theory useful for this study. They state that user technology acceptance is a crucial issue for organizations in the healthcare sector who are planning to offer telemedicine-enabled health-care services.

In implementation of information systems in companies, the majority of innovations fail. Many of these failures are caused by low usage among the perceived users, which are the employees of the firm. Lots of studies have addressed this issue in the last fifteen years, in order to find out which types of information systems have been accepted and which have not been accepted and predict the success of future innovations. According to Venkatesh et al (2003) the underlying idea of all these user acceptance of information technologies studies is the following:

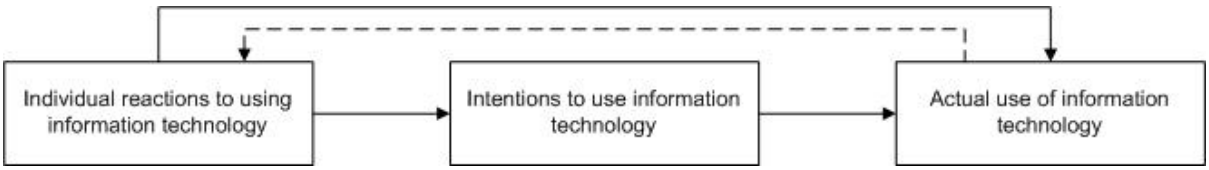

Figure 8: The basic concept underlying user acceptance models (Venkatesh et al, 2003).

One of the most cited and used studies in innovation literature, was done by Davis (1989) which describes the Technology Acceptance Model (TAM). It suggests that "users' intention to use is the single best predictor of actual system usage" (Davis & Venkatesh, 1996, p. 20). This also appears from the basic concept in figure 4. Behavioral intention is expected to have a significant positive effect on the actual usage of the technology (Venkatesh et al, 2003). A relevant question for the perceived users' intention to use is: once implemented, would the health professionals use the subjective information from the home-based device (a lot) in their working process?

This intention to use, which determines the actual usage, is influenced by two factors: the first one is perceived usefulness, which is "the user's perception of the degree to which using a particular system will improve her/his performance" (Davis & Venkatesh, 1996, p. 20).
This perceived usefulness is comparable to the 'relative advantage' from Rogers: what advantage does the innovation give the user compared to the previous solution. Another study by Venkatesh et al (2003) confirms the importance of perceived usefulness. In their study they created a unified model in which different models of individual acceptance are merged into one 'unified theory of acceptance and use of technology' (UTAUT). In this model performance expectancy, which is to what extent the user expects the innovation to cause advantages in his job performance, is one of the constructs that play a significant role in determining the user acceptance (Venkatesh et al, 2003).
In fact it is stated that performance expectancy is "the strongest predictor of intention and remains significant at all points of measurement in both voluntary and mandatory settings" (Venkatesh et al, 2003, p. 447).
Additionally in their study executed in health care Chismar & Wiley (2002) confirm that perceived usefulness had a strong and significant influence on the health professionals' intention to use. The perceived ease of use was not significant in this case (Chismar & Wiley, 2002). Therefore it can be expected that the perceived usefulness should be high for an innovation to be able to succeed.
A question that applies to the information extraction of the home-based device encompassing the perceived usefulness is: do the health professionals expect the subjective information to be useful in their provision of health care?

The second factor influencing the intention to use is perceived ease of use, which is “the user’s perception of the extent to which using a particular system will be free of effort” (Davis & Venkatesh, 1996, p. 20). The perceived ease of use can be compared with the complexity of Rogers’ theory. The less complex an innovation is in use, according to the potential adopter, the more likely the potential adopter is to actually adopt the new idea. Additionally Venkatesh et al (2003) include the effort expectancy in their model, which is defined as “the degree of ease associated with the use of the system” (p. 450). This factor can be expected to be relevant because it is included in many similar models.
The question that can be posed here is: do the health professionals expect the subjective information from the home-based device to be easy to work with?

From the research by Hu et al (1999) among physicians, which is the target group of this study, the aforementioned perceived usefulness appeared to have a bigger influence on the intention to use than the perceived ease of use. Additionally Keil et al (1995) stated that “no amount of ease of use will compensate for low usefulness” (p.89). However, this quote might be a bit drastic: the ease of use being not equally important does not mean that it should be left out. Furthermore the study by Venkatesh et al (2003) brings up a third factor influencing intention to use, namely social influence. In the Technology Acceptance Model below this is included in the ‘external variables’ factor.

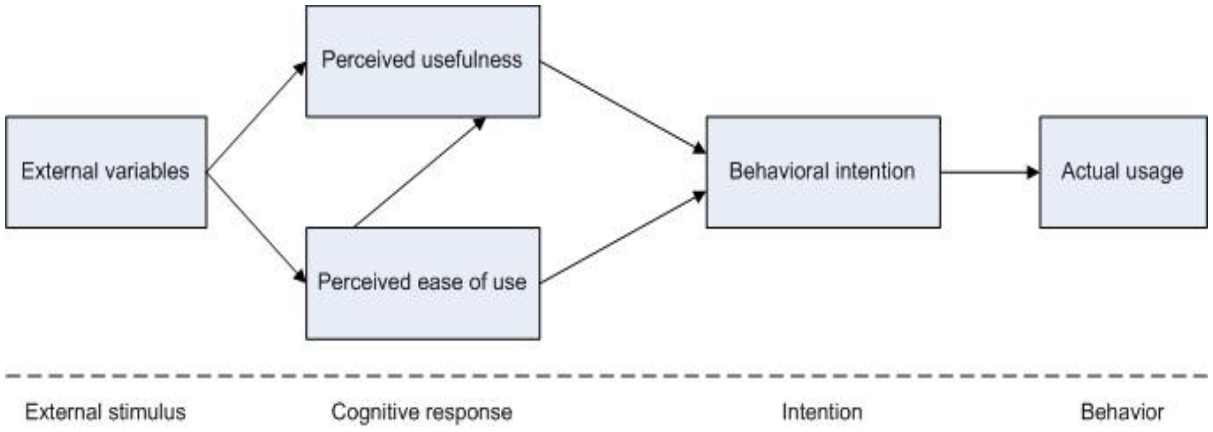

Figure 9: Technology Acceptance Model (Davis & Venkatesh, 1996).

As can be seen in the figure above the perceptions of the potential users (perceived usefulness and perceived ease of use) are influenced by external variables. These shape their opinions about the new technology.
In a later study Venkatesh & Davis (2000) extended the Technology Acceptance Model. Several constructs are added in the ‘TAM2’ encompassing social influence processes and cognitive instrumental processes. Both these constructs consist of multiple factors, displayed in the figure below.
In this new model the external variables (individually named) influencing perceived usefulness are emphasized. The external variables no longer influence perceived ease of use, according to TAM 2. However, in addition to the already described models these external variables do not add new aspects influencing the adoption of innovations. Most of the external variables are encapsulated in another variable, in the exact same form or a deduction of it.

'Output quality' for example, is encapsulated by the relative advantage factor by Rogers: increasing quality of the service (the output) is part of the improvement an innovation causes, compared to the old situation.

It could also be argued that the UTAUT model (Venkatesh et al, 2003) mentioned earlier in this paragraph should be used in this study. It is chosen not to do so, because some of the models used in this study (TAM) or factors of models used in this study (diffusion of innovation, TAM, task technology fit) are also included in the UTAUT model. Therefore these theories would be included in this study in twofold and consequently be emphasized too much, or influence the outcome in an unbalanced way.

Therefore the first technology acceptance model will be used in this study.

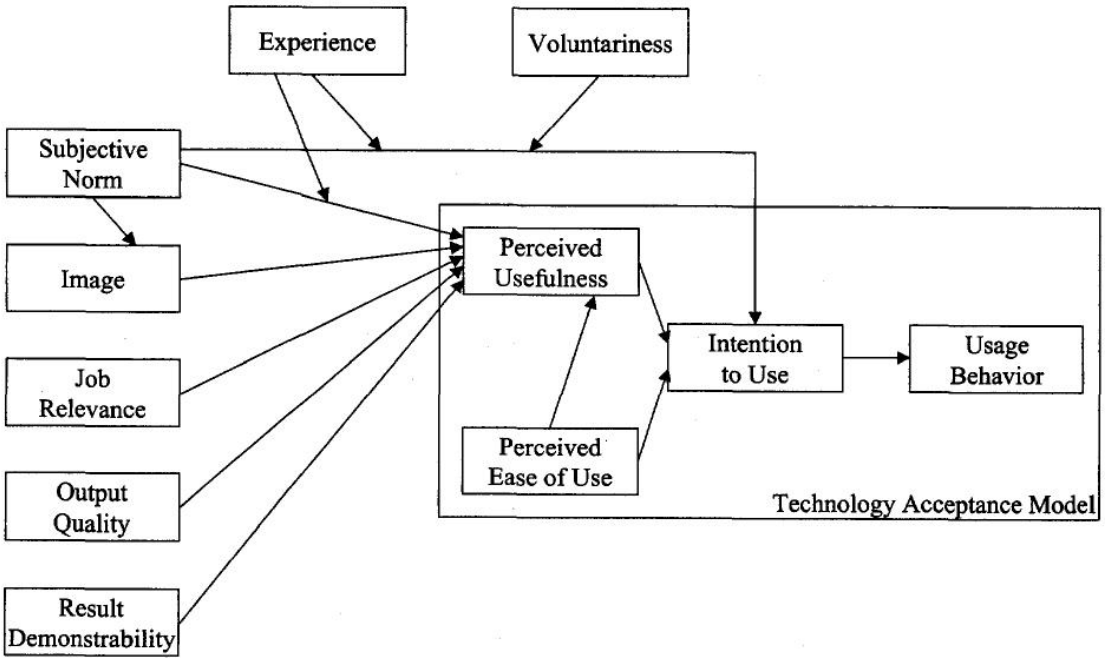

Figure 10: 'technology acceptance model 2' by Venkatesh & Davis (2000)

In summary, Davis & Venkatesh state that in technology acceptance (and thus the actual use of the innovation) behavioral intention influences the actual use. Behavioral intention is formed by perceived usefulness and perceived ease of use. These two factors are shaped by external variables.

