Patient generated health data and its effects on user experience in digital healthcare

Linn Norberg and Linus Emme

DIVISION OF PRODUCT DEVELOPMENT | DEPARTMENT OF DESIGN SCIENCES
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Supervisor: Johanna Persson
Co-supervisor: Daniel Fridgren
Examiner: Mattias Wallergård

Abstract

By the year of 2025, Sweden aims to be the best country in the world at using the opportunities offered by digitalization in healthcare. One way to digitalize healthcare is through the use of connected health devices and patient generated health data. So far, most research regarding patient generated health data in healthcare have been focusing on applications concerning chronically ill people, where research agrees upon the great benefits. However, the applications and benefits in primary healthcare is less investigated.

From a user experience perspective, this Master Thesis explored the relevance and applicability with patient generated health data for one of the two biggest digital primary healthcare providers in Sweden. The main focus was to present possible application areas, design a user experience and detect user benefits of including patient generated health data at digital health centres.

To understand the future of connected health and user needs, a literature review and multiple user interviews were conducted. The gained insights were converted into storyboards with user interfaces and tested through low fidelity prototypes in order to design a user experience concept.

The Master Thesis implied that patient generated health data could bring great potential to digital health centres. In the near future, the most relevant and applicable approach is through self-diagnostics, momentary snapshots of state of health and monitored awaiting and treatment processes. In regard to the user experience of digital health services, patient generated health data might result in more engaged patients and move the focus from doctors to patients. Furthermore, digital healthcare services might be perceived as more trustworthy and qualitative when including health data.

Keywords: Digital healthcare, doctor, patient, health data, connected medical devices, user experience design

Sammanfattning

År 2025 har Sverige som mål att vara det bästa landet i världen på att utnyttja möjligheterna med digitalisering av vården. Ett sätt att digitalisera sjukvården är genom användningen av uppkopplade hälsoenheter och patient-insamlad hälsodata. Än så länge har forskningen fokuserat på användningsområden för kroniker, och där är man eniga i de stora fördelarna. Däremot är användningsområden och fördelar för primärvården är mindre utforskat.

Med användarupplevelsen i fokus har detta examensarbete utforskat relevansen och applicerbarheten av patient-insamlad hälsodata för en av de största digitala primärvårdscentralerna i Sverige. Syftet var att presentera användningsområden, designa en användarupplevelse och fastslå fördelar med att inkludera patient-insamlad hälsodata hos digitala vårdcentraler.

För att förstå framtidens uppkopplade sjukvård och användarbehov utfördes en litteraturstudie och flertalet användarintervjuer. De erhållna insikterna omvandlades till storyboards med användargränssnitt som testades genom enkla prototyper. På så sätt designades ett koncept med en ny användarupplevelse.

Examensarbetet visade att patient-insamlad hälsodata har stor potential för digitala vårdcentraler. I en nära framtid är egenvård, ögonblicksbilder av hälsotillstånd och monitorerad exspektans och behandling några av de mest relevanta och applicerbara användningsområdena. Angående användarupplevelsen för digitala vårdcentraler så kan patient-insamlad hälsodata leda till mer engagerade patienter samt förflytta fokus från läkaren till patienten. Digitala vårdcentraler kan också komma att uppfattas som mer pålitliga och kvalitativa än vad de gör idag.

Nyckelord: Digital vårdcentral, läkare, patient, hälsodata, uppkopplade hälsoenheter, Design av användarupplevelse

Preface

This report is a result of a Master Thesis in Mechanical Engineering with industrial design. The thesis has been conducted at the division of product development at the faculty of engineering at Lund University and in cooperation with a digital healthcare centre.

We would like to thank our supervisor Johanna Persson from Lund University and our co-supervisors Daniel Fridgren at the digital health centre for all the guidance and support.

During the project, several employees at the digital health centre have contributed with their expertise and support. A special thanks to Catherine Descure, Henrik Kangroo and Magnus Nyhlén for their expertise in user research and medical knowledge. We would also like to thank all users supporting us with comments and thoughts during interviews and testing of the prototype.

Lund, June 2017

Linn Norberg and Linus Emme

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1 Introduction

This chapter presents an introduction to the area to be examined, as well as the purpose and restrictions of the project.

Consumer interest in connected health devices and collected data has grown considerably in recent years as more and more gadgets are released (Accenture Federal Service, 2016). An overview of how connected health devices can be used in healthcare are shown in Figure 1.1. Main focus has been on fitness and wellness as companies like Apple, Fitbit and Withings produce devices measuring heart rate, steps, weight, sleep, calories and more.

The current market of wearables and medical devices is big, 120 million units, and have a high growth-rate. Forecasts predict over 400 million units will be shipped by 2020, worth over 30 billion dollars (Lampkin, 2016) which is two times more than in 2016.

Figure 1.1 An illustration of connected health devices in healthcare.

To demonstrate the progress of connected health devices, Gonzalo Tudela, CEO & Co-Founder of Vandrico, has used a so-called Gartner Hype Cycle (Tudela, 2014), see Figure 1.2. As shown, most devices are placed quite early in concern to maturity meaning that they are facing lots of publicity and success stories, but also failures and decreased interest. However, next up in the progress is when more clear benefits of connected health devices arise and second- and third-generation products are launched. During a Ted Talk, Tudela claimed that "What we see is that there is a new rise of new sensors that are going to create medically relevant sensor data." (Tudela, 2014). This is in line with predictions saying that "From ECG to blood pressure and lab markers, everything will be simple and will take place unnoticed." (Mesko D. B., Healthcare Is Coming Home With Sensors And Algorithms, 2017). The question is, do this technology have any comprehensive relevance and could it be used on a greater scale?

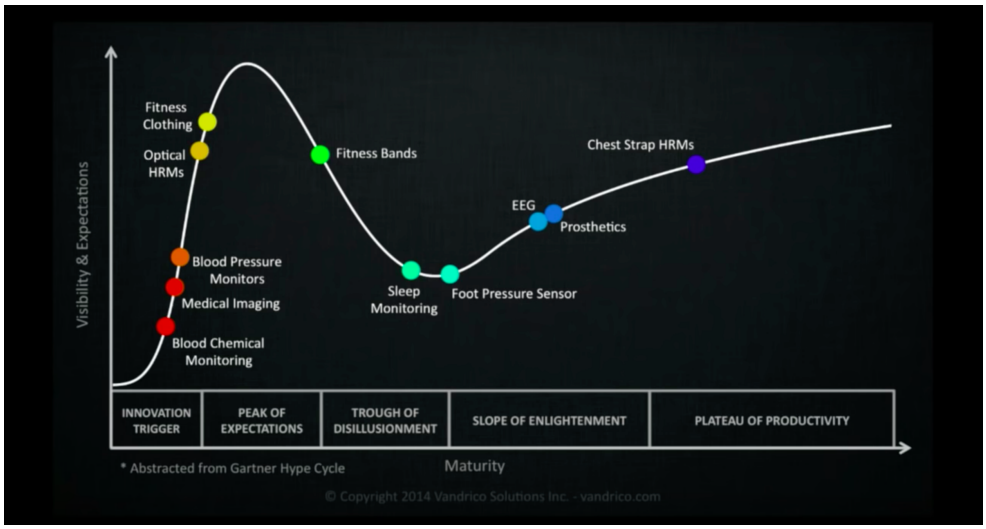


Figure 1.2 The Gartner Hype Cycle containing connected health devices.

1.1 Digitalization of Swedish Healthcare

Swedish healthcare struggles with increasing costs due to an ageing population and a larger number of patients with illnesses that require difficult and demanding treatments. To solve this, Swedish health care needs to go through some big changes. An extensive report by McKinsey from 2016 claims that one way is through a systematic implementation of digital technologies, see Figure 1.3 and Figure 1.4. Furthermore, the report states that through digitalization, Swedish health

care can decrease its costs with up to 25 % during a period of ten years, which would save up to 180 billion SEK until year 2025, see Figure 1.3. (McKinsey, 2016)

Besides cost reductions, a digitalization of healthcare could also mean a relieve for hospitals and healthcare centres as well as more effective care processes, avoided mistreatments and shorter queues. In fact, the McKinsey report claims that the digitalization could reduce the number of physical visits in the primary healthcare by half. However, the healthcare sector is known for slow and cumbersome transformations as well as low adoption to new technologies. (McKinsey, 2016)

Nevertheless, the vision of Swedish eHealth is that by 2025, Sweden aims to be the best country in the world at using the opportunities offered by digitalization and eHealth in both health and welfare (eHälsomyndigheten, 2016). According to World Health Organization, "eHealth is the use of information and communication technologies for health." (World Health Organization, 2016). eHealth may include digital services such as virtual doctor visits, disease tracking and rehabilitation as well as electronic journals, prescriptions and patient's health information.

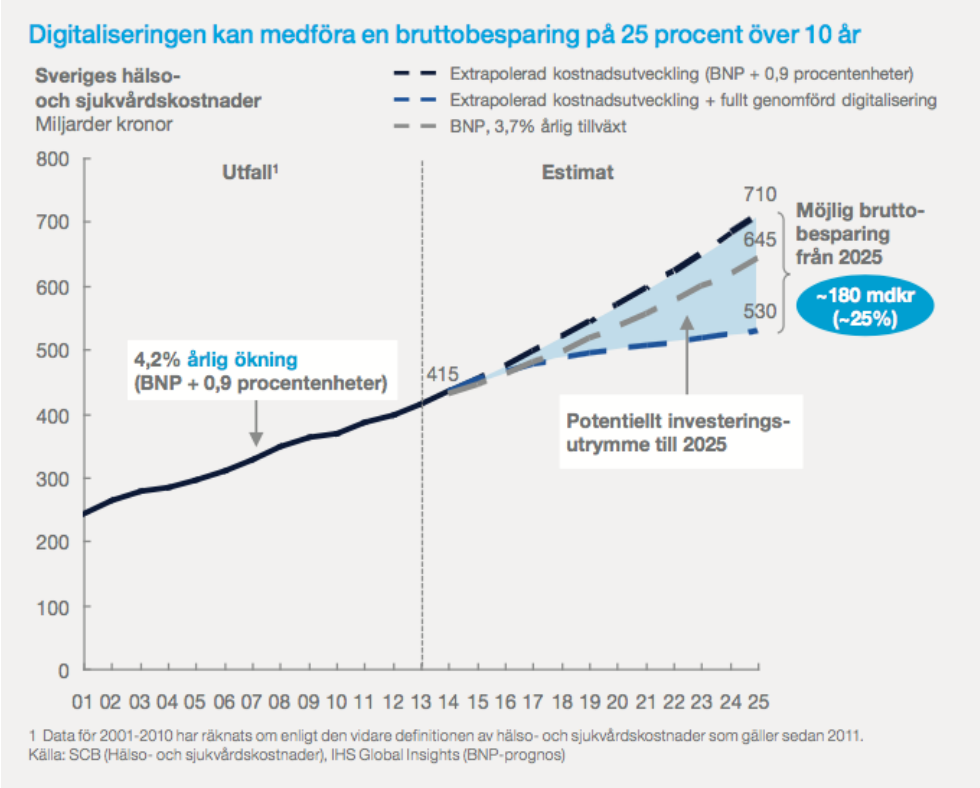


Figure 1.3 Estimated cost reductions of 180 billion SEK until year 2025 due to a digitalization of Swedish healthcare.

Figure 1.4 14 potential areas within the healthcare industry where an implementation of digital technologies could bring great cost reductions.

1.2 Patient Generated Health Data

One way to digitalize Swedish healthcare is through the use of connected health devices and patient generated health data (PGHD). PGHD is health-related data created or gathered by patients through connected health devices to help address health concerns (Accenture Federal Service, 2016). The data may include health and treatment history, biometric data, symptoms, lifestyle choices and more. In difference from data collected in a clinical setting, the patient is responsible for capturing the PGHD and deciding how and to whom to share it with.

A report from Accenture clearly states that the use of PGHD will increase (Accenture Federal Service, 2016). In fact, see Figure 1.5 states that by the year of 2023, a broad market of people will adopt the technology by capturing and sharing data. This is acknowledged by various sources saying that "Everyone will measure

data about their health because it makes no sense not doing that." (Mesko D. B., Healthcare Is Coming Home With Sensors And Algorithms, 2017).

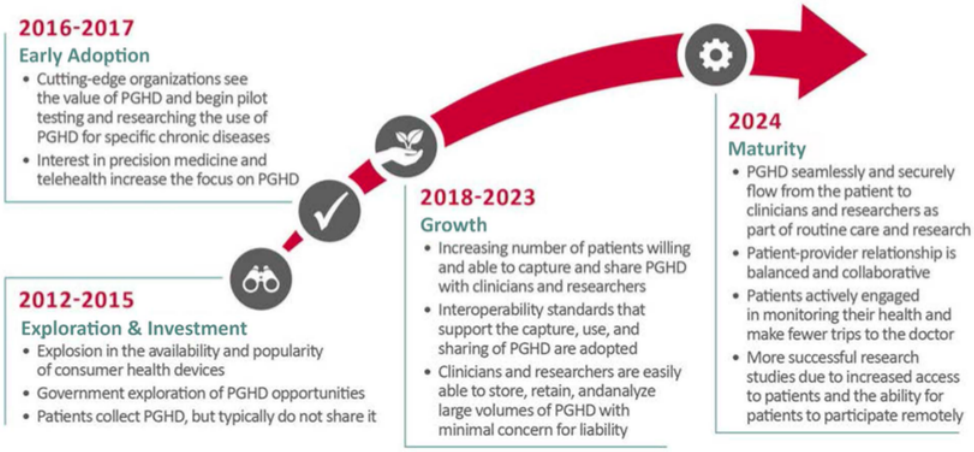


Figure 1.5 Predictions indicating that we are still in the early stages of using PGHD.

1.3 Project and purpose

This Master Thesis was carried through at one of the two biggest digital healthcare providers in Sweden, here referred to as *the digital health centre*.

As described in the sections above, forecasts imply that we are in the beginning of a revolution regarding usage of connected sensors in the healthcare industry. When a broad market of people adopts the technology and patients capture and share their PGHD, it will disrupt the way healthcare providers work. To not risk falling behind competitors, it is of high importance for the digital health centre to understand what PGHD could imply by analyzing the relevance and applicability for them and its users.

So far, most research regarding PGHD in healthcare have been focusing on applications concerning chronically ill people, where research agrees upon the great benefits. However, the digital health centre focuses on primary care patients and this field is less investigated.

This Master Thesis will investigate the potential of introducing PGHD at the digital health centre. The viewpoint is to study this through a user experience (UX) perspective. Therefore, the main focus has been to present possible application areas, design a user experience and detect user benefits of including PGHD at the

digital health centre. As a way to visually illustrate this, the Master Thesis presents a user scenario in the form of a storyboard with a few user interfaces (UI).

1.3.1 Research questions

This report will cover the following questions:

1. What are the overall opportunities with patient generated health data for a digital health centre?
2. In what ways may patient generated health data support the digital care work at a digital health centre?
3. How might patient generated health data affect the user experience of a digital health centre?
4. How might the type of health device affect the user experience?

1.3.2 Project limitations

As described in the introduction, the evolution of connected devices is rapid. Accordingly, new and better devices reach the market every single day. Since the technology alters, it is not of interest to explore specific devices. Rather, the focus has been on outlining various types of devices, both those currently on the market and those coming in a near future. Nevertheless, this report presents some specific technology as a way to lessen the abstractness and sharp the reasoning.

Since the viewpoint was user experience design, aspects regarding data privacy, data security, data storage and compatibility have not been explored to any further extent. By the same reason, neither have ethical aspects been in focus.

2 Method

During this Master Thesis, the main design methodology was Kumar's design innovation process, Figure 2.1. Furthermore, a mindset based on the Double Diamond model, Figure 2.2, and principles from Lean UX, Table 2.1, were used. An outline of the design process practiced in this Master Thesis is shown in section 2.1.2.

Motivation and ability are two central notions in user experience design (Nir, 2014). Motivation is about the desire to take a specific action while ability defines the effort and capacity to do so. Both notions are equally important when creating a service. However, developers within digital solutions sometimes argue that it is more cost- and time efficient to start focusing on ability and thereafter move on towards motivation. "This is important because increasing your user's ability to do something is far more within your control than boosting their internal motivation. " (Nir, 2014). Consequently, this project puts most focus on the ability to perform desired actions in the user experience concept.

2.1 Theory about design methodologies

2.1.1 Kumar's design innovation process

The overall phases of Kumar's process (Kumar, 2013), see Figure 2.1, are Research, Analysis, Synthesis and Realization. The main objective of the Research phase is to understand the context (technology, market, competitors etc.) and the people (users, needs, experiences etc.). In the Analysis phase, the extracted research is turned into insights and opportunity areas are defined. The next phase, Synthesis, is about converting the insights into tangible ideas. The final phase, Realization, is when the idea is implemented and delivered. The arrows in the figure illustrate that the process could be iterative.

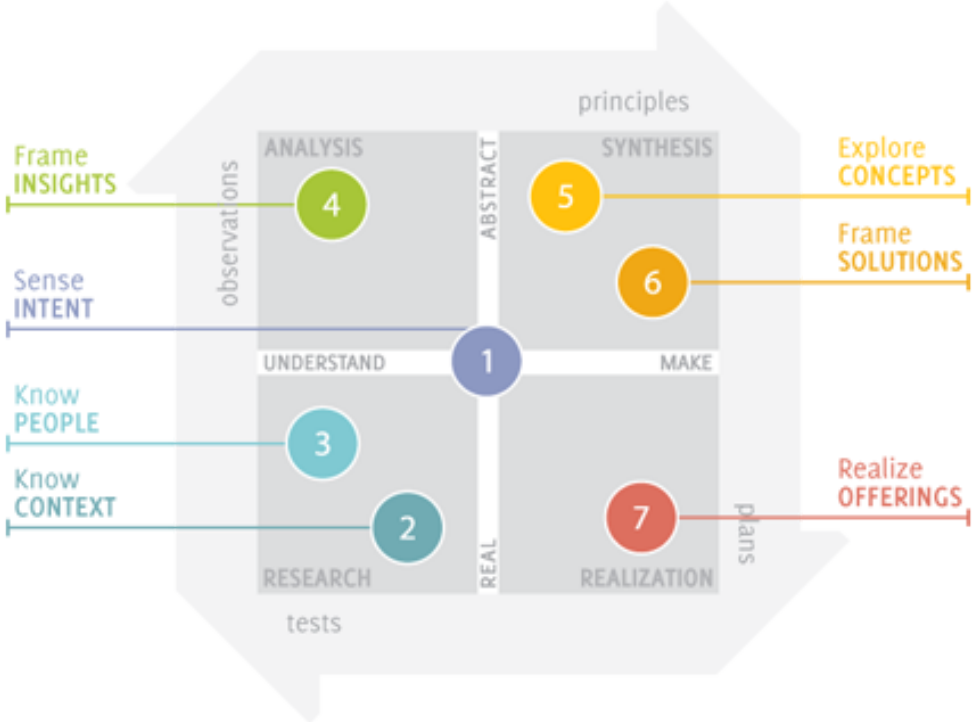


Figure 2.1 Overview of Kumar's design innovation process.

2.1.2 Double Diamond model

The Double Diamond model illustrates a design thinking method where divergent and convergent thinking are applied to various phases throughout a design process (Design Council, 2005), see Figure 2.2. Divergent thinking implies a wide thinking in various directions, while convergent thinking is about narrowing it down to one matter.

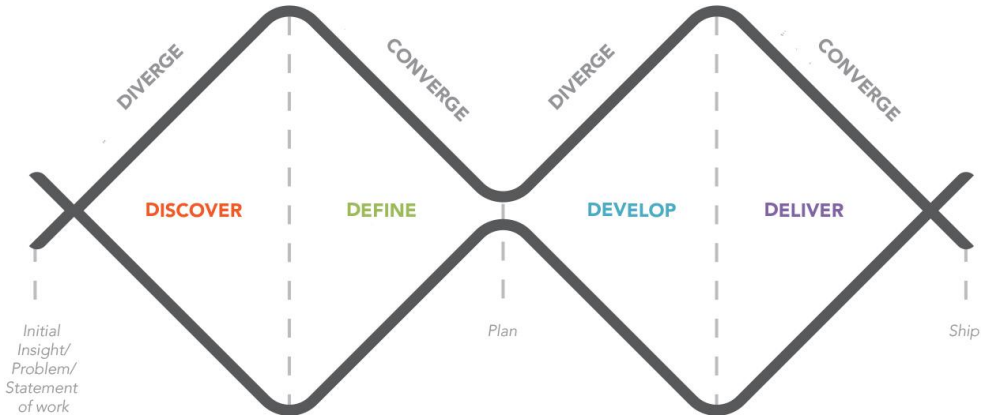


Figure 2.2 The Double Diamond model

2.1.3 Lean UX Principles

A selection of design principles from Lean UX (Seiden, 2013), are described in Table 2.1.

Table 2.1 Lean UX principles

Continuous Discovery	The ongoing process of engaging the customer during the design and development process. Regular customer conversations provide frequent opportunities for validating new product ideas.
Getting out of the building	The realization that meeting-room debates about user needs won't be settled conclusively within your office. Instead, the answers lie out in the marketplace, outside of your building.
Permission to fail	Breeds a culture of experimentation. Experimentation leads to creativity, that in turn, yields innovative solutions.
Externalizing Your Work	Gets ideas out of teammates' heads and onto the wall, allowing everyone to see where the team stands.

2.2 Design process practiced in this Master Thesis

The project team used the main methodology from Kumar's design innovation process and applied the divergent and convergent thinking from the Double Diamond model. Figure 2.3 describes an outline of the project team's design process.

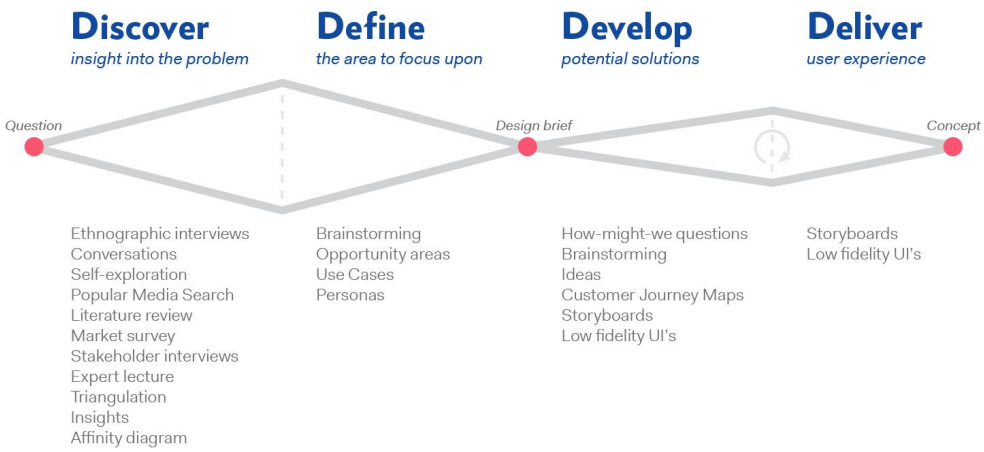


Figure 2.3 Design process practiced in this Master Thesis.

The four stages (Discover, Define, Develop and Deliver) refer to the four phases of Kumar's design innovation process. Each phase took about the same time to go through, however, it is important to point out that they were iterative and overlapping. The main takeaway from the Double Diamond model was to apply divergent and convergent thinking to the design process. As the model indicates, this happened twice. Figure 2.3 lists a high number of methods used throughout the project. Moreover, were the Lean UX principles considered throughout the project. More information about the methods are found in the beginning of each chapter.

2.2.1 Discover

During the Discover phase, the project team collected information that later was built on to answer all four research questions. The aim was to understand the context and the users. Context covered technology, digital healthcare, health data, market, competitors, complementors, trends etc. Understanding the users was about user group, user needs, user behavior, user experience of current service etc. As seen in Figure 2.3, this was a divergent phase where a huge amount of information was gathered. Several methods were used and the most extensive ones were user interviews, popular media search and literature review. The extracted research, both context and user, were turned into actionable insights that later were sorted using

affinity diagrams. The Discover phase is mainly covered in chapter *3 Discover*, divided into *Context research* and *User research and insights*.

2.2.2 Define

The Define phase was about narrowing down to one area to focus upon. The most intriguing insights were converted into a high number of opportunity areas through a couple of brainstorming sessions. The presented opportunity areas describe benefits with patient generated health data for various stakeholders and how the data may support the digital care work. Accordingly, the first two research questions were processed in this phase. The opportunity areas were evaluated, combined and refined until only one area remained. The focus area was further defined through personas and use cases. The Define phase is presented in chapter *4 Define*, divided into *Opportunity areas* and *Focus area*.

2.2.3 Develop

In the Develop phase, the project team turned the quite abstract focus area into numerous tangible ideas. Based on the use case created during the Define phase, several how-might-we questions were established and brainstormed upon. This led to a high number of concepts translated into customer journey maps. Three main iterations took place, where every iteration improved the concept by constantly refining and evaluating it. The two first iterations are covered in the Develop phase while the last iteration is included in the Deliver phase. The Develop phase is presented in chapter *5 Develop*.

2.2.4 Deliver

The Deliver phase aimed to narrow down to one final concept. The project team did this through the use of storyboards and low fidelity UI's. The final concept is presented through a storyboard focusing on user experience, thus covering the third and fourth research questions. The Deliver phase is found in chapter *6 Deliver*.

