CHALMERS

Diagnosis Support using AI

Human-AI Interaction and User Experience in a Digital Healthcare Platform

Master of Science Thesis

ERIK BJÖRNÖR & TOBIAS WOLLTER

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg Sweden, 2018

Department of Industrial and Materials Science
Division of Design & Human Factors

Master of Science Thesis

Diagnosis Support using AI

Human-AI interaction and User Experience
in a Digital Healthcare Platform

ERIK BJÖRNÖR & TOBIAS WOLLTER

SUPERVISOR: MARAL BABAPOUR CHAFI

EXAMINER: HELENA STRÖMBERG

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg Sweden, 2018

Department of Industrial and Materials Science
Division of Design & Human Factors

Diagnosis Support using AI
Human-AI Interaction and User Experience in a Digital Healthcare Platform
Erik Björnör & Tobias Wollter

Chalmers University of Technology
SE-412 96 Göteborg, Sweden
Telephone: +46(0) 31–772 10 00

Cover illustration: Erik Björnör & Tobias Wollter
Print: Reproservice Chalmers
Gothenburg, Sweden 2018

PREFACE & ACKNOWLEDGEMENTS

This master’s thesis presents a project conducted in the spring semester of 2018 in collaboration with a company (henceforth referred to as Company X), one student from the Industrial Design Engineering programme and one student from the Interaction Design & Technologies programme at Chalmers University of Technology. The extent of the project was 30 ECTS credits.

Throughout the course of this project, many people have helped us. We would like to thank all the employees of Company X for their full-hearted support throughout the entire project. Your insights in both the research and evaluation phases helped us greatly in our final result. We are especially grateful to our supervisor at Company X, who with constructive discussions helped us guide the direction of the thesis.

Furthermore, we want to thank every single one who helped us in our user studies and evaluations. We appreciate that you could take your valuable time to help us, even though you work in a stressful environment. A special thanks to the employees at the hospital of Kungälv for repeatedly letting us interview and observe you in your daily work.

We would like to direct a big thanks to the examiner of this project, Helena Strömberg, for taking time for us whenever we had questions. Furthermore, a warm thank you to our supervisor Maral Babapour Chafi for guiding us, sharing your thoughts and for always believing in us. Lastly, we would like to give our deepest thanks to all the students who have enrichened our time at Chalmers throughout the years, it has been a pleasure.

Gothenburg, June 19th, 2018.

Erik Björnör and Tobias Wollter

ABSTRACT

The healthcare system is under increasing pressure and costs, with digital healthcare and research of AI in healthcare being two efforts to mitigate it. However, as these are both in their early stages, challenges include quality assurance and trust in the AI respectively. This study aims at introducing AI in the diagnosis process to ensure effectiveness and efficiency is maintained, while keeping the medical practitioner in control.

User studies, consisting of interviews and observation, elicited and defined the problems in the diagnosis process. The problems concerned managing time and tasks, preserving competence, facilitating for qualitative communication, aligning data-driven and intuitive processing, and enabling the build-up of trust in a human computer system. Requirements for a system were elicited from these problems.

Ideation and iterative development with regards to the requirements resulted in conceptual solutions of three systems. The final, proposed concept is a digital interface of the diagnosis process, where the medical practitioner interacts with visual elements to collect symptoms, perform additional examination, and decide on diagnosis and treatment. As the practitioner is continuously interacting within the system, the input is used to improve the AI based tools, suggestions and reminders.

User testing of the system, and evaluation against trust and design theory, showed that practitioners trust the delivery of the AI based features. This indicates that the proposed design is a viable way of introducing AI in the diagnosis process and ultimately facilitating for a more systematic workflow that assists the practitioner in maintaining effectiveness and efficiency.

CONTENTS

INTRODUCTIVE PHASE

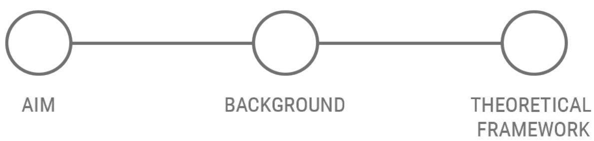
EXPLORATION PHASE

DEVELOPMENT PHASE

CONCLUSIVE PHASE 95

INTRODUCTIVE PHASE

This phase defines the aim and scope of the study, introduces the problem, provides background to previous research in the field, and introduces theoretical frameworks for the project.



1 INTRODUCTION

The healthcare system is under increasing pressure and costs. The majority of patient complaints in Sweden regard the availability and long waiting times to see a medical practitioner (IVO, 2017). The diagnosis accuracy is reportedly low in the first visit (SKL, 2007) and 40 percent of the patients states that the healthcare staff lack important information about their medical history (Vårdanalys, 2016). However, patient satisfaction related to individual healthcare visits is high and the human interaction between patient and healthcare staff is highly valued (Socialstyrelsen, 2017).

Causes for increased patient dissatisfaction include bottlenecks in the availability and allocation of resources. For instance, variation in the patient flow is difficult to foresee and match with availability of the suitable competence, which leads to long waiting times and low availability (Palmgren & Eklund, 2014). Two trends to combat these issues are digital healthcare products and data-driven tools such as pattern recognition and machine learning.

The digital solutions enable patients to meet with medical practitioners online, alleviating the need for the patients to visit a physical healthcare centre, resulting in a more flexible system with better resource management. Digital healthcare actors, such as KRY and MinDoktor, are working in parallel to primary care; they are private, virtual healthcare providers which the patient can contact instead of the traditional primary care units (kry.se, 2018; mindoktor.se, 2018). Another approach is from the company with which this study is conducted in collaboration (henceforth referred to as Company X), a digital healthcare company which applies its services in series to the primary care units, rather than parallel. This means that they act as an extension to already existing healthcare centres, as a digital solution for the primary care to come in contact with, diagnose and follow-up patients. The patients who are eligible for digital treatment will receive it through the digital platform (henceforth referred to as Product X), while those who need physical examination will be referred to the healthcare centre for a visit, but the overall case administration and follow-up is still managed within the digital platform. However, criticism has been raised in media in recent years, pointing to the lack of scientific evidence that quality healthcare can be provided online (Krey, 2018; Ahlzén, Berggren, Metsini, Olsson, & Tegelberg, 2018).

Working with systematic, data-driven methods is widely adopted in other industries to mitigate efficiency and resource bottlenecks. However, healthcare is still mostly performed in a traditional, top-down fashion, where intuition and experience guide the actions, rather than a bottom-up approach of analysing data. While collection of data within healthcare is nothing new and has been ongoing for decades, through for instance medical records, the notion of interpreting and implementing the data in new constructive ways still has ways to go (Chang, 2016; Shortliffe, 2009). Still, studies in this area show promise for a more data-driven approach to the diagnosis process and researchers reason that data-driven systems, in combination with the intuition of the human, could reach further than the sum of its parts (Chang, 2016; Bennett & Hauser, 2013; Berthold, 2009).

However, there are some obstacles to overcome for AI (artificial intelligence) to become fully integrated into the healthcare system, ranging from technical implementation challenges such as data management and regulations, to challenges involving the interaction between the AI and the medical practitioner (Shortliffe, 2009; Patel, 2009).

This study focuses on some of these mentioned challenges by exploring how to incorporate advanced tools using AI in Product X, and how to facilitate for an effective interaction between medical practitioners and the system. Ultimately the goal of these tools is to improve healthcare through saving time and resources by making practitioners more efficient and make the care more effective by having the tool act as an extension of competence to the practitioner.

1.1 AIM & RESEARCH QUESTION

The aim of this study was to explore how a medical practitioner's work in Swedish healthcare might be advanced with AI diagnosis support, facilitating for improved efficiency and effectiveness in the diagnosis process. Of special interest was the human computer interaction. This was achieved by developing a conceptual system which was evaluated with medical practitioners in healthcare.

This study revolved around the following question:

> *How should AI be introduced in the diagnosis process to improve efficiency and effectiveness, while ensuring that the medical practitioner remains in control?*

To guide the study, a set of specific action points were defined:

- Explore the internal structure of and mechanisms governing the diagnosis process.
- Identify the problems in the diagnosis process that halter effectiveness and efficiency.
- Determine the perception of introduction of technology in healthcare.
- Elicit system requirements that address the identified problems.
- Design a system that meets the requirements and facilitates for the introduction of AI in healthcare.
- Evaluate and define which and how information should be presented to the medical practitioner to induce trust in the system.
- Evaluate and define how the system affects the workflow of the medical practitioner.

1.2 DELIMITATIONS

The scope of this study did not include the technical aspects of the AI system, but was limited to the interaction between the AI and the human operator. Consequently, some assumptions were made regarding the AI's performance and technical implementation, as it is yet to be fully developed.

The final concept is an interactive visual prototype, not a fully developed product, as coding was outside the scope of this study.

1.3 ETHICAL, SOCIETAL & REGUALTORY ASPECTS

Working with diagnosis support within healthcare has implications on several levels, spanning from the patient and medical practitioner perspective to the societal and, ultimately, global perspective.

Patients and healthcare staff are concerned about patient data and how it is treated in systems. The patients' well-being and privacy is a top priority concern and the system needs to be designed, and the study needs to be conducted, with it at its core.