2.5 Task technology fit

According to Ammenwerth et al (2006) something very important is still missing in these highly valued technology acceptance models: interaction between user and task. They developed a model that did include interaction of users, tasks and technology in IT adoptions in a clinical environment: the FITT framework, in which FITT stands for Fit between Individuals, Tasks and Technology (Ammenwerth et al, 2006):

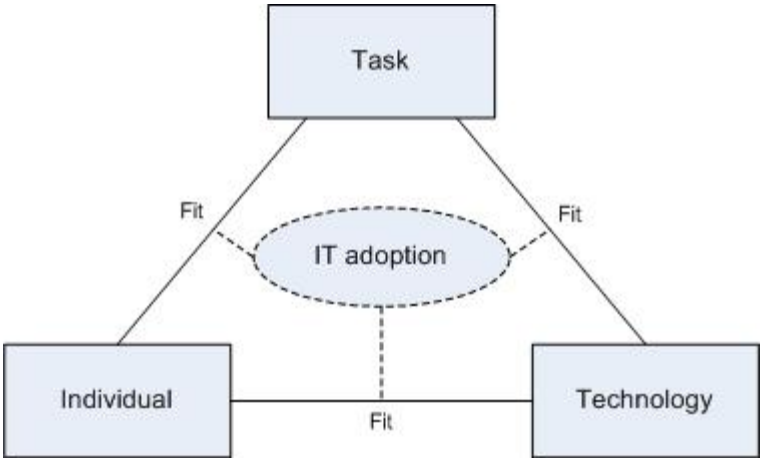

Figure 11: the FITT framework (Ammenwerth et al, 2006).

- The individual is the user of the new technology. That can be an individual or a group of users.
  From the perspective of this study the individuals are the health professionals treating COPD patients, who consequently get to work with the information that is collected using the home-based device.
- The technology is the set of tools the user needs to accomplish his tasks. This means not only the new technology but also the paper-based tools.
  In this case the most important technology is information about the medical history of the patient (from the electronic or paper medical record) and information about the current complaints of the patient.
- The task encompasses all the tasks performed in the working process of the user, in which the new technology should support the user.
  The most important task for the health professionals working with COPD patients, is the examination of the course of the disease of the patient and guiding the patient to relieve as much complaints and exacerbations as possible.

This model by Ammenwerth et al is based on the description of an organization according to Leavitt & Whisler (1958). They state that an organization consists of four interrelated elements: technology, structure, task and people. Later organizational culture is added by other theorists (Bui et al, 1996). Three of these elements are the same as Ammenwerth et al use in their FITT framework. In Leavitt's model a change in one element inevitably causes a change in the other elements. This can be planned as well as unplanned. The influence on the other factors can also be seen in the FITT framework: the interaction between the three elements is emphasized by Ammenwerth et al.

In the aforementioned study by Markus & Tanis (1999) fit is also brought up. They point out that "lack of feature function fit between the company's needs and the packages available in the market place" (p. 181) is one of the most important reasons for not or partially adopting the new system, or terminate the use after adoption. This can be considered to be the "collective level" of the fit described in the FITT framework (which is focused on the individual employee).

Dorr et al (2007) also acknowledge the importance of fit: they state that for an information system to be doing well "an appropriate non-IT system of care must be in place, and the use of specialized IT components must fit with systems of care" (p. 161-162). This means the usability of the system in the tasks of the employee must be present for IT to be successful. In Ammenwerth's model that is the fit between task and technology. Rogers (1983) names this compatibility.
Another important remark with this model is mentioned by Leavitt (2002). It should be kept in mind that technology always accelerates, probably caused by curiosity and generalized angst. As a consequence of this constant development attention should be given to the fit between the factors. However it is also possible that exactly because of the evolving technology the task and individual change.

From this model the following questions, applied to the case of the home-based device are the result: what is, in the implementation of an IT-innovation, necessary for a good fit between the individual and the technology from the FITT-model? What is necessary for a good fit between the individual and the task? What is necessary for a good fit between the task and the technology?

In summary, Ammenwerth et al (2006) developed a model that includes interaction of users, tasks and technology in IT adoptions in a clinical environment: the FITT framework, in which FITT stands for Fit between Individuals, Tasks and Technology.

2.6 The merging of theories

In the evaluation of the research question the user acceptance was assessed to be the most important aspect in the study. For that reason the model by Davis & Venkatesh is used as a starting point. The factors from the other theories have been added to clarify and to broaden. The result is two tables (table 1 and 2 on page 27 and 29) with the description of the transfer from the theories to the created model, and the new created model in figure 12 on page 30.

First the factors of Rogers' diffusion of innovations model were arranged into the perceived usefulness and perceived ease of use boxes. Knowledge about these factors comes from the external variables. With this knowledge (positioned below the dotted line) the intended users form their opinion about the different factors in the perceived ease of use and perceived usefulness boxes. This is the persuasion which is referred to below the dotted line. Relative advantage is considered the most important factor in the perceived usefulness. The compatibility is also placed in the perceived usefulness, because it encompasses the way the innovation fits into the working method of the perceived user. It could possibly be placed in perceived ease of use, but from a previous study compatibility not appeared to be a significant determinant for perceived ease of use (Chau & Hu, 2001). Additionally Moore & Bensabat (1991) state that there is a strong relationship between compatibility and relative advantage, and they are also largely congruent with perceived usefulness of the technology acceptance model. Therefore it would be rational to place those two in the perceived usefulness. The description of the compatibility factor also makes clear that the FITT-framework by Ammenwerth, Iller & Mahler is part of the compatibility. Consequently it is situated with compatibility in table 1.
Complexity is obviously part of the perceived ease of use box. The complexity directly influences the perception users have of the ease of use. The experimenting with an innovation (the trialability) can show if the system is easy to work with or not. Therefore it is placed in perceived ease of use.

The visibility of the results of the innovation (observability) demonstrate in what way the innovation can be useful for the user of the system and is for that reason part of the perceived usefulness.

From Greenhalghs factors, additional to Rogers, only two were not comparable or linkable to one of Rogers' factors and therefore the other factors are not included. They do not add anything new. The factors potential for reinvention and technical support are positioned in perceived ease of use in the created model. It is remarkable that these factors are both part of the in paragraph 1.5 described business model: they both partly determine the possibility of diffusing and exploiting the device. The first one is placed in perceived ease of use because the possibility of adjusting the system to the users' wishes will influence the ease with which he or she can work with it. The technical support is an additional service that increases the ease of use.
The fuzzy boundaries are not placed in the created framework because it is very similar to potential for reinvention. Additionally this is not relevant for the home based device because it is in a very early stage. Later on in the development it might be more relevant. Risk is comparable to the observability in Rogers' model. Observability is the visibility of the results of an innovation. In Rogers' commercially oriented view the positive effects of an innovation are particularly emphasized. However, these results also include the risks concerning the new system. The visibility of risks will decrease the rate of adoption. Task issues are, as already stated in paragraph 2.2, a specification of Rogers' relative advantage. Therefore it would just be a duplicate item. Nature of knowledge required is part of the complexity of an innovation. The more complex it is, the more knowledge is required to be able to work with it. For that reason nature of knowledge required is also not included in the created model.

The elements of the 'staff-box' are most relevant from the flowchart based on Gustafson's theory as explained before. Additionally it is the part of the model that best fits the scope of this study. Therefore it is chosen to place them in the newly created model. Staff needs assessment, involvement and support is placed in the perceived usefulness, because it concerns the wishes as well as possible benefits of the perceived users. Relative advantages already exist in the new model, as this factor is also present in Rogers' model.
The staff changes required is located in the perceived ease of use for the reason that the adjustments the staff needs to make to use the innovation is considered an element of ease of use. This is consistent with the literature: Chau & Hu (2001) state that health professionals are likely to consider an information system easy to use when its use does not involve major changes in their procedures.
The last factor used from this model is supporters and opponents. This factor is positioned in the box with the behavioral intention. The perceived usefulness and perceived ease of use persuade the user, they determine whether the innovation is a good thing for him or not. This will lead to the user being a supporter or an opponent of the innovation. Linked to that he will form the behavioral intention (using the innovation or not). The 'choosing sides' and the behavioral intention eventually lead to the decision of actual usage, which is the last box of the created model. This actual usage is obviously linked with implementation.
The model also has a possibility of 'confirmation', which is the evaluation of the decisions made concerning the innovation (Rogers, 1983) and the effects they produced. Consequently adjustments can be made, decisions may be reversed and errors can be eliminated. This may lead to a new or improved innovation for which the process will start over, beginning with the external variables.