Furthermore, all four research questions are summed up, by discussing and repeating the most important takeaways for each question, in chapter *8 Conclusion*.

3 Discover

The Discover phase was about getting insights into the problem and understanding the context and the users to answer all four research questions. Context covered technology, digital health care, health data, market, competitors, complementors, trends etc. Users referred to user group, user needs, user behavior, user experience of current service etc.

3.1 Methods

3.1.1 User interviews

A user interview is a qualitative research method where both observations and one-to-one questions are included (Arvola, 2016). Worth to notice is that in this Master Thesis, *users* refer to three separate user groups; doctors working at the digital health centre, patients using the digital health centre and early adopters of wearables and various tracking devices.

The project team held eleven user interviews. An overview of the interviewed people is seen in the list below. Among the interviewees, two were female and eight were men. The ages varied from 33 to 67 years and they all lived in Skåne.
Interviewees

- Five patients (called P1-P5)
    - Using various kinds of connected health devices (Fitbit, Apple Watch, Jawbone, S Health etc.)
    - Had used the digital health centre service within 6 months
    - Had indicated themselves as available for user research
    - Recruited by convenience sampling (Kristensson, 2014)
- Three quantified Selfers (called E1-E3)
    - People who continuously track as much as they can about themselves. Food intake, state, performance, position etc.
    - Using wearables and various tracking devices (Gyroscope, uBiome, Moves, Fitbit, Beddings etc.)
    - Recruited in a co-worker's acquaintance

- Three doctors (called D1-D3)
    - Working at the digital health centre
    - Open for changes in the healthcare system
    - Genuine technology interest
    - Hand-picked by the project team

All interviews were semi-structured with questions divided into eight subjects. An interview guide can be seen in appendix B. All interviews aimed at exploring user needs, behaviors and experiences. Therefore, they were focusing on specifics and things that had happened in the past, instead of hypothetical questions. Questions about the future often only lead to opinions or guesses, which would not contribute to any reliable insights (Fitzpatrick, 2013). In addition to talking, spontaneous demonstrations of the used devices were made, so that the project team could observe behaviors.

Audio recordings were used as a way to ease the compiling process. Thus, Non-disclosure Agreements were signed, see appendix C. Due to geographical reasons, two interviews were conducted over Skype. The rest were carried out in physical meetings in places where the participants felt relaxed. All interviews lasted for approximately one hour.

3.1.2 Conversations

A conversation is an informal interview characterized by talking about specifics in the past instead of generics, opinions or hypotheticals about the future (Fitzpatrick, 2013). To avoid compliments and approval seeking it is also important not to disclose the conversation purpose more than necessary. Instead, the focus should be on the individual's life and personal experiences.

In the beginning of the Discover phase, several conversations took place during field visits. The objective was to find opportunities and areas for further research. The project team went to places where they thought that people using wearables would be, like a student exhibition about interaction design at Lund University, several technology stores in Malmö and a gym in Lund.

For each conversation, a list of three important questions was defined. Every list included at least one question that potentially could risk the project team's ideas. Examples of questions are, in order of decreasing risk: What is motivating them to use it? What do you use it for? Do they analyze the data? By using questions like these, the bias effect may have been decreased resulting in valuable user insights.

3.1.3 Expert lecture

The project team attended Kirsten Ostherr's Medea lecture titled "Where is 'the Human' in Digital Health Technology?" at Malmö University Feb 21. The purpose of the attendant was to get a wide knowledge about the future of digital healthcare. Ostherr is the director of Medical Futures Lab at Rice University and her lecture covered the human experience of digital health technologies.

3.1.4 Literature review

Literature reviews summarize the studied field and include scholarly papers about current knowledge, theories and methodologies (Kumar, 2013). The objective of the literature review was to get familiarized with the subject and build a credible foundation. The literature review was quite wide and was based on defined topics of interest. For example, *connected health, eHealth, connected health device, wearables* etc.

Not much relevant research has been done within the investigated field, thus there are very little scholarly material published. Because of that, the literature review mainly consisted of so called grey literature such as news reports, company reports and academic journals.

3.1.5 Popular media search

Popular media searches cover the topics of interest through credible blogs, articles, photographs, broadcasts and more (Kumar, 2013).

The search consisted of

- Material by Dr. Bertalan Mesko who has the blog The Medical Futurist (Mesko D. B., About The Medical Futurist, 2017)
- Episode “Doktorn i fickan” in the podcast Kropp & Själ at Sveriges Radio (Hjalmarson, 2015)
- Ted Talks “How wearable technology will change our lives” by Gonzalo Tudela (Tudela, 2014), “Switching healthcare into autopilot with wearable technology” by Niamh O'Mahony (O'Mahony, 2013), “The Future of Wearables” by Lee Shupp (Shupp, 2015)
- Presentation at 2016 Connected Health Symposium by Lauren Costantini (Costantini, 2016)

The popular media search inspired to areas for further research and it identified the latest developments and trends. Furthermore, it displayed user needs and expectations of wearable technology and digital health.

3.1.6 Market survey

A market survey explores the current market of competitors and complementors in the studied field (Kumar, 2013). The objective was to get inspiration, display possible collaborations and reveal opportunities related to the research questions.

Competitors and complementors to the digital health centre, both in Sweden and abroad, were explored. The survey was based on a list with companies given by the digital health centre, and it was further developed during the whole Discover phase.

Examples of companies

- Min Doktor: Digital health care provider offering online doctor consultations, treatments, prescriptions and referrals, based on asynchronous chat. They act within primary health care (mainly), but also in maternal health care and physiotherapy.
- KRY: Digital health care provider offering online consultations, treatments, prescriptions and referrals, based on video calls with a doctor. They act within primary health care.
- Hälsa för mig: Personal health account collecting, compiling and sharing health information as prescriptions, lab results and journals.
- Mediktor: Symptom evaluator compatible with Apple Health for vital signs integration
- Babylon: Similar to the digital health centre in terms of offering. Compiles vital signs, cholesterol, diabetes, blood sugar and hormone levels etc.

3.1.7 Stakeholder interviews

Interviews with various stakeholders at the digital health centre were conducted throughout the project. Most of them were with people within, Clinic, Data & Analytics, Business development and UX design. The interviews took place at the digital health centre for about 30-45 min each and were like semi-structured interviews.

3.1.8 Self-exploration

Throughout the Master Thesis, the project team has used various health related services and devices to gain personal experience and to become one with the studied subject.

Utilized devices and services

- Apple Watch (smartwatch)
- Fitbit Charge HR (fitness-tracker)

- Moves (location-tracking)
- SleepCycle (sleep-patterns)
- RescueTime (computer usage)

3.1.9 Triangulation

Triangulation is a process to increase the validity of a result by using multiple sources and methods (Arvola, 2016). Because of the grey literature, the credibility of the information could be questioned. Therefore, the project team used triangulation to find fuzziness and contradictions and thereby increase the validity of the findings.

3.1.10 Insights

An insight is a conclusion, often based on user research, inspiring to spark innovation and creativity (CIID, 2017). The extracted research was analyzed, interpreted and turned into insights written as concise and objective statements. All insights were marked to ease traceability.

3.1.11 Affinity diagram

Affinity diagram is a tool used to organize data by grouping it (Arvola, 2016). Through affinity diagrams, the most valuable and interesting insights were sorted into themes based on similarity. The themed insights were later compared, combined and refined in order to get a condensed overview of all gathered knowledge, see Figure 3.1.

Figure 3.1 Overview of process during the Discover phase. The picture to the bottom-left shows the themed insights.

3.2 Context research

This section consists of three research areas; digital healthcare, health data and technology. Digital healthcare includes a description of the digital health centre service, an overview of the most common diagnostic procedure process and information about artificial intelligence in healthcare. The section Health data describes various relevant health parameters and a model of the data collection process. The last section, Technology, covers Internet of Things, wearables, medical devices and connected health devices.

3.2.1 Digital healthcare

3.2.1.1 The digital health centre service

When consulting a doctor, the patient needs to log in to the mobile app and start a case. Among 21 predefined cases such as headache, urinary problems and herpes, the patient chooses the most suitable one. Thereafter, the patient fills in a questionnaire, here referred to as a guide, regarding symptoms and disease progression. All this can be done from any place in the world with internet access.

In addition, each patient has their own health profile that they fill in and/or update when going through a guide. The health profile is about general health such as weight, length, smoking and alcohol habits, medications, allergies, diseases and other health issues. After filling in the health profile and answering questions in the guide, the patient files the case and waits to be contacted by a doctor.

When receiving a case, the doctor takes part of the patient's health profile and guide answers. To review, diagnose and propose a suitable treatment, the doctor and patient communicate through an asynchronous chat. Video and phone calls are also used, but only when it's necessary. If needed, the doctor can make referrals to samplings at medical centres. The digital platform make it possible for doctors to work from anywhere.

3.2.1.2 Diagnostic procedure

The diagnostic procedure for today's primary health care is similar regardless if it's physical or digital. The procedure starts with a patient's complaint and that consists of the following stages; Collecting data & information, Process findings and Treatment (Mark B. Mengel, 2002). The stages are further detailed and explained

in Figure 3.2. Certain steps are hard to digitally execute, for example physical examination, while other are easier, for example doing follow-ups.

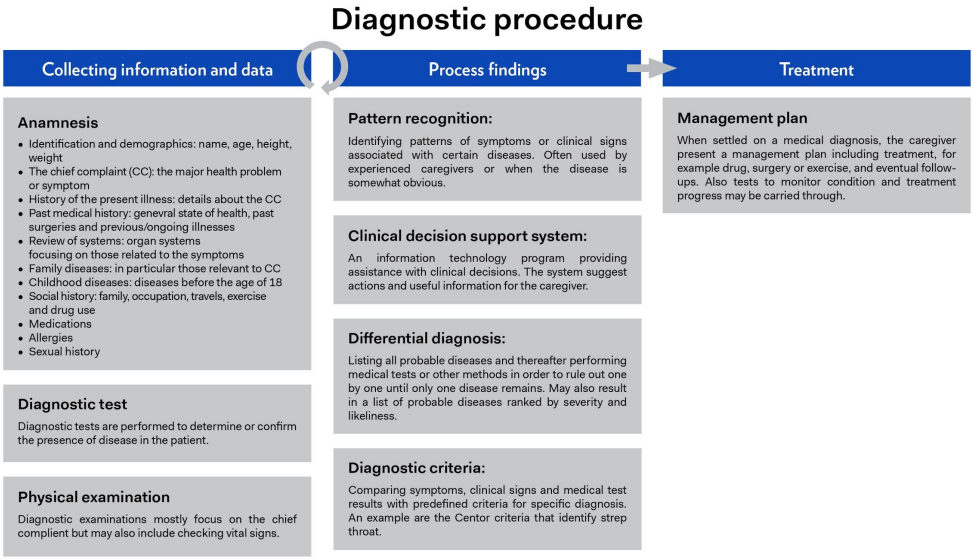


Figure 3.2 Explanation of all stages and methods in the diagnostic procedure.

3.2.1.3 Artificial Intelligence in healthcare

Artificial Intelligence (AI) is a term used to generally describe a more human- like way for computers to analyze data, compared to the old way that requires us to tell the computer exactly what it can do and it could only do that (Niven, 2017). Computers based on AI don't need to know exactly what to do. By giving it a set of parameters and data points, it can compute answers with assigned accuracy on its own.

Already today, a primary health care company called Babylon uses AI in their chat-service to help patient discover and get advice without contacting a person (Babylon, 2017). Along the chat-conversion the system analyzes the symptoms to find possible illnesses and finally suggest what the patient should do. AI-Systems like these are predicted to contribute towards a more proactive healthcare. However, exactly how AI-systems will be used in health care in the future is unsure, although the potential is great (Mesko D. B., Artifical Intelligence will redesign healthcare, 2017).

3.2.2 Health data

This section describes various health parameters that might be relevant for primary care.

3.2.2.1 Vital signs

Vital signs is a group of the most important body signs, that indicate the status of the most basic body functions. The five vital signs most commonly used are; Body Temperature, Pulse (Heart Rate), Blood pressure, Breathing rate (Respiratory Rate) and Blood oxygen saturation (Pulse oximetry, SpO_2). In a primary care setting, vital signs may be used to indicate infections (increased body temperature), pneumonitis (increased respiratory rate and decreased SpO_2), status of the cardiovascular system (resting heart rate and blood pressure) and more.

3.2.2.2 Physical Activity data and Body Composition

Physical activity data are measurements of a person's daily physical activity, for example walking, bicycling and exercising. It may give a hint of an individual's activity level which can be used to indicate whether a symptom is caused by sedentary or not. Body Composition is a measurement of the percentage of fat, bone, water and muscles in the body. The measurements can be used to indicate if a person is overweight, underweight or physically active and thereby can be helpful to find a cause of the symptom.

3.2.2.3 Blood-samples

Blood-samples can be used for many things. It's often used in diagnosis to verify a certain disease. Other applications are to measure for example cholesterol, triglycerides, blood glucose levels which can be used to indicate whether a person have an increased risk of getting a grave disease or not.

3.2.3 Technology

3.2.3.1 Data collection process

To understand how people act when they are using tracking devices, Li describes a stage-based model (Ian Li, 2010), see Figure 3.3. Li suggests that self-tracking includes five iterative stages; *Preparation, Collection, Integration, Reflection* and *Action*.

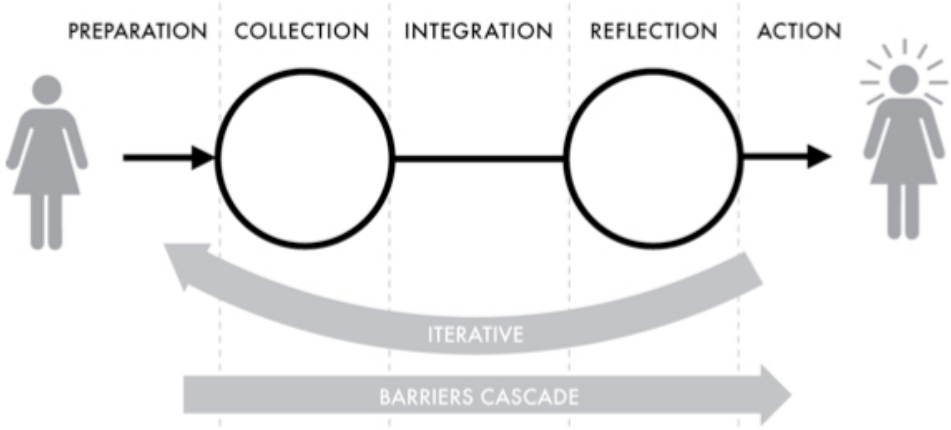


Figure 3.3 Visualization of Li's stage-based data collection model.

- *Preparation stage* takes place before people start tracking and the issues include deciding what to track and how to track it.
- *Collection stage* occurs when people collect information about themselves. The issues arise because of lack of time, lack of motivation or not remembering to record information.
- *Integration phase* is the time when the collected information is prepared for the following stage. The problems are related to the user's effort of preparing the information.
- *Reflection stage* occurs when the user reflects on their data, it can take place immediately after recording it or several weeks afterwards. Issues here are due to lack of time or difficulties retrieving and understanding information.
- *Action stage* takes place when the user acts on their new understanding of themselves. The main problem is that most systems don't have specific suggestions on what action to take.

3.2.3.2 Internet of Things

Internet of Things (IoT) is an overall term for smart devices that communicate with each other over internet. There are many ambiguous categories of devices that can be seen as subsets of IoT and the definitions of these categories are not clearly defined. However, the coming paragraphs attempt to explain them briefly.

3.2.3.3 Wearables

A wearable is a product with incorporated sensors worn on a day-to-day basis (U.S. Food and Drug Administration, 2016). The most common wearables automatically collect parameters like steps, distance, calories, heart-rate and sleep in order to help users live healthier. Some examples of wearables are shown in Figure 3.4, including smartwatches, smart headphones and connected rings.

Figure 3.4 Overview of wearables: Headphones, smart watches, connected rings etc. [B2]

3.2.3.4 Medical devices

Products measuring medically relevant parameters such as blood pressure, temperature, glucose, cholesterol and hormones, with high accuracy, are defined as medical devices (U.S. Food and Drug Administration, 2015). These devices often require the user to manually start and end the collecting process. Examples include Withings' thermometer Thermo and Withings Blood Pressure Monitor, see Figure 3.5. However, when devices are continuously worn on a person's body, medical devices can also be seen as a subset of wearables, for example a heart monitor chest strap.

In order to be perceived as clinic data and thereby be used in diagnostics, the device must be CE-certified Class II or classified by FDA. The CE-certification is mandatory for medical devices in EU and the certification process is rigorous and include meeting a strict set of security requirements (European Commission, 2017). A similar classification is the one set by the U.S. Food and Drug Administration (FDA). With the arising interest in connected health, market researchers forecast an increased market value to about USD 1344 millions by 2021 compared to 414 millions in 2016 (Markets and markets, 2016).

3.2.3.5 Connected health devices

To have a clear approach to the above described devices, this report introduces an additional concept; connected health devices (CHD). The term CHD includes all connected devices collecting some kind of medically relevant data, in other words CHD will be used to collectively describe wearables and medical devices. Important to point out is that ordinary stationary hospital equipment isn't included in the term. Most of the time, CHDs come with related apps that visually present the collected data through various kinds of graphs, discrete or continuous values and other types of information visualization. Most services also allow the user to reflect over the collected data, get advice for improvements and share results with friends and family.

For chronically ill people, CHDs have started to play a valuable role. For example, CHDs are used to continuously or regularly monitor diabetes and cardiovascular diseases which results in enhanced life quality and reduced health-care costs (Tuba Yilmaz, 2010). Today, it is possible to measure a patient's vitals in their home. However, barely no primary care centre does this. Examples of available CHDs that are medically certified are seen in Figure 3.5. Together, these devices measure body temperature, pulse, blood saturation, blood pressure and breathing rate (via audio).

Figure 3.5 First 2 rows: Withings' connected thermometer and blood pressure monitor. Third row: CliniCloud's Digital stethoscope and thermometer. Last row: Medisana's blood pressure monitor, Pulse-oximeter.

3.2.3.6 The evolution of connected health devices

As mentioned in the introduction, the evolution of connected health devices is rapidly progressing. The overall tendency is towards more continuous monitoring processes and this is apparent in the four major trends described below.

One single device collecting multiple parameters

Companies are developing devices that can measure multiple parameters. One example is CheckMe that measures all vital signs except breathing rate (Vitatom, 2017) see Figure 3.6. Another example, that is under development, is TytoHome (Tytocare, 2017). In addition to collecting vitals, TytoHome will come with supplements such as a stethoscope, audio, photo and video recording, see Figure 3.6.

Embedded sensors

Products with embedded sensor are starting to appear on the market, for example headphones, clothes and patches.

Connected clothes with embedded sensors, also known as smart clothes, are growing and interesting product category since people wear them every day. Smart clothes are in its youth. However, products like Hexoskin's Smart Shirt for fitness improvements are available today (Hexoskin, 2017), see Figure 3.7. It can measure ECG, respiratory rate, heart rate and more.

Patches with embedded sensors do continuous measurements of the body. Patches that only measure body temperature are available today but not medically certified, like TempTraq (Temptraq, 2017), seeFigure 3.7. Medically certified patches that continuously measure multiple parameters will soon be available on the market. One example is Vital Connect's VitalPatch (Vital Connect, 2017) which continuously measures ECG, respiratory rate etc. for at least 72h, see Figure 3.7.

Along with technological improvement, medically certified headphones, smart clothes and patches will probably start to appear in a few years' time. This will start to allow medical usage in healthcare.

New measuring methods

Headphones is a product category which is ideal for body measurements (David Da He, 2010). One company, among many, will soon start to sell their headphones called Bodytrak. These headphones will have embedded sensors to measure body temperature, heart rate and more in and behind the ear (Bodytrak, 2017).

New ways of doing blood pressure measurement are under development. A company called Blumio are developing a method for blood pressure measurements using radar (Blumio, 2017).

Additional parameters

Products measuring parameters that previously only were possible to measure at healthcare centres are upcoming, for example taking blood-samples. One upcoming product that is based on taking blood samples is Cor (Cor, 2017), see Figure 3.8. Cor measures parameters such as cholesterol and fasting blood glucose. All data from Cor is generated by the user in their home and is currently not accurate enough to be medically used.

Figure 3.6 Top four picture: TytoHome, A product for examination at home including stethoscope, camera and video-camera. Bottom four picture: CheckMe Pro, measuring ECG, blood pressure, blood saturation and more.

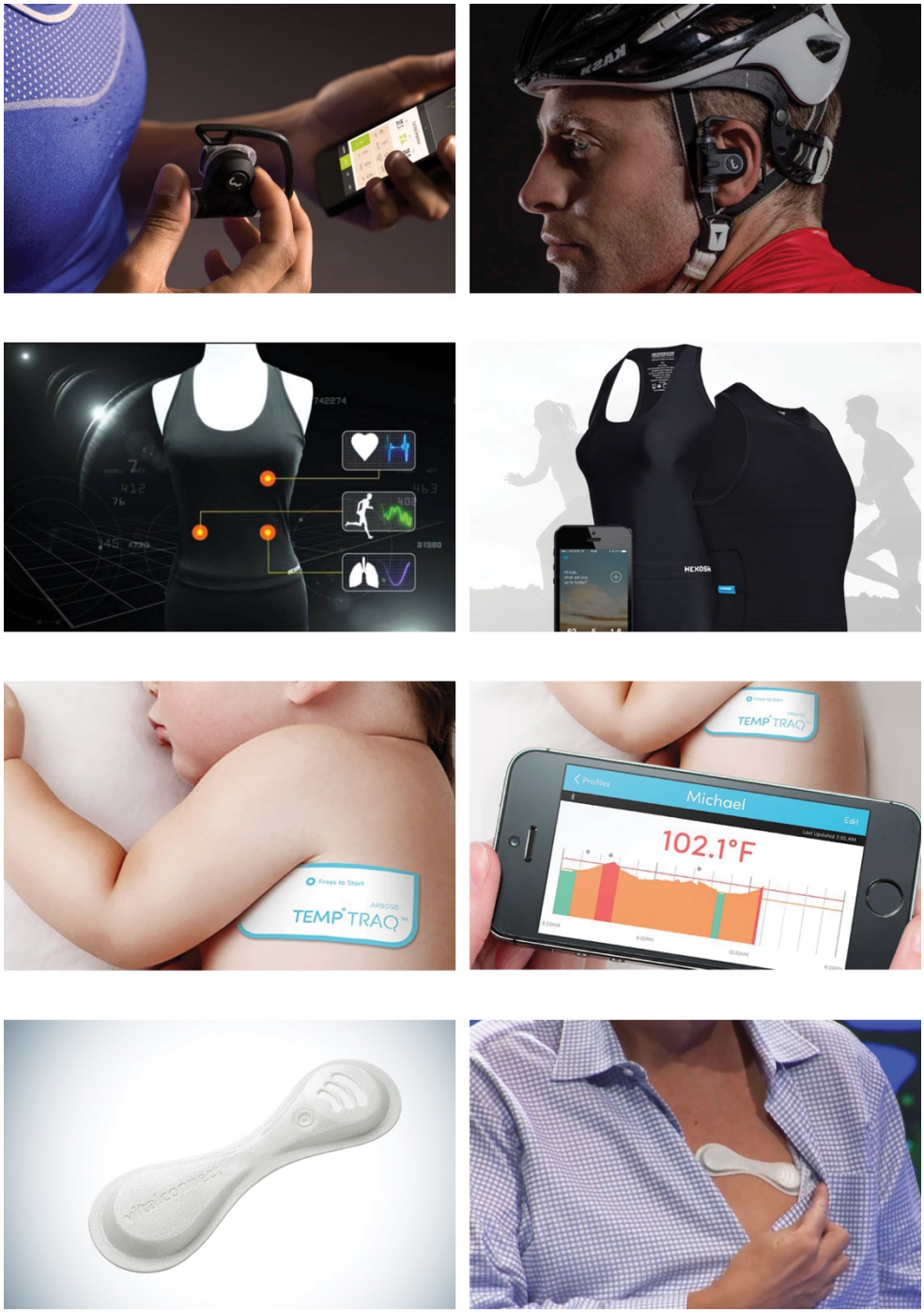


Figure 3.7 First row: Headphones from Bodytrak. Second row: A Smart shirt by Hexoskin. Third row: TempTraq's Thermometer. Fourth row: VitalPatch from Vital connect.

Figure 3.8 Blood sample device Cor can measure cholesterol, fasting blood glucose and more.

3.3 User research and insights

This section presents insights based on conducted user research. From a doctor's point of view, this section covers the user experience of the digital health centre service, their needs regarding patient generated health data and their relation to new technologies. Furthermore, it includes people's user experience and needs of connected health devices and their user experience of patient generated health data. The presented insights were extracted from affinity diagrams based on similarity and relation to the research questions. The sections below are structured so that they present the construed insight, further information and some of the quotes (translated into English) the insight was based on.

3.3.1 Doctor's user experience of the digital health centre service

Insight: Doctors appreciate the work freedom at the digital health centre. Nevertheless, it can sometimes be difficult to determine how much effort a case will take which is interfering the work freedom.

The doctors appreciate the ability to choose when and where to work and for how long. They often choose cases based on their current situation since assigning a case doesn't require that much planning due to the use of asynchronous communication. However, it can sometimes be difficult to determine how extensive a case will be and what the case will require from the doctor.