Diagnosis support in healthcare has several degrees of complexity, from simply providing extra data to the medical practitioner, to potentially becoming a fully automated system, completely controlled by AI and thus independent from human intervention. This study focuses on a collaboration between the human and the AI system, and is consequently positioned in the middle of these two extremes. To cater for this, screening the healthcare staffs' attitudes towards decision support as well as an autonomous system will be important in the data collection phase.

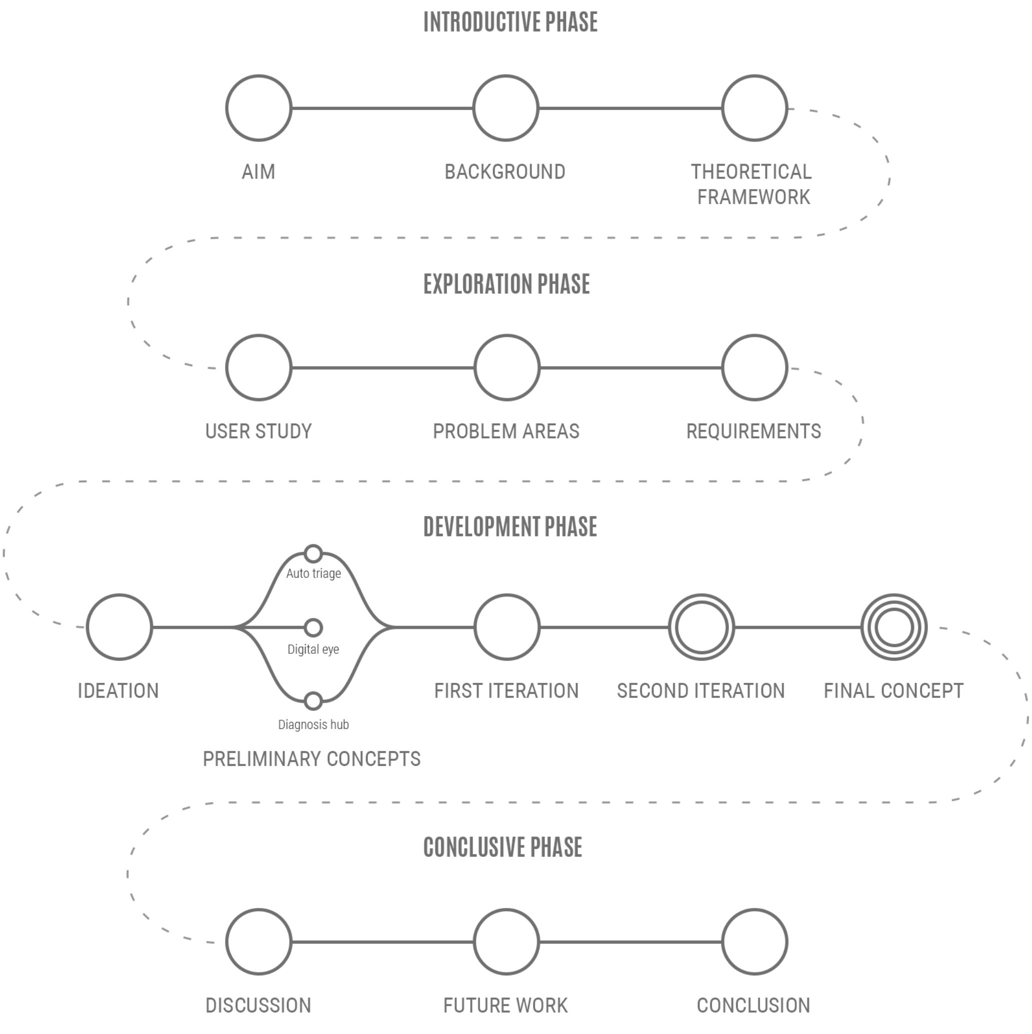
A system involving an AI brings forth some relevant questions in terms of trust and reliability. Is the system reliable in producing results? Can it be trusted to not induce negative bias to the human operator, in case the AI has done an incorrect analysis? Will the human still feel freedom of choice when considering the support provided by the AI, or will they experience that the decision was imposed on them by the system?

When considering a future state of the AI, at a point when it has become so reliable and versatile that the human operator has essentially been made redundant, what implications will that have on the patient care and the society at large? Will the lack of human-human interaction affect the patient care and the patient's trust in the system? Will an automated system completely replace the human occupation or will the tasks merely shift to new ones? Who will be responsible for any potential mistakes or incorrect diagnosis? The companies producing the AI system, the institution operating it, or something else entirely? Concerns regarding IT security and patient data will also need to be addressed. These are aspects to take into consideration when developing the service, as a solution too disruptive might end up not being accepted by the healthcare staff. Although the AI soon might be able to successfully diagnose, extra care will have to be taken in the evaluation phases of the concept iterations, to ensure the right level of diagnosis support is presented and to ease the healthcare staff into a future possibility of an AI-based diagnostic system.

Finally, developing and applying new ways of diagnosis and assistance in a healthcare environment is regulated by Swedish law. The result of this study needs to be assessed from a societal perspective before it can be implemented into the daily work of the healthcare centres. The healthcare is also obligated to continuously develop and improve their routines (Socialdepartementet, 2017). To release a medical product on the market a CE-classification is required. This is done by the company when their product fulfils the requirements set up by Swedish Medical Products Agency. There are different levels of CE-classification depending on the risk of the usage of the product (Läkemedelsverket, 2014).

1.4 REPORT STRUCTURE

This study is divided into four phases. The introductive phase, which defines the aim of the study and provides insight in research made in this area, followed by the exploration phase, consisting of user studies to define the problem and set up requirements for how to solve them. Tackling the problems found in this phase is done in the development phase, covering the generation of ideas and their development into concepts fulfilling the set requirements. Lastly, the conclusive phase presents reflections on the result of the study.



2 BACKGROUND
ON HEALTHCARE & AI

In this chapter, information regarding healthcare and insights from previous research in the field is presented. How the Swedish healthcare is organised is followed by a walkthrough of Company X's digital product. A brief summary on decision making related to healthcare is necessary to showcase, as it explains why a system aimed at supporting the practitioner might fail. Finally, a section concerning AI in healthcare is presented, along with challenges and potentials of implementing it.

2.1 HEALTHCARE CENTRES & HOSPITALS

In Sweden there are primarily two different types of care; primary care and healthcare. Primary care is mainly conducted in healthcare centres (vårdcentral) while healthcare is performed in hospitals and specialist's clinics. The different facilities apply care in different ways, depending on the case and its severity. However, both include diagnosis processes, and are therefore relevant to investigate further in the study.

Healthcare centre is a collective name for several types of clinics with the same principal goal of being the first stop for sicknesses or troubles that are not life-threatening or emergencies. Generally healthcare centres provide care for the following (Bengtsson, 2017):

- Urgent or chronic illnesses, injuries and troubles
- Rehabilitation
- Preventive care, such as vaccinations, health checks etc.

If the case is too complex or urgent for the healthcare centre to handle, it will be forwarded to a specialist or emergency room in a hospital.

Hospitals and specialists deal with more urgent and serious illnesses and injuries. A patient will come in contact with them if they go to the emergency room or call 112, the national emergency number, and receive assistance from an ambulance. Had the patient visited the healthcare centre first, they may receive a medical letter of referral to the hospital, if the injuries are outside of the healthcare centre's realm of treatment (Bengtsson, 2017).

This study was initiated with the primary care in mind, as that is the current target of Product X, but the explorative user study was conducted in both domains to better understand the diagnosis process and domain dependent differences.

2.2 PRODUCT X

Product X is a digital platform that acts as an extension to existing healthcare centres, enabling patients to interact asynchronously, online with a medical practitioner. The service is reportedly developed with the patient in mind, to provide care on the patient's terms as the patient can access Product X whenever and wherever they see fit. Company X's ultimate vision is for the product to be used for the full patient journey, from initial contact to follow-up.

Patients log into the service on the web using the Swedish mobile identification system BankID, and are presented with a chat view (Figure 1) where they fill in an initial form to express their reason for contact and answer questions about their problems. Once the information is entered, they are triaged by a nurse to an available medical practitioner who has prepared for the meeting by reading the results from the patient form.

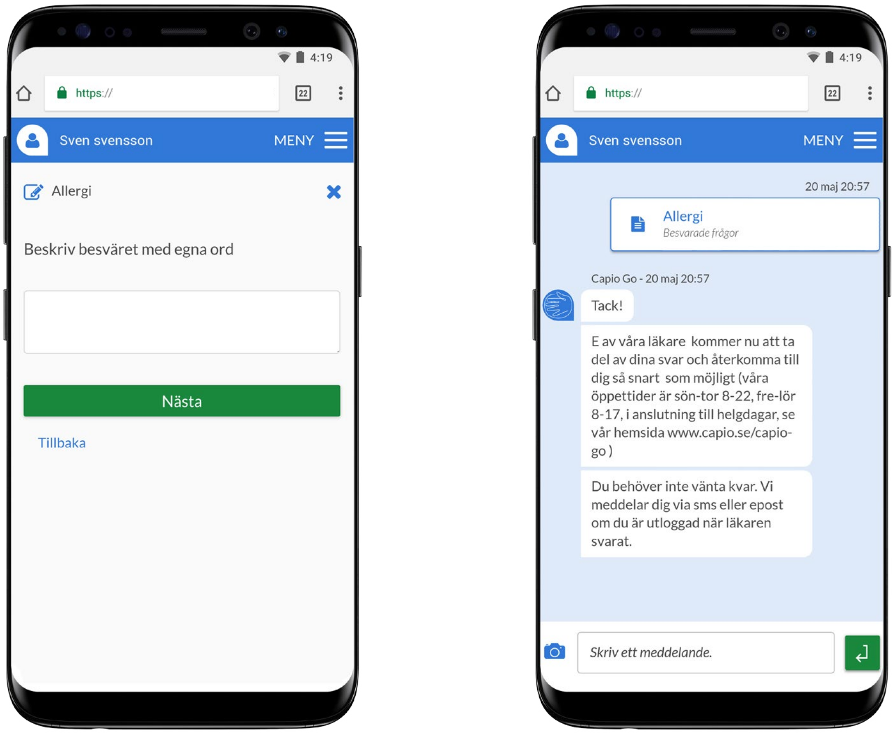


Figure 1. Patient's view from a smartphone. Left: form; right: chat view.