The created model might be a bit unbalanced: perceived usefulness and perceived ease of use encompass far more elements than the other factors. Next to these two factors the supporters and opponents and behavioral intention is relevant for and in the scope of this study and is still too weak. Therefore additional theories were sought to complement this factor.
First the distinction between behavioral intention and behavioral expectation is made. According to Warshaw & Davis (1984) this difference is very important and underexposed in previous research. They define behavioral intention as "the degree to which a person has formulated conscious plans to perform or not perform some specified behavior" (p. 214). Additionally behavioral expectation is defined as "the individual's estimation of the likelihood that he or she actually will perform some specified future behavior" (p.215). Most research considers the named definition of behavioral expectation as behavioral intention, even though it is totally different. Therefore the element behavioral expectation is added in the created model.
In order to clarify behavioral intention further, the study by Ajzen & Fishbein (1969) with a psychological tendency is used. They split up behavioral intention in: two types of normative beliefs, namely personal normative beliefs and social normative beliefs, and 'attitude toward the behavior in a certain situation'. With this last factor the comment is placed that it is especially focused on the attitude in a given situation and not on the attitude toward the innovation itself. These factors are proven to be relevant for and highly correlated with behavioral intention (Ajzen & Fishbein, 1969). Therefore this division is also included in the created model.
Next to that it was found in literature that self efficacy plays an important role in determining a person's feelings and behaviors (Compeau & Higgins, 1995; Bandura et al, 1977; Betz & Hackett, 1981; Barling & Beattie, 1983; Brown & Inouye, 1978; Stumpf et al, 1987). People with high self-efficacy will consider themselves as capable of performing difficult tasks, whereas individuals with a low level of self-efficacy will consider themselves as only capable to perform simple varieties of the tasks (Compeau & Higgins, 1995). Therefore self-efficacy is considered to be a good complementary factor in the box with behavioral intention, behavioral expectancy and supporters and opponents.

These theories combined are put in table 1 (page 27). In this table the first column contains the factors placed in the model. The second column encompasses the factors that are similar to the matching factors in the first column and therefore left out of the final combined model.

In the model	Enclosed
External variables	
Perceived usefulness	
Relative advantage	Task issues, Relative advantage
Compatibility	Fit between: task, technology and individual
Observability	Risk
Staff needs assessment, involvement and support	
Perceived ease of use	
Complexity	Nature of knowledge required
Trialability	
Potential for reinvention	Fuzzy boundaries
Technical support	
Staff changes required	
Behavioral intention	
Attitude	
Normative beliefs	
Behavioral expectation	
Self-efficacy	
Supporters & opponents	
Actual usage	

Table 1: Factors used in the model of combined theories

In table 2 on the next page the factors in table 1 above are arranged according to the theories they originally came from.
In the left column Davis' theory is placed. In the next columns the factors from the other theories are placed in the row between the dotted lines of the factor from Davis' model in which they are placed in the clarification above.
The factors with the same borders are the ones that are similar and placed in the same row in table 1: these are aggregated when placed in the model of combined theories. For example: the fuzzy boundaries are very similar to potential for reinvention. Therefore they are placed in the same row in table 1, they have the same border in table 2, and potential for reinvention is not placed in the created framework in figure 12.
The factors that are added later in order to enforce the weak part of the created model are described on page 26 and they are listed below table 2 because they did not come from one of these five theories.

Table 1 and table 2 are a step towards the final model of combined theories.
The flowchart of this new model is displayed in figure 12 on page 30. The factors in italic did not originate from one of the five used theories, but were extracted from other sources and added later.

The most important questions this model raises are:

- How can the perceived usefulness and perceived ease of use be optimized in order to improve the users' perception and with that, the actual usage?
- Which of the two perceptions (usefulness or ease of use) have the biggest influence on the behavioral intention?
- Which factors are most determining within these perceptions?

Davis	Rogers	Greenhalgh	Gustafson	Ammenwerth
External variables				
Perceived usefulness	Relative advantage Compatibility Observability	Task issues Risk	Relative advantage Staff needs assessment, involvement and support	Fit between: task, technology and individual
Perceived ease of use	Complexity Trialability	Nature of knowledge required Potential for reinvention Fuzzy boundaries Technical support	Staff changes required	
Behavioral intention			Supporters & opponents	
Actual usage				

Not used from the Gustafson model:

1. Tension for change
2. Exploration of the problem and customer needs
3. Source, funding and mandate
4. Design of the innovation
5. Influence
6. Preparation and implementation
7. Monitoring and feedback

Added in the combined theory from other sources:

1. Behavioral intention divided in:
   attitude
   normative beliefs
2. Behavioral expectation
3. Self-efficacy

Table 2: Model of combined theories: factors used from the five source models

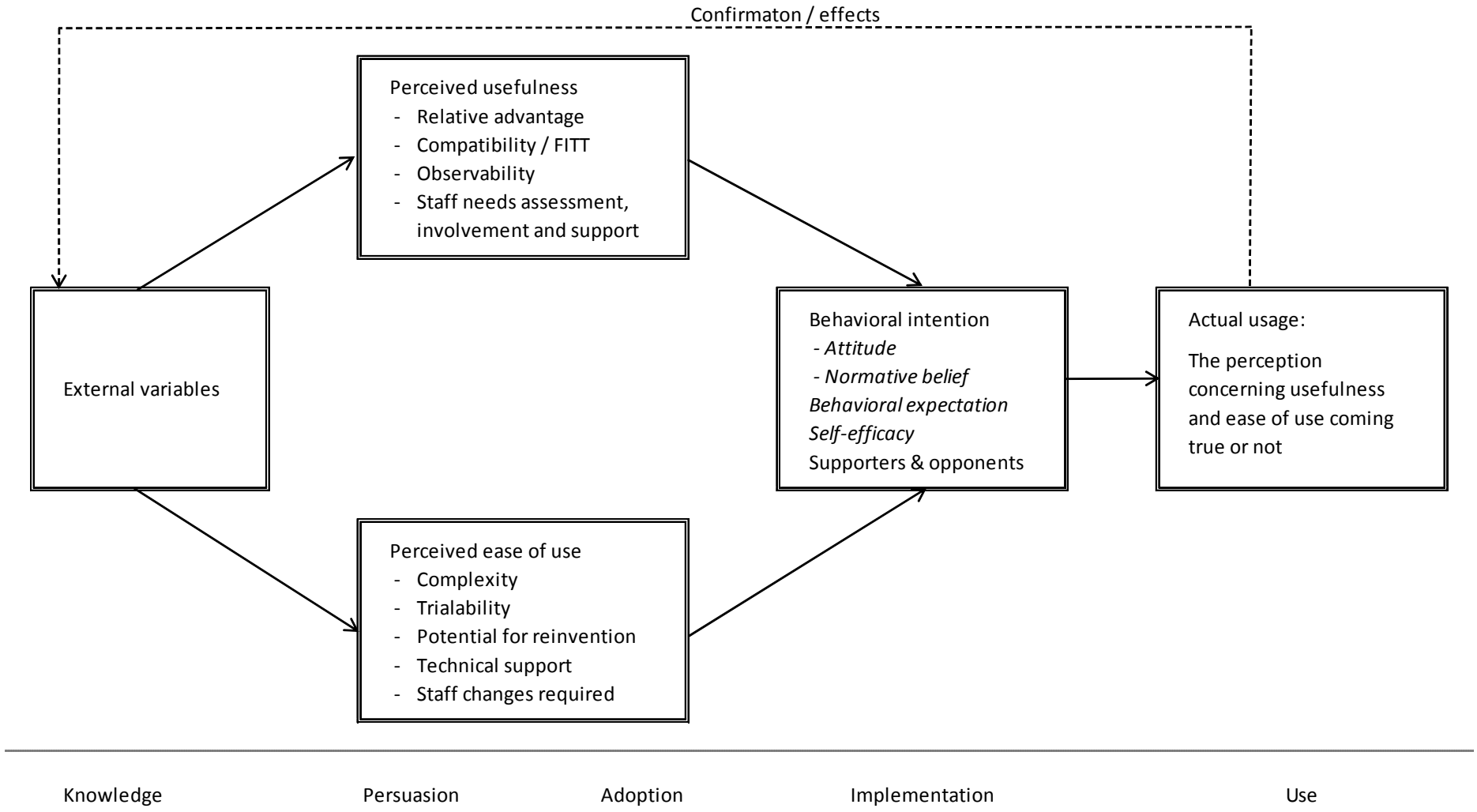

Figure 12: the theories combined, with the TAM model as the point of departion.

3. Method

Health professionals of different disciplines were interviewed face-to-face with a semi-structured interview protocol in order to collect data to test the theoretical framework and to answer the research questions. In this chapter, the choices made concerning selection of questions and selection of respondents are justified.
The results from the interviews will be analyzed and discussed in the next chapter.

3.1 Research design

Interviews are chosen as the best way for this study to get the answer to the research questions and the questions raised in the theory. This choice can be justified by the following factors: first, the target group of this study is limited; second, a personal approach is expected to have the intended effect and yield more extensive answers to the questions; third, a face-to-face interview gives the possibility of illustrating and clarifying the questions. Consequently the respondents have a clearer picture of what the question actually means and their answer is expected to be truthful.

3.2 The interview questions

The interview questions were devised as follows: first, all the questions that could be derived from the theory were written down. Some with modifications, additions, and parts left out. This list of questions was filled up by brainstorming on additional questions.
Subsequently the irrelevant questions were eliminated. From the relevant questions the most important subjects were chosen. The questions concerning these subjects were correctly formulated and placed in the list of interview questions, in the right order. The subjects of the questions are: familiarity with the device, earlier implementations of information systems, expectations of the health professionals, their needs, possible barriers they can identify, and the most important advantage as well as the contribution of the subjective information in these improvements.
Finally it was checked if there were questions in the list that were not necessary for answering the research questions, and if all the research questions were covered (could be answered) by these interview questions. The final list of questions used for the interviews can be found in appendix 4.