> D2's statement regarding what he likes with the service:
> *"Work from any environment, anytime."*
>
> Quote by D2 regarding using video calls:
> *"Nothing you can do if you want to spontaneously take cases."*

Insight: Doctors appreciate that a lot of information is presented when assigning a case. However, they sometimes lack important information.

Doctors value that relevant information about patients is presented to them when they assign themselves to a case. However, doctors also say that it can be difficult for patients to know what information is of importance and not. Thereby, leading to a higher amount of interactions in the doctor-patient communication. Regarding the health profile in the digital health centre service, doctors have various opinions. Some claim that the profile gives a good overview of the patient while some say it is insufficient and brings unnecessary extra work.

> D2 and D1 about the health profile:
> *"It is quite sufficient.", "Patients miss to fill in things, exaggerate, don't fill in all medications, check penicillin allergy even though they have antibiotics allergy."*
>
> P2 regarding why she wants to send her health data to doctors:
> *"Good to send so one not forgets to mention things [...] so they can notice things to ask questions about."*

Insight: Doctors believe the digital platform affects the relation and what's discussed between doctor and patient. However, data may close the digital gap.

The relation between doctors and patients is affected due to the digital interaction channel. For example, doctors are less likely to give general health recommendations (regarding smoking, obesity and more) to patients at the digital health centre compared to primary care units. Some doctors don't perceive the asynchronous chat as an appropriate channel for this. In addition, patients turning to the digital health centre tend to have quite specific problems making it unsuitable to discuss things not related to this. Nevertheless, having access to patient's health data might open up for new discussions and make it more natural for the doctor to comment on the data.

D1 regarding missed opportunity for giving general health advices during a case:
"If someone seeks for coughing and I see that the person has an unhealthy high BMI, I do not mention it […] I make a quick, focused diagnosis for the specific case."

Insight: Due to the lack of personal interaction and visual cues, doctors sometimes find it hard to understand patients and their symptoms.

Several doctors believe that understanding patients can be a bit more difficult at the digital health centre than at primary care providers. This is mostly because of the loss in personal contact and lack of visual cues. Doctors therefore have to put a lot of trust in what the patients say and it might be easy for patients to exaggerate their symptoms. However, doctors seem to find it quite easy to verify the patient's statements. Being able to catch the symptoms when they occur is also a difficulty, both for the digital health centre and primary care units. Therefore, doctors have to completely rely on descriptions from patients. Mostly, this isn't that big of a problem. However, the ability to catch the symptoms when they occur could increase the patient safety.

D2 about missing visual cues:
"When I see patients, I quickly realize whether they are sick or not. Much visual information [...] data is therefore even more important in order to weigh up for the lost visuals."

D2's comment about verifying information given by patients:
"Everything relies on trust. No system to find made-up statements exists. Patients who want x-ray can exaggerate their symptoms."

D3 regarding symptoms that currently aren't present:
"Often, it is not acute if the symptom isn't present just then, unless they have certain critical symptoms."

Insight: The decreased user effort when seeking care reduces compliance rates.

There seems to be a decrease in compliance at the digital health centre compared to primary care units. Patients don't follow their treatment plan in the same extent. For example, in physiotherapy it is common that exercises need to be carried out long term, even long after the symptoms are gone, and the compliance is quite low. The reason for this could be that it doesn't require that much of an effort and time to seek help at the digital health centre compared to a visit at a primary care provider. Furthermore, doctor's recommendations don't have the same impact in text as face to face communication.

D3 about compliance rate:
"About maximum 10% who stick to the treatments, and of those about 90% do it wrongly."

D1 regarding following doctor's advice:
"The patient's engagement is sometimes lower since digital care requires less from the patient compared to a primary care provider [...] a different trust since the patient doesn't see the doctor."

Insight: The digital platform isn't suitable for all health care cases and the doctors find it quite easy to sort these out. However, it would be beneficial to do this more quickly and earlier in the process.

Some doctors mention that it sometimes is difficult to know how acute a case is. This includes people seeking care without being sick but also people in the need of acute treatments. Some cases might also be too extensive and complex to be suitable for a digital healthcare provider. However, doctors find it quite easy to decide whether the case is appropriate for digital care or not. But it would be beneficial and cost effective to earlier in the process filter out people not suitable for digital care.

Statements by D1 and D2 about filter out patient not suitable for digital care:
"It is quite apparent in patient's descriptions whether they can be treated online or not."
"Difficult with stomach symptoms when I can't examine physically."

Insight: Health and technology literacy is a challenge for digital health care.

The Accenture report states that patients struggle with health and technology literacy (Accenture Federal Service, 2016). This includes health-related activities such as to accurately describe their symptoms, especially if the symptoms are vague or the case is very complex. Patients also struggle to estimate pain and to describe what they want help with. Regarding technological challenges, people have difficulties with completing digital questionnaires and to correctly interpret messages received through new digital technologies.

D1 about health and technology literacy*:*
"Patients have difficulties when describing their problems [...] linguistic problems. Patients tend to exaggerate symptoms [...]. Technically ignorant so their answers delay, they don't notice that they have messages."

3.3.2 Doctor's needs regarding patient generated health data

Insight: For PGHD to be useful, the circumstances when measuring must be known.

For a doctor to trust the measured value, the situation when measuring must be known. For example, by presenting only a heart-rate value, doctors don't know if the patient sits, stands or just came in from a walk etc. Without knowing the circumstances, it is difficult to draw any conclusions from the measurements.

Quote by D1 about knowing the circumstances while doing measurements:
"The context of vital parameters is also important [...] a patient who is scared and anxious should have a high pulse, it is not abnormal."

Insight: Doctors want data that is as accurate as in hospital settings. However, the reliability of clinically measurements in health centres aren't guaranteed.

Another concern is the accuracy and validity of device measurements at home (Accenture Federal Service, 2016). The biggest doubt is that CHDs are less accurate than medical-devices in a hospital setting. However, vital signs collected in hospitals are not that accurate either. This is because of the *white-coat effect*, a phenomena occurring when patients get anxious when meeting a doctor, which leads to higher blood-pressure levels. Thereby, less accurate measuring-devices at home might give more reliable values than devices at hospitals. Despite the doubt among doctors, historical data describing variations of PGHD over time can be useful even if it is less accurate. For example, a trend of progress could be of more relevance than the precise current value.

Furthermore, in the current digital health centre service, patients can send their vital values through the chat conversation. In primary care units, doctors are used to correlate measured parameters and their impression of the patient as a way to validate the data. However, the digital platform makes it difficult to do this.

D2's statement about validity of measurements made at home:
"Patients at a hospital get affected by the white coat effect [...] more adequate vital parameters could be measured at home than at the hospital."

D3 about the importance of the overall impression of the patient:
"When I meet a patient, I get a perception of the person and depending on that I know whether I can trust the data or not."

D1's comment about knowing illness progression based on PGHD:
"A trend can point to acute conditions and how they progress, even though the patient has measured in the wrong way."

Insight: Doctors believe PGHD could give them more insights about their patients. However, depending on phase of the care process, the relevance of different type of data may change.

A study claims that 60% of health care professionals believe eHealth apps will give them more insights into their patients (Research Now, Inc, 2015). What data considered as useful depends on the phase in the case process and the case itself. Various kinds of data might be useful for understanding the patient, diagnosis, treatment and evaluation. For example, blood-pressure measurements can be used

to monitor the effects of hypotensive agents. For rashes on the other hand, blood-pressure measurements are of no use at all.

> D3 regarding how PGHD can be used:
> *"Within patient understanding, investigations, assessments, treatments and evaluation."*

Insight: Doctors are concerned that large volumes of data will create noise and make it hard to sort out what's relevant for the specific case.

Many doctors raise concerns about large volumes of data fearing that they will struggle to draw insights when receiving more data than needed (Accenture Federal Service, 2016). For example, one study reveals that doctors fear the PGHD to add inefficiencies and disrupt their workflows (Christopher A Harle, 2015). Also, "providers reported concern that indiscriminately collecting patient-generated health data would distract them from treating an acute condition deemed more vital than what the patient reported.". In other words, the PGHD may add noise to the clinical data.

Despite this, many doctors are still open-minded and positive towards PGHD. However, the doctors pointed out the importance of making the collected data useful and easy to absorb. If the collected data get overwhelming, the doctors will not use it. In order to minimize the risk of being overwhelmed by data, only relevant data for the current case should be presented to the doctor. Furthermore, the data should be simplified to allow for a quick overview to keep the efficiency of the digital health centre.

> D3 about sorting data:
> *"Too much data quickly get difficult to survey."*

> D2 regarding large amount of data:
> *"I could never look through big amounts of data. Much of the good points with the digital health centre would be lost from the doctor's perspective."*

Insight: Some doctors believe that screening of healthy people could have a value. However, they are concerned about the required effort due to verification.

A survey conducted by Research Now stated that among 1,000 healthcare professionals in U.S. and U.K., 61% believe that health apps will help those people who are at rising-risk of developing health issues and 55% believe they can help healthy people (Research Now Group, Inc., 2015). In contradictions, research claims that healthy people will not be able to get help from doctors to analyze their data (Hjalmarson, 2015). Doctors claimed that screening of healthy people will create extra work, especially when data needs to be verified due to false-positives.

P1 about getting help from a doctor to interpret his data:
"I kind of felt that I wasn't totally fit and by a coincident I looked at the resting heart rate and I saw a peak [...] then I actually talked to a doctor that I know."

Quote by D1 regarding uncertain measurements:
"If you receive a measured value that indicates something, you should check for false-positives to validate the value. The value may indicate a certain thing but a new test may indicate the opposite."

Insight: Introduction of PGHD in health care could allow doctors to compare ill and healthy values for each patient for deeper understanding.

In order to make the PGHD useful, the values must be compared, either with a reference database or historical personal data. Historical personal data are not available for doctors at the digital health centre today, but they say that comparing information about the patients healthy and ill state are useful.

A stakeholder who is medically responsible at the digital health centre, about comparing healthy and ill values:
"It would be grateful being able to compare healthy and ill values [...] problems with only knowing how it is when they are sick and not when they are healthy."

3.3.3 Doctor's relation to new technologies

Insight: Artificial intelligence in healthcare must be implemented with caution.

Many doctors doubt the reliability of new disruptive technologies, such as artificial intelligence. However, some doctors are more open-minded and believe that AI-systems could help analyzing data, give recommendations and reduce human-error. However, common sense and experience must be used to evaluate the outputs from AI-systems.

D1's comment about how AI could affect care processes:
"It could be more convenient, easier, it should be a support system and, if possible, prevent human errors."

3.3.4 People's user experience of connected health devices

Insight: Due to high abandonment rates of connected health devices, the whole data collecting ecosystem needs to work seamlessly.

A report from Endeavour indicates that "More than half of individuals who purchased a wearable device stop using it and, of these, one-third did so before six months" (Dan Ledger). Abandonment occurs mostly because of lack of time and motivation, struggle with charging and syncing, data at multiple platforms and poor

data visualization and analysis. Furthermore, unplanned pauses, maybe because of vacation, are a high risk since they let users reflect on why they track (Epstein, 2015).

> Quote by P3 about why he stopped using his Garmin-watch:
> *"I stopped because the process of transferring the data through a USB was quite cumbersome."*
>
> P5 statement about unplanned pauses of tracking:
> *"I dropped all my routines when I renovated the house and lived with my parents-in-law."*
>
> E3 regarding the purpose of using rescueTime:
> *"Switched computer and thought; what should I do with all this data? Then I never reinstalled it."*
>
> E2 about why he stopped using exist.io:
> *"It felt pointless, it didn't feel like any of the analysis gave me anything."*

Insight: People facing issues with their connected health device might stop using it, even if the issues are quite small.

This is related to the fact that quite small issues in earlier phases of the data collection process (see Figure 3.3), might grow and carry through to later stages. For long-term usage, small issues usually become more and more annoying, which increase the risk of abandonment.

> E1's statement regarding why he stopped using his tracking devices:
> *"All my tracking devices have been annoying, sometimes I forgot to charge them or to sync them. My self-discipline is too bad when they hassle."*
>
> Quote by P3 why he stopped using his sleep-tracking app:
> *"Awkward to keep the phone under my pillow."*
>
> P3's opinion regarding the data visualization on his apple watch:
> *"A bit annoying that they aren't more accurate."*
>
> P5 about why he stopped using his pulse chest strap:
> *"Measuring pulse took so much battery. And the measurements weren't that accurate."*

Insight: People sometimes adjust their behavior according to what the CHD requires.

Today's CHD require that users change their behavior to fully take advantage of all the benefits. Long term usage of CHD sometimes creates new habits that affects

users lives, whether they are wanted or not. The behavioral change has led to that the CHD have been a part of people's routines and won't act without them.

> Quote by E3 about behavioral change:
> *"We shape our tools and then our tools shape us."*
>
> P5 about using his Garmin-watch:
> *"I always make sure to have everything charged before going somewhere. Actually, it is not that important to log, it is more of a routine, like in the scouts where some things always should be brought."*
>
> P5 about adjusting to technology:
> *"One should not be a slave to the technology, it should be a complement to reaching one's goals [...] one shouldn't achieve things simply because the technology can track it."*
>
> E3 about changing his behavior to satisfy his running device:
> *"The GPS doesn't work in the forest but I love to run in the forest. Now I avoid it since I don't get any data."*

Insight: Sometimes, patients use tracking devices incorrectly. They therefore need instructions.

Doctors disclose that patients sometimes use their tracking devices in a wrong way. Thus, affecting the data so that it become biased or even unusable. However, they believe that patients can collect PGHD in an accurate way if they get instructions. Nevertheless, the doctors themselves don't have time to instruct their patients.

> D1's statements about patients' ability to take useful pictures and to measure correctly:
> *"You get a picture of the throat and the tonsils in the best scenario, sometimes you just see lips and tongue, which indicates nothing."*
> *"It's not just about the devices themselves, it's about how patients use them. We don't have time to instruct patients."*

3.3.5 People's needs regarding connected health devices

Insight: Collecting a manageable number of parameters is of high importance.

One reason people quit tracking is because they track too many things and thereby experience data fatigue. With an increasing number of collected parameters, it becomes more and more difficult to interpret the data and gain valuable insights.

> From the conference proceeding by Choe et al. *(Choe, 2014)*, P61's statement about collecting and analyzing data:
> *"I can honestly say that I've made the classic newbie self-tracking mistake which is that I track everything."*

"It's not that we lack the information, we're virtually drowning in it. The obstacle is that we don't have the proper tools to interpret the significance of our data."

Insight: People want to understand and be able to act on their PGHD. However, most services lack informative explanations and analysis of the data.

People want to understand themselves and get knowledge about how health parameters affect their life. Here, health data could play a valuable role. However, most services don't provide sufficient analysis, instead they simply present PGHD in graphs or tables. This results in difficulties since people don't always know how to interpret and make use of the collected data. This may also lead to unnecessary concerns. The troubles often occur when lacking relevant medical knowledge, for example regarding deviation and significance of tracked parameters. Therefore, many people request services compiling and analyzing data in an informative way. Not to forget, the analysis must be relevant for each individual person and his or hers needs.

Dr. Mesko *(Mesko, 2017)*, about analyzing data:
"I need to be a doctor, a researcher and a geek to get the most out of my data."

E2, about what he is missing in terms of analysis:
"Why am I extremely tired some days and not others?"

E2, about lack of meaningful analysis of data:
"It is very much logging but quite little analysis. I would like to correlate the data in a better way and be able to extract insights."

P5 regarding the lack of explanation in devices:
"It is very easy to get the values but very difficult to get a great understanding of what to use them for and how to manage them."

E2 about what he is missing in terms of analysis of his heart rate: *"I don't know what to do with the data [...] do I have a good resting pulse, is it better when I sleep better, or when I am more active? Or is it lower when I listen to a certain type of music?"*

Insight: For long term use of CHD, the device and related app need to be flexible to always meet the user's changing needs.

One of the reasons for abandoning CHD is that the service no longer teaches the user anything new, this was particularly true for behavior changers. For long term use, the service needs to state a clear purpose and intention in how to help the user (Epstein, 2015). Furthermore, when the desired effect has occurred, people tend to stop tracking. Therefore, it is important that the service creates new engagements for the users (Fredrik Ohlin, 2015).

P1 about why he stopped using his food app:
"After one year, I had changed my behavior [...] then I knew what was good and not. It costed money so therefore I stopped using it.

From the paper *(Epstein D. A., 2016)*, P45's statement about why he stopped tracking:
"Had a very good idea of the number of steps I was taking without the app [...] I knew without the app if I was accomplishing my goal."

E3 about using devices long term:
"I often find it fantastic to start using a new device, all the questions it brings. I find out less and less new things [...] I have stopped using a lot of things, they lack a long-term purpose."

Insight: People can gain insights not only when looking at the actual data but also during the collection process itself. Therefore, CHDs should enable this.

Manual tracking often leads to less spare time to reflect during the actual Reflection phase (see Figure 3.3). To weigh up for this, many services offer reflection and expose insights during the Collection phase itself. Automated tracking doesn't bring the same awareness and self-reflection since the user isn't engaged in the collection process (Epstein, 2015). For services with automated tracking, a manual self-reflect function or a way to force the user to interact with their data may bring an increasing awareness and engagement.

E3's statement about collecting and reflecting on data simultaneously:
"I look at my pulse during running. Try to learn how it works, how does it feel when I am close to maximum pulse and so on. I don't run based on the pulse, I use the info to get better."

E2 regarding reflection of collected data:
"One key is to regularly receive notifications regarding progress. Many services are totally automatic which is great, but it also makes me forget about them from time to time."

From the conference proceeding *(Choe, 2014), P9's statement regarding* tracking outcomes:
"I realized that just by tracking my emotions, I was completely changing them."

Insight: People who generally are in good health are less motivated to track themselves.

A report from Accenture claims that "healthy patients not already tracking their health data or are interested in changing their health behaviors may be less motivated to do so without tangible benefits or incentives" (Accenture Federal Service, 2016). This implies a conflict since long term data could be of high value if certain illnesses occur.

D3's opinion about long-term data:
"For specific illnesses and directed questions, I would find long term registrations valuable."

E3 about not seeing the value of certain health data:
"I almost bought a pulse tracker. Pulse variable frequency is a good parameter to measure depression [...] but what should I use this for? Probably the first QS-device that I thought; no, what should I have this data for?

Insight: Knowing that a doctor observes the health data and gives advice can be a motivator to keep tracking.

Research shows that people get enthusiastic about getting professional reflections about their own health data. Furthermore, knowing that a professional looks at the data can be a motivator in itself for the user to collect the data.

P2 about motivation for tracking:
"It is a difference since you have to perform when it is a doctor [looking at the data]. Think about the relationship with a professor, you have to behave."

Insight: The willingness towards using manual CHDs largely depends on the user's intrinsic motivation.

Manual tracking requires more of the user's time and effort. If it takes too much effort, people don't track as much as they would need to. However, when having an intrinsic motivation, like a specific health goal, people show more willingness towards manual tracking since they believe it will give them the desired effect. To increase the manual tracking, the collection process needs to be easy and quick. For example, the service could use a decreased data granularity in a way to increase the data points. On the other hand, research shows that even binary methods, such as a simple click, can be a micro-cut that in the long run leads to abandonment.

P2 about manual tracking:
"Manual takes too much time."

P1 about intrinsic motivation:
"When I had trouble sleeping, it was so great being able to register my sleep."

P4, about manually tracking her food intake and weight:
"I want to lose weight [...] I weigh and register myself once a week, register the food intake all the time. It works fine."

3.3.6 People's user experience of patient generated health data

Insight: People tracking themselves become more aware and knowledgeable of their health. However, knowing too much may harm the person more than helping.

Research indicates that an aware society is a healthier society (Hjalmarson, 2015). People get more aware and learn more about themselves when they look and reflect on their health data. They gain knowledge about health parameters that they are concerned about which guide them to take actions. Data can also be a help to get objective confirmations about feelings, sometimes people trust the data more than their own gut feeling. However, it's not healthy to go around and worry about eventual illnesses.

> P1, regarding tracking food intake:
> *"I realized what wasn't good for me."*
>
> P5, regarding getting aware of his health:
> *"Had high blood pressure, had chest pressures [...] it can be handled without medications."*
>
> P5 about risk for illnesses:
> *"You can't go around worrying about that, you have to be here and now and do the best you can, and be pleased with that."*
>
> P2 about not monitoring her weight every day:
> *"I'm afraid I will end up with negative thoughts."*
>
> P1 about verifying his sleep:
> *"When I feel off in the morning, I log in and check [...] just to verify; how did I sleep? It's like a confirmation."*
>
> P4 regarding getting objective confirmations:
> *"Here, I register my breakfast. I haven't registered this morning. Every night, I look through the day to check if everything was alright. I get my food intake in black on white."*

Insight: Being aware of one's health often lead to more engagement and responsibilities regarding state of health.

The Accenture report claims that people collecting and reviewing their health data are more prepared for clinical visits (Accenture Federal Service, 2016). Furthermore, seeing positive trends regarding illness progression or behavior changes, might motivate people to continue tracking and working towards the desired state of health.

E2 about reflecting about data:
"Exercising, exactly how does that affect me? Does it make any difference if I run three times a week or not?"

P2 about measuring her pulse during a stressful period:
"I was concerned. Measured like once a month [...] it was an index of how good or bad it was."

P3 about actions due to his data:
"Most of the time, it isn't more than a verification on how I already feel [...] shows when it is time to take further actions."

3.3.7 Key takeaways from user research and insights

One of the main findings is that the asynchronous communication, which contributes to the highly-valued work freedom, makes it harder for doctors to get the full picture and understand patients and their symptoms. Research implied that PGHD could help closing the digital gap. However, in order for the data to be useful, it must be manageable and relevant for the specific case.

In regards to the data collection process, the devices and related apps need to work seamlessly to not risk being abandoned. Research showed that people tracking themselves often become more aware and engaged in their health. However, knowing too much may result in unnecessary concerns. In order for people to act on their PGHD, services need to provide adequate explanations and analysis of the data.

4 Define

The Define phase aimed to convert the most intriguing insights into opportunity areas and later narrow down to one focus area for further exploration. Accordingly, the first two research questions are processed in this chapter.

4.1 Methods

4.1.1 Brainstorming

Brainstorming is a common tool to generate as many ideas as possible. When having a brainstorming session, it is of high importance to be open minded, optimistic and creative (Design Kit, 2017). The Define phase started out with quite extensive brainstorming sessions based on the most intriguing clusters of insights, current and coming technology and competitors. This led to multiple papers filled with mind maps of ideas, see Figure 4.1.

4.1.2 Opportunity areas

An opportunity area is a field for further exploration. It is often based on a group of insights or learnings from the fieldwork (CIID, 2017). The ideas from the brainstorming sessions were combined and refined into a high number of opportunity areas describing the main idea, benefits with patient generated health data and how the data could support the digital care work. The opportunity areas were sorted due to similarity and grouped into several themes, see Figure 4.1.

All opportunity areas were evaluated through discussions with the supervisor at the digital health centre. Six areas were believed to have most potential for the digital health centre and were therefore chosen for further exploration, see Figure 4.1. The six areas presented in section *4.2 Opportunity areas*, have been further refined throughout the whole Master Thesis as additional information and discussions with stakeholders have taken place.

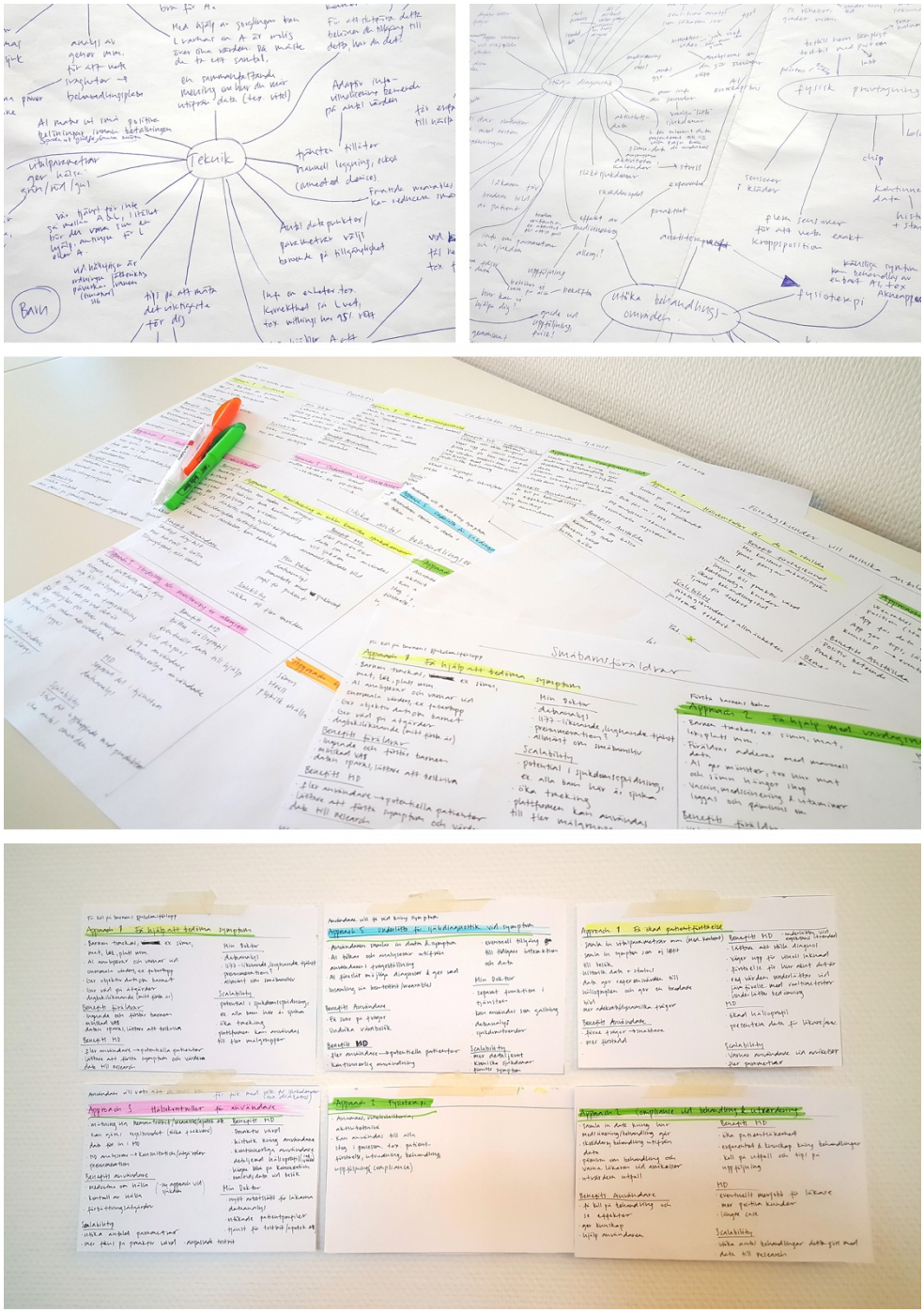


Figure 4.1 Top: Mind maps with ideas. Middle: Opportunity areas sorted into different themes. Bottom: The six opportunity areas with most potential for the digital health centre

4.1.3 Evaluation scales

To enable comparison between the six opportunity areas, the project team came up with the idea of evaluation scales. Three aspects were believed to have vital parts in evaluating and narrowing the areas, see Figure 4.2; *Incremental/Radical, Near future/Long term* and *Low/high-scalability.*

Incremental/Radical shows how much the opportunity area differ from the digital health centre's current service. *Near future/Long term* indicates whether it is possible to implement the idea today or if further research is needed. *Low/high-scalability* describes the concepts' potential of starting small and over time grow and extend the idea. The opportunity areas were placed based on estimations by the project team.