The practitioner (Figure 2) asks follow-up questions through the chat and decides on a diagnosis and provide treatment digitally if possible. As the communication is done via asynchronous chat, the conversation enables the patient to reply whenever convenient for them. If the data provided digitally is not sufficient for the practitioner to diagnose digitally, they may request the patient to go to a healthcare centre for a clinical test or for a normal physical examination. If necessary, the medical practitioner can also issue a referral to a specialist clinic.

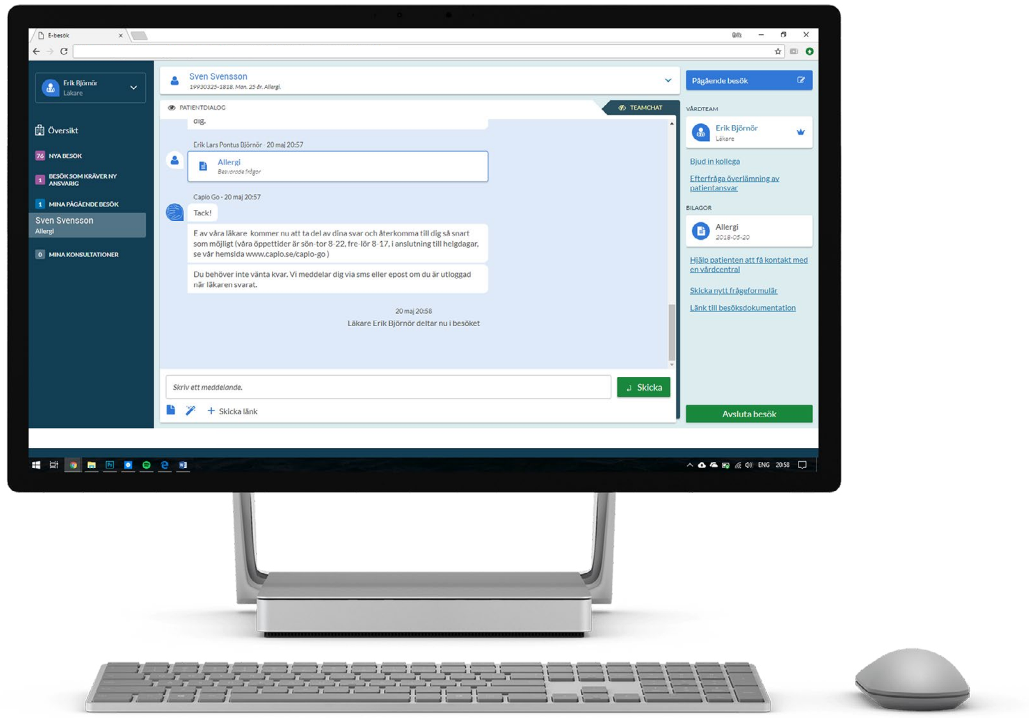


Figure 2. Medical practitioner's view from a desktop computer when opening a new patient visit.

After the patient meeting, the practitioner documents the diagnosis to the medical records. A full transcription of the chat is saved automatically in the medical records.

2.3 DECISION MAKING IN HEALTHCARE

Understanding how decisions are made in healthcare is important to consider when designing a system aimed at supporting the practitioner. Kushniruk (2001) describes decision making as a function of the task at hand and how experienced the decision maker is. In healthcare, the information available might be hard to interpret, which could possibly lead to a variance in the diagnosis based on the decision makers prior knowledge and interpretations of the problem. The description supplied by the patient might also contradict data from diagnostic tests, which further complicates the diagnosis.

It has been shown that medical practitioner students consider different types of information based on their experience, and Kushniruk suggests that this has implications for how a computer-based information system should be designed. The content should be customised to match the experience of the user, and that it should be adaptable to the complex decision situations. Practitioners do not always work in a linear fashion, but rather looks at the problem from different angles depending on the data at hand, something a decision support system must cater for. A problem with support systems today is that they are poorly matched with the practitioner's workflow, which result in them not being used (Kushniruk, 2001).

2.4 AI IN HEALTHCARE

The definition of AI changes with time, and may be different depending on whom you ask, but the definition used in this study is as follows:

"Artificial intelligence is concerned with the development of computers able to engage in human-like thought processes such as learning, reasoning, and self-correction." (Stephenson Smith, 2014)

Big data can be sorted and annotated in a systematic way and achieve efficiency that no human would be able to. AI can ultimately derive new relationships between data points and groups, essentially discovering new knowledge (Halevy, Norvig, & Pereira, 2009).

According to Chang (2016), the accumulation of biomedical big data is a large asset to future healthcare, but its current unorganized state obstructs its utility. Applying AI and machine learning algorithms in order to make sense of, and capitalise on, this data is an attractive thought. In this section, applications of AI in healthcare today are reviewed, as well as challenges with incorporating it.

Vast amount of data has been collected continuously over decades in healthcare, but the quality of it is often too low. For instance, the medical records are often incomplete or inaccurate (Berthold, 2009; Szolovits, 2009). While it certainly helps to have much data to analyse and confirm relationships between the data points, the quality of the data is what defines the result. AI should also be directed towards solving a specific problem, rather than analytics itself, something that is notoriously missing in data-driven healthcare (Chang, 2016; Berthold, 2009).

A more reliable and consistent data collection is required as a foundation for AI in healthcare to contribute to future goals of safety, efficiency and effectiveness (Stefanelli, 2009). Perhaps this data could be used to implement decision support in every step of the healthcare journey (Berthold, 2009; Szolovits, 2009).

2.4.1 EXAMPLES OF AI IN HEALTHCARE

The following three examples show some of the potential and feasible applications of AI in healthcare; treatment decision support, predicting the next move of a surgeon, and image analysis of malignant melanoma.

Bennet and Hauser (2013) attempted to develop a non-disease-specific AI that learns to decide on the suitable treatment over time, using decision processes and dynamic decision networks. The study showed the feasibility of implementing such a system with significant cost reductions (the AI was 38% of the cost of regular treatment) and a potential to achieve 30% increase in patient outcomes. Even more improvement of patient outcomes could be achieved, though at the expense of lower cost reduction (Bennett & Hauser, 2013).

A study regarding whether AI could assist the prediction of a surgeon's next move showed that complex situations could systematically be broken down by an AI to perform reliable actions. The results showed an accuracy of 95%, outperforming the current state of the art. The AI was also able to recognise when the predictions became inconsistent and deciding when it was reasonable to make predictions. It also had a number of other advantages, such as ensuring better procedure consistency by notifying when the surgeon deviated from standard practice (Forestier, Petitjean, Riffaud, & Jannin, 2017).

A study conducted by Esteva, et al. (2017) trained a deep learning algorithm to be able to identify malignant skin conditions in photographic images on par with dermatologists. It was trained on 1.41 million images of both malignant and benign skin conditions, thus being able to calculate the probability of either case. Hence, the system was able to produce an output regarding the risk of the nevus being cancer. The algorithm was made in a similar fashion as the neural network in the human brain, which may make it hard to identify how the data was processed in the artificial network.

2.4.2 IMPLEMENTING AI IN HEALTHCARE

Apart from the external limitations in resources, the practitioners themselves must be considered. The amount of knowledge and skill that modern healthcare includes is rapidly expanding and memorising it all is virtually impossible, even within the domain of their speciality. Introducing aids to support the gathering, analysis and presentation of information is, therefore, of great interest. Taking advantage of the strengths of the different actors in a human-computer system is worth pursuing as humans have a superior intuition, while computerised systems excel at managing raw data. A combination will reach further than the sum of its individual parts, making for an efficient and accurate system (Chang, 2016; Bennett & Hauser, 2013).

It might also ease some of the concerns of the healthcare staff as the technology then will act as a tool to deal with repetitive task, rather than replacing their entire occupation. Moreover, the concern that big data will depersonalise healthcare might have the opposite effect for this reason; the healthcare staff will potentially spend less time and stress on monotonous and administrative tasks, leaving more quality time to interact with the patient (Chang, 2016; Berthold, 2009).

Shortliffe (2009) states that a majority of the barriers for a data-driven AI approach within healthcare has not been technical, but political, social, cognitive and regulatory. Furthermore, according to Patel (2009), implementation is hindered by the gulf between the technology and the user, as many information technology attempts within healthcare fail due to them being inconsiderate towards the cognitive aspects of the human user in the system, urging for more research in how to bridge this gap with design.