The goal of the interviews was to answer the research questions. More specific: what subjective information the health professionals need in their process of health provision, how they intend to handle the flow of information collected with the home-based device, and how the device will change and (or) improve their way of working.

3.3 Selection of respondents

Respondents were selected from the following health professions: pulmonologists, nurse practitioners and physiotherapists. This choice was made, because earlier in the COPD.com project the involved parties established that professionals from these three disciplines were most important in the provision of health care to COPD patients.

In the beginning of this study an introductory conversation was held with a pulmonologist, a researcher and a physiotherapist. Later on two of them also participated in an interview. A snowballing approach was used to find possible respondents: Other possible respondents were brought forward by the pulmonologist, who were then contacted for an appointment.
After the interview the respondents were also asked if they knew possible respondents within the three selected disciplines. A downside of snowball sampling is that it results in questionable representativeness (Babbie, 2004). All respondents work at the MST hospital in Enschede or cooperated in the previously executed COPE II study.
Therefore the results of the interview may be biased or not optimally valid. As a result of the 'homogenous' group of respondents the results may not be generalizable over a broader population.

All eight approached health professionals were willing to cooperate in an interview. Therefore the non-response was zero.

3.4 Analysis of the interviews

The interviews were recorded. Afterwards they were transcribed. The average duration of the interviews was approximately 45 minutes.
After the transcription the analysis took place. It was done as follows: first the interviews were summarized. Then the essence of the answers was written down, sorted by question. A list of eight answers per question was the result. The results were outlined per question consistent with the list of answers. Subsequently it was checked if the results were corresponding or contradicting the literature.
The interviews were inspected to make sure nothing important was missed. Some of the respondents made some notable remarks and statements that could not be classified in one of the interview questions. These were placed in a separate paragraph (4.6).

The results are discussed, analyzed and linked to the theory in the next chapter.

4. Results

In this chapter the results of the interviews with the three groups of health professionals (pulmonologists, nurse practitioners, and physiotherapists) will be discussed and analyzed.

4.1 The respondents analyzed

Within the specified selection criteria eight people were found who were willing to cooperate in an interview. From these eight respondents four are pulmonologists, three are physiotherapists, from who two work in a practice and one in the hospital, and one is nurse practitioner.
The division in gender is as follows: three of the participants are male, five are female. This general information about the respondents can be found in table 3, below.

	hospital		practice		total		grand total
	m	f	m	f	m	f	
pulmonologist	1	3			1	3	4
physiotherapist	1		1	1	2	1	3
nurse practitioner		1			-	1	1

Table 3: General information about the respondents

4.2 Familiarity with the device

From the eight respondents, four have heard of the home based device. Three have heard of comparable projects, but not specifically this one. One has not heard of it.
Of the four respondents who have heard of it, three know what the home based device encompasses. The other five respondents do not know.

	Yes	No	In a different form
Heard of the home-based device?	4	1	3

Table 4: Heard of the home-based device

	Yes	No
Do you know what it encompasses?	3	5

Table 5: What the home-based device encompasses

When their opinion about the home based device was asked, three were positive. The other five did not have a clear opinion about it, because they did not have a clear view of what it was, what it would encompass, and what it would deliver. From those five, two declared their opinion on the device was dependent on the definition of the objective.

	Positive	Not really clear
What is your opinion about it?	3	5

Table 6: Opinion on the home-based device

Therefore, it can be concluded that the knowledge among health professionals on the home based device project is moderate, but their positive attitude is very low.
When it will actually be implemented this should be higher. Additionally it should be explained how the information can be utilized and how they can benefit.

4.3 First expectations

The first question in this part of the interview was: “what are your expectations concerning the home-based device? (What do you expect to be able to do with it?)”. Several variations on ‘overview’ and ‘insight’ were given as an answer, like: connecting relevant information; insight on the course of the disease; signaling, monitoring and acting timely; signaling and controlling small changes with the help of the course in the shape of a curve. These factors all applied to insight for the health professionals themselves. Furthermore insight for the patient was also named: insight in their own clinical picture; awareness and actions taken consequently; support in controlling their illness and being less anxious and dependent.

The health professionals were also asked what subjective information they need in their process of health care provision. The most important factors named were:

- How the patient feels;
- Shortness of breath (which can be objectified by the validated MRC score. In appendix 5 this score is reproduced);
- Limitation in activity or participation (or in daily life);
- Coughing;
- Mucus;
- Exacerbations and disturbances.

These factors were mentioned by (almost) all respondents, which means that this information is needed by the health professionals in their process of providing health care, in order to get a clear picture of the health status of the patient since the last time they saw him.
Some of the other factors, referred to by fewer respondents, were: medication use, how active the patient is (at home as well as at the physiotherapist), smoking status, shape and fatigue, occurrence of life events, comorbidity. It is of interest to include the factors enumerated above in the application of the home-based device, because “users think that appropriate, comprehensive and quality content improve the usefulness of the service” (Topacan et al, 2008, p. 2456).

All respondents except one had a clear view of how the subjective information from the home based device could change their way of working. To a large extend, the expected change in their way of working follow from the earlier discussed expectations: overview and insight. Most interviewed health professionals expect the information to give an overall view of the patient during a certain period. As a result from this overview they expect to be able to adjust better and quicker. The possibility to get an overview of the information on the past period is also named. This can function as an extra tool in their consult. Additionally, the time it would normally take to ask for that information, can then be used to clarify vagueness and presumptions, based on the overview.

4.4 Possible barriers

The enormous amount of information the home based device delivers, might be a problem in using the device. Therefore the health professionals were asked how they thought the information should be handled. In general the health professionals agreed that something should be done with the information, because otherwise there is no need to collect it. Additionally the health professionals all except one agreed that they did not want to check the incoming information themselves, especially when the patient is doing fine. The one respondent that did want to look at the information himself only had ten patients, so it would not be a lot of work to check the information weekly for example.

Four respondents would like to see some kind of alarm system that alerts them, when something is wrong with a patient. An alarm function is also used in the studies by Topacan et al (2008) and Liddy et al (2008). However, one responded doubted if it would be possible to link a threshold to a subjective measure. Another point of discussion here is whether the alarm should go off in the device of the patient or in the system of the health professional. Most respondents had the opinion that the patient should be responsible for his own health. Therefore the alarm should go off at the patients' system. Three respondents explicitly said they did not want an alarm system, because that would create a sense of unrest or even panic. According to these three respondents an 'action plan' would be a good alternative: the device should tell the patient for example to start with prednisolone or call the pulmonary division of the hospital. This action plan should be based on the answers the patient gave to the questions in the diary function of the device.

Another way of dealing with the information that was brought forward is that the patient will print an overview of his complaints and health status filled in in the device and bring it to the consult with the pulmonologist. Then the pulmonologist will have all the information he needs in one glance.

Recapitulating, the health professionals suggested three different solutions:

- some kind of alarm function;
  - for the patient
  - for the health professional
- an action plan for the patient;
  - contact the pulmonologist
  - take prednisolone and/or antibiotics
- a printed overview.
  - with the info in numbers
  - or visually displayed

The disadvantage of the last option is that it does not help to intervene earlier, and consequently it does not decrease the severity or even the occurrence of an exacerbation. Additionally it does not encourage self management of the patient. The stress an alarm causes in COPD patients may lead to increased shortness of breath, because emotions have a considerable influence on shortness of breath (Buck, 2009). Therefore the action plan is considered to be the best solution. It should tell the patient what he could do, in a calm and clear way. The tendency from these solutions is that the health professionals want to spend as little time as possible on use of the system.

The respondents were also asked to name aspects of the device that they are less enthusiastic about, or aspects they worry about. Some named multiple aspects. Three of the health professionals stated that they are most worried about possible privacy issues. Five respondents worried about the patients: if they would really use it:

- The patients should take the device with them on vacation for example (Topacan et al (2008) call the mobility aspect time and place independence);
- COPD patients are in general not used to working with computers;
- The patients should want to fill in the questions every day (from the study by Topacan et al (2008) it was concluded that if filling in the questions takes too much time the users prefer to see the physician instead of using a device);
- It may not be suitable for any COPD patient. One patient may find it comforting and will be less insecure on what to do, but another patient may become very restless;
- Patients tend to fill in the same score, if they have to fill in a number. Also patients could figure out how to fill in the system in order to avoid the warnings in the system.

Three health professionals wondered where the money should come from to finance the enactment of the whole project, because the execution of these kinds of projects entails lots of expenses. Only one health professional stated not to have any worries as long as he will not get trouble from it.

In order to predict possible problems with the implementation of the system, the respondents were asked how earlier implementations of information systems have worked out. Some explanation about the functioning of the implemented systems and getting used to it was required, but after that the respondents were able to work with it. So in previous implementations of information systems no major barriers were identified. This is different than the conclusion from a study by Anderson (1997) in which the following is stated: “as a result of their low level of expertise, residents were not able to use the system to its fullest capabilities” (p. 86). It is also not in complete contradiction, because Anderson (1997) did not state that the studied subjects were not able to use the system at all, they were just not able to use it optimally.

4.5 Expected advantages

The health professionals as end users of the device in this case, should see a relative advantage of using the new technology, if the adoption is to be successful. Two kinds of advantages are distinguished: in their own process of health care provision and in the cooperation with other health professionals.