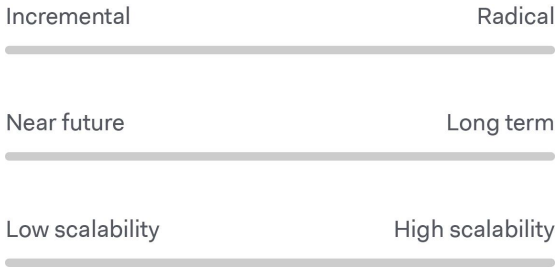


Figure 4.2 Evaluation scales for comparison between opportunity areas.

4.2 Opportunity areas

4.2.1 Outline of opportunity areas

Opportunity area 1:
Using PGHD to compensate for missing visual cues in the initial understanding of patients and their condition.

Opportunity area 2:
Ease and sharpen the awaiting and treatment process, so doctors can monitor patient's illness progression.

Opportunity area 3:
A service for self-diagnostics and advice for people to treat and understand themselves better.

Opportunity area 4:
Using PGHD to support worried parents regarding their sick children.

Opportunity area 5:
A monitoring service to reduce the risk of getting heritable illnesses.

Opportunity area 6:
Using PGHD to improve digital physiotherapeutic cases.

4.2.2 Opportunity area 1

Using PGHD to compensate for missing visual cues in the initial understanding of patients and their condition.

Related insights

- Doctors appreciate that a lot of information is presented when assigning a case. However, they sometimes lack important information.
- Due to the lack of personal interaction and visual cues, doctors sometimes find it hard to understand patients and their symptoms.
- Doctors believe PGHD could give them more insights about their patients. However, depending on phase of the care process, the relevance of different type of data may change.

Fictitious Scenario

From time to time, individuals may record their health parameters through some kind of health device provided by the digital health centre. Once a person gets sick and seek help through the app, the doctor will have access to personal long-term health data. The PGHD function both as a snapshot of current condition but also as a comparison with the person's baseline. Combined with described symptoms, the doctor will get a comprehensive picture of the patient and his or her illness progression.

Benefits for the digital health centre

- Getting people to engage in the app before they seek care will increase the probability that they also will turn to the app once they get sick. Therefore, this approach may result in more paying customers and lower abandonment rate.
- Getting a momentary view of a person's general health may lead to an increased patient safety.

Benefits for doctors

- Having long-term data and baselines for individuals may bring more details to the anamnesis and enable the patient to compare sick values with healthy ones. In combination with described symptoms, this could help doctors to understand more about the patient and to more effectively perform the diagnostic procedure.
- The objective data may verify and validate described symptoms, for example regarding pain estimation, which will support the doctor in understanding the symptoms.
- The PGHD may help closing the digital gap and compensate for the lack of visual cues.
- When patients have reflected on their data beforehand, they are more likely to describe their symptoms in a detailed way. This decreases the number of interactions in the doctor-patient communication.

Benefits for patients

- Being evaluated based on one's own health parameters will most likely result in a more individually customized care that is improving the patient safety.
- The collected health data will bring engagement, responsibility, knowledge and awareness about one's health and eventual improvement areas.
- A service compiling health data may close the digital gap and be perceived as reassuring and trustworthy.
- PGHD may lead to less basic questions since the doctor can draw conclusions based on the health data.
- The patient will always have access to look at their health data. This may make people confident in their own ability to evaluate their state of health.

Relation to current service

- Closely related to the current service.
- The approach would require extended health profiles compared to the current relatively inadequate profiles.

Scalability

- More health parameters and their correlation to illnesses could be explored and eventually included in the data analysis.
- When having more knowledge about people's baselines and their correlation to cut off values, symptoms and illnesses, the evaluation could be further individualized. Eventually, a person's health parameters would play a more important and valuable role.
- Due to technology evolution and increased market maturity, a higher number of parameters could be collected by the health device. Also, as more

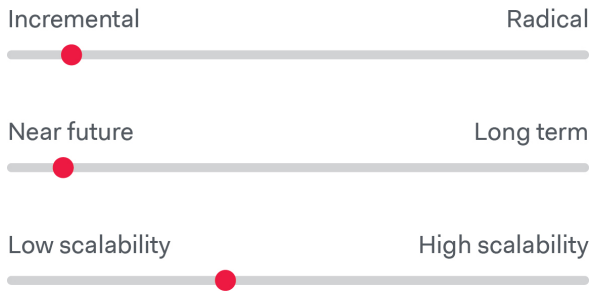
devices are being incorporated in clothes and wearables, continuous health data will be available. This will increase the benefits for this approach furthermore.

- By expanding the health profiles, this could function as a united platform containing all the patient's health data at one place, for all stakeholders to use. Eventually, also other healthcare providers could grant access to this.
- The collected health data could be used in research studies.

Challenges

Sorting through and displaying relevant information, such as deviations and possible conjunctions, to the doctors would require extensive data analysis including causal models. More knowledge about correlations between health parameters, symptoms and illnesses is also needed. Also, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale



4.2.3 Opportunity area 2

Ease and sharpen the awaiting and treatment process, so doctors can monitor patient's illness progression.

Related insights

- Doctors believe PGHD could give them more insights about their patients. However, depending on phase of the care process, the relevance of different type of data may change.
- Being aware of one's health often lead to more engagement and responsibilities regarding state of health.
- The decreased user effort when seeking care reduces compliance rates.

Fictitious Scenario

By asking the patient to record specific health parameters through a health device after being diagnosed, the doctor may monitor the treatment progress and compliance rate. In this way, the doctor has the ability to switch treatment and evaluate the effects throughout the whole treatment period. This approach may also be applied to the awaiting process which thereby can be done in a more controlled way.

Benefits for the digital health centre

- The ability to continuously follow the treatment progress is a huge opportunity rarely seen in regular healthcare. The digital health centre could use this distinction as a market advantage.
- An individually customized treatment will most likely lead to an increased care quality and patient safety. Examples include more effective recovery plans and lower risks for complications.

Benefits for doctors

- The health data will present objective results concerning recovery and clearly state patients progress over time. In this way, the doctor will have more transparency in the patient's development and compliance.
- Awaiting can be carried through in a secure and controlled way. This could assist the doctor to make sure that the patient's condition has not worsen.
- Objective data can support the patient's descriptions of their health during follow-ups. The data may also imply when it is necessary to have a follow-up and not.
- Doctors could be warned if certain health parameters reach given cut off values. This may lower the mental load for the doctors since they don't have to check up on every single patient.
- PGHD describing the patient's general condition may support the doctor when determining if a case should be closed or stay open.

Benefits for patients

- The collected health data will bring engagement, responsibility, knowledge and awareness about one's health and recovery.
- Knowing that a doctor has access to one's health data during the treatment period may be perceived as reassuring and trustworthy.
- Awaiting can be carried through in a controlled and secure way. This may bring feelings of trust and confidence.
- Through PGHD, the treatment will be customized for the individual and his or her conditions. In cases where the recommended treatment does not work, patients can get help to switch treatment before the intended period has come to an end. Therefore, the patient will get the right care in the right

time.

- Data could assist the doctor in cases when patients deviate from the treatment plan. The doctor can then give additional instructions or adjust the treatment which may favor the patient in their recovery.
- Having access to one's health data and seeing objective results may engage the patient to continue following the treatment plan.

Relation to current service

- Closely related to the current service.
- Follow-ups are quite easy to schedule and carry through in the current service. However, the use of CHDs could assist and for example schedule a follow-up if the condition of a patient has worsened.
- Getting notifications regarding deviations, cut offs and progress could imply a change in the doctor's workflow.

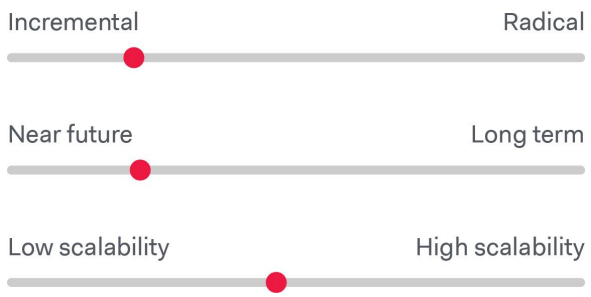
Scalability

- When having more knowledge about people's baselines and their correlation to cut off values, illnesses and recovery, the treatment plan could be further individualized. Eventually, a person's health parameters would play a more important and valuable role.
- Due to technology evolution and increased market maturity, a higher number of parameters could be collected by the health device. Also, as more devices are being incorporated in clothes and wearables, continuous health data will be available. This will increase the benefits for this approach furthermore.
- The collected health data could be used in research studies.

Challenges

More knowledge about correlations between individual cut offs, health parameters, illnesses and treatments is needed. Furthermore, sorting through and displaying relevant information, such as deviations and possible conjunctions, to the doctors would require extensive data analysis including causal models. Also, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale



4.2.4 Opportunity area 3

A service for self-diagnostics and advice for people to treat and understand themselves better.

Related insights

- People want to understand and be able to act on their PGHD. However, most services lack informative explanations and analysis of the data.
- The digital platform isn't suitable for all health care cases and the doctors find it quite easy to sort these out. However, it would be beneficial to do this more quickly and earlier in the process.
- People tracking themselves become more aware and knowledgeable of their health. However, knowing too much may harm the person more than helping.

Fictitious Scenario

From time to time, individuals could record relevant health parameters through the health device provided by the digital health centre. When experiencing illness, people will be able to log and describe relevant health parameters and symptoms to their health profile in the app. They will then be presented with likely illnesses and get advice about what they can do by themselves and whether there is a need to continue to a doctor consultation or not.

Benefits for the digital health centre

- Since the app will be useful for people before they feel the need to seek care, the app creates an additional application leading to increased usage. Providing a continuous usage may lower the abandonment rate.
- Getting people to engage in the app before they seek care will increase the

probability that they also will turn to the app when they get sick. Therefore, this approach may result in more paying customers.
- Helping people to understand when a doctor consultation is needed and not will filter out people who aren't sick enough to pay for their consultation.

Benefits for doctors

- Having long-term data and baselines for individuals will enable the patient to compare sick values with healthy ones. In combination with symptoms, this may help doctors to understand more about the patient.
- When the patients have reflected on their data in beforehand, they are more likely to describe their symptoms in a detailed way. This decreases the number of interactions in the doctor-patient communication.

Benefits for patients

- This approach facilitates the understanding of when it's necessary to seek care or not. This will help people to avoid unnecessary doctor consultations.
- Through PGHD, the service will bring professional advice customized for the individual. Therefore, the patient will receive correct care in the right time.
- More accessible self-care will make people confident in their own ability to evaluate their state of health.
- The collected health data will bring engagement, responsibility, knowledge and awareness about one's health and eventual improvement areas.
- A service compiling health data may close the digital gap and be perceived as reassuring and trustworthy.
- The patient will always have access to look at their health data.

Relation to current service

- The approach would require extended health profiles compared to the current relatively inadequate profiles.
- The digital health centre is currently developing a feature where likely illnesses based on symptoms and demographics will be presented to the doctors. To also include health parameters, as vital signs, could increase the accuracy of these proposals.

Scalability

- More health parameters and their correlation to illnesses could be further explored and eventually included in the data analysis.
- By continuously developing and refining the diagnostic models, the recommendations and the likely illnesses would play a more important and valuable role. Eventually, even complex cases with diffuse symptoms could benefit from this approach.

- In the long run, potential illnesses could be forecasted based on a person's health data, even before the symptoms have shown. The service could present recommendations of how to best avoid and deal with the coming illness and treatments could be added early on.
- By expanding the health profiles, this could function as a united platform containing all the patient's health data in one place, for all stakeholders to use. Eventually, also other healthcare providers could grant access to this.
- By focusing on enhancing the patients experience when using the health device together with the service, this could potentially change the way people think and act when feeling ill. So instead of using Google or 1177, which are the current approaches for most people, they may turn to the health device.
- The collected health data could be used in research studies.

Challenges

Displaying likely illnesses and giving advice would require extensive data analysis including causal models. Also, more knowledge about correlations between health parameters, symptoms and illnesses is needed. In addition, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale

4.2.5 Opportunity area 4

Using PGHD to support worried parents regarding their sick children.

Related insights

- People want to understand and be able to act on their PGHD. However, most services lack informative explanations and analysis of the data.
- People tracking themselves become more aware and knowledgeable of their health. However, knowing too much may harm the person more than helping.
- The digital platform isn't suitable for all health care cases and the doctors find it quite easy to sort these out. However, it would be beneficial to do this more quickly and earlier in the process.

Fictitious Scenario

When worried about the health of one's child, parents could collect relevant health parameters through a health device customized for children. The data will be displayed in the app and analyzed based on the parent's worries. The app will then give advice, present probable causes, likely illnesses and recommend whether the parent should seek help or not.

Benefits for the digital health centre

- Since the app will be useful for parents before they feel the need to seek care, the app creates an additional application leading to increased usage. Providing a continuous usage may lower the abandonment rate.
- Getting parents to engage in the app will increase the probability that they also will turn to the app when they get sick. Therefore, this approach may result in more paying customers.
- Helping parents to understand when a doctor consultation is needed and not will filter out those who aren't sick enough.
- Getting a momentary view of a child's general health may lead to an increased patient safety.

Benefits for doctors

- Having long-term data and baselines for children will enable the patient to compare sick values with healthy ones. In combination with earlier symptoms, this may help doctors to understand more about the child.
- The objective data will support the understanding of the child and his or her symptoms and disease progression.
- When the parents have seen and reflected on their child's data in beforehand, they are more likely to describe symptoms in a detailed way. This decreases the number of interactions in the communication.

Benefits for parents

- Facilitate the understanding of when it's necessary to seek care and not will help parents to avoid unnecessary doctor consultations. Also, this approach may lower the concerns and worriment.
- Through PGHD, the service will bring professional advice customized for the individual. Therefore, the child will receive correct care in the right time.
- The PGHD will increase awareness and make parents confident in their own ability to evaluate their child's state of health. Also, the data may help parents to correctly remember and describe the child's disease progression to the doctor.
- A service compiling health data may close the digital gap and be perceived as reassuring and trustworthy.
- The parent will always have access to look at their child's health data.

Relation to current service

- The approach would require extended health profiles compared to the current relatively inadequate profiles.
- The digital health centre is currently developing a feature where likely illnesses based on symptoms and demographics will be presented to the doctors. To also include health parameters, as vital signs, could increase the accuracy of these proposals.

Scalability

- More health parameters and their correlation to illnesses could be explored and eventually included in the data analysis.
- By continuously developing and refining the diagnostic models, the recommendations and the likely illnesses would play a more important and valuable role. Eventually, even complex cases with diffuse symptoms could benefit from this approach.
- In the long run, potential illnesses could be forecasted based on a child's health data, even before the symptoms have shown. The service could present recommendations of how to best avoid and deal with the coming illness and treatments could be added early on.
- By expanding the health profile, this could function as a united platform containing all the child's health data at one place, for all stakeholders to use. Eventually, also other healthcare providers could grant access to this.
- By focusing on enhancing the experience when using the home kit together with the service, this could potentially change the way parents think and act when worried about their child's health. So instead of using Google or 1177, which are the current approaches for most parents, they may use the health device and app.

- By including big data, warnings about areas with high risk of catching infections could be presented in the app.
- The collected health data could be used in research studies.

Challenges

Displaying likely illnesses and giving advice would require extensive data analysis including causal models. Also, more knowledge about correlations between health parameters, symptoms and illnesses is needed. In addition, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale

4.2.6 Opportunity area 5

A monitoring service to reduce the risk of getting heritable illnesses.

Related insights

- Being aware of one's health often lead to more engagement and responsibilities regarding state of health.
- People who generally are in good health are less motivated to track themselves.
- Doctors believe the digital platform affects the relation and what's discussed between doctor and patient. However, data may close the digital gap.

Fictitious Scenario

When having heritable illnesses in the family, for example diabetes or cardiovascular disease, the patient can monitor health parameters related to the illness through a health device. By continuous monitoring and having regularly consultations with doctors at the digital health centre, the risk of suffering from the feared disease will be reduced.

Benefits for the digital health centre

- The digital health centre will contribute to proactive healthcare which is of high importance in managing an ageing population. This could be communicated through marketing material to benefit the digital health centre.
- This approach creates an additional application leading to increased usage of the app. Providing a continuous long-term usage to these people may lower the abandonment rate.
- Getting people to engage in the app will gain the probability that they also will turn to the app when they get other illnesses. Therefore, this approach may result in more paying customers.
- Continuous monitoring of people may ease the filtering, so that people not suitable for digital care won't send in cases.

Benefits for doctors

- Having long-term data and baselines for individuals will enable the patient to compare sick values with healthy ones. Consequently, the patient may understand more about the patient and his or her illness.
- The doctor can treat causes instead of symptoms and thereby get a more supportive role in the patient's health. The doctor can also recommend treatments suitable for the individual patient.
- When the patients have reflected on their data in beforehand, they are more likely to describe their symptoms in a detailed way. This decreases the number of interactions in the doctor-patient communication.

Benefits for patients

- Objective data will be strong incentives and thereby motivate the patient to do eventual necessary behavior changes related to the heritable illness.
- Through PGHD, the service will be up to date and bring professional advice customized for the individual on how to avoid the feared heritable disease. Therefore, the patient will receive customized care in advance.
- More accessible self-care will make people confident in their own ability to evaluate their state of health.
- The collected health data will bring engagement, responsibility, knowledge and awareness about one's health and potential improvements.
- A service compiling health data may close the digital gap and be perceived as reassuring and trustworthy.
- The patient will always have access to look at their health data.

Relation to current service

- The approach would require extended health profiles compared to the current relatively inadequate profiles.

- The current service is focusing on short isolated cases. A rising amount of long-term cases would therefore imply a big change, for example concerning workflow for the doctors.
- Proactive care entail a different payment model, for example a subscription.

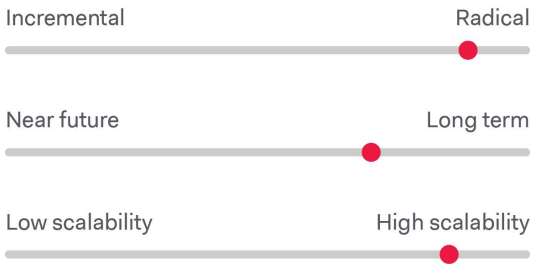
Scalability

- More health parameters and their correlation to heritable diseases could be explored and eventually included in the data analysis. Diabetes and cardiac diseases could be a good start since there already are numerous apps within these areas.
- By continuously developing and refining the causal models, the recommendations on how to avoid the diseases would play a more important and valuable role.
- In the long term, the digital health centre could screen the public to early on find risk groups of people and offer their service to them.
- By expanding the health profile, this could function as a united platform containing all the patient's health data at one place, for all stakeholders to use. Eventually, also other healthcare providers could grant access to this.
- The collected health data could be used in research studies.

Challenges

Analyzing and giving advice based on health data and information about a specific illness would require extensive data analysis including causal models. More knowledge about correlations between health parameters and various heritable diseases is needed. Also, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale



4.2.7 Opportunity area 6

Using PGHD to improve digital physiotherapeutic cases.

Related insights

- Due to the lack of personal interaction and visual cues, doctors sometimes find it hard to understand patients and their symptoms.
- The digital platform isn't suitable for all health care cases and the doctors find it quite easy to sort these out. However, it would be beneficial to do this more quickly and earlier in the process.
- Doctors believe PGHD could give them more insights about their patients. However, depending on phase of the care process, the relevance of different type of data may change.

Fictitious Scenario

When consulting a physiotherapist, the patient import data that they have collected continuously through a health device, such as activity level, basic condition, body composition, sleep patterns, restrictions in movements and pulse related to activity. By analyzing the data, the patient is given an individual treatment plan and the physiotherapist can easily monitor the compliance and make adjustments.

Benefits for the digital health centre

- Improving the physiotherapy care may lead to an increased amount of cases within this field. Therefore, this approach could bring in more customers.
- Since physiotherapy often results in long-term cases this approach may rise the continuous usage and reduce the abandonment rate.
- Getting a momentary view of a person's general health may lead to an increased patient safety.

Benefits for doctors

- Having access to the above-mentioned parameters may bring more details to the anamnesis. This could help the physiotherapist to understand more about the patient and to figure out what causes the pains.
- The health data may help the physiotherapist to decide on exercises and other treatments suitable for the individual patient.
- The activity level and movement data could support the physiotherapist in supervising the treatment compliance and moreover customize the exercises based on the patient's conditions and needs.
- The data will also present objective results and clearly state the patients progress over time. In this way, the physiotherapist will have more transparency in the patient's development.

- When the patients have reflected on their data in beforehand, they are more likely to describe their symptoms in a detailed way. This decreases the number of interactions in the communication between the physiotherapist and the patient.

Benefits for patients

- Through PGHD, the treatment will be customized for the individual and his or her conditions. Therefore, the patient will get the right care.
- If the recommended exercises are conducted wrongly, the data could help the physiotherapist to discover this and give additional instructions. This will favor the patient to correctly follow the treatment plan.
- Since many treatments within physiotherapy need to be carried through in a long term, it can be difficult to motivate oneself. Seeing objective results may engage the patient to continue following the treatment plan.
- The collected health data will bring engagement, responsibility, knowledge and awareness about one's health and potential improvements.
- A service compiling health data may close the digital gap and be perceived as reassuring and trustworthy.
- The patient will always have access to look at their health data.

Relation to current service

- The approach would require extended health profiles compared to the current relatively inadequate profiles.
- The physiotherapy care is currently a quite small share of the total amount of cases. Improving this area would require great investments in physiotherapists.
- The current service is focusing on short isolated cases. A rising amount of long-term cases would therefore imply a big change.

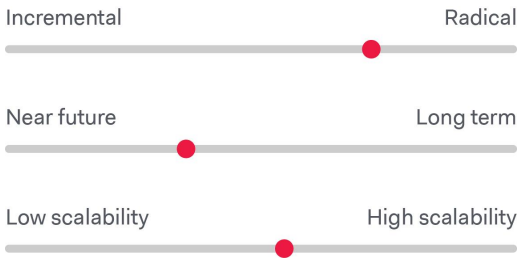
Scalability

- More health parameters and their correlation to pain and causes could be explored. Eventually they could be included in the data analysis so that more physiotherapeutic cases could be suitable for digital care.
- When more advanced devices are released, the ability to treat cases within physiotherapy will rise. For example, regarding analysis of movements.
- In the long run, potential risks could be forecasted based on a person's health data, even before the symptoms have shown. The service could present recommendations of how to best avoid and deal with the coming pains and treatments could be added early on.
- By expanding the health profile, this could function as a united platform containing all the patient's health data at one place, for all stakeholders to use. Eventually, also other healthcare providers could grant access to this.
- The collected health data could be used in research studies.

Challenges

Sorting through and displaying relevant information, such as deviations and possible conjunctions, to the physiotherapists would require extensive data analysis including causal models. More knowledge about correlations between health parameters, symptoms and illnesses is also needed. Also, more CHDs need to meet CE-certification Class II or better to be used in diagnostics.

Evaluation scale



4.2.8 Evaluation of Opportunity areas

The opportunity areas considered to have the most valuable effect for the digital health centre and its users, were number 1, 2 and 3.