Healthcare staff often apply heuristic approaches and intuition when diagnosing. However, these methodologies risk bringing human bias into the diagnosis. For instance, misconceptions regarding probability and inconsistencies when validating a hypothesis. AI can complement the human induction by providing a more data-driven consistent approach, and to analyse the human reasoning itself to see its fallacies (Patel, 2009).

Szolovits (2009) mentions four main challenges with AI in medicine:

1. Data collection and management
2. Design of workflows and modelling
3. Reassurance of patient confidentiality
4. Modelling techniques

In addition, Chang (2016) mentions further challenges in introducing AI in medicine:

5. Signal-to-noise problem where the quality data representing the actual disease is overwhelmed by the noise data, that is the data which is irrelevant in regard to the disease
6. The data should be accessible to the healthcare staff, not only physically but also cognitively
7. Healthcare staff may feel unsettled by the technology replacing their work tasks
8. Storing and ownership of the data, especially data with privacy concerns such as patient data

Combining AI and healthcare has great potential to generate value for both society and the individual. However, as the challenges in these domains are cross-disciplinary and involving many parameters, it might be hard to even define the problem itself.

2.5 TAKEAWAYS FOR STUDY

An important gap in the current research is the interaction between the AI and the user. This study investigates the implementation of AI into a diagnosis support, why considering the above mentioned challenges and previous work in the field is important. This includes supporting the practitioner in digesting complex data in the diagnosis process and how this data is transformed into a decision.

Furthermore, considering on what level the care is offered, be it primary care or healthcare, will further direct the level of the system. Lastly, ensuring the compatibility with Product X is necessary, to make for a smooth implementation into Company X's existing product.

3 THEORETICAL FRAMEWORK

Models and theories useful to the thesis are presented in this chapter. It covers an introduction to design problems and how different paradigms of human computer interaction shaped the view on usability and user experience. Finally, theories of the mechanisms of trust from different perspectives are presented, as trust is significant in a system with automation.

3.1 WICKED PROBLEMS

Rittel and Webber (1973) states that a problem can be said to be wicked when the problem itself is difficult to define. To fully understand the matter at hand, one must comprehend the context by constructing hypotheses regarding solutions to the problem, which in turn directs the data collection, contributes to the understanding of the problem space. A wicked problem is never fully solved, as more information could always be gathered, or more effort be put in to achieve a larger view of the problem space. Furthermore, solutions to a wicked problem might not be classified as true or false, but rather good or bad depending on how well they address the scope of the problem.

Given the complexity of a wicked problem, it is difficult to analyse its sources. One problem might be a symptom of another, underlying problem. This might be mitigated by expanding the scope of a study, formulating a higher-level problem. Doing so will ensure several factors are caught, facilitating for a broader and more comprehensive solution to be developed. As the domain of AI in digital healthcare is relatively uncharted, the notion of wicked problems motivates a user study to extract and define the problems as well as understanding their implications for the development phase.

3.2 HUMAN COMPUTER INTERACTION

Over the course of human computer interaction, perspectives on what is deemed important for a successful interface has changed (Harrison, Sengers, & Tatar, 2007). The authors describe three paradigms, each focusing and promoting different approaches to interaction. The first paradigm focus on the fit between the human and machine, where optimisation is done through identifying and solving problems in the coupling between the two. The second paradigm views the interaction as a symmetric information processing. Usability aspects are important to optimise the usage, and the system should be efficient to use. However, aspects regarding the pleasure of using the product is mostly left un-recognised.

According to Harrison, Sengers and Tatar (2007), a new paradigm is initiated when something previously left in the margin is brought to the centre of attention. A term gaining traction in recent years is user experience (Hassenzahl & Tractinsky, 2006). This is described as a reaction to the usability-dominated domain of human computer interaction and calls for a new and third paradigm in human computer interaction (Harrison, Sengers, & Tatar, 2007), described as promoting embodied interaction. The meaning is derived from the context of use, as opposed to the second paradigm, where the meaning is built from cognitive and information-based coupling. It is important to consider a rich interaction when considering the third paradigm, rather than an objective one. However, the paradigms are not mutually exclusive, and aspects from the previous paradigms might play a role in a product situated in the third.

Developing an interface situated in the third paradigm calls for the support of theories regarding user experiences, which is relevant to this study. Although the move into a new paradigm is imminent, the previous paradigms are not obsolete. Thus, to consider usability aspects is still important. Building trust is important when considering the coupling between the user and the computer, as an automated system might risk leaving the operator feeling a loss of control.

3.3 DESIGN FOR EXPERIENCE

To understand the full user experience of a product or service, the analysis needs to probe deeper under the surface of the design. As this study aims to introduce a relationship between human and AI in the diagnosis process, leveraging trust and increasing effectiveness, an understanding of the underlying mechanisms is required.

According to Norman (2004), user experience acts on three different information processing layers; the visceral, behavioural and reflective layer. The visceral layer can be described as preconscious and prewired; the animal instincts level. For instance, in products this is the initial reaction to the artefact, such as the look and feel. The behavioural level is the subconscious level and processes everyday events, which translates to the usability aspects of a product. Finally, the reflective level is where the user is conscious about the information processing. These involve for instance the ethics, moral and cultural aspects of said product and may, for example, be expressed by actively buying a particular brand because of the social status it would infer.

Norman's model of design for experience was used throughout the concept development in testing and evaluation to ensure that all aspects of the experience were considered.

3.4 USABILITY

Developing an interactive and user-friendly system calls for usability. Nielsen (2012) defines it as “a quality attribute that assesses how easy user interfaces are to use”, by using five different, measurable factors; learnability, efficiency, memorability, errors, and satisfaction.

Learnability considers how easy a product is to use for a specific purpose the first time. The user’s ability to perform tasks after a period of usage is determined by efficiency. Memorability is the term to define how easy a user effectively can start using a product after a period of not using it. Errors refers to the prevalence and severity of errors the user may make during usage, and how easily they may recover from them. Lastly, satisfaction is about how pleasant the usage of the product is to the user (Nielsen, 2012).

Combining a product’s usability with its utility results in a measure of how useful it is. Utility regards if the product delivers the features a user needs to effectively be able to conduct their task. The terms building up usability will be used in this study to evaluate the user testing of the prototypes, as well as assist in building the requirement list.

3.5 TRUST

Considering a system using automated support, it is important that the user can trust the system. Presented below are theories targeting this topic from different angles, providing a more nuanced way of considering trust, which are used to evaluate the concepts in this study.

Lee and See (2004) defines trust as something necessary when an automated system used for a specific task is too complex to fully understand how it works; “expectancy held by an individual that the word, promise or written communication of another can be relied upon”. Although some humans are more prone to trust a system early on, as time goes by, personal differences regarding how trusting they are, will play a lesser role in how trustworthy you perceive an automated system, as the human-system relation is improved over time. However, the system must be stable and provide evidence of its benefits for trust to grow.

Aligning the trust to the system capabilities in automation generates the desired and productive use of the product. It also ensures the level of trust is consistent on a healthy level throughout the use and between uses (Figure 3). The model is largely linear, meaning deviation from the calibrated line will lead to either distrust, if the trust is insufficient to the system capabilities, or overtrust if the opposite is true. Resolution refers to the relation between a range of trust and a range of system capabilities (Lee & See, 2004).

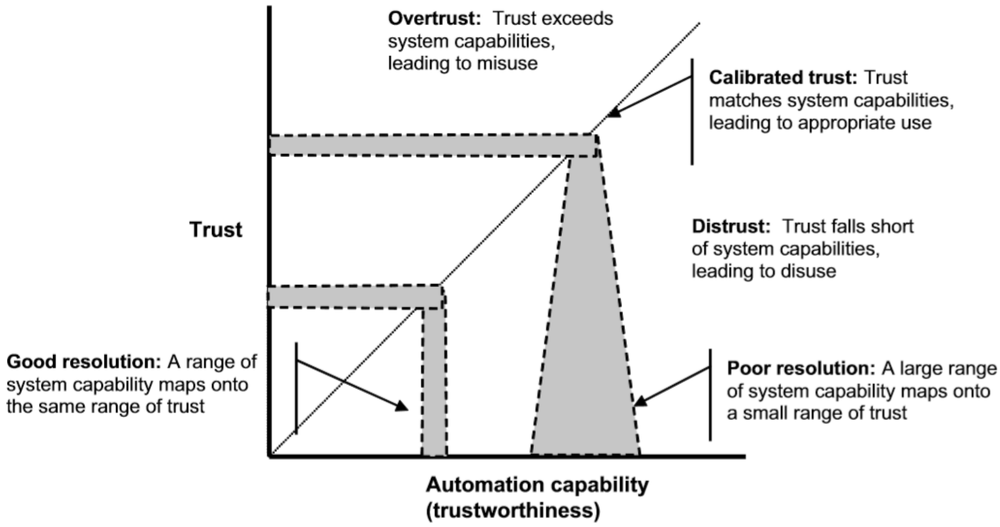


Figure 3. The relationship between trust and automation capability, where deviation from the calibrated line leads to overtrust or distrust (Lee & See, 2004).