The following advantages are named in the health professionals' process of health care provision:

- An overview (insight) from the (objectified) disturbances of a certain period. These long term trends are also found very useful by health professionals in the study by Liddy et al (2008);
- To be able to adjust better and quicker;
- To be able to observe gradually increasing disturbances;
- Make the patient more conscious of his clinical picture.
- Early detection

The (early) detection possibility is also named as an important advantage of electronic health information and monitoring systems in a study in head and neck cancer problems (Topacan et al, 2008).
The advantage of the insight and overview, or a variation on that, was referred to most often: by six health professionals. According to the literature potential users pay great attention to the way in which the system improves job performance (Davis, 1989; Taylor & Todd, 1995; Venkatesh et al, 2003; Topacan et al, 2008).

The advantages in the cooperation with other health professionals are also related to overview. The following advantages are pointed out:

- access to complete and adequate information;
- insight in what other health professionals do with the patient;
- gearing activities to one another.

These advantages are in line with the study by Paré et al (2008) who state that the integration of the care process is an important benefit of clinical information systems.
A comment that should be placed here is that two of the respondents explicitly stated that they did not think that the advantages they named could not be accomplished without the device. They said that improvement of the cooperation should mainly be accomplished by linking records, having all the information integrated in one system, and the sharing of information as an effect.
Another remarkable result based on the answers to this question is that most respondents consider the contact with the general practitioner as least effective. Therefore they want to improve cooperation with him.
Most of the respondents also wanted more information on the medication use of the patient. This applies to daily medication as well as use of prednisolone and antibiotics. Therefore cooperation with the pharmacist should be improved.

The health professionals definitely see a role for the subjective information in the advantages described above. Again the overview over a period of time is mentioned. One of the respondents stated that a combination of objective (lung function and saturation) and objective information (how the patient feels) is always needed. So the objective and subjective information should be equally important.

4.6 Other notable results

In this paragraph notable results are discussed that could not be included in the questions above. These notable results could not all be linked to the theory and therefore the reliability of the following reasoning cannot be guaranteed.

The first thing that attracted attention was the fact that only three health professionals made critical comments. The other respondents were very accommodating and positive. It was anticipated that more of the respondents would be critical and less accommodating. It was expected that some of them would see it as just another system, for which their efforts were required and would not deliver any good.

There were also some notable results concerning the COPD patients.
First of all, the discussion about whether the patients should be able to see their own 'history' in the device. Some health professionals would consider it to be positive: it will give the patient insight in his own health status and it could stimulate 'healthy behavior'. On the other hand, there were also health professionals that were not sure if the patient should be able to see their own history. COPD cannot be cured. Therefore even if the health status or quality of life of a patient improves, there is always an upper limit they cannot break through. Question is if the patients want to see their health status, especially if their status is bad or getting worse? Additionally it is questionable if COPD patients can interpret medical data.

What also attracted attention was the fact that some health professionals compared the use of the device with previously executed studies concerning COPD patients. Most of them concluded that from the results of the COPE II study hope can be gained that self-management has good potential for COPD patients. This is in line with the conclusion Thielscher & Doarn (2008) draw from their study about telehealth: patients want to play a more active role in the care provision instead of just accepting what health professionals tell them. Self-management is a rational solution in that case. Only one respondent made a comment on possible downsides of COPD studies already being executed: patients that have already participated in scientific programs are more aware than those who have not. In Twente lots of patients have participated. Therefore a pilot study in this area is probably not representative for all COPD patients in the Netherlands. Additionally, a problem with these scientific programs is that people are willing to do a lot for it, especially when they know the researcher. The fact that a pilot is temporary can also play a part. The success of a pilot and the cooperation from patients in these pilots does not guarantee that it will work after implementation.

What also appeared in the interviews was that most of the patients from the pulmonologists and the nurse practitioner are patients with GOLD status III or IV. The home-based device was aimed at status II and III, but the general practitioner who treats most GOLD II patients is not involved in the project.

The last notable result applies to the things not said in the interview.
None of the health professionals mentioned an expectation of spending more or less time because of the use of the device. They only referred to a different arrangement of their time.
Additionally the respondents did express their worries about the costs of the enactment of the project which also confirms the importance of the financial design of the business model. Not a single respondent mentioned anything about possible savings in costs.

5. Analyses

In this chapter the results described in the previous chapter will be analyzed and linked to the theory discussed in chapter two. The results will also be placed in the model of combined theories and analyzed on the basis of this created model.

5.1 Linking results to the theory

In this paragraph the results of the previous chapter will be linked to the theories discussed and merged in chapter two.

Familiarity with the device

First the results concerning the questions about the respondents' familiarity with the home-based device can be placed in the merged theory just behind the external variables in the flowchart. External variables have caused the health professionals to hear or not hear anything about the home-based device. The respondents that did hear about it, already produced a first opinion about it, based on the information coming from these external variables. However, this first opinion is not enough to form a behavioral intention, because most of the respondents do not have a clear enough vision on what the home-based device exactly is and can do.

As can be seen in table 4, two of the respondents want to base their opinion on what the goal of the device is. The goal can also be seen as part of the perceived usefulness. It is not likely for the health professionals to perceive an innovation as useful if the goal does not match their daily activities.

First expectations

The question on the health professionals' expectations, what they expect to be able to do with it, can be placed in the perceived usefulness. It discloses the relative advantage they cautiously expect from the information collected with the device. It is very promising that the given answers are positive, because it is referred to in the literature: "attitude appears to be the second most important determinant of a physicians' intention for accepting telemedicine technology" (Chau & Hu, 2002 p. 307). A positive attitude at this point in time predicts a positive intention for accepting the system. Within these relative advantages the respondents do not only think of themselves, but also the relative advantage for the patients: insight, awareness, control and support. The relevance of the control aspect is in line with the literature (Buck, 2009; Liddy et al, 2008). As Buck (2009) states it: "people feel safe if they think they can control a situation" (p. 56).

The subjective information that the health professionals need in their process of health care provision is part of the staff needs assessment involvement and support. In order to create a clear picture of how the information from the device could be useful to the health professionals, this question lists the information the respondents need to support their process of health care provision. It could be a relative advantage for them to have an overview of these factors on paper filled in by the patients in the period between consults. In the current situation the health professionals ask the patient about these factors. However, lots of patients do not remember (the development of) these factors and filling it in for an overview for the physician would have added value.

Expected change

Health professionals' expectations on the change in their way of working is part of the perceived usefulness in two ways: first if it has advantages compared to the 'old situation' (relative advantage), and second the compatibility or FITT with the current way of working. Most of the respondents have a positive view on the influence the overview/insight could have on their process of health care provision. The impression was given that working with an overview as an extra tool would fit in their way of working very well. Furthermore it was seen as an improvement to have complete information on the patient from the period between consults.

Possible barriers

The most obvious possible barrier with this system is the information overload. , It is a logical thing to worry about with hundreds of COPD patients filling in a dairy every day. This overload might cause the physicians to think that the system will be too complex or that a big change is required from them. Both factors are part of the perceived ease of use. Staff changes required can be limited to a minimum if the earlier mentioned overview can be used as an extra tool. A minimum of change is required and the health professionals will benefit. This overview will also limit the complexity if the information on the patient is clear in one glance (which was also stated as a condition). This is in line with the barrier to widespread dissemination referred to by Paré et al (2008), namely the complexity of the interface development.

Privacy issues were mostly named as important possible concern next to the information overflow. This is in line with the study by Mairinger et al (1998), who identified that 53% from their population of health professionals were concerned about data security. The possibility of issues will be dependent on external variables: the design of the information system, the other technologies used and the people who want to abuse the collected information.

Another expressed worry was the lack of confidence in the possibilities offered by the combination of the COPD patient and the computer based system. As stated in chapter 1 most COPD patients are over 40 and not used to working with computers, or are digital illiterates. This is confirmed by the literature in which it is stated that age is considered as a factor that influences easy use of the system (Topacan et al, 2008).

It is very striking that another study, executed in Canada among patients with multiple chronic illnesses is in complete contradiction with this. The average age of the population was 73 years and the patients were really positive about the home monitoring system. Additionally they found it easy to use and useful (Liddy et al, 2008).

From the point of view of the health professionals the patients being able to work with the devices is an external variable. Without the patients filling in the data the physicians cannot work with the information, because it is not there. This risk factor is also found in the literature: failure to gain user commitment (Paré et al, 2008).

From the point of view of the COPD patients themselves being able and willing to fill in the data is part of perceived usefulness as well as perceived ease of use. However, that cannot be placed in the model displayed in paragraph 2.6, because that model is applicable to the health professionals and not the patients.

Expected advantages

The expected advantages in the health professionals' process of health care provision can be placed in relative advantage. All the factors named by the respondents are expected to help them in their work, to make them able to do a better job and to be more efficient.

The anticipated advantages in cooperation with other health professionals can also be placed in relative advantage. Just like the previously mentioned advantages, these should help the physicians to do their job better and to be more efficient. This is in line with the results of the study by Buck (2009), who concluded that "telemedicine applications enable communication between different participants" (p.57).

5.2 Results reflected on the model of combined theories

In order to get a clear view of the results they will now be reflected on from the perspective of the created model that is displayed in figure 12 on page 30.

The diagram starts with the external variables, in which the following factors resulting from the interviews can be positioned:

- Familiarity with the device
- Preventing privacy issues (design of the information system, the other technologies used and the people who might want to abuse the information)
- The ability and willingness of patients to work with the device

The following interview results can be placed in the perceived usefulness:

- The goal of the device
- The relative advantage cautiously expected from the information collected with the device
- The relative advantage for the patients (insight, awareness, control, and support)
- Subjective information the health professionals need in their process (part of the staff needs assessment involvement and support)
- Having overview before the consult, as a result of the subjective information filled in by the patient (relative advantage)
- Expectations about the change in the physicians way of working: relative advantage compared to the 'old situation' and compatibility or FITT with the current way of working
- Expected improvement in cooperation with other health professionals (relative advantage)

The next factor is part of the perceived ease of use:

- Way of dealing with the possible information overload (complexity, staff changes required)

From the enumerations above the list of perceived usefulness encompasses the most factors. Therefore it can be concluded that in the opinion of the health professionals the perceived usefulness is most important in an information system. Benefits are considered more important than effortlessness use.