- *Opportunity area 1:*
  "Using PGHD to compensate for missing visual cues in the initial understanding of patients and their condition"
- *Opportunity area 2:*
  "Ease and sharpen the awaiting and treatment process, so doctors can monitor patient's illness progression."
- *Opportunity area 3:*
  "A service for self-diagnostics and advice for people to treat and understand themselves better."

Number 1 and 2 may bring the most impact on the doctor's workflow and will benefit the care quality. These concepts are also quite close related to the current service. Furthermore, for the digital health centre to see the potential of CHD, opportunity areas 1 and 2 were believed to spark the stakeholder's interest and enthusiasm the most. Opportunity area number 3 is directed towards the current customer group of the digital health centre and is believed to fit well into the current service. Furthermore, this concept has a high scalability but could also be implemented bit by bit.

Comparison of all evaluation scales

All the evaluation scales are combined, in Figure 4.3, to ease the comparison between the opportunity areas. Each opportunity area is marked by their number.

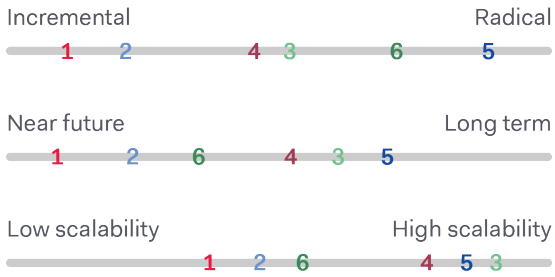


Figure 4.3 Combination of all evaluation scales.

4.3 Focus area

In the following section, opportunity areas 1, 2 and 3 were combined and further developed into one focus area. To do this, various use case diagrams were created. Since use case diagrams tend to be on an abstract higher-level view, two personas, a specific medical scenario, and a fictitious connected health device were first developed.

4.3.1 Persona

A persona is a fictitious identity of a user group, often based on user research so that they possess frequent emerging personal attributes, needs, motivations, expectations and goals etc. (U.S. Department of health & Human Services, 2017). One patient, Stina, and one doctor, Martin, were established. Stina and Martin were based on user interviews made during the earlier user research so that they possess frequent emerging personal attributes, needs, motivations, expectations and goals etc.

Stina

This is Stina. She is 30 years old and lives a busy life. Stina is generally in good health, with occasional colds and minor illnesses now and then. Stina has a holistic view of health and aims for being healthy in the long run.

Stina has tried *the digital health centre* a couple of times and enjoys the quick and convenient service. A few months ago, Stina started a subscription at *the digital health centre*, where she, for a small fee, received a health device (see section 4.3.3) Since getting the health device, Stina has measured her parameters once or twice per month.

Martin

Martin is 45 years old and works as a doctor at a hospital. Alongside this, he works at *the digital health centre*, mainly during gaps in his regular work schedule, in the evenings and on the weekends.

Martin started at *the digital health centre* since he was fond of digital technologies and intrigued by the new way of working. He enjoys the work freedom that comes with *the digital health centre*.

4.3.2 Medical scenario

In order to create use case diagrams, a medical scenario was created. This helped the project team to be more specific in their ideas. However, it's important to point out that the illness itself not was in focus. Tonsillitis was perceived as a suitable medical scenario since it could benefit from PGHD and is treated at the digital health centre.

Tonsillitis is a viral or bacterial infection in the tonsils (1177 Vårdguiden, 2015). Common symptoms are a sore throat, swollen lymph glands, pain while swallowing and fever. Cough and runny nose are normally absent. Most cases of tonsillitis are viral and the infection self-heal, without antibiotics. However, when the infection is bacterial, often cause by the streptococcus bacteria, it can be treated with antibiotics to reduce the duration of the illness.

Tonsillitis is quite easy to diagnose but it can be difficult to determine whether it is caused by virus or bacteria. There are four significant symptoms indicating the infection to be bacterial; white spots on tonsils, tender and swollen lymph glands, fever above 38,5°C and absence of cough. If three or more of these are present, the patient does a test, called strep-A, to verify whether bacteria are present or not. However, it's possible that dead bacteria exist on the tonsils and there it's only validated to do a Strep-A-test if it is reason to believe that the infection is caused by bacteria.

4.3.3 Connected health device used in the focus area

Vital signs were considered the most useful PGHD because of the wide variety of application compared to data from activity and blood-samples. Also, the market maturity of connected vital signs monitor is higher compared to the others. Vital signs are especially helpful in the medical scenario (see section 4.3.2) since it can be used throughout the course of the disease.

To gather vital signs data, one single device or multiple devices can be used for measurements. As described in chapter, 3 Discover, it is possible to compile a kit of medically certified devices that measure all vital signs. Furthermore, multi-parameter devices are under development. Consequently, it is likely that a medically certified multi-parameter device is available in a near future. A fictitious device measuring body temperature, pulse, blood oxygen saturation, blood pressure and breathing rate, will therefore be used in the next chapter, 6 Develop. Based on our research one single device is preferable for easing the usage. An additional benefit of choosing one single device is that context of the measurements can be defined to a restful home environment and thereby will it be easier to verify the measurements for doctors.
The fictitious device is from now on referred to as *the health device* and is visualized in Figure 4.4. The health device is assumed to be available to buy from the digital health centre, at a highly-subsidized price or through a subscription.

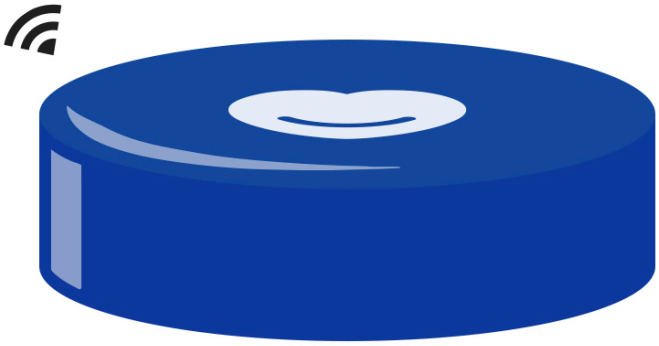


Figure 4.4 Visualization of the fictitious health device.

4.3.4 Use case diagrams

Use case diagrams visually narrate the interactions between a user and a system by listing possible actions and showing their relation to each other (U.S. Department of health & Human Services, 2017). The use case diagrams included the two users, Stina and Martin, see Figure 4.5 and Figure 4.6, and their potential interactions regarding the specified medical scenario. The service whereby the interactions occurred was notional and had no details more than extracted key points from the three opportunity areas.

The final use case diagram contained overall sequences of actions and interactions from both user perspectives, see Figure 4.7. In addition, it identified individual steps of where PGHD could be included to benefit the users. Thus, it served as a design brief for the following concept development phase.

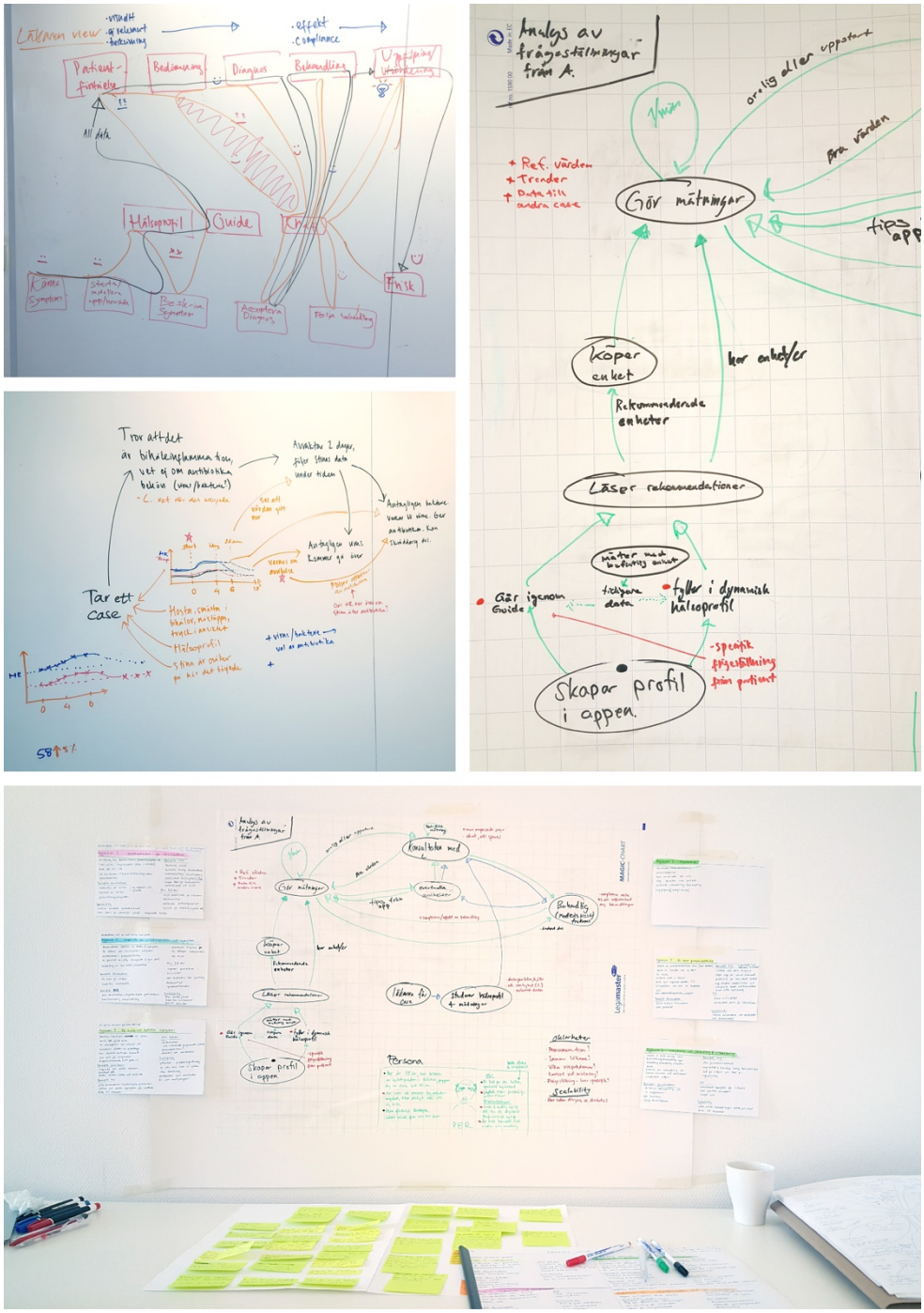


Figure 4.5 The created use case diagrams with actions

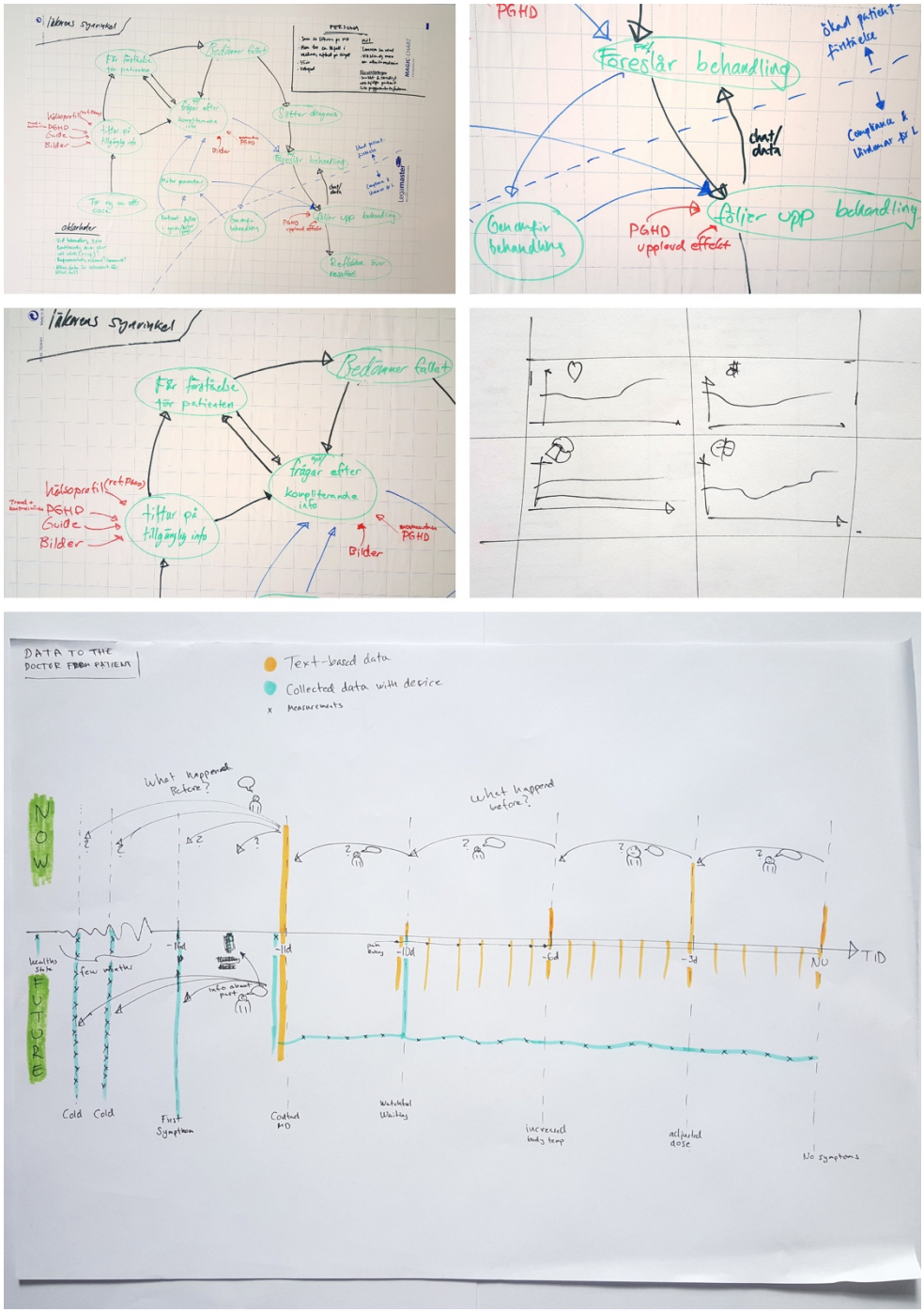


Figure 4.6 The created use case diagrams further detailed

Use case diagram - Patients

1. Approach service
   1. Reflect upon condition
   2. Decide to seek help
   3. Log in to app

2. Seek help
   1. Describe health problem
   2. Update health profile
   3. Send in case

3. Get treatment
   1. Take eventual lab test
   2. Communicate with doctor
   3. Get diagnosed
   4. Receive treatment
   5. Get eventual prescription

4. Recover
   1. Follow treatment
   2. Take eventual drugs
   3. Eventual follow up

Use case diagram - Doctors

1. Take case
   1. Register as online
   2. Look through case
   3. Evaluate case
   4. Accept case

2. Understand health problem
   1. Review answers
   2. Ask further questions
   3. Make eventual video call
   4. Support eventual lab test

3. Diagnose patient
   1. Process findings
   2. Propose treatment
   3. Prescribe drugs

4. Follow up
   1. Review illness progression
   2. Evaluate treatment
   3. Close case

Figure 4.7 Use case diagrams for patients and doctors. Highlighted steps could be improved with PGHD.

5 Develop

In the Develop phase, the project team turned the focus area into numerous tangible ideas with the objective to create a user scenario in the form of a storyboard with a few user interfaces. Three major iterations were carried through (the third is found in chapter 6 Deliver) and every iteration improved the concept by constantly refining and evaluating it.

5.1 Methods

5.1.1 How-might-we questions

Questions following the format "How might we…?". They help turning challenges into opportunities and they are a good basis for brainstorming sessions since they suggest that a solution is possible (Design Kit, 2017).

5.1.2 Customer Journey Map

A Customer Journey Map visually explains the overall story from a user's point of view (Design Kit, 2017). It usually expresses emotions, channels, and touchpoints with the specific service or product over time. Customer Journey Maps are often used as a communication tool across stakeholders.

5.1.3 Storyboard

Storyboards function as narratives illustrating concepts as real-life stories (Design Kit, 2017). A storyboard could consist of everything from rough sketches to neat images, where a visual sequence of events depictures the user's interactions with the product, like a comic strip.

5.1.4 Low fidelity UI's

A low fidelity UI function as a quick and simplified prototype of a user interface (U.S. Department of health & Human Services, 2017). It enables exploring, discussing and evaluating ideas before investing in development.

5.2 Outline of iterations

Three main iterations were carried through (the third is found in chapter, *6 Deliver*).

Iteration 1:

Explored how to use and include PGHD in the earlier identified steps and refine the user's touchpoints within the service.

Iteration 2

Specified the user's actions and interactions and plotted the desired emotions and benefits towards these.

Iteration 3

Refined the overall user experience and validated the pinpointed emotions and benefits.

5.3 Iteration 1

5.3.1 Goal

The objective of iteration 1 was to explore how to use and include PGHD in the earlier identified steps and refine the user's touchpoints within the service.

5.3.2 Process

Based on the identified steps where PGHD could be of value, a couple of How-might-we questions were created. Examples include:

- How might we help people to know more about their condition.
- How might we help doctors to understand their patients better.
- How might we enable doctors to use PGHD in diagnoses or

treatments.

- How might we enable doctors to use PGHD during the awaiting process.

The How-might-we questions served as basis for generating ideas, mostly in the form of user scenarios and quick graphical user interfaces, see Figure 5.1.

5.3.3 Evaluation

In this iteration, evaluation was conducted through internal discussions within the project group and with the supervisor at the digital health centre. The evaluation consisted of finding the most promising ideas and analyzing whether they were believed to meet the listed benefits from the chosen opportunity areas or not.

5.3.4 Revision

The chosen ideas were revised, combined and plotted against the earlier use case diagram seen in Figure 4.5, to create the Customer Journey Map in Figure 5.2. The timeline spans from the moment Stina gets ill, seeks help through the digital health centre, gets treated by Martin to when she eventually feels well again. The map covers the user experience from two perspectives, Martin and Stina, but with the main focus on Martin.

The green post-its include touchpoints of actions and interactions between the users, Martin and Stina respectively, and the service. Furthermore, they describe the channels through rough graphical user interfaces. The pink and yellow post-its contain desired user emotions and the acknowledged user benefits for each sequence of actions, see Figure 5.2 and Figure 5.3.

To further develop the user experience and use the Customer Journey Map as a communication tool with stakeholders, it needed to be more specific and on a lower-level view. This was done during the following iteration.

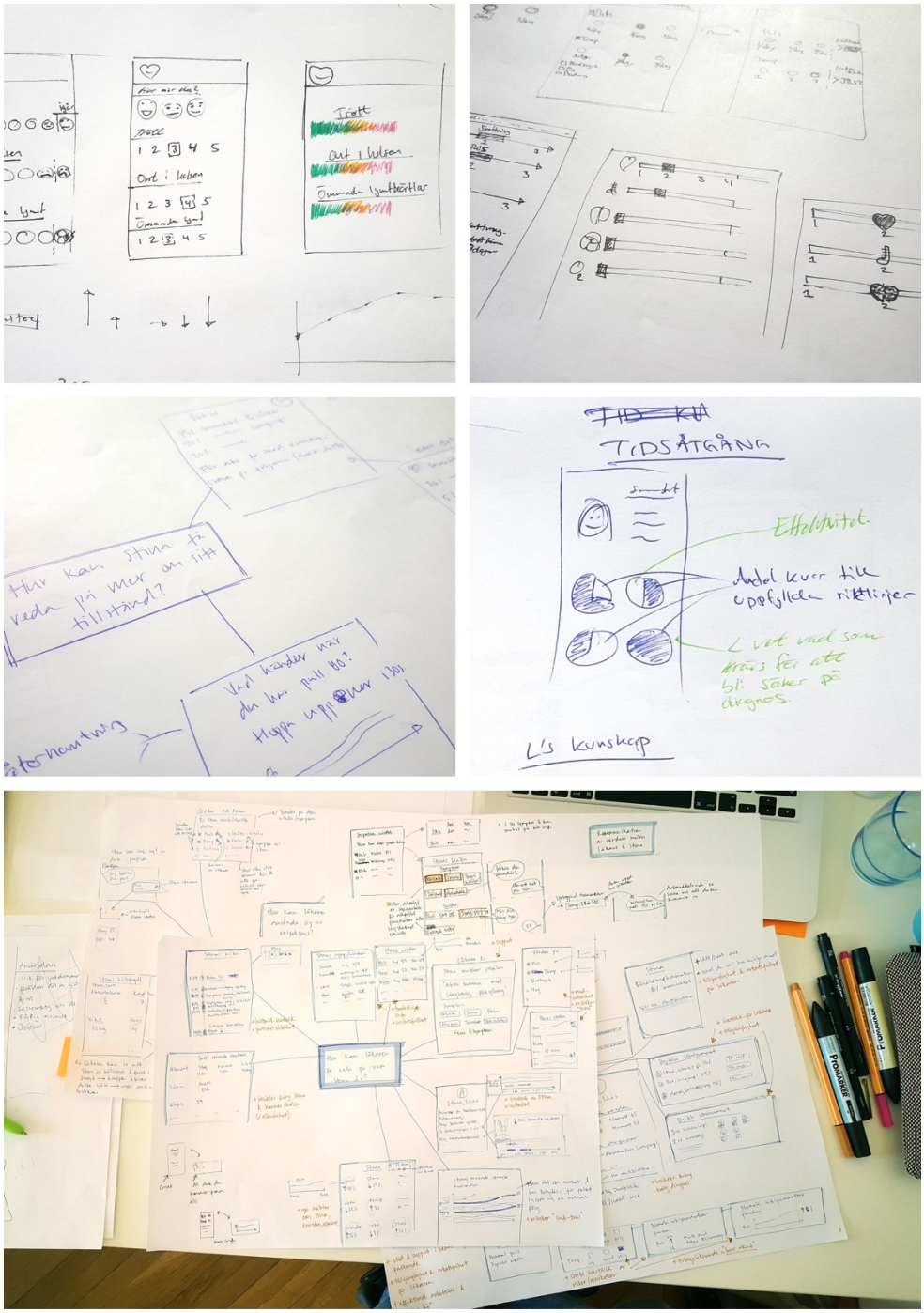


Figure 5.1 Papers filled with ideas for user scenarios and UI's

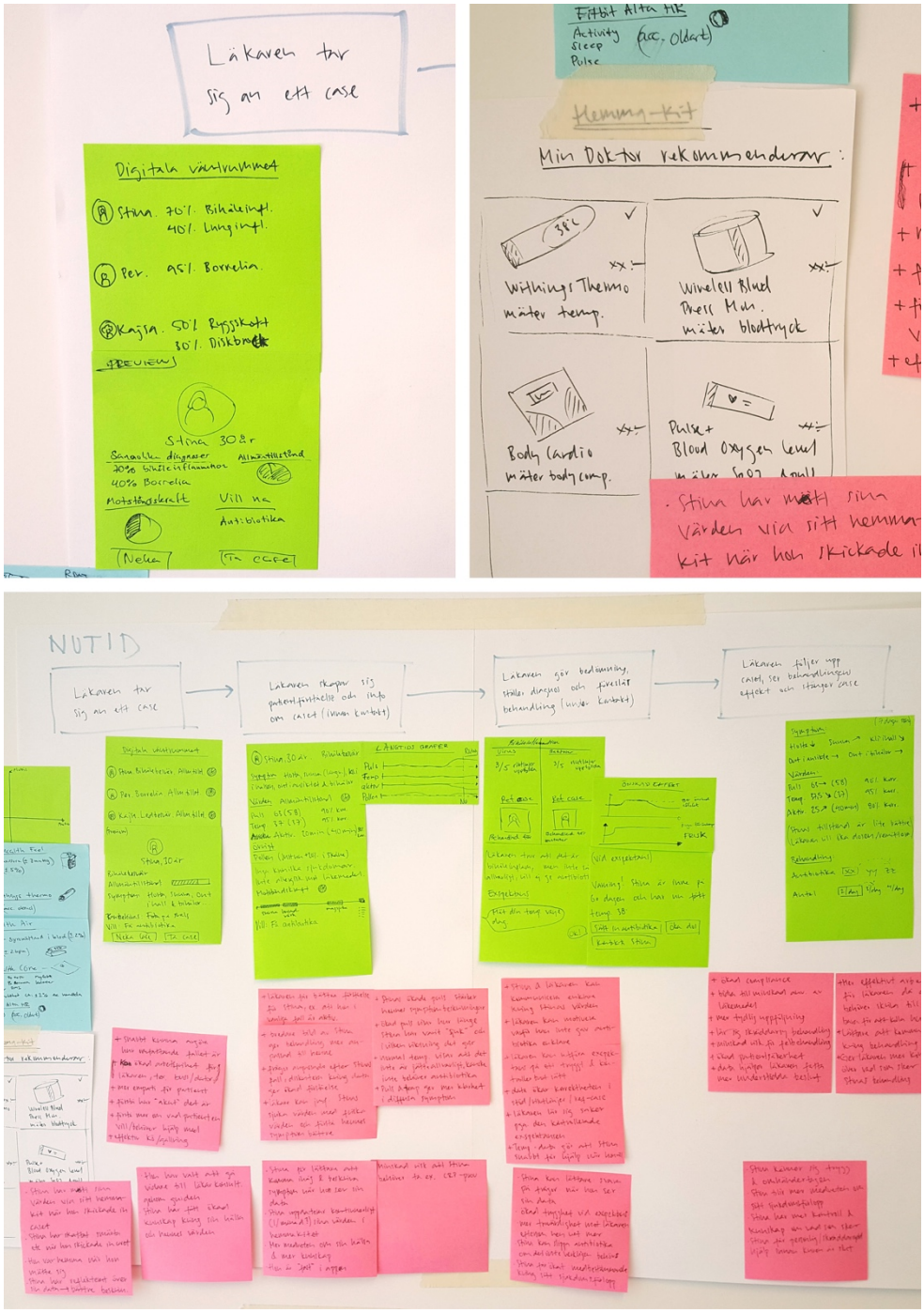


Figure 5.2 Customer Journey Map with focus on Martin's perspective.