Mayer, Davis, and Schoorman (1995) describes interpersonal trustworthiness using three factors: ability, benevolence and integrity. Ability refers to the individual competence and skills of a party, making it reliable to produce results in that domain. Benevolence is the altruistic willingness of a trustee to be helpful to a trustor. The third factor, integrity, states that the set of values and principles of the trustee are aligned, or accepted, by the trustor. In isolation, these characteristics are insufficient for building trust; a combination of the three is preferred. However, as trust is not perceived as binary, but rather a continuous scale, the level of trust can be expected to vary depending on actors and context, given the same level of these three aspects.

The three factors transform when the system is changed from an interpersonal one, to one involving an automated component. Instead, they are transformed into: performance, purpose and process (Lee & Moray, 1992). Performance describes the possibility to understand the system's behaviour, purpose refers to the possibility to understand how the system is intended to be used, and process concerns the understanding of how the system makes a decision. It is noteworthy to point out that trust is based on the user's perception of the system rather than how trustworthy the system actually is.

Ekman, Johansson, and Sochor (2018) lists a series of factors directly applicable to a system in development (Table 1):

Table 1. Factors affecting trust in a human machine interaction system (Ekman, Johansson, & Sochor, 2018):

TRUST FACTORS	DESCRIPTION
Mental model	The system should be aligned with the user's mental representation of the task to ease the understanding of the system.
Expert/Reputable	The tone of the system should be that of an experienced agent.
Common Goals	The system should strive for unifying its goals with the user's by suggesting courses of actions that the user then can accept or decline.
Training	The user should have the opportunity to train on the system before the actual usage takes place to improve the user's knowledge of the system.
Anthropomorphism	A system that is human-like.
Feedback	Output that appeals to different senses.
Adaptive Automation	The system should be able to adapt to the preferences of the user.
Customization	Non-critical functions should be customizable to the user.
Uncertainty Information	The system should present information if it is uncertain about if an action can be carried out, because of external factors.
Why and How Information	The system should give information about decisions made, both how it will tackle a problem and why it will do so.
Error Information	If an error occur, information should be presented explaining why it occurred and what the consequences were.

An understanding of the trust mechanisms between the human operator and an automated system were used in the concept development to evaluate the origins of mistrust and adjust different parameters to find a balance.

3.6 TAKEAWAYS FOR STUDY

How the gathering of data is to be conducted will be guided by the theory of wicked problems. The development of solutions will be dependent on which paradigm to place the system in, putting different needs on the user experience and the level of usability. To develop a partly automated system also calls for the consideration of how to build trust in such a system.

EXPLORATION PHASE

This phase aims to define problems and derive requirements from the result of explorative interviews and observations. The result is utilised for solutions in the development phase.

4 METHODOLOGY
FOR EXPLORATION PHASE

In this chapter, the methods and processes for conducting the user studies are described. The explorative user studies involve conducting interviews and observations, analysing data, and identify problems through KJ analysis and interaction mapping. Then a requirement list is generated to facilitate for the development phase.

4.1 USER STUDY METHODS

To define the wicked problem, achieving a thorough understanding of the healthcare domain was necessary. This was done by conducting eleven semi structured interviews and one observation.

4.1.1 SEMI STRUCTURED INTERVIEWS

A semi structured interview is a method used to gather users' experiences, perspectives and opinions on a subject with a script as basis, but the interviewer can deviate from this to pursue interesting side tracks (Wikberg Nilsson, Ericsson, & Törlind, 2015).

In total, ten interviews were held (Table 2) with medical practitioners; four general practitioners in the primary care, four medical practitioners in specialised fields in hospitals, and two nurse practitioners at an emergency room. In addition, one interview was conducted with a software developer working on machine learning and deep learning (Appendix 1.1). The interviewees were recruited based on their specialisation. Focus was on recruiting general practitioners, as they are often the first instance in the healthcare chain, thus holding insights in a wide spectrum of diagnoses. The specialists were recruited to capture the insights of more specific patient cases. Each interview lasted for roughly 60 minutes, with one interviewee and two moderators, one interviewing and one taking notes on a computer.

Table 2. Participants in semi structured interviews.

INTERVIEWEES	TITLE	TYPE OF CARE
4	General practitioners	Primary care
4	Specialists	Healthcare
2	Nurse practitioners	Emergency room
1	AI software developer	-

An interview guide for the practitioner interviews (Appendix 1.2) was developed to ensure comparability between the different interviews and to keep the interviews on topic. The interviews were kept semi-structured to enable interesting leads to be pursued, which helped increasing the amount of data collected. A pilot study was carried out with two practitioners at Company X to evaluate the interview guide before using it with external practitioners. Due to their insight in the digital healthcare domain, these interviewees were considered to be key persons in eliciting requirements in said domain. This is an application of the model by von Hippel (1988).

The covered topics in the healthcare interview guide were regarding the practitioners' diagnosis process, their perspective on intuition and a data-driven approach to diagnosing, the technical advances in healthcare during their years of working, and lastly their perspective on AI. Topics covered in the interview with the software developer included the basics about AI, how an AI could be used in diagnosing a patient, how an AI would fit into healthcare, and issues regarding security of personal information's security.

Three of the interviewees had experience working with Product X. However, the initial part of the interview with these practitioners still concerned the diagnosis process as a whole, complemented by probing questions regarding how different aspects were managed in and affected by the product. The distinction in the interviews between the traditional healthcare environment and Product X was evident.

The data collected in the interviews fed into the identification of problems, which formed the basis for the concept development.

4.1.2 OBSERVATION

Observations are conducted to identify how a user actually performs their daily tasks in a specific context. It aims at providing insights regarding relations of tasks, as well as attitudes and goals not easily expressed through an interview. It is also used to identify actions carried out intuitively, which the user might not reflect upon them doing, why they might not be able to describe their reasons verbally (Wikberg Nilsson, Ericsson, & Törlind, 2015).

The observation was unstructured and was performed in the emergency room at the hospital of Kungälv. One nurse practitioner was followed for eight hours, and it was also possible to observe several other practitioners performing their work in the emergency room. Both project members attended the observation, documenting the practitioner's actions and words in their daily work. This included observing the practitioner treat a patient, reviewing medical records and attending meetings. The outcomes were new insights regarding non-verbal actions and problems prevalent in healthcare.

4.2 ANALYSIS & PROBLEM IDENTIFICATION METHODS

The analysis of the user study concerned mainly the overall diagnosis process, in its current state within traditional healthcare. How Product X is applied and affects different aspects was analysed separately to avoid any confusion between the two. This distinction also helped to analyse the diagnosis process from a broader perspective to avoid defining too narrow problems and consequently sub-optimising the solutions. Lastly, a requirement list was elicited.

4.2.1 KJ ANALYSIS

KJ analysis is a tool used to structure and compile large amount of qualitative data. The data is sorted into different categories depending on the subject and is then arranged according to its inherent relations. This is done to achieve a better understanding of the problem area and to discover how the different parts relate to each other. This leads to an extensive overview of the different problem areas present in a given field (Spool, 2004).

A KJ analysis was made to organise the findings from the user study. Citations and remarks were put down on sticky notes and then placed in to different categories. This led to an extensive collection of problem areas which individually could be discussed and processed further. Furthermore, it helped unifying the view of the different subjects, resulting in a common view regarding how the problems related to each other and defining the wicked problems.

4.2.2 INTERACTION MAPPING

To understand the relationship between different actors in a process, it was necessary to develop a new method. The method was inspired by the KJ analysis (Spool, 2004), but adds how the different actors in the categories interact with each other, both in terms of input and output.

The result was an interaction map, where the different inherent parts and their connections to each other were defined. Furthermore, problems regarding the internal process of an actor was mapped to that specific entity, resulting in a comprehensive overview of the problems present in a system. To make the identification of common problems easier, grouping the different types of problem in themes were made by determining suitable categories which reflected the different problem areas.

4.2.3 REQUIREMENTS ELICITITATION

A requirement list is used to systematically value the level of importance of different aspects and is used to ensure they are all considered in the development process. First, the goal is defined, which are obstructed by the problems. The requirements are elicited in order to overcome these problems and achieve the goal (Kaulio, Karlsson, Rydebrink, & Klements , 1996).

The requirements were systematically derived from the problems and grouped into new categories, symbolising different areas of development. A rating of 1-3, where 1 is less important and 3 is very important, was given for each requirement, representing its importance to solve the problem. The requirement list was used as a basis for generating ideas as well as verify concepts in the development phase.

5 USER STUDY INSIGHTS

In this chapter, the results of the user studies are presented. It starts off with a walkthrough of the diagnosis process, followed by the interaction mapping of actors and tools. Furthermore, findings regarding working as a practitioner in Product X will be presented, concluding with the interviewed practitioners' collected perception of technology in healthcare. The next chapter summarises these insights into five different problem areas.

5.1 DIAGNOSIS PROCESS

The study identified six distinct parts in the diagnosis process (Figure 4). Although the process is iterative, it was deemed necessary to construct a chronological timeline for easier comprehension. The six steps were defined as triage, preparation, anamnesis, examination, diagnosis and delivery and treatment. Furthermore, following up a patient as well as the iterative nature of the diagnosis process is described. The timeline was constructed from the practitioner's point of view.

Figure 4. Overview of the diagnosis process.

5.1.1 TRIAGE

When a patient applies for care, they start by explaining their concerns. This explanation forms the basis for the healthcare the patient will receive. This can either be done online, with the patient describing their problems or in an interview with a nurse. The patient is then sorted to the right instance based on the level of priority. This also affects when the patient will receive care.