This matches with the literature in which the perceived usefulness is also stated to be the most significant factor in predicting the health professionals' acceptance of telemedicine technology (Chau & Hu, 2001; Chismar & Wiley, 2002). The perceived ease of use can only be found in one factor named in the interviews and is not thought to be important.

This construct is also expected to have no significant effect on the attitude of behavioral intention (Chau & Hu, 2001). In this aspect the results and the literature line up.

From the last two boxes in the created model no factors are referred to in the interviews. That is a logical consequence of the phase in which the project is now. These last two boxes are part of the implementation and use of the innovation. Those phases are not yet attained.
Nevertheless, it is possible to make a cautious prediction about the behavioral intention, based on the two factors influencing it: perceived usefulness and perceived ease of use. The behavioral intention was split up in two elements. The normative belief of a health professional is expected to be hardly amendable. The attitude is easier to amend. Additionally the attitude of the respondents was already modestly positive. So if the expected relative advantages and other factors of the perceived usefulness are carried out the behavioral intention is expected to be positive concerning the implementation of the home-based device. Hopefully this will also result in wide actual usage.

In figure 13 on the next page the factors listed above are placed in the new created model to supply a clear overview of which factors are part of which element of the created model.
The factors extracted from the interviews are in italics. The factors that are the same as the 'theory-version' of the figure are not in italics.

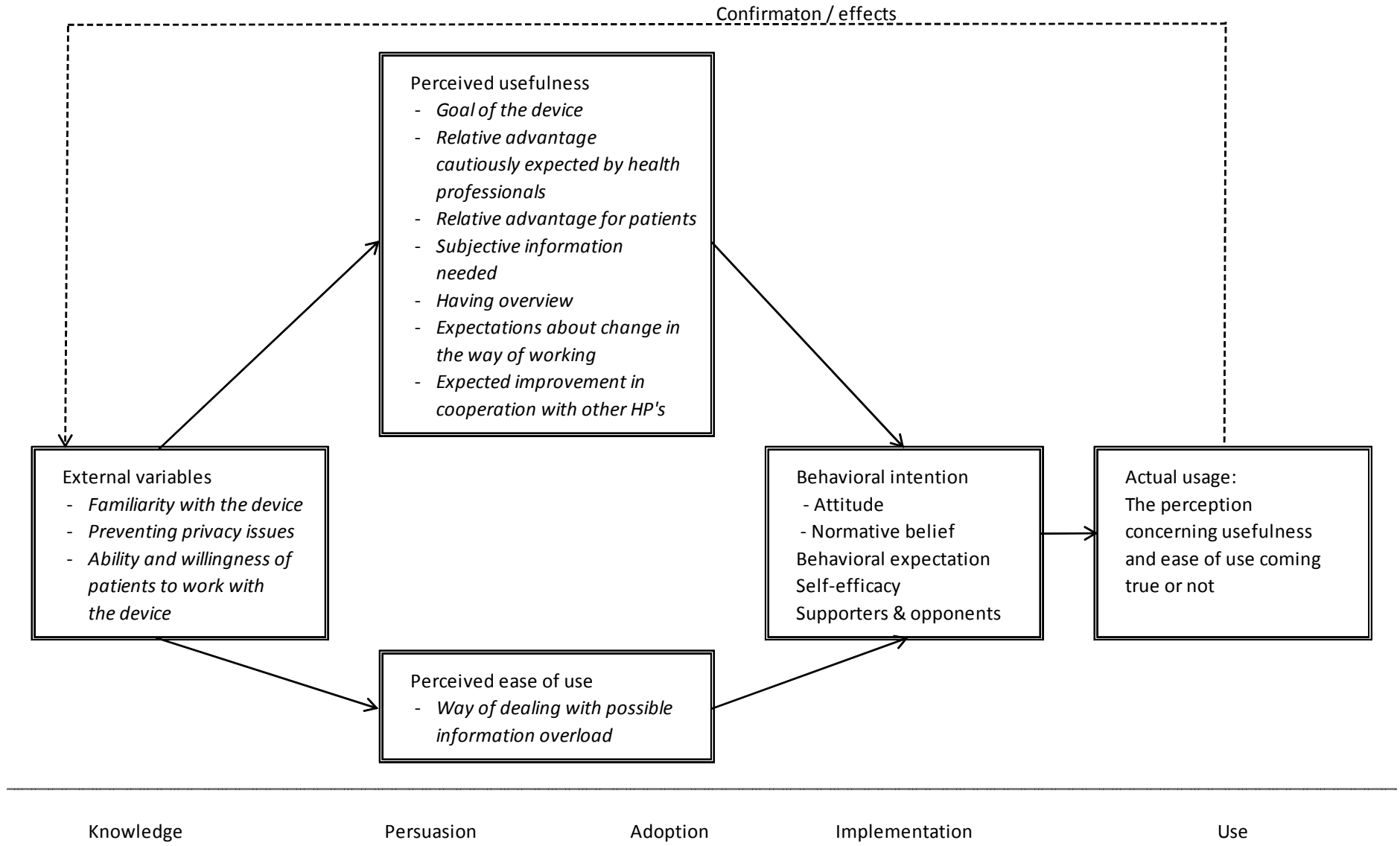

Figure 13: the results in the model of combined theories

5.3 Results reflected on business modeling

In order to be able to make recommendations concerning the business model of the COPD.com project, the results from the interviews will be reflected on the theory described in paragraph 1.5 about business models.

The majority of the information, from the answers given by the health professionals, is part of the service design or the technology domain. This is a logical consequence of the high number of answers that can be categorized in relative advantage. These are part of the service domain because these are the added value the new service offers in comparison with the 'old situation'. These relative advantages can also be part of the technical design because they are wanted technical specifications from the health professionals to be included in the system.
The organization design and finance design are underrepresented.

6. Conclusions, discussion and recommendations

This chapter will give a synopsis of the conclusions that can be drawn from this study. First the research questions will be answered. Subsequently the conclusions will be discussed. Based on the conclusions and the discussion recommendations will be given.

6.1 Conclusions and discussion

From the interview results and its analysis the answers to the research (sub-)questions can be derived:

1. *According to the health professionals, what subjective information should be included in the device, serving what purpose?*
   The information that should be included is the information about how the patient experiences his or her disease. Several factors are included:
   - shortness of breath (which can be displayed by the MRC score);
   - limitations the patient experiences in daily life;
   - coughing;
   - the extent to which the patient can move/exercise;
   - smoking habits;
   - co morbidity;
   - exacerbations;
   - medication use.

   The purpose the device serves is to give the health professional a complete view on how the patient is doing, how he feels he is doing and consequently being able to provide health care adjusted to the personal needs of the individual patient.

2. *Which health care professionals are interested in which information (within the diary function) during the patients' consultation?*
   The health professionals are interested in the information named in the first research question.
   All specialists are interested in exacerbations and medication use.
   Physiotherapists are mainly interested in (the limitations in) activity and shortness of breath.
   Pulmonologists and the nurse practitioner are mainly interested in the overview of how the patient has been doing in the period of time that they didn't see the patient.

3. *How often and in what way do the healthcare professionals want to provide feedback to the COPD patient or intervene?*
   In general the health professionals thought there should either be an alarm function, or a "plan of action" should be given by the device (take prednisone or call pulmonologist for example) based on the patient's answers. So the feedback should be given by the device itself so that no physician has to be involved.

Relying on the answers to these research questions the following answer can be given to the main research question of this study:

- *How can the subjective information from the diary function of the home based device be utilized by health professionals in health care provision to COPD patients?*
  Most health professionals would use the information from the device as an extra tool: an overview/insight on the patient from the period between consults, also for a longer time period for example to make a comparison between the seasons. It should give them an overview in one glance (in the form of graphs or pie charts). With this information they can provide better and more efficient care, adjusted to the personal needs of the individual patient. Additionally the health professional can make the patient more conscious of his illness and he can advise on how to cope with it.

Next to the answers on the research questions some general conclusions can be drawn:

- The general view on the home-based device is moderately positive;
- The most important and the most often mentioned advantage of the information from the home-based device is an overview and insight on the patients' health status. This is referred to in the first expectations as well as in the expected advantages. Therefore the overview and insight are important from the respondents' point of view;
- The information the health professionals need must give a complete view on how the patient is doing and how he feels about that (subjective information). This information should be included in the overview, for the overview to be relevant;
- The information should be displayed in a graph or pie chart, because in that way it gives a clear view in one glance. The information should be objectified: presented in numbers in order to be suitable to be presented in a graph or pie chart;
- An action plan for the patient was identified as the most suitable solution to the possible problem of information overflow;
- The privacy issue is expected to be solved in the development of the system, because it has also been done with other information systems containing personal information, like an electronic medical record;
- The most critical barrier and a frequently expressed worry is that the patients should be able and be motivated to fill in the device every day. Without the input from the patient the expected advantages will not be achieved. Therefore working with the device should be made as easy and amusing as possible in order to keep the patients interested in the device. With this in mind a user-friendly interface with application of persuasive technologies is already being developed. It could also be sensible to only have the instable patients work with the device. For the patients whit a stable state it can be terribly boring to fill in the same thing every day. The possibility of using it temporarily should also be kept in mind;
- To make the overview even more relevant and useful objective data should be included as well. Together with the subjective information it should give a complete and integral picture on the health status of a patient.