Figure 5.3 Detailed pictures of the Customer Journey Map.

5.4 Iteration 2

5.4.1 Goal

Iteration 2 aimed at specifying the user's actions and interactions and plot the desired emotions and benefits towards these.

5.4.2 Process

Based on the Customer Journey Map in Figure 5.2, multiple storyboards were created, see Figure 5.4. The main focus was to specify the actions and interactions and to involve the user's emotions and benefits into one single story. The storyboards were refined until deciding on one that was good enough for evaluation.

5.4.3 Evaluation

The storyboard in Figure 5.5, was shown to various stakeholders at the digital health centre. The objective was to explore what people interpreted and test whether the touchpoints, emotions and user benefits were clear enough.

5.4.4 Revision

The storyboard was subsequently updated, see Figure 5.5, all along the evaluation process as concerns, misunderstandings and questions were expressed.

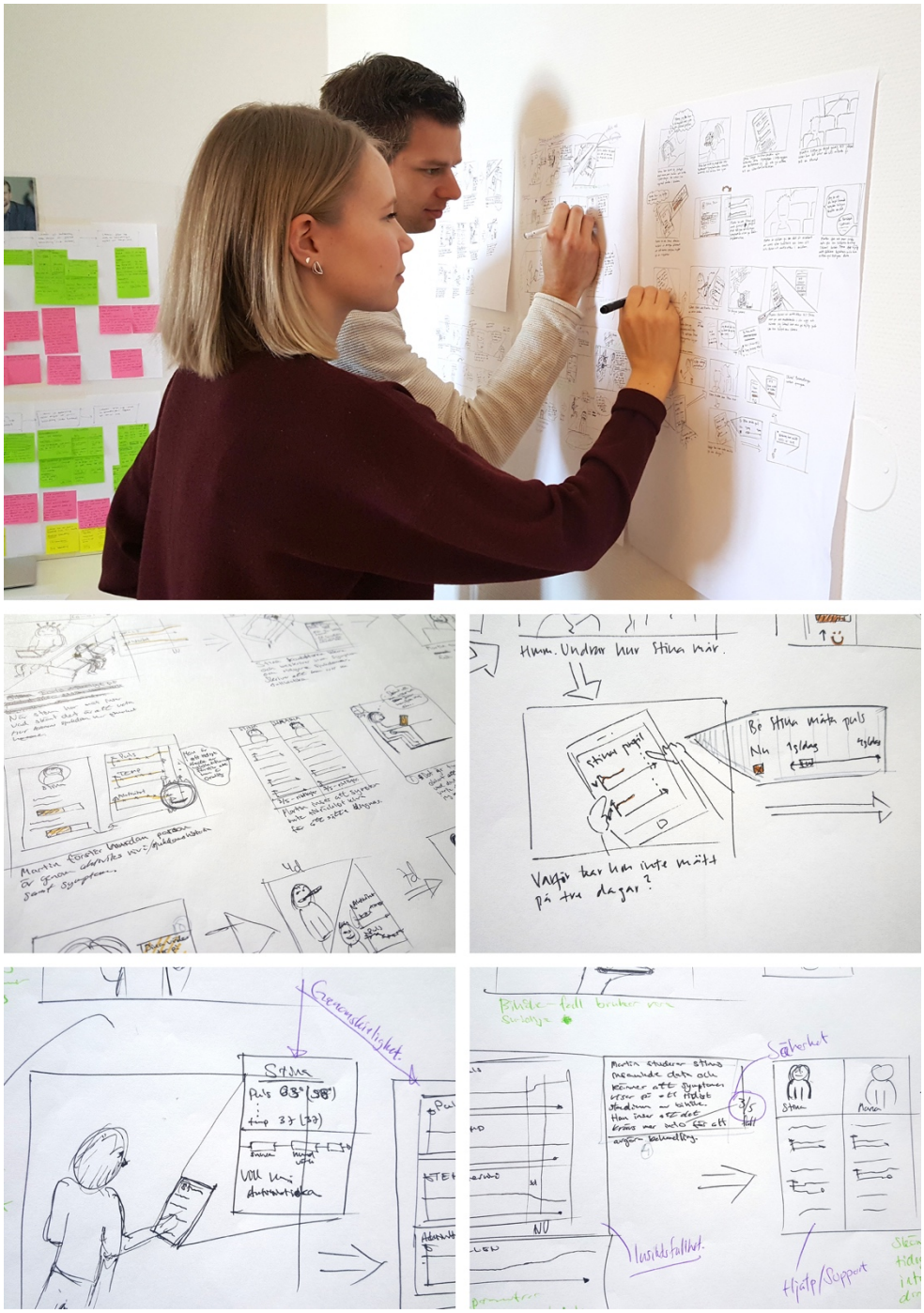


Figure 5.4 The first iteration storyboards.

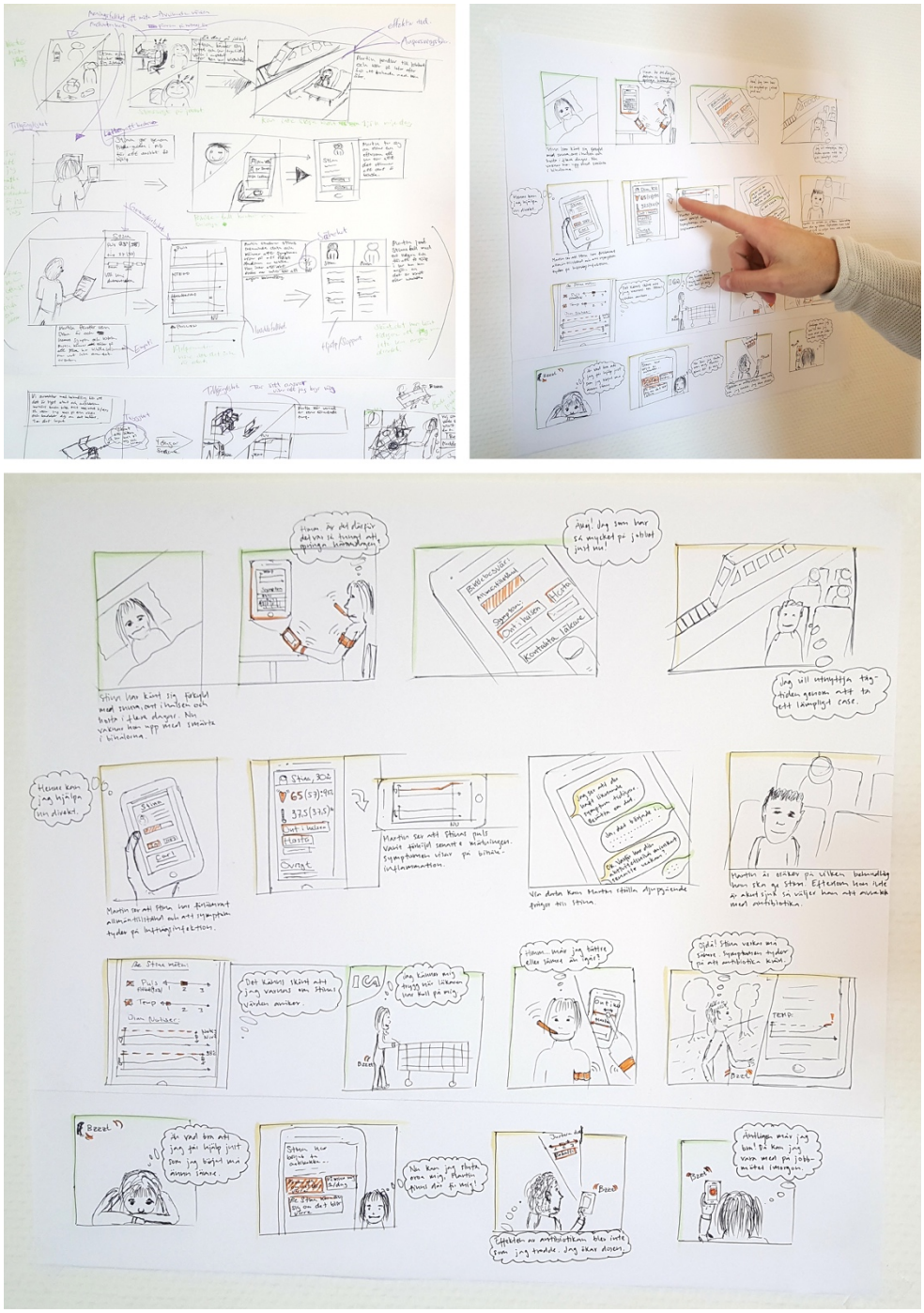


Figure 5.5 Top: Updating process of the storyboard. Bottom: The storyboard used for evaluation.

6 Deliver

During the Deliver phase, a third iteration was carried through narrowing down the ideas to one final concept. The final concept is presented through a storyboard focusing on user experience and benefits, thus covering the third and fourth research questions.

6.1 Methods

This phase utilized the already described methods Storyboard and Low fidelity UI's. For more information, see section *5.1.1 Methods*.

6.2 Iteration 3

6.2.1 Goal

The objective of iteration 3 was to refine the overall user experience and validate the pinpointed emotions and benefits.

6.2.2 Process

Based on the updated storyboard in Figure 5.5, simplified lo-fi screens were created. The screens, see Figure 6.1, contained various ideas and aspects of the user experience. They were believed to enable deeper discussions about specific touchpoints and channels. To not risk end up discussing details in the graphical user interfaces, the screens were designed with minimal visual elements.

Figure 6.1 The created simplified lo-fi screens and storyboard used as discussion material.

6.2.3 Evaluation

In this iteration, evaluation was conducted through discussions based on the storyboard made in iteration 2 and the lo-fi screens, see Figure 6.2. The discussions took place with one person within data analysis working at the digital health centre, two stakeholders medically responsible at the digital health centre and one treating doctor working for the digital health centre. In addition, the concept was further evaluated by several people in the roles of patients.

One example of an aspect that was discussed during the evaluation was the idea of displaying Stina's likely illnesses to Stina and Martin. From a data analysis point of view, this idea will be possible and feasible in a near future. However, it would require extensive data analysis including causal models, and more knowledge about correlations between health parameters, symptoms and illnesses.

Regarding the medical perspective, it may bring new possibilities for the doctors, for example concerning the diagnostic procedure and the workflow. However, it risks violating the doctor's ability and be perceived as offensive. Furthermore, the doctors still want to see the underlying data and they want to have the system fully validated. From a patient point of view, this feature was interpreted as comfortable and convenient as it may help the patient in deciding on whether they need to seek care or not. Combining all these thoughts, this feature has great potential but must be applied with caution.

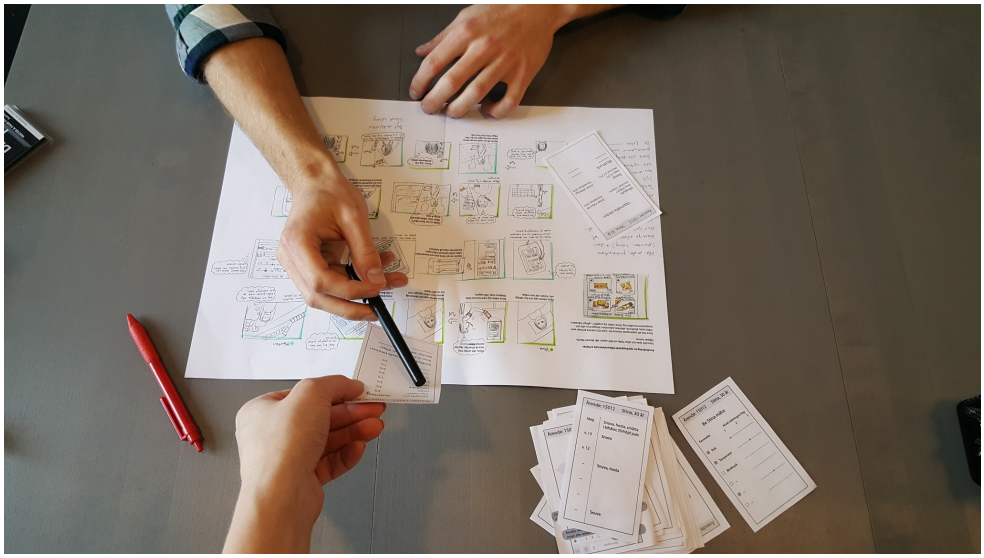


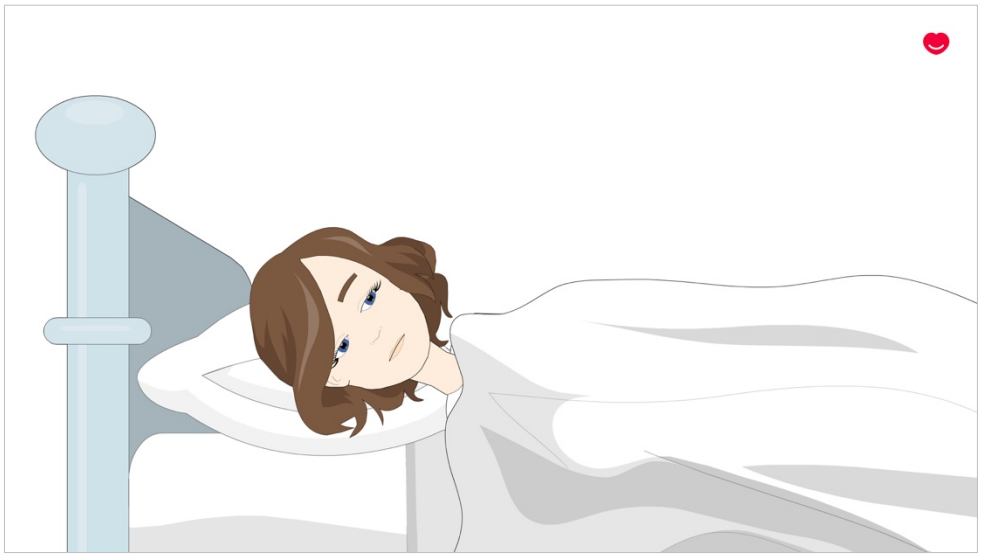
Figure 6.2 Evaluation of the storyboard and the simplified UI's

6.2.4 Revision

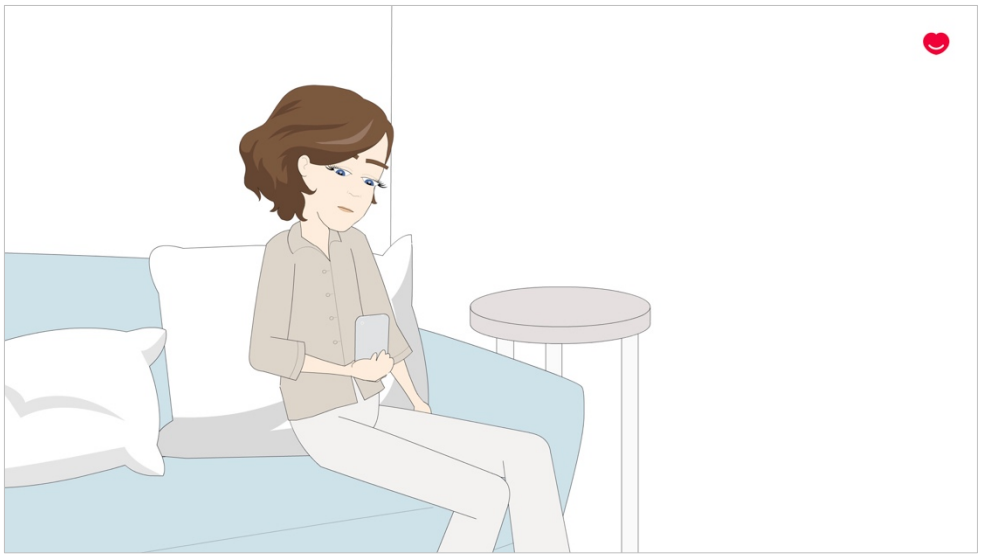
Based on the evaluation, the storyboard was updated. Furthermore, some of the low fidelity screens were refined and applied to the concept. The final version of the concept is presented in the next section, *6.3 final concept*.

6.3 Final user scenario

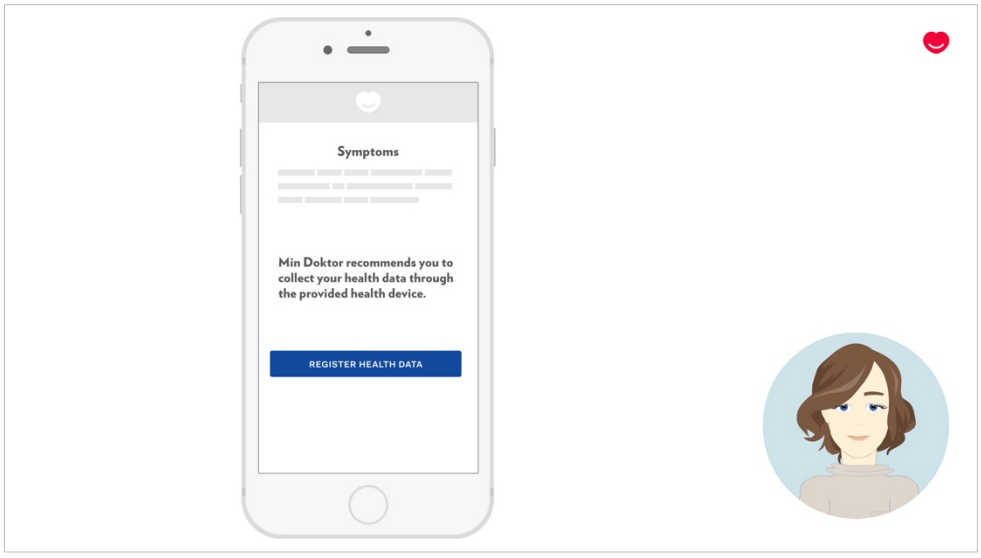
In this section, the final user scenario is presented in 26 pictures with accompanied descriptions. The user scenario follows Stina's and Martin's actions, emotions and thoughts throughout the course of Stina's disease (tonsillitis).



Stina wakes up and is not feeling well. She is warm and more tired than usual. She is also experiencing a sore throat and tender swollen glands.

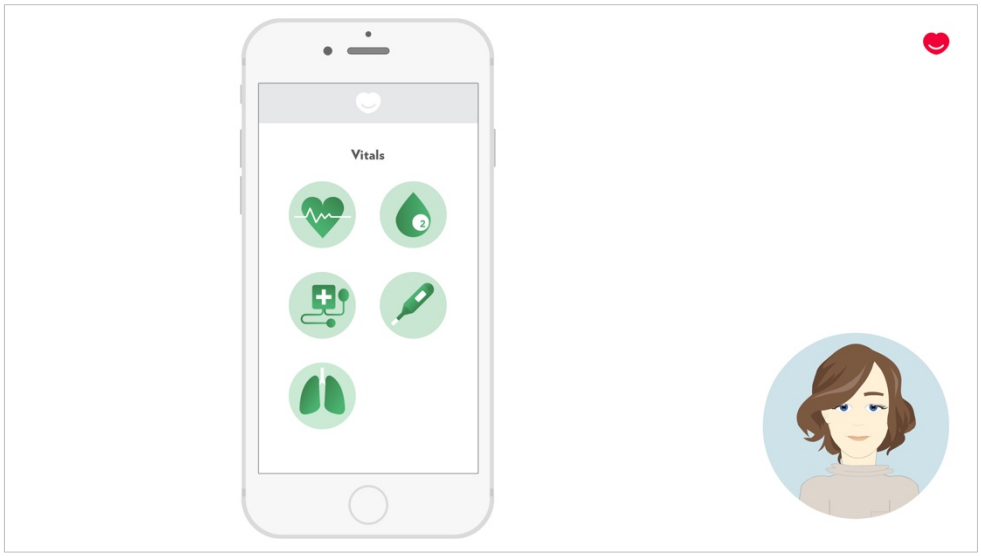


Stina wants help to determine what to do. Therefore, she turns to the app for professional self-care. She describes her symptoms and answers questions about her state of health.

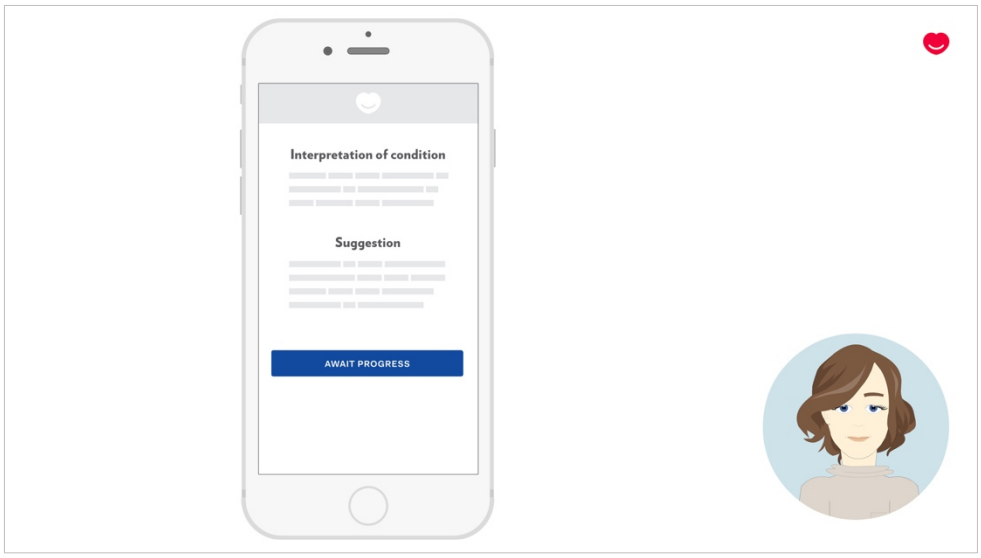


To give Stina as adequate help as possible, the app asks Stina to use her health device to register her current vitals.

Stina finds it meaningful to measure since she knows that she will get objective data to reflect upon.

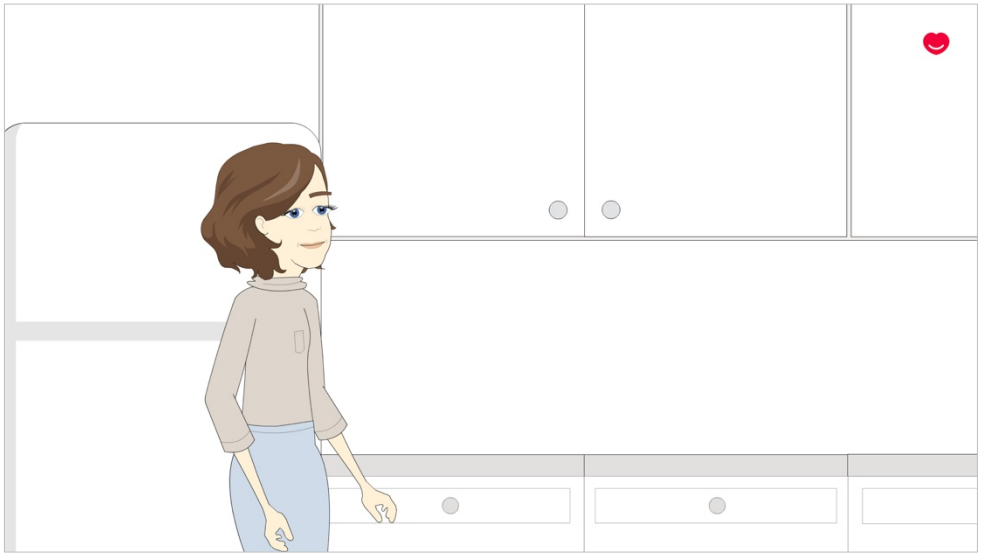


Stina feels calm when she perceives that her vitals are within her normal range, implying that her overall health is stable.

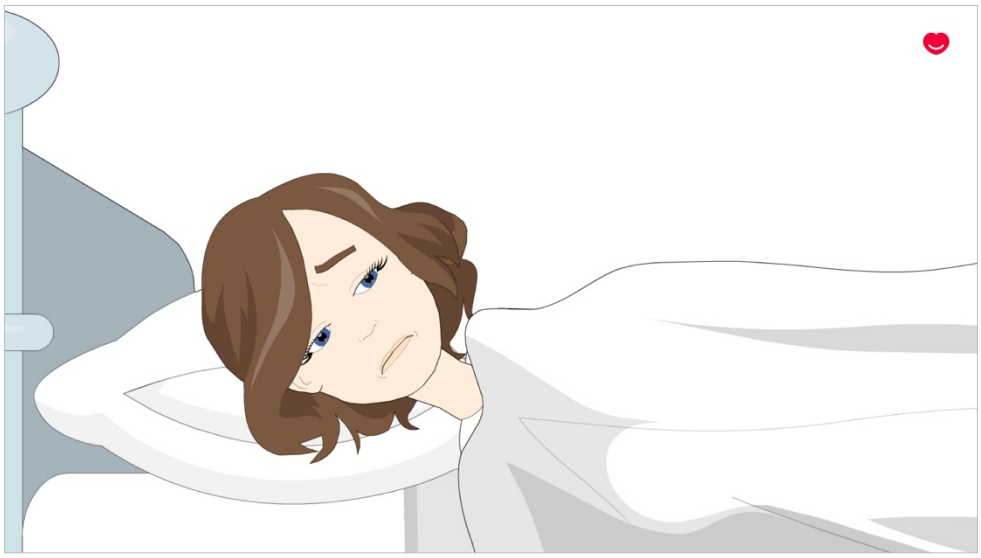


Through artificial intelligence, the app analyzes the described symptoms and measured parameters. The interpretation shows that Stina probably has a throat infection.