5.1.2 PREPARATION

The practitioner prepares for the patient visit by reading up on the patient's medical history, potentially contained in multiple medical records, depending on where the patient has received care before. The medical records contain information regarding previous healthcare visits, medicines the patient may be on, and general findings a previous practitioner might have noticed. This information may in some way affect the current visit, why the practitioners express a desire to thoroughly understand the comprehensive medical history. However, due to time constraints, the medical records are often not thoroughly examined, why often only the latest visits are reviewed, although interesting information could be found earlier in the medical records.

5.1.3 ANAMNESIS

When the patient meets the practitioner, they are interviewed about their problems. The interview is laid out in an open fashion, where the patient is prompted to explain their symptoms in their own words. The anamnesis is regarded as very important by the practitioners interviewed, as the answer to the diagnosis often in some way is expressed through the patient's words. However, the practitioner also uses standardised forms for questions to ask the patient. They are used to ensure the practitioner covers vital parts about the patient's medical history. Furthermore, the practitioner is often able to tell the state of the patient only by looking at them, identifying the severity of a problem, or if the patient is suffering from something else than what they are seeking care for. This is often referred to as the clinical eye.

To conclude the anamnesis, the practitioner asks follow-up questions necessary to accurately decide on a diagnosis. Another important task for the practitioner is to set up a common goal for the patient's visit. It is important to understand what the patient expects so the treatment in some way can accommodate for this.

A problem expressed regarding the anamnesis is patients being subjective in their interpretations of their symptoms. It might be hard to quantify variables such as pain, or for how long a symptom has been prevalent. This, in combination with different personalities of patients the practitioner treats, forces the practitioner to be attentive throughout the visit and trust must be built to accommodate for a constructive anamnesis to be collected.

5.1.4 EXAMINATION

The examination is split in two parts, physical examination and clinical tests. In the physical examination the practitioner searches for physical symptoms that might direct the diagnosis. Clinical tests are performed to further strengthen or dismiss the practitioner's hypothesis of the diagnosis. The tests include among others blood samples, different kinds of x-rays, electrocardiograms (ECG) and ultrasound.

Depending on if the test is performed at a hospital or a healthcare centre, the time to receive test results may vary greatly. At a healthcare centre some of the machines required for a test might not even be accessible, why a referral to a hospital might be needed. This leads to a disruption in the healthcare procedure, as the patient might need to return at a later date or go to another facility to conduct their tests. Furthermore, the output of the test might be difficult for the practitioner to comprehend and analyse, why further consultation with a specialist or the one conducting the test might be needed. Given the output of the test, the hypothesis might also have to be altered. However, this might not always be to the better, as the input defines the output. If the test shows an abnormal result, it might be because of an incorrect input, and may not reflect the actual state of the patient.

5.1.5 DIAGNOSIS

When the anamnesis has been collected and the physical examination and the clinical tests have been performed, the practitioner has to assess all the information and form a diagnosis. When the collection of symptoms is not enough, or the practitioner is unsure about the diagnosis, they search for external information to guide them in the process. This is done by either searching online knowledge databases or reaching out to a colleague. However, the practitioner often draws from previous experience when conducting the diagnosis, as most often the reason for visiting a primary care unit is because of a common disease.

When deciding on a diagnosis, the practitioner considers the risk of them being wrong in their prediction and what this implies for the patient. It is sometimes hard to assess the definite diagnosis, why the most probable condition is chosen as the diagnosis to start with. The patient is then followed up on their treatment, and if the practitioner realises that it has no effect, the diagnosis may be reassessed.

5.1.6 DELIVERY & TREATMENT

When delivering the diagnosis to the patient, it is important that the practitioner is sure whether the patient understands the implications of the diagnosis or not. One practitioner asked the patient to repeat the diagnosis, which helped assessing to what extent the patient had understood. Furthermore, it is important to encourage the patient to follow through with the suggested treatment plan.

After the healthcare visit, the practitioner fills in the medical records of the patient. The anamnesis is included, along with personal notes from the practitioner and if a medication was prescribed. Sometimes the practitioner does this on their own, but it is common for them to dictate what is to be filled in and then having a medical secretary writing it down in the medical records. The practitioner then has to review and correct the notes written down.

5.1.7 FOLLOW UP

After a patient visit, the practitioner has the possibility to reach out to the patient to ensure the proposed treatment is working. This was pointed out as something that is not commonly practised, as the means of communication is either by mail or a phone call, which both are time consuming and inconvenient. Thus, the practitioner rarely receives any feedback on whether or not the treatment made the patient better, consequently not knowing if the diagnosis decided was correct.

5.1.8 ITERATION

As mentioned above, the diagnosis process is not always linear. Retracing back to extend the anamnesis as well as conducting further examinations and clinical tests might sometimes be necessary. The practitioner might have several possible diagnoses in mind and conduct tests to figure out which one is most probable. Should one practitioner not be able to settle on a diagnosis, the patient might be referred to a specialist, and because of poor documentation after each visit, the patient might need to repeat their anamnesis for the new practitioner treating them.

5.2 DIAGNOSING USING PRODUCT X

The practitioners who diagnose patients via the platform Product X reportedly utilise the same diagnosis process as when diagnosing in a physical environment. The main difference is the asynchronous mode of communication which the chat implies.

Consequently, the practitioner needs to be more specific in their wording and may ask the patient to more vividly describe symptoms, as they cannot be physically examined digitally. Although the ability to send photos and videos partly mitigates for the loss of a clinical eye, the lack of tactile sense and the overall non-verbal communication which a patient subconsciously expresses is still significant. Product X is, therefore, ideal for common diseases which are simple to diagnose without physical examination, but more complicated patient cases might be referred to a physical healthcare centre for a more thorough physical examination or to perform clinical tests.

Another effect of the asynchronous chat is that the practitioner may not receive a reply from a patient immediately, the way they will in a physical encounter. Instead, it may take several minutes for the patient to notice the message and compose a reply, a delay which quickly adds up to unnecessary downtime for the practitioner. So, it is not uncommon for practitioners to treat several patients simultaneously to become more efficient. Some interviewees reported of up to seven concurrent patient visits, resulting in a fundamental change of workflow for the practitioner, compared to a traditional setting where one patient is focused on at a time. Maintaining a split concentration between different patients in this manner is challenging and it may also take a bit of time to shift from one patient to another and re-engage and resume that case. Some practitioners used paper notes to remember the status of the different patients to ease these factors.

Finally, two concerns were raised from working in a system such as Product X. Firstly, the distribution of resources, as the medical practitioner ends up doing more administrative tasks than in a traditional setting where they are supported by nurses. Secondly, practitioners may be hesitant to introduce yet another system into their workflow, since they are already managing multiple computer systems in their work.

5.3 ACTORS & INTERACTIONS

During the user studies, several actors were identified in the general diagnosis process; the practitioner, patient, human support, and tools and diagnosis support. These actors interact with each other in multiple ways, with the primary actor being the practitioner (Figure 5). They act as the centre piece, leading the patient through the diagnosis process, utilising different resources along the way to conclude on a diagnosis. Below the different actors are described, as well as how their interactions affect the diagnosis process.

Figure 5. Interaction map, showcasing the different actors in the diagnosis process.

5.3.1 PRACTITIONER

A practitioner is often able to find rudimentary diagnoses without any support. Experience builds routines regarding how to detect certain diagnoses. This is more prominent in primary care, where the symptoms the patients search treatment for are more easily assessed. However, as primary care often is the first step in the healthcare chain, the practitioner must be able to detect the cases which needs attendance from a specialist. Furthermore, a practitioner often lacks perception of probability and statistics.

The science of healthcare is constantly evolving, and as such a practitioner needs to update their knowledge continuously. Thus, the practitioner regularly attends educative courses to hone and develop their skills. As knowledge becomes outdated, the practitioner often relies on knowledge support databases when assessing the diagnosis. However, it is important that the practitioner preserves internal knowledge, should the technical systems fail.

5.3.2 PATIENT

In the communication between the practitioner and the patient, it is important for the practitioner to cater for the different needs, fears and expectations the patient might hold. The practitioner might also have to adapt their communication to the patient's level, by being more descriptive in talking about symptoms and expressions that the patient might not understand. It is also important to build trust between the practitioner and the patient, for the patient to feel at ease and open to share important, but maybe sensitive, information which might affect the assessment.

If the patient has ambiguous symptoms which contradict each other, it might be difficult for the practitioner to interpret them consistently. The clinical eye is an important tool to intuitively guide the diagnosis in the right direction. However, it might lead the diagnosis in an incorrect direction and cause tunnel vision for a specific hypothesis, which might lead to a false diagnosis. Another problem regarding the clinical eye is that it might be disrupted by prejudice and subjectivity, for instance something perceived by the practitioner as a symptom might in fact be unrelated to the health state of the patient.

5.3.3 HUMAN SUPPORT

When the practitioner needs help or guidance in a case, they might reach out to a specialist or a colleague for advice. Similar to the online knowledge support, the colleague acts as an extension of the practitioner's competence, but the colleague offers a personalised explanation to their advice and provides a new perspective on the case to the practitioner. The colleagues, however, also have their daily work to attend, which might make them hard to reach when the practitioner needs them. Furthermore, the personal relationship between the two parts plays a role in how well the communication works, and the practitioner might be reluctant to reach out to certain colleagues because of this, even though their perspective might be useful.