6.2 Recommendations

From the conclusions above the following recommendations can be derived. They are divided in three categories: the device, the target group and cooperation. Then, under the heading 'priority' the importance of the recommendations is discussed.

The device

The first recommendation has to do with the goal of the home based device. The health professionals said that their opinion about the device depends on the goal. However the goal was not known. Therefore communication of the goal is recommended. This can be done in sessions combined with the next recommendation.

The second recommendation is to show the involved health professionals what the home based device is exactly, what they can do with the information from the device, what advantages it gives them. According to the literature information sessions on advantages are more important than explaining detailed procedures (Chau & Hu, 2002). In this case the overview is the most important advantage. It is also wise to include the overview-function in the application, because it is referred to very often by the respondents and they consider it to be important and helpful.

Additionally it is advisable to develop a long-term plan for the post-pilot stages (Cho et al, 2008). In order to make it more than just a successful pilot these plans can help to find parties interested in commercializing and distributing it, as stated in paragraph 1.5 about the business model. Most rational would be to search for a company that produces electronic equipment, preferably also equipment for the medical sector. More research is needed to establish the best way to exploit a telehealth device.

These recommendations concerning the device are part of the technology domain in the STOF business model.

The target group

It is advised to evaluate the definition of the target group of the project. In the current project specification the target group is stated to be CODP patients with GOLD status II and III. The health professionals considered to be the most important are the pulmonologist, the physiotherapist and the nurse practitioner. There is a contradiction: most GOLD II status patients go to their general practitioner and not to the pulmonologist when there is a worsening in their health. The device is not intended to be used by patients who only see their general practitioner. The advice is to either include the general practitioner, or to exclude COPD patients with GOLD status II.
Additionally it does not seem realistic to provide every COPD patient who comes to the consult of the pulmonologist with a device. As stated in the results and conclusions several potential problems exist in having people of over 40, generally with a low socio economic status fill in a questionnaire on a computer-like device. Therefore it is advised to narrow the target group.

The target group is part of the services design in the business modeling context and therefore these recommendations can be placed in the services domain.

Cooperation

Further research is recommended on the possibilities of improving the communication and cooperation between the pulmonologists and the general practitioners. Improvement in the cooperation cannot be achieved through the device because the patients of the pulmonologists are part of the target group of the COPD.com project and the patients of the general practitioner are not. It would be rational to outline the current situation and how the health professionals would like it to be (best case scenario). Based on those results an action plan can be made and executed.

The configuration of involved actors is an element of the organization design in the STOF model. Consequently this recommendation can be positioned in this organization domain.

Priority

From the above mentioned recommendations the definition of the target group is essential for the further development of the COPD.com project and therefore this recommendation is most important for the course of the project. It is inconsistent and consequently it is necessary to change it. The change in the target group will most likely influence the goal as well. Changing the goal could result in completely useless results of already executed test or studies within the project. To minimize the disadvantage of having useless results, it is of great interest to reassess the target group definition as soon as possible.

From the point of view of this study the most important recommendation is to include an overview function in the application for the health professionals. It was referred to very often by the physicians. It was considered an important element of the functionalities of the device that they had in mind. Additionally it would be very useful to them (relative advantage), because they named the overview-function in the first expectations as well as the anticipated advantages.

6.3 Limitations

In addition to the possible business modeling issues, a possible limitation of this study is found in the literature: “the limited penetration of telemedicine technology in most of the surveyed hospitals could make it difficult for physicians to anticipate potential barriers for facilitating conditions to its utilization” (Gagnon et al, 2003, p.111). This can also be applied here. When more experience is present it is easier to anticipate possible problems. The execution of the COPE II study might decrease this limitation. However the absence of experience with electronic telehealth could still cause potential barriers to stay unidentified.

A second limitation from this study is the possibility of a low external validity. It is questionable if the results of this study can be applied to other regions for example. The execution of the different studies in the MST hospital (for example the COPE II study), might have changed the attitude and knowledge of the health professionals and the COPD patients.

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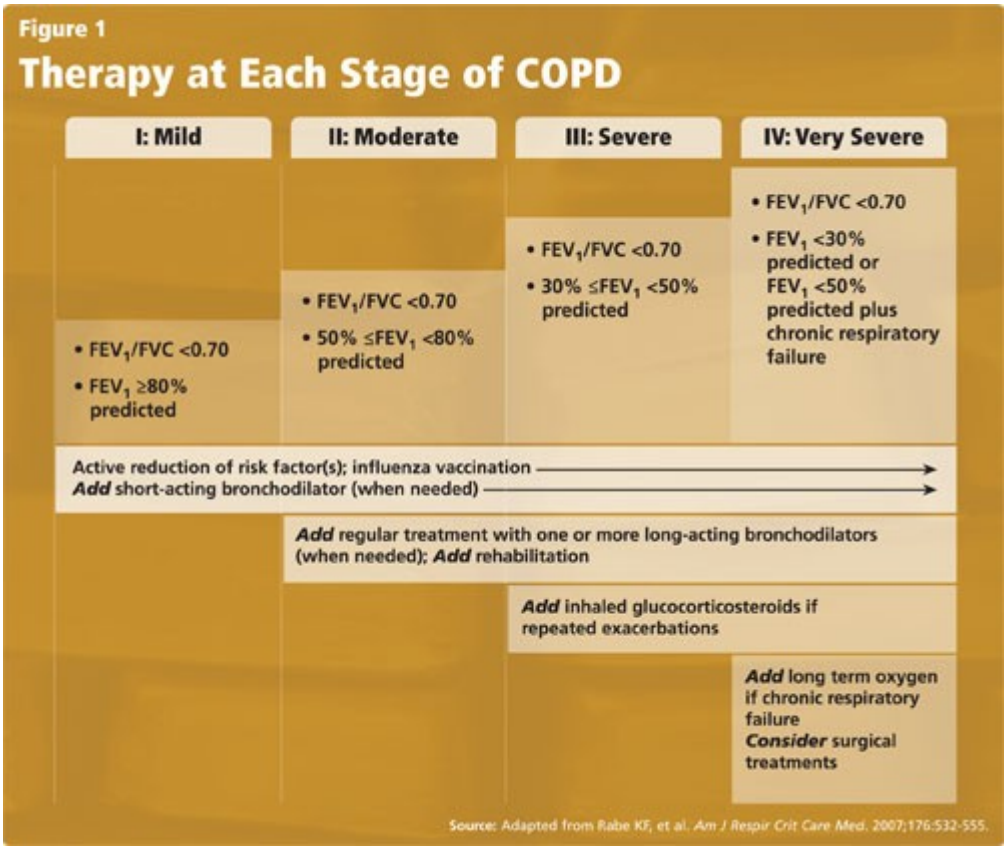
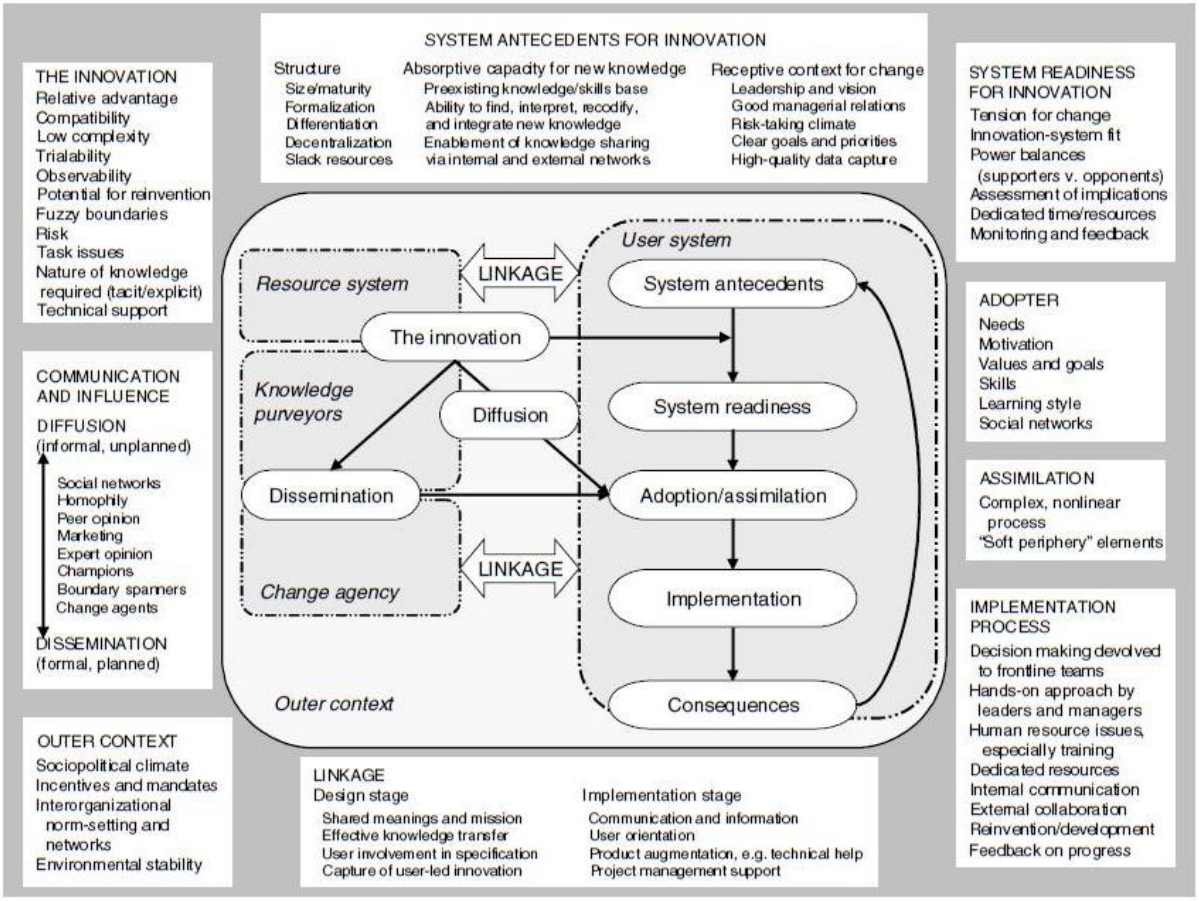
Appendixes

Appendix 1: GOLD stages of COPD with matching treatments.