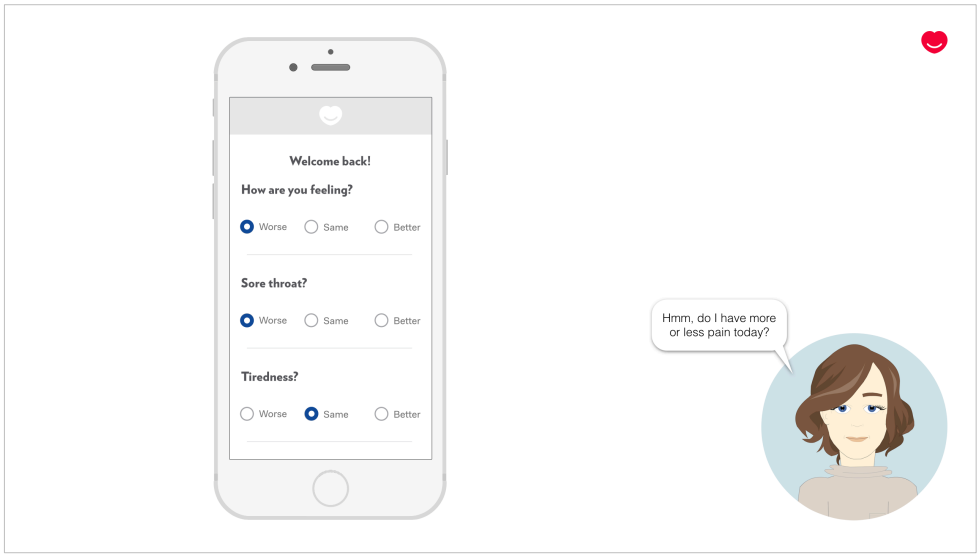
Stina is reassured by knowing that her parameters are close to her healthy ones. Therefore, she follows the app's recommendations to wait and see if the infection heals out by itself, which the app says they often do. To further help Stina, the app presents ways to sooth the symptoms.



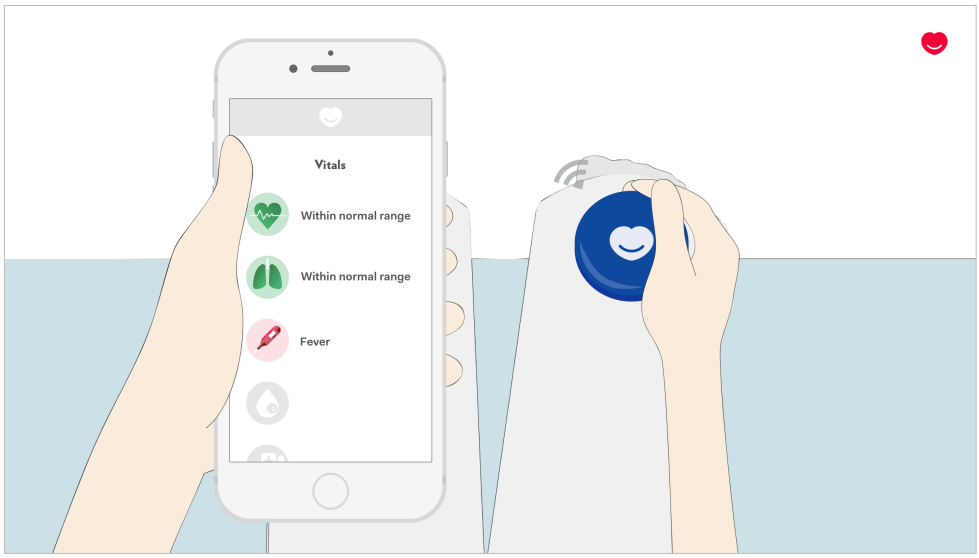
Stina feels confident in managing her condition by herself since she knows when and where to seek further assistance if it gets worse.



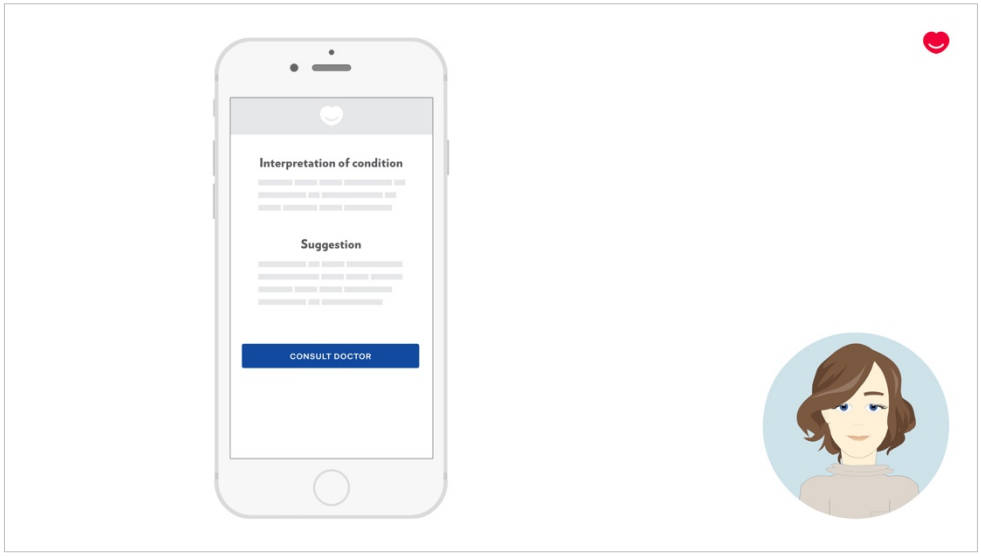
Next day: Stina wakes up the following day with more pain than the day before. She turns to the app to get help.



Stina indicates whether her symptoms have worsened or not compared to the day before. Based on this, the app recommends her to update her vitals.



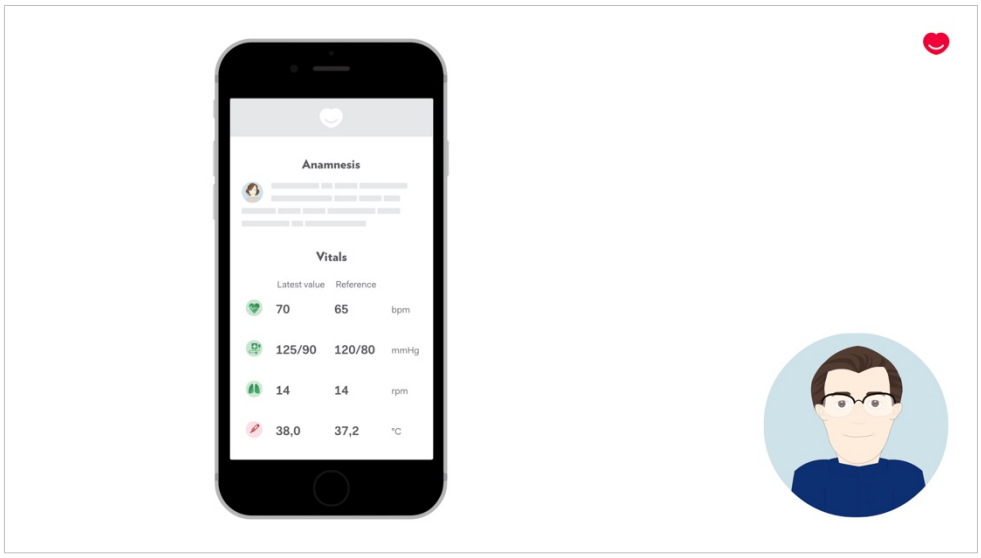
Stina sees that the health data confirm her feelings of getting worse.



Stina is worried by the rapid illness progression acknowledged by the app. She follows the recommendation to consult a doctor.

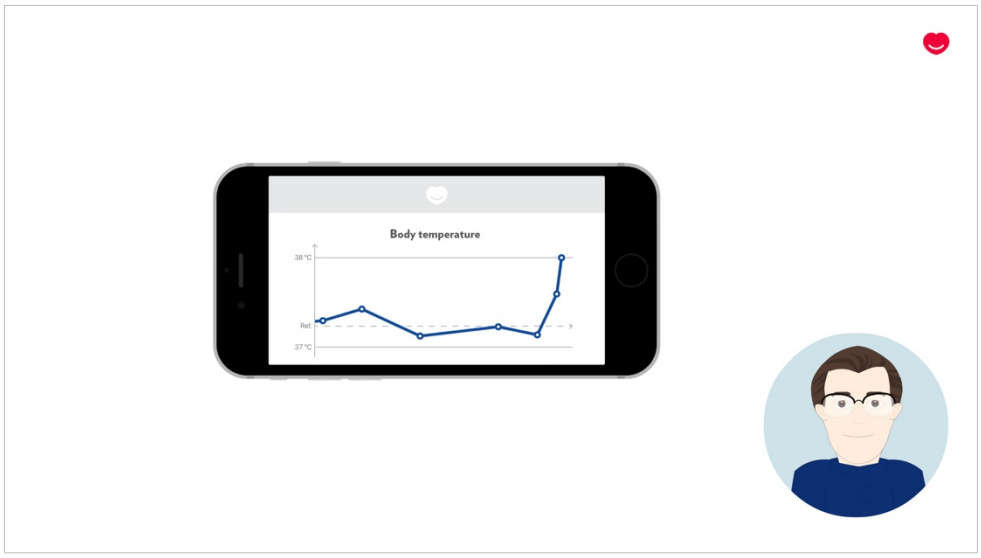
The same morning, Martin is commuting to work and he wants to make use of the time by taking a case at the digital health centre.

Martin sees that tonsillitis is indicated as the most probable diagnosis. He quickly realizes what Stina requires and expects from him.

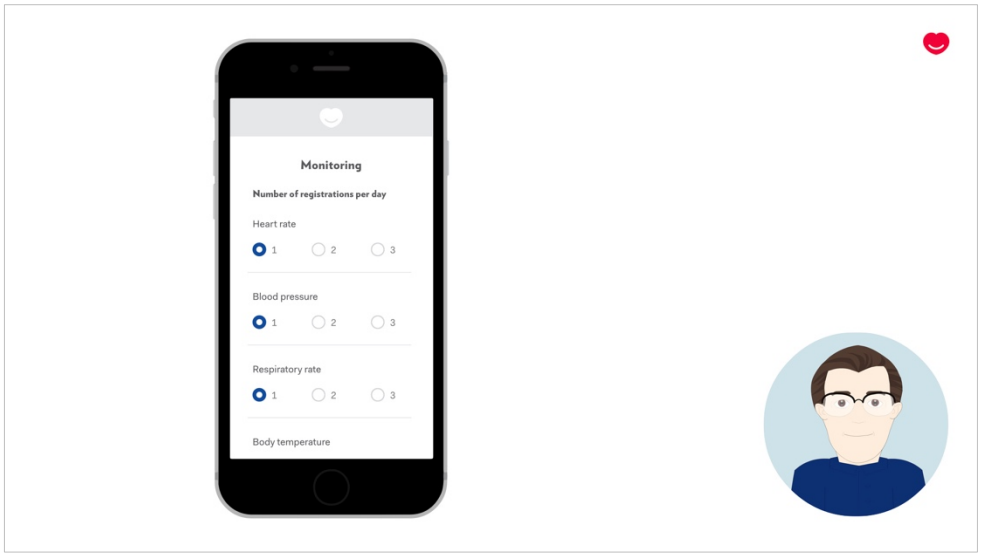


By looking through Stina's case, Martin directly notices that the symptoms and increased body temperature confirm the presented diagnosis. He feels reassured by the other vitals, that are close to Stina's healthy ones, implying that her overall health is stable.

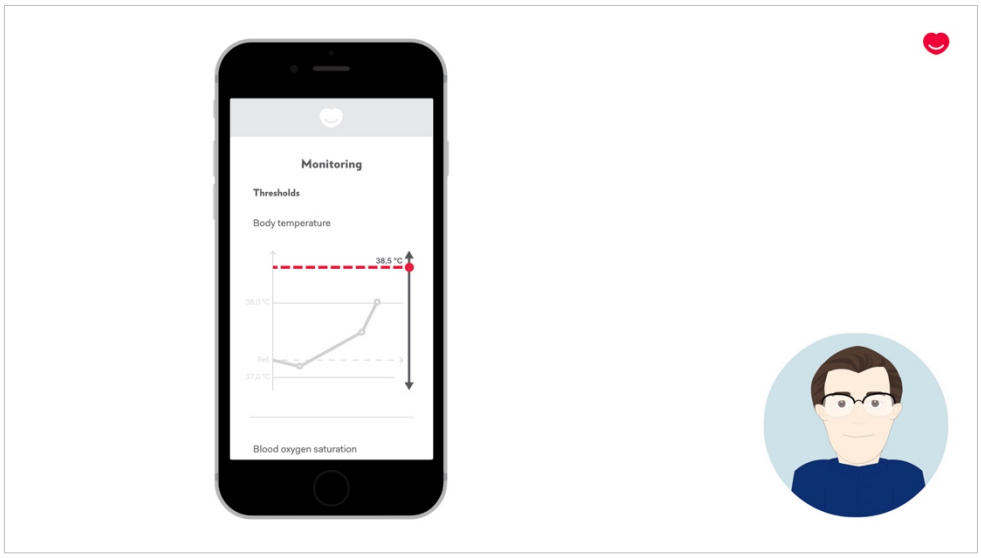
Martin wants to give Stina the right treatment. To do this, he needs to investigate whether the infection is caused by bacteria or virus. Because, bacterial infections may require antibiotics while viral heal out by themselves.



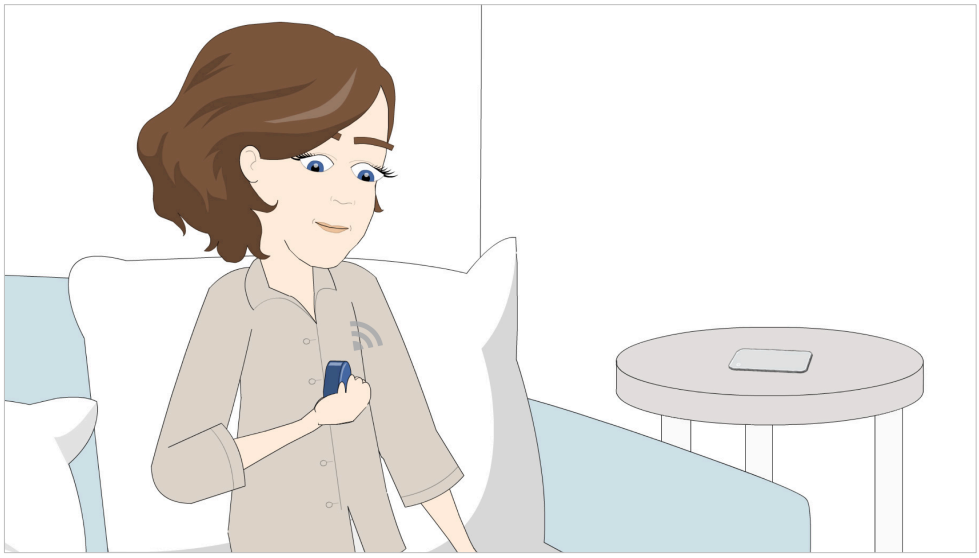
By looking at the trend of Stina's body temperature, Martin believes the infection to be viral. But due to the short course of the disease, Martin isn't sure.



Therefore, Martin wants to see how Stina's illness progresses through a secure and controlled monitoring process where Stina continuously measures her vitals. Martin glances through the pre-set options for the recommended number of registrations, and confirms.

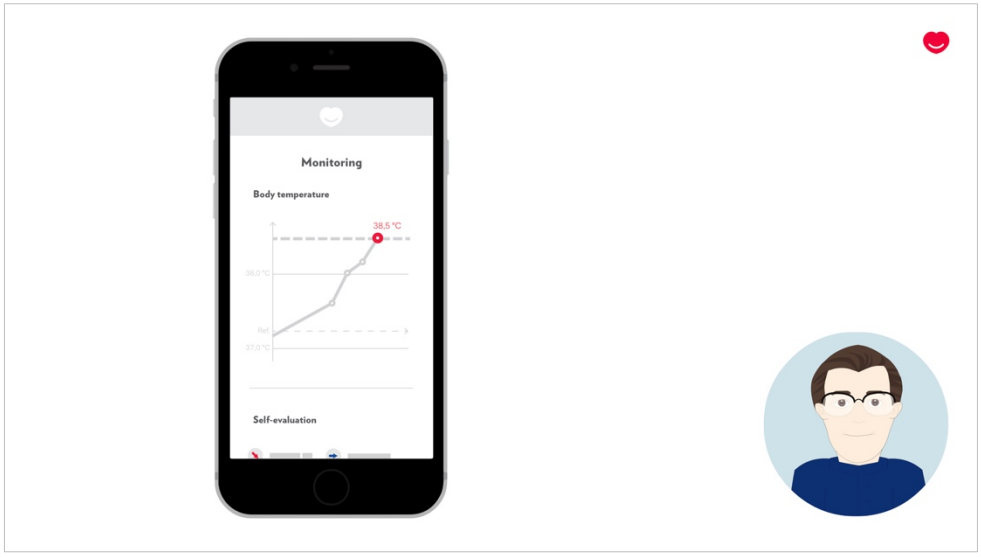


To lower his mental load and only engage in the case when needed, Martin chooses to get notified if Stina's values deviate. He looks at Stina's body temperature and confirms to be informed if it rises above the specified cut off value.



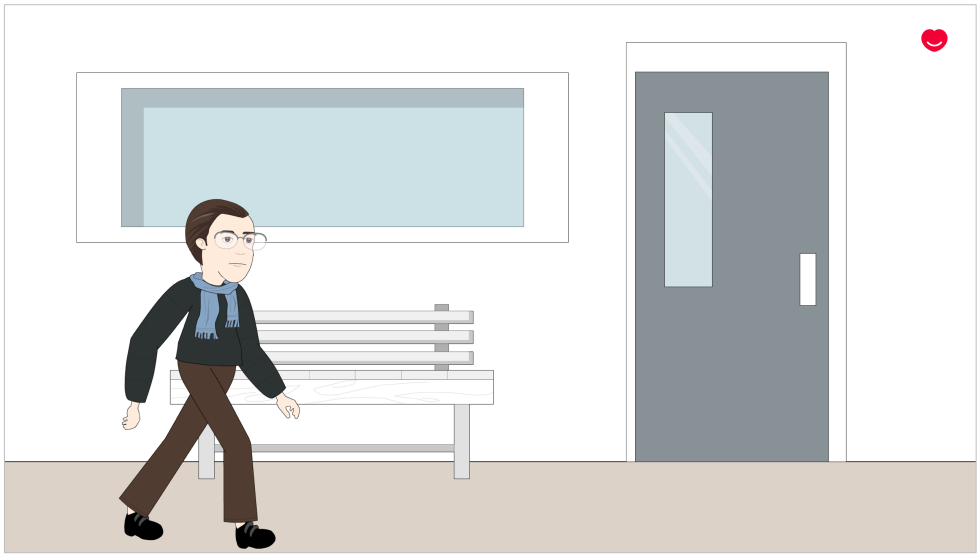
Next day: Just as Martin proposed, Stina tracks her vitals continuously. At the same time, she reviews and reflects about her health data which gives her a deeper understanding about her illness progression.

Later that day, Martin receives a notification.

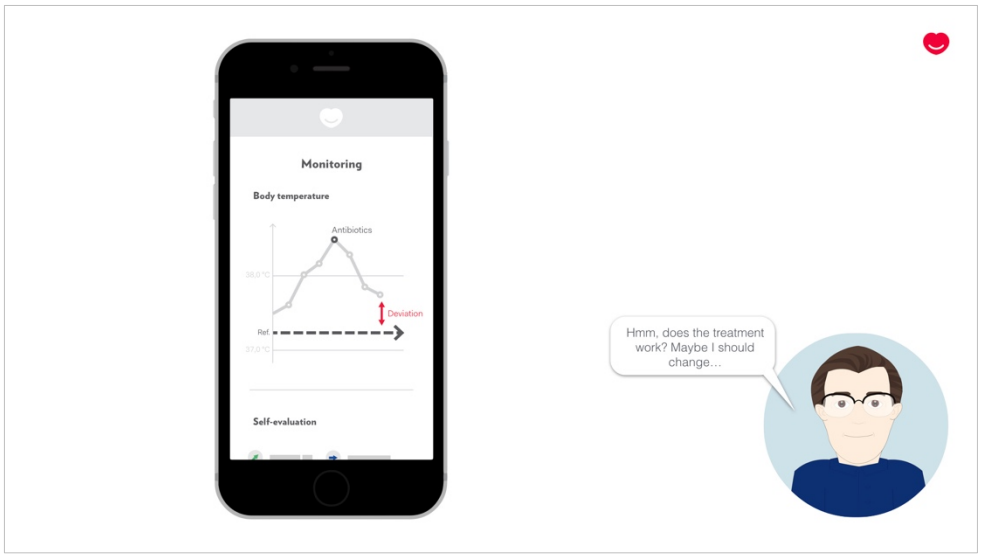


Martin sees that Stina's body temperature has exceeded the specified cut off value and that she is feeling worse. Based on the notification, Martin takes an adequate action, at the right time, without being contacted by Stina; he asks her to do a strep-A-test at her closest lab centre.

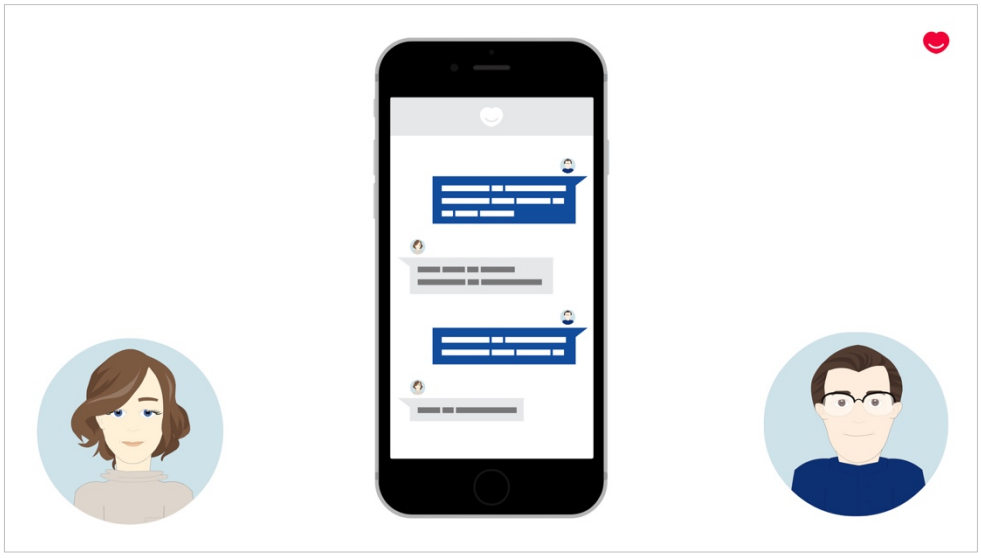
Stina takes the test which indicates that she has bacterial tonsillitis and she gets antibiotics.



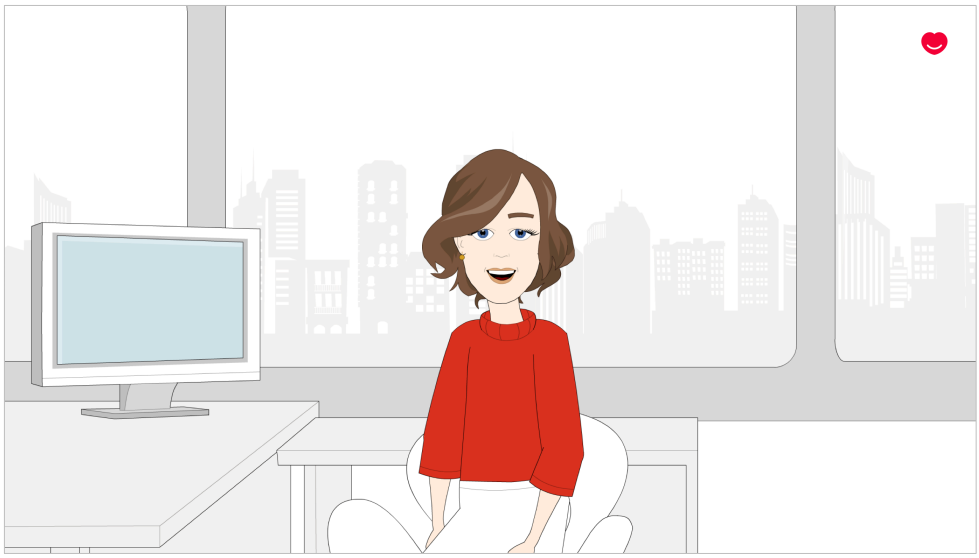
Three days later: Martin receives a notification.