A problem regarding specialists is that they are prone to consider problems in their own field. As a specialist also tends to treat the more uncommon cases, their relative view on distribution of diagnoses might be skewed. Thus, if a practitioner reaches out to a specialist with a potentially more common diagnosis, they might receive a biased answer in the probability of it being something worse than it actually is. It is also important to consider that different fields of specialisations might have different opinions regarding the same symptoms, as they might imply one thing for one specialist in one field, and another to someone specialised in another field.

5.3.4 TOOLS & DIAGNOSIS SUPPORT

A practitioner has many tools at disposal in assessing the diagnosis. They include diagnosis forms with standardised procedures to follow to find a diagnosis, clinical tests, knowledge support databases and the medical records of the patient. A common denominator for the tools, excluding the medical records, is that the practitioner requires transparency in order to use them. They must be able to trust the sources and that the tool does what it is supposed to do in order to rely on them.

Medical records

The medical records contain information regarding the patient and their previous visits, as well as medications the patient may be on. Furthermore, the practitioner writes down noticeable findings and what has been considered for the proposed treatment. However, the information is split on many different medical record systems, which might not be accessible between different hospitals or counties. Within one healthcare unit, there might also be different systems for different notes, for instance regarding the actual visit and lists of prescribed medicines. Thus, extracting information from the combined medical records is often time consuming, as the practitioner must jump between different views, which often prompts the practitioner to log in to each system.

Although the medical records contain much information, it sometimes lacks aspects which are important for a future practitioner who should treat the patient. Thought processes from a previous practitioner might not have been written down, which could include relevant information regarding observations made or general concerns the practitioner might hold about the patient. Ultimately, the lack of continuity could lead to risks for the patient, as potential diseases might not be detected in time to conduct preventive healthcare.

Checklists and guidelines

In the diagnosis process, the practitioner sometimes uses diagnosis forms. These are standardised checklists aiming to identify certain diseases. Scoring systems, where the practitioner ranks symptoms according to their prevalence, are also gaining traction in the Swedish healthcare. These aim at finding critical conditions and states if the patient needs treatment urgently. Hospitals also develop internal documents regarding how certain symptoms and diagnoses should be handled. Although the forms are expressed as helpful in pinpointing a diagnosis, they are seldom strictly followed, as the practitioner favours flexibility in their process of finding symptoms.

Online knowledge support

In their daily work, the practitioners regularly use online knowledge support. These are websites directed at giving information regarding diagnoses, as well as the criteria which defines them. There are many different websites which offers these services, and usage is often based on preference, but sometimes the hospital or primary healthcare centre recommends a specific system the practitioners should follow. The reason for using knowledge support is that the science of medicine is constantly evolving, why it is difficult to be updated on the latest practices. In this regard, it acts as an extension of the practitioner's competence, as they can hold a general idea regarding a specific diagnosis, and then use this idea to find extensive information about it online.

Common online knowledge databases the interviewed practitioners used:

- Internetmedicin.se
- Fass.se
- Viss.nu
- Janusinfo.se
- Medibas.se

Clinical tests

Clinical tests are used to find internal conditions that might affect the diagnosis. The tests are often conducted with a machine, which leads to an objective output from the systems, but then the practitioner has to interpret this output for their specific patient. Due to this, there may be errors, grounded in the practitioner's preconceptions regarding what the output should be to fit the hypothesis from the anamnesis. The tests might also be prone to errors in the input, as the test might have been conducted in a wrongful way, resulting in an inaccurate output. If this is not catered for, and the practitioner base their decision on the faulty test, the diagnosis might not be correct.

5.4 PERCEPTION OF TECHNOLOGY IN HEALTHCARE

Healthcare is a workplace mixed with highly advanced equipment as well as a multitude of old, redundant, and hard to use systems. In specialised areas, new machines may be introduced fairly regularly, but everyday computer systems such as the medical records and the way to contact a patient remain obsolete. Moreover, practitioners express frustration at how various systems which need to deal with shared information cannot communicate directly with each other, but need the practitioner to act as a manual mediator between them.

Two of the interviewed practitioners stated that a significant recent shift in healthcare technology was the digitalisation of the medical records system. This contributed to a safer patient management as well as enabling instantaneous access to previous medical records from across the country. However, many of the medical staff were sceptical of the digital revolution within healthcare, due to the big changes in the systems and their concerns for security as they thought of digital data as fragile. The response to the change signalise the attitude and adaptation to major shifts in their systems. In comparison, specialised tools such as x-ray technology and ultrasound have been dramatically improved the last ten years. They have contributed to diagnoses with higher accuracy and been adopted auspiciously.

As for the new trends of digital healthcare, most of the interviewees see it as an inevitable step of healthcare, and that it can become a big paradigm shift in how the care is distributed. Positive expectations include better accessibility, a better distribution of resources, and lower strain on healthcare units. However, there is worry regarding the quality of care provided. The worry is rooted in that the patient will not receive the care required for their needs and will end up needing to visit a physical healthcare centre either way to follow up on the misdiagnosis. Thus, nothing is gained from the digital care, in fact, the patient receives care twice instead of once, only benefitting the digital healthcare provider, but causing more strain on the whole system. Another concern is that, for instance, antibiotics will be prescribed unnecessarily, due to the lack of quality care.

When envisioning the future, the practitioners expressed ambitions to become more systematic in their workflow and use advanced tools that assist in probability calculation and understanding of statistics. Another is more personalised treatment, where the diagnosis and treatment are tailored for the patient's state of body and mind to a higher degree, perhaps in the future even based on their DNA. A common wish was to integrate medical records and other internal healthcare systems into a continuous accessible system, sorted in a timeline.

Most of the interviewed practitioners had heard the term “artificial intelligence” or “AI” before and described it as an advanced system that could think for itself, without human intervention. However, some had not heard the term before, or associated it with robots in science fiction.

The subjects were positive towards the development of AI within healthcare, but also expressed a healthy dose of scepticism. Most importantly, the system should be trustworthy and provide clear benefits to the user. They were positive regarding having the AI assist in accessing information or suggesting the next course of action as it then would act as an assistant to the practitioner. Having a second opinion on a difficult matter was also regarded as useful, but it might also be irritating to have a system which opposes actions or decisions, even though this might actually be desirable if the accuracy was improved as a result. Some stated that full transparency of the inner workings of the AI would mitigate this, but even if the AI would be consistently correct, there is a worry that the AI system might make the practitioner lose its internal competence or even feel redundant with time.

Overall, the attitude to introducing new technology is that of welcome, but the implementation is key. As there are already problems with seemingly basic systems, there is a resistance to introducing even more advanced systems, such as AI, for fear they will end up the same, negatively impacting the workflow of the practitioner and reduced time for the patient.

6 PROBLEM AREAS

Based on the user studies, five problem areas were derived: time and tasks, competence, communication, processing, and trust. These five problem areas represent different dimensions where complexity arises during the diagnosis process. While they might overlap in some areas, considering them separately provides a clearer understanding of the overall complexity.

6.1 TIME & TASKS

This first problem area concerns inefficiency in time management and disrupted multitasking in the practitioner's work, spanning from managing the medical records to treating multiple patients simultaneously.

The medical record is a tool with which the practitioner can access and add information about the medical data about the patient. But the medical records consist of multiple systems, which all need separate logins and different platforms, making an overview or scan over the most relevant information problematic for a particular visit. Information can be both unstructured and redundant, and in different media; some documents are scanned in documents which are hard to read. The medical records system is both physically and cognitively demanding for the practitioner as well as time consuming, potentially leading to the practitioner not considering vital information about the patient.

Keeping track of numerous systems is a reoccurring theme across healthcare, and managing them correctly and consistently takes up much of the practitioner's cognitive resources. In addition, the practitioner often needs to multitask when, for instance, waiting for test results or using other tools, leading to them having several parallel ongoing tasks at one time. While some practitioners argue that they have built this into their routines, it continues to be a cognitive load which disrupts their workflow.

This is especially true for the practitioners who work in Product X, where the practitioner communicates with the patient asynchronously, so they must wait for the patient to answer. This has led to the practitioner examining up to seven simultaneous patients. Although many of the patient cases in the product are relatively straightforward, this still means the practitioner needs to keep all individual characteristics in their head or catch up in the conversation every time they reply. Their workflow becomes disrupted between patients, rather than continuous. Furthermore, access to human support is problematic as they have their own tasks to tend to and the practitioners do not wish to bother them and take up their time.

Moreover, as the most common way to introduce specific AI tools is in a computer software, a growing number of AI tools will impose an even greater number of systems for the practitioner to keep track of. Disregard to this will risk disrupt their workflow significantly.

A diagnosis tool needs to take the cognitive load of the practitioner into account. If another tool is introduced, it should be incorporated into, or replace, already existing systems to limit the number of systems in use. The tool should facilitate for a continuous workflow and allow for unobtrusive communication with other practitioners.

P 1.1	The medical records contain lots of information, but it is difficult to access, both physically and cognitively
P 1.2	Many different and redundant systems to keep track of
P 1.3	Administrative tasks eat time, for instance keeping in touch with patients and filling in the medical records
P 1.4	Multitasking disrupts the practitioners workflow and concentration
P 1.5	A specialist might be hard to reach, as they have their own tasks to tend to

6.2 COMPETENCE

This problem area concerns the competence, knowledge, and skills of the practitioner. All practitioners have completed extensive education within their respective fields, but the understanding of medicine and the world at large is everchanging, leading to knowledge becoming irrelevant or outdated. To cater for this, healthcare staff are continuously attending internal educations and courses to keep their competence up to date.