Physicians Weekly (2007)

Appendix 2: Greenhalgh's model



"Conceptual model for considering the determinants of diffusion, dissemination, and implementation of innovations in health service delivery and organization, based on a systematic review of empirical research studies" by Greenhalgh (2004).

Appendix 3: The elements of the transformation from Gustafson's model to a flowchart.

- Tension for change
  - tension for change;
- Exploration of the problem and understanding customer needs
  - exploration of the problem and understanding customer needs;
- Source, funding and mandate
  - source of ideas;
  - funding;
  - mandate/project launch;
- Design of the innovation
  - flexibility of the design;
  - radicalness of the design;
  - evidence of effectiveness;
- Staff
  - staff needs assessment, involvement, and support;
  - relative advantages;
  - staff changes required;
  - supporters and opponents;
- Influence
  - change agent prestige and commitment;
  - middle manager goals, involvement, and support;
  - leader goals, involvement, and support;
- Preparation and implementation
  - work environment;
  - complexity of implementation plan;
- Monitoring and feedback.
  - monitoring and feedback.

1. Tension for change

The first thing to occur in a change process is 'tension for change', which is the existence of dissatisfaction among the employees about the current state of affairs (Gustafson, 2003). This is a logical first step in the process to invent a solution to the 'problem' causing the dissatisfaction. In some cases, innovative people will come up with a solution that is just a better procedure for a certain action. In those cases, the tension for change is left out.

2. Exploration of the problem and customer needs

This encompasses analyzing the organizational circumstances, the problem (which caused the tension for change), and the needs in order to come up with the right solution for the right problem.

3. Source, funding and mandate

The third step encompasses source of ideas, funding and mandate. Gustafson (2003) states that the best ideas for change come from outside the organization. A successful change needs sufficient 'funding': money, time and manpower. This should be determined at the start of the project. A communicated mandate is an important success factor for the change process (Gustafson, 2003). The responsible person is appointed at the start of the project. These three steps are similar to the first phase in the enterprise system experience cycle by Markus & Tanis (1999) called the chartering phase. This stage encompasses: building a business case, identifying a project manager, approving a budget and a schedule. From the results of these actions the decision is made whether to proceed or not (Markus & Tanis, 1999).

4. Design of the innovation

Following the previous step the design of the change can be established. In the design the following factors are important:

- The flexibility of the design: the possibility to adjust the application to the current culture and practices of the organization. This is also brought up by Markus & Tanis (1999) as an important factor in the adoption decision.
- The radicalness of the design: covering the extent to which the change is threatening to or incompatible with the current conditions. If a reasonable amount of adjustment is desired, the change is more likely to be accepted and adopted (Gustafson, 2003).
- The evidence of effectiveness: A trail can be used to show that the change is effective. After that it is more likely to be implemented.

According to Thielscher & Doarn (2008) the design of a telemedicine system is utterly important, because a poorly designed technique may worsen the patient's condition or treatment.

5. Staff

The design of the change is also influenced by factors concerning the staff (Gustafson, 2003):

- 'Staff needs assessment, involvement and support': the personnel is more likely to co-operate and support a change if they will benefit. Therefore needs of the staff should be identified and the plan of action should prove that the change is in the best interest of the employees.
- 'Relative advantages': Employees preferring the new situation in comparison to the old situation are more likely to co-operate in the change process.
- 'Staff changes required': refers to the degree of complexity of the skills required from the affected employees. The chance of resistance is lower if the amount of new skills is low and level of complexity fits available skills.
- Supporters and opponents are always present in the process. An employee is more likely to support the change, if more relevant fellow workers also support the change.

6. Influence

The generic term 'influence' is used for change agent prestige, commitment and customer focus; middle manager goals, involvement and support; and leader goals, involvement and support.

- Change agent prestige, commitment and customer focus: Emphasizing the presence of the change agent who creates intelligibility before, during, and after the change process. He should have a positive attitude and as much knowledge about the change process as possible focusing on participants commitment and holding customer focus.
- Middle manager and leader goals, involvement and support: middle managers as well as leaders are more likely to support if they are involved and their goals can be identified in the change.

In comparison with the enterprise system experience cycle by Markus & Tanis (1999) design of the innovation, staff and influence (the three aforementioned categories) are part of the project phase. In the project phase activities are executed to get the new system up and running. Problems and errors might occur.

7. Preparation and implementation

Influenced by the 'staff-factors' as well as the 'influence-factors' are:

- The 'work environment': the preparation of the organization and its staff for the upcoming change. Dropping a change into a firm with no adaptations in advance will definitely decrease the chance of success.
- 'Complexity of the implementation plan': often changes are unnecessarily complex. Simplicity and intelligibility about tasks and planning will ease the implementation of the plan for everyone involved.

These preparation and implementation factors can also be placed in the enterprise system experience cycle, in the shakedown phase. In this phase activities are mostly about optimizing the system: fine-tuning and fixing inefficiencies. The shakedown phase is said to be ended when 'normal operations' have been achieved (Markus & Tanis, 1999).

8. Monitoring and feedback

The last factor which is part of the organizational change manager is ‘monitoring and feedback’. It is not possible to arrange this factor into the timeline. It includes the measuring and tracking of the change and employee feedback throughout the whole change process. Therefore it is not reproducible in the timeline.

Now all the categories from Gustafson’s model are assigned to one of the phases in the Markus & Tanis cycle. The onward and upward phase of their model is still ‘abundant’. During this phase the system is in operation until it is upgraded or replaced by a new system (Markus & Tanis, 1999). The reason for the absence of this phase in Gustafson’s model is considered to be the following. In his organizational change model Gustafston focuses on the change process. Originally it is not a timeline and the created flowchart does not include iteration. Therefore reinvention, upgrading and replacement are not included in Gustafson’s model.

Appendix 4: The final list of questions used for the interviews

Have you heard anything about the home-based device already?

What do you know about the home-based device? (do you know what it encompasses?)

What is your opinion about it? (What is your opinion on the initiative? What view do you have about it? Positive or negative?)

How did earlier implementations of information systems go? Are systems chosen by the health professionals? Did you experience difficulties in working with the system? Did all health professionals have the same opinion?

What are your expectations concerning the home-based device? (What do you expect to be able to do with it?)

If you would have the disposal of the device, how would you work with it? (What would you use it for? For what parts of the process of health care provision?)

What does your contact with the COPD patient look like?

What (subjective) information do you need in the process of providing health care?

In what way would you use the subjective patient information? How would it change your way of working? (What benefits will it yield for you?)

This will have loads of remote subjective patient information as a result. How do you think it should be handled? (Presentation of the data, providing feedback to the patient?)

Are there aspects of the device that you are less enthusiastic about, or that you worry about? Which? (Comparing with the implementation of another information system: EMR for example)

What is in your opinion the biggest advantage of the implementation of the device:

- in provision of health care?
- in the cooperation with other health professionals?

(Quicker, easier, more efficient, more effective, better, relation with the patient, providing feedback)

What is the contribution of the subjective information in these improvements/advantages:

- in provision of health care?
- in the cooperation with other health professionals?

Do you think something important/relevant was left undiscussed during this interview?

Appendix 5: The MRC score

The first table is the original list of the MRC score in Dutch. For the completeness, an English translation is made and added below.

Bent u wel eens kortademig? En zo ja, welke van de onderstaande uitspraken is voor u het meest van toepassing	
❍ Ik heb geen last van kortademigheid	0
❍ Ik word alleen kortademig bij zware inspanning	1
❍ Ik word alleen kortademig als ik me moet haasten op vlak terrein of tegen een lichte helling oploop	2
❍ Door mijn kortademigheid loop ik op vlak terrein langzamer dan andere mensen van mijn leeftijd, of moet ik stoppen om op adem te komen als ik mijn eigen tempo loop	3
❍ Na ongeveer 100 meter lopen op vlak terrein moet ik na een paar minuten stoppen om op adem te komen	4
❍ Ik ben te kortademig om het huis uit te gaan, of ik ben kortademig tijdens het aan- of uitkleden	5

Are you ever short of breath? If yes, which of the statements below is most applicable to you?		
o	I am not short of breath	0
o	I am only short of breath when I make great efforts	1
o	I am only short of breath when I have to hurry on flat surface or when I walk on a slightly ascending slope	2
o	Because of my shortness of breath I walk slower on flat surface then people of my own age, or I have to stop to catch my breath when I walk in my own pace	3
o	After walking 100 meters on flat surface I have to stop a few minutes to catch my breath	4
o	I am too short of breath to leave the house, or I am short of breath while I get dressed/undressed	5