Martin is informed that Stina's vitals haven't fully gone back to normal yet, as they should, even though she seems to feel better. Because of this, he is unsure whether the treatment is working or not.



To follow up on Stina, Martin contacts her. Stina tells him she is starting to get better and she appreciates that Martin continuously keeps an eye on her.



A few days later: Stina feels well again and her vitals have returned back to normal.

7 Discussion

This section will discuss topics related to the final concept, issues during this project and recommended further research.

7.1 Further reflections about the designed user experience

7.1.1 Three key takeaways from the user scenario

Accessible self-care

The first key takeaway is accessible self-care. By introducing PGHD and artificial intelligence, the app can recommend the most appropriate actions for the patient. Thereby it will be easier for patients to determine whether they should seek help or wait. Self-care also increases safeness and confident for patients since they know where and how to seek further help if needed.

It is important to present just enough details about the data to increase the awareness. Otherwise the data might be overwhelming and create unnecessary worries. As the final scenario shows, patients are presented with just enough information to see that their vital signs are within or outside of their normal range.

Better patient understanding

The second aspect is patient understanding. The presented health data is useful and manageable for doctors since it changes depending on stage of the diagnostic procedure. For example, doctors can quickly get an overview of the patient's state of health by comparing the current vital signs with their healthy ones.

Furthermore, by studying long-term diagrams of each vital sign containing measurements from before the patient sought care, doctors get a better sense of how the symptoms have developed over time. This can be useful in order to separate diseases with different progress.

Secure and controlled monitoring

The third aspect is that PGHD brings the opportunity to, in a secure and controlled way, keep an eye on patient's illness progression. This type of monitoring doesn't exist in today's primary care. However, it could lead to increased patient safety and care quality. It could be used when doctors want to wait with treatment or when they want to follow up on how the treatment worked out. Patients will benefit from this as it brings feelings of trust in knowing that they will receive right care at right time.

Furthermore, the notifications support doctors so that they in a quick and convenient way find out if patient's values deviate. In this way, doctors don't need to manually look through every single care case. Another important feature is the pre-set options that ease doctors' workflows. At the same time, they bring the opportunity to manually customize the monitoring process to every single patient.

7.1.2 The notifications and its effects on user experience

As seen in the final concept, doctors could choose to get notified when patients get deviant health parameters. This might bring many great advantages, both for doctors and patients.

From a patient's perspective, the notifications could improve their safety since the doctors get contacted immediately when a certain health parameter deviates outside of the general limits, compared to the current service where patients either need to reach out to the doctors or wait until an eventual scheduled follow-up. Furthermore, the notifications might bring an impression of feeling secure and protected.

From a doctor's perspective, the notifications enable them to perform controlled awaiting and treatment processes. The notifications alert if the patients worsen, they reveal illness progression and they disclose whether treatments work or not. Thus, the alert notifications bring an added transparency to the current digital health care service. As seen in the final concept, the service should provide pre-set options for thresholds and recommended number of registrations for the patients. The pre-set options are needed to not risk increasing the workload for the doctors. However, it should be easy for the doctors to modify and customize the thresholds and number of registrations in order to fit each individual patient.

Apart from all the benefits of alert notifications, they may be too unmanageable and stressful for the doctors. Especially for those taking large amounts of cases. In order to prevent this, the project group suggests three ideas. One alternative is to gather and send out the notifications in set time intervals, for example once every other

hour. Another option is to send out the notifications based on the doctor's calendar, for example during gaps in their schedule. Doctors could also indicate themselves as available for notifications every now and then. These ideas could potentially solve the added stress for the doctors.

From a patient's point of view, it is unlikely that not getting help immediately could harm the patient since the medical cases at the digital health centre aren't that severe. The patients' mental model of how a doctor works is based on traditional healthcare. This is a problem since the doctors working for the digital health centre can work whenever and wherever they want. Patients will therefore be unable to understand why doctors sometimes replies quickly and sometimes slowly.

In the long-term, the most likely situation is that artificial intelligence will support the doctor's in managing all notifications which would ease the doctor's effort.

7.1.3 The connected health device and its effects on user experience

As mentioned in section *3.2 Context research*, there is an apparent progress towards individual devices collecting multiple parameters. Therefore, a single device collecting all desired vitals, didn't seem too far away to be used in the final concept. However, implementing the concept today would likely require a kit of various devices complementing each other.

The fictitious device was imagined to be used at home. However, as mentioned in section *3.2 Context Research*, the tendencies are towards more continuous monitoring processes and embedded sensors into everyday things. Therefore, a future implementation of the concept might make more use of wearables or other types of devices that could be carried around by the user.

In the sections below, the project team has reflected upon ways the user experience may be affected due to type of connected health device.

One device versus a kit of multiple devices

The project team suggests there are two main benefits of using a single device compared to multiple ones; lower user effort and better mental model.

The user effort, especially in the phases Preparation, Collection and Integration (see Figure 3.3), may be lowered. In the Preparation phase, the user needs to decide what health data to collect and how to collect it. By presenting one single device to be everything the user needs, the amount of choices would be reduced. Thus, lowering the user effort. During the actual Collection phase, one single device implies a more convenient, practical and accessible management for the user. The user might be freer in deciding when and where to track since it is quite easy to carry the device

with them. In the Integration phase, when the collected information is prepared for the Reflection stage, having only one device would most definitely lower the issues when managing and syncing the data.

Using one single device might imply a better mental model for the user since it is more comprehensive to turn to one specific device instead of a kit containing various ones. For example, having multiple devices might bring concerns in the Collection phase regarding which order to use the devices in and if they should be used one at a time or simultaneously. However, similar issues could come up with the single device if it needs to be handled in different ways based on the tracked parameter. In addition, user research implies that collecting too much data may lead to data fatigue. Even though the single device collects the same number of parameters as a kit of multiple devices, a single device may not seem as mentally exhausting as multiple ones.

The main benefit with a kit of devices compared to a single device, is the higher flexibility and customizability. Based on user research, creating a flexible service that meets the user's changing needs, is vital in keeping the users in the long-term. Regarding the kit, the user could choose from a list of recommended devices to be included in the kit so that it is individually customized. The kit could also be upgraded from time to time to include additional devices if or when the user's needs changes. Another take on this is the quite big abandonment rates. When having multiple devices, the user could stop using one of them and continue with the others. For the single device, the project team believes the risk of not measuring at all is bigger.

Stationary device versus wearable

One of the main differences between stationary devices and wearables is that stationary devices often imply manual handling while wearables often collect the data automatically. This brings a big difference in required user effort and wearables have the advantage. First and foremost, it is more time consuming to track manually since users need to plan and take their time for it. Wearables on the other hand are more accessible and easier to carry around resulting in more freedom in where and when to track. Another drawback with manual devices is that users need to remember to use it. Nevertheless, automatic devices might risk being forgotten due to the lower user engagement.

Section *3.3 User research and insights*, revealed that manual and automatic devices affect the Reflection phase differentially. To reflect on one's data is vital in order to gain awareness and knowledge about one's state of health. As user research implied, reflections do not only take place after the Collection phase, for manual tracking it often happens during the actual collection as well. Because of this, manual devices provide a natural situation for the Reflection phase which automatic devices don't do. However, reflection after collection happens less for manual tracking than

automatic tracking since the tracking itself takes up longer time. The time for reflection might affect the reflection itself due to the differences in data visualization. During the actual data collection, the data tend to be presented as momentary snapshots compared to more extensive trends and summaries that might be presented after the Collection phase. Obviously, this difference affects the gained awareness and knowledge about one's state of health that comes with reflection.

Related to this, is the amount of data points. Wearables tend to bring more data points than stationary devices due to the continuous registrations. Consequently, this affects the user's level of analysis. The more often people register their health data, the more accurate will the individual baseline be. Thus, increasing the potential in knowing one's healthy state. Furthermore, a high amount of data points result in detailed historical trends (see Figure 4.6 an illustration of the effects of continuous measuring). Once ill, the data points may indicate when changes in one's general condition occurred, what the changes implied and for how long the illness has taken place. Thereby making it easier to correctly convey illness progression, perceived symptoms and so on compared to when only having access to a small number of registrations.

Worth to mention is that from a doctor's point of view, a high number of data points does not necessarily imply better data analysis. Most of the time, the health parameters will vary between general limits and these specific values are usually not of interest for the doctors since they aren't perceived as sick values. As an example, a normal respiratory rate for an adult is between 15 and 20 breaths per minute and variations within this reference range points to nothing. On the other hand, a high amount of data points makes it more likely that eventual deviations outside of the threshold are caught.

7.2 Reflections about the process

7.2.1 Difficulties throughout the project

The scope of the Master Thesis

The Master Thesis started out with quite wide research questions and not many project limitations, which the project team experienced as intriguing and inspiring. However, throughout the project they noticed it was difficult to pinpoint what was of importance and not, especially during the literature review.

In retrospect, the project team believe it would have been good to earlier in the project narrow it down and clearly define the research questions. Nevertheless, the project team has learned a lot from this process.

Inexplicit deliverable

One of the objectives with the Master Thesis was to design a user experience and this brought some concerns in respect to finding a suitable deliverable. Based on the team's educational background, a lo-fi app was the most evident and practiced alternative. However, it didn't quite match with the project purpose and research questions. The project team were looking for something on a higher level of abstraction with respect to the lo-fi app. They didn't want to risk focusing too much on graphical user interfaces and they were keen on capturing the user's emotions and benefits throughout the whole service.

Eventually, a storyboard combined with a few UI's were believed to be inclusive of all this. The project team had only a basic understanding of storyboards and the literature was quite insufficient for this type of usage. This brought some difficulties in how to apply this tool as a deliverable. In retrospect, this deliverable was a great way to visually illustrate the overall user experience concept and at the same time bring in the most important findings from the research questions.

Drives for innovation

The project team chose to use a design-driven innovation methodology, mainly because of the big focus on user experience, but also because it has been evident in the team's educational background. Thus, that felt as the natural approach. From time to time, the project team experienced difficulties with this method, especially when creating the opportunity areas. In retrospect, the struggle may have had to do with the fact that the main objective of the Master Thesis was to explore the opportunities with CHDs, which didn't necessarily imply including user needs.

In contradiction, a more technology-driven innovation process could have benefited the project. Therefore, when generating opportunity areas, the project team based the brainstorming not only on user insights, but also on other aspects like current and coming technology and competitors. Nevertheless, the project team mapped all ideas against the extracted user insights and only continued with those ideas that met specific user needs. In this way, the project team still applied the main notions of design-driven innovation, described in the chapter *2 Method*.

7.2.2 Sources of error/bias

Literature review

As mentioned in Project purpose, there hasn't been much research regarding PGHD in primary health care. Because of this, the project team based much of the literature review on so called grey literature like news reports, company reports and academic journals. Also, various blogs, podcasts and Ted Talks covering topics of interest

were used. The credibility and validity of these sources of information could be questioned, however the project group used triangulation as a method to enhance the validity of the findings.

Selecting interviewees

During the User research phase, the project team met with three doctors working at the digital health centre. The doctors were hand-picked based on their openness towards changes in healthcare and their great interest in technology meaning that they all had a positive attitude towards CHDs and PGHD. Accordingly, the interviewed doctors may be categorized as early adopters and may not be representable for the healthcare industry in whole. This may have biased the extracted user insights and thereby the defined opportunity areas. On the other hand, early adopters tend to bring distinct insights since they have great knowledge about the technology and its use.

7.3 Recommended further explorations

7.3.1 Data properties

Information privacy, data security, data storage and compatibility are aspects that haven't been explored in this Master Thesis. However, the project team recommends this to be of high priority in future research.

PGHD may include sensitive and identifiable information and along with the rise of IoT, the amount of data will grow rapidly. Accordingly, information privacy, here with main respect to individual integrity, should be of high priority to the digital health centre. The required disclosure and security level regarding health data is not clearly defined and it constantly alters due to changing threats. However, when choosing CHDs it is of high importance to take their data security and storage options into account.

Another important aspect is data compatibility. The rapid progress in information technology implies that a higher number of apps and devices will be compatible, enabling the digital health centre to enter and read data in many different ways. Even so, the project team recommends this to be further considered when choosing suitable health devices.

7.3.2 User motivation

As mentioned in the section, *2.2 Design process practiced in this Master Thesis*, the project team chose to focus on ability rather than on motivation. Nevertheless, the user research clearly implied that CHDs face quite big abandonment rates and that there are some severe reasons for people not to track themselves, the biggest two being lack of value and poor data analysis. On the other hand, as mentioned in the introduction, research indicate that the use of CHDs will increase sooner than we think and a broad market of people will adopt the technology.
However, taking the user's motivation in mind when creating the service, is of high value and recommended as future exploration. Otherwise, the digital health centre risk creating a service that only a few feel incentivized to use.

7.3.3 User study

This Master Thesis was carried through with a user experience design viewpoint. Therefore, much focus has been on the users of the digital health centre; doctors and patients. To refine and validate the designed user experience concept, multiple evaluations were conducted, see section *6.2 Iteration 3*.

To cover the doctor's point of view regarding medical aspects, workflow and needs regarding the service, the evaluations consisted of discussions about the prototype, a storyboard with UI's. The conversations included one treating doctor working for the digital health centre and two stakeholders medically responsible at the digital health centre. The prototype served as a great base for discussions and many important aspects were revealed.

However, evaluating the concept with patients turned out to be a bit more difficult. Presumably, this has to do with the prototype not being appropriate to validate soft values like emotions and user benefits. To compensate for the lack of testing with patients, discussions based on the storyboard with UIs took place with several people in the roles of patients. In this way, the concept was evaluated in a more generic way leading to conversations about opinions, hypothetical experiences and interpretation of the concept itself. This may have biased the concept and led to important aspects being neglected.

For further explorations, the project team believes a high-fidelity prototype is needed to truly evaluate the concept from patient's point of view. Therefore, the project team suggests that one approach is to conduct a user study. For example, in the form of 50 devices sent out to specific individuals.

8 Conclusion

What are the overall opportunities with patient generated health data for a digital health centre?

Section *4.2 Opportunity areas* presented six opportunity areas where patient generated health data could be of value for the digital health centre. The opportunity areas were:

- Using PGHD to compensate for missing visual cues in the initial understanding of patients and their condition.
- Ease and sharpen the awaiting and treatment process, so doctors can monitor patient's illness progression.
- A service for self-diagnostics and advice for people to treat and understand themselves better.
- Using PGHD to support worried parents regarding their sick children
- A monitoring service to reduce the risk of getting heritable illnesses.
- Using PGHD to improve digital physiotherapeutic cases.

In what ways may patient generated health data support the digital care work at a digital health centre?

The main aspect with patient generated health data is that it might help closing the digital gap that comes with digital health centres. The data could compensate for the lack of visual cues and thereby help doctors to understand more about the patient and the illness. For example, the objective data may verify and validate described symptoms and pain estimations. In addition, vital parameters might give a quick momentary view of a person's general health and indicate whether the health condition is severe or stable.

Long-term data enable doctors to continuously follow an illness progression. This is a huge opportunity rarely seen in regular healthcare. By monitoring the patient, awaiting can be carried through in a secure and controlled way making sure that the patient's condition does not worsen. This is also of value during treatment since the doctor will have more transparency in the patient's recovery and compliance, thus enabling the doctor to earlier change treatment when needed. Therefore, the patient will get the right care in the right time.

Another great aspect is that patient generated health data imply a more individualized healthcare. For example, having access to baselines for individuals enable the patient to compare an individual's sick values with their healthy ones. Accordingly, the treatment could be customized for the individual and his or her condition.

In the long term, artificial intelligence is believed to support doctors with automatic diagnoses. To do that, access to patient generated health data is crucial.

How might patient generated health data affect the user experience of a digital health centre?

By reflecting about health data in an insightful way, patients will gain awareness and knowledge about their health, illness progression and recovery. Thus, they might become more confident in their own ability to evaluate their state of health. This could change the user experience of digital health centres so that patients are more engaged in their own healthcare.

Through patient generated health data, doctors will be able to provide care customized for the individual. Consequently, the doctor will participate more in their own care and the service will be more patient-centric.

Including patient generated health data into the app might result in a more convenient and efficient service. For example, it could reduce basic questions from the doctor, leading to fewer interactions in the doctor-patient communication. An additional example is that patients can take adequate actions, at the right time, without being contacted by doctors.

Knowing that a doctor has access to one's health data might be perceived as reassuring and trustworthy which is of high importance for digital health centres due to the digital gap.

How might the type of health device affect the user experience?

The type of device affects the user experience greatly. Two aspects that were discussed in section, *7.1.2 the connected health device,* were single devices versus kits of multiple devices and stationary devices versus wearables.

Single devices bring lower user effort and better mental models than multiple devices. A single device implies a more convenient and accessible management for the user. In addition, it is more comprehensive to turn to one specific device instead of multiple ones. However, a kit of devices brings a higher flexibility and

customizability compared to a single device. Creating a flexible service that meets the user's changing needs is vital in keeping the users in the long-term.
Stationary devices often imply manual handling while wearables often collect data automatically. This brings a big difference in required user effort and wearables have the advantage since they are more accessible and easier to carry around resulting in more freedom in where and when to track.

Manual devices provide a natural situation for reflection which automatic devices don't do. However, reflection after collection happens less for manual tracking than automatic tracking since the tracking itself takes up longer time. The time for reflection might affect the reflection and interpretation itself due to the differences in data visualization.

8.1 Summary

To summarize, PGHD could bring great potential to the digital health centre. When looking at the near future, the most relevant and applicable approach is through self-diagnostics, momentary snapshots of state of health and monitored awaiting and treatment processes. In regard to the user experience of the service, PGHD might result in more engaged patients and move the focus from doctors to patients. Getting patients to engage in the service on a regular basis could also keep the patients and lower the risk of abandonment. Furthermore, the healthcare service might be perceived as more trustworthy and qualitative when including PGHD.

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Appendix A Work distribution and time plan

A.1 Work distribution

The vast majority of the time, the two project members conducted the work side-by-side at the digital health centre office. The work distribution, both theoretical and practical, was shared equally in as large extent as possible. Further, parts of the report have been written separately but thoroughly discussed and read through by both project members.

A.2 Time plan

In the beginning of the project, it worked out well when combining literature studies with searching for interviewees and planning of field studies. However, after the wide discover phase was completed and due to the inexplicit deliverable, the time plan was adjusted.

The new time plan included three iterative cycles which enabled constant refinements of the concept until the end of the project and thereby eased the time management. Despite the difficulties discussed, in section *7.2 Reflection about the process,* the outcome turned out to correspond to the time plan quite well.

Figure A.1 The initial time plan

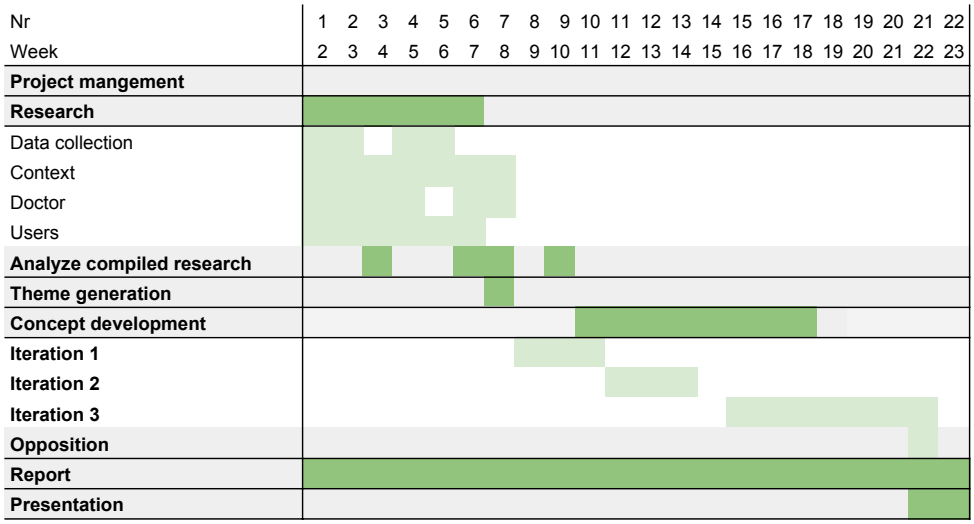

Figure A.2 The new time plan

Appendix B An example of an interview guide

Bakgrund	● Vill du presentera dig själv lite kort för oss? ● Vad har du för huvudsaklig sysselsättning? ● Vilka är dina fritidsaktiviteter utöver din primära sysselsättning? ● Hur ser en vanlig dag ut? Benämn hälsorelaterade saker.
Vid sjukdom	● Vad är dina första tankar när du känner att du inte mår helt bra? ● Hur agerar du när du anar att du börjar bli sjuk? ● Hur ofta besöker du vårdcentralen eller är i kontakt med vårdpersonal? ● Hur ofta kommunicerar du med din läkare? ● Hur kommunicerar du med din läkare? ● Beskriv relationen till din läkare vid det senaste besöket? ● Hur noga följer du läkarens rekommendation eller medicinering? ● Efter du har fått behandling av läkaren och kommit hem, hur ser du på din relation till vårdgivaren?
Hälsa	● Hur ofta funderar du på din hälsa? Varför? ● Vad innebär hälsa för dig? ● Vad påverkar din hälsa? ● Vad har påverkat din hälsa allra mest det senaste året? ● Hur är din hälsa nu? ● Är det något hälsorelaterat som regelbundet undersöks på dig? ● Av vem utförs undersökningen? ● Antecknar du detta på något sätt? ● Har du några mål gällande din hälsa? ● Har du någon plan på hur du ska leva hälsosamt?

	● Är det någon annan än du själv som har koll på din hälsa? ● Hur viktigt är det för dig att dina vänner och familj vet hur du mår? ● Hur får dina vänner och familj reda på hur du mår? ● Har du koll på någon närståendes hälsotillstånd eller hälsodata? ● Hur får du idag reda på hur vänner och familj mår?
Enhet	● Vilken hälsotracker är det du använder? ● Hur gick dina tankar innan köpet? ● Varför köpte du din hälsotracker? ● Vad var viktigt för dig vid valet av hälsotracker? ● Vad hade du för förväntningar på den? ● Vad gillar du mest med din nuvarande hälsotracker? ● Vad gillar du inte med din nuvarande hälsotracker? ● Har du haft någon tidigare hälsotracker? ● I så fall, varför slutade du använda den? ● Beskriv vad som hände mellan bytet? ● Har du funderat på att köpa andra hälsotrackers? ● Vet du vad som finns på marknaden?
Användning av enhet	● Beskriv hur du brukar använda din hälsotracker i vardagen? ● Kommer du ihåg att använda din hälsotracker? ● Hur ofta tar du på/av din hälsotracker? ● Vad händer när du inte har den på dig? ● Motiverar din hälsotracker dig att fortsätta att förbättra hälsan? ● Vad gör du om du får notiser med t.ex. tips på vad du borde göra? ● Hur känns det när du får upp sådana? ● Har ditt liv påverkats av din hälsotracker?
Data	● Beskriv hur du går tillväga när du samlar in data? ● Vilken data samlar du in? ● Gör du någon manuell mätning idag? ● Vad tycker du om automatisk vs manuell insamling? ● Vad tycker du om presentationen av hälsodata i din hälsotracker? ● Hur ofta tittar du på den insamlade datan? ● Vad tittar du efter?
Reflektion	● Tittar du på den insamlade datan?

	● Hur känner du när du ser positiv respektive negativ data? ● Reflekterar du kring din insamlade data? ● Vad gör du om data är fel? ● Vad vill du veta om dig själv som du i nuläget inte vet? ● Vad tänker du om lagring av din hälsodata?
Delning	● Delar du din insamlade data med någon? ● Vilken sorts hälsodata är du mest angelägen att dela med någon? Vem? ● Hur känner du inför att digitalt dela din hälsodata med vänner, familj och läkare? ● Vill du att din läkare eller vårdpersonal har tillgång till dina mätningar och värden? ● Vilken sorts hälsodata är du mest angelägen att ta del av från någon? Vem?

Appendix C Nondisclosure Agreement & Recording Consent

Syftet med studien
Studien ingår i ett examensarbete vid Lunds Tekniska Högskola i samarbete med *företaget*. Syftet är att få en inblick i hur användare upplever *företagets* tjänst och därigenom hitta förbättringsmöjligheter av tjänsten.

Tillvägagångssätt
Studien består av en intervju som tar ca en timme. Om du tillåter det, kommer ljudinspelning ske under samtalet.

Avbryta studien
Du kan alltid låta bli att svara på en fråga.
Du kan när som helst under studien välja att avsluta din medverkan och eventuellt insamlat material från dig kommer då inte att användas.

Sekretess
Allt som sägs under intervjun och allt material som samlas in kan komma att användas på *företaget* samt i en offentlig examensrapport, om du inte säger någonting annat.
Du kommer vara helt anonym och inget material kommer kunna kopplas till dig eller de eventuella personer du nämner under intervjun.

Kontaktinformation
Om du har frågor och funderingar eller vill lägga till någonting är du välkommen att kontakta oss via e-mail.
Linus Emme: linus@emme.nu
Linn Norberg: linnk.norberg@gmail.com

Frivilligt deltagande
Jag intygar härmed att jag frivilligt ställer upp på följande intervju enligt ovan

Datum:_____ Ort: _____

Namnteckning:_____

Namnförtydligande: _____