Another problem concerns the internal human knowledge database and its limitations in capacity and extraction of information on command. Remembering and extracting knowledge at will might then prove more difficult, potentially risking incorrect diagnoses.

Competence varies depending on the practitioner and its field expertise. This is an advantage in the sense that it may provide new perspectives if two different practitioners were consulting each other. They can give a customised and condensed version of a suspected diagnosis. However, due to the practitioner being specialised within this field, they might be biased in overexposing the symptoms relating to their field, in relation to their actual statistical probability.

The importance of internal competence is expressed as having an understanding of each action, even if the practitioner is using a tool to perform the action. A problem is, therefore, when a practitioner relies too heavily on an instrument or tool and it fails to function properly.

P 2.1	The practitioner has a limited knowledge capacity, and needs to continuously keep up to date with new knowledge
P 2.2	Specialists can share knowledge about their field of expertise, but may also give a biased view of their own field
P 2.3	Preservation of the practitioner's internal competence is necessary if technology should fail

6.3 COMMUNICATION

The diagnosis process contains a multitude of different interactions and with them comes different types of communication. Fundamentally, there are two different types: human-human communication, where the practitioner interacts with the patient or another practitioner for advice, or human-machine communication, where the practitioner interacts with a tool or instrument. In all communication, however, transparency is a common factor for an effective diagnosis process. The ability to explain and to be open, to allow for the other party to see the inner working that generates the results.

Human-human communication, between practitioner and patient, is a fluid process where the practitioner must provide a comfortable environment for the patient to tell their anamnesis. The patient is subjective and easily susceptible to bias when expressing their symptoms. The practitioner needs to be aware of this and ask open yet directed questions, while interpreting non-verbal cues, such as body language, tone of voice and facial expressions. Moreover, the practitioner must acknowledge that different patients have different needs, fears and expectations and settle them in the beginning of the patient meeting, in order to be able to adapt the communication to the patient's level and not hinder, or alter, the patient perspective.

Human-human communication, between practitioner and another consulting practitioner, experience much the same problems as practitioner-patient communication, but is acting on a different level, with often already established relationships between the actors. This will influence the effort with which the consulter participates and may so alter the diagnosis.

Human-machine interaction consists of two actors which are of radically different composition and workings, often causing mismatches in input and output. The usability of the machine might affect the performance. For example, the machine might not communicate the type or quality of input it requires, making it difficult for the practitioner to provide it. Moreover, the raw output from the instrument may require internal interpretation from the practitioner, leading to potential inconsistencies between diagnoses.

P 3.1	Ambiguous symptoms are hard to interpret consistently
P 3.2	Difficult to cater for patients with different needs, fears and expectations
P 3.3	The patient is subjective and susceptible to bias when expressing their symptoms
P 3.4	Absence of transparency in communication leads to distrust, both in human-human interaction as well as in human-machine interaction
P 3.5	Practitioner's internal interpretation of tool output is susceptible to inconsistencies and errors

6.4 PROCESSING

While communication concerns how the different parties interact with each other, processing deals with the internal processes of these parties. Again, there is a difference between human and machine in this area.

The human thought process is very intuitive, meaning it relies on experience to reach its conclusion. This is exemplified with the clinical eye, where the practitioner sees the sum of the patient's symptoms and draws conclusions based on subconscious clues. An intuitive mindset provides a holistic view and can find new perspectives, but relying too heavily on intuitive and subjective mechanisms, such as the clinical eye, may also be prone to make rushed decisions as the practitioner may think the diagnosis is already settled, when there in fact may be more possible diagnoses with similar symptoms. Furthermore, as intuition is built upon experience, a practitioner is more vulnerable to make incorrect diagnoses in areas they have not previously experienced.

The human mind is limited in understanding probability and relies more on past experience which may be unrepresentative of the actual probability. Due to the fluid nature of the mind, ambiguous symptoms expressed by the patient can be hard for the practitioner to interpret consistently.

Machines and instruments tend to have a more data-driven approach, as opposed to intuitive. This means they compute data in a systematic and consistent manner according to pre-set algorithms, independent of previous experience. Due to their predetermined computing mechanisms, they are limited to generating the result for which they are designed. This is something the user must take into consideration before using the machine, to avoid tunnel vision. Also, data-driven approach is heavily dependent on the quality of the input, as the system cannot fill in the gaps of incomplete or low-quality input the way an intuitive mindset can. A machine is very apt at calculating probability but is limited in the learnt sample size and cannot reason whether it seems faulty or not.

Different types of processing are suitable for different tasks. An intuitive mindset provides a holistic view and can reason whether something is probable, while a data-driven approach can systematically generate consistent results, provided good input. However, both types also have their shortcomings and they must therefore be self-conscious about their processing and analyse their results. A careful combination of these types has the potential to mitigate each other's shortcomings while generating consistent qualitative results.

P 4.1	An intuitive mindset provides a holistic view but is subjective and limited in understanding probability
P 4.2	The clinical eye of the practitioner is susceptible to tunnel vision
P 4.3	Machines are data-driven, systematically generates output from input according to pre-set routines and probability, but lacks a holistic view
P 4.4	Machines are highly focused on a specific task and dependent on the quality of the input

6.5 TRUST

The trust problem area is in many ways a culmination of several of the aforementioned problems, as they together build up a sense of trust if those problems are solved. However, taking trust into account separately will provide a good overview perspective for what aspects a diagnosis system should take into consideration.

Building trust between the practitioner and the patient, and achieve patient satisfaction are dependent on several aspects, many of which are constructed throughout the conversation in the diagnosis process. The practitioner should communicate on the patient's level in order to be able to extract information about the symptoms, but should at the same time show authority and confidence that they are proficient in their occupation and are dealing with these issues in a professional manner. Quickly establishing respect and a temporary relationship may prove difficult for the practitioner and is highly dependent on the agreeability of the patient. Sometimes the patient is reluctant to provide personal information and to express the true severity of the symptoms until a trustworthy relationship is recognised. This may require patience and some extra time from the practitioner, emphasising the importance of allocating time for the patient meeting.

In terms of practitioner-tool interaction, there is a threshold of external verification that needs to be overcome before the practitioner starts using the tool. This is achieved by studies and recommendations from other practitioners. Then, the practitioner needs to work with the tool and see its effectiveness and results before actually becoming comfortable using it and relying on it. There is a dose of scepticism towards new technology such as artificial intelligence and its applicability, especially for those who have little to no knowledge of what it implies. Moreover, the word has been widely portrayed in media as inferring it will replace professions, which adds to the negative perception of the technology.

P 5.1	Mistrust between practitioner and patient may lead to an incomplete anamnesis and deliverance of diagnosis
P 5.2	Studies and valid results are required for a practitioner to trust a new tool
P 5.3	Mistrust in the source of a diagnosis suggestion may affect its perceived validity

7 REQUIREMENTS
FOR DIAGNOSIS SUPPORT

Insights from the user studies and the problem areas led to the elicitation of a requirement list, which is used both in the ideation phase and to validate developed concepts. Each of the requirements is presented with a rating 1-3, where 1 is less important and 3 is very important, along with their area of concern.

ID	Requirement details	Rating	Area of concern
7.1 TIME & TASKS			
R 1.1	The system should facilitate for efficient and effective documentation.	3	Documentation
R 1.2	The system should cooperate with other healthcare systems.	3	Compatibility
R 1.3	The system should assist the practitioner in keeping track of multiple patients simultaneously.	3	Ergonomics
R 1.4	The system should ensure that the patient only meets the most relevant practitioners.	2	Performance
R 1.5	The system should not disrupt the workflow of the practitioner.	2	Workflow
R 1.6	The system should encourage the practitioner to work systematically so as to develop routines.	2	Workflow
R 1.7	The system should enable the practitioner to access information about the patient's previous visits.	2	Compatibility
R 1.8	The system should encourage documentation of the practitioners thought-process.	1	Documentation
R 1.9	The system should provide a perceived decrease in workload for the practitioner.	1	Ergonomics

7.2 COMPETENCE

R 2.1	The system should be able to access and extract information from online medical knowledge databases.	3	Collection of data
R 2.2	The system should facilitate for the practitioner to preserve and develop knowledge and competence.	3	Assurance
R 2.3	The system should highlight the risk of a practitioner's potential bias due to their field of research.	1	Assurance
R 2.4	The system should encourage a certain degree of scepticism to the system so the practitioner stays vigilant.	1	Assurance

7.3 COMMUNICATION

R 3.1	The system should cater for patient subjectivity in the anamnesis and interpretation of symptoms.	3	Collection of data
R 3.2	The system should encourage open questions in the anamnesis.	2	Collection of data
R 3.3	The system should facilitate for both text and media input by the patient.	2	Collection of data
R 3.4	The system should present relevant information from the medical records to the practitioner.	2	Presentation of data
R 3.5	The system should strive for an unambiguous presentation of output from tests and processes, regardless of the practitioner.	2	Presentation of data
R 3.6	The system should be easy to learn how to operate.	2	Usability
R 3.7	The system should ensure that the involved actors' goals and expectations are aligned.	1	Workflow
R 3.8	The system should ensure that the established goal is fulfilled.	1	Workflow
R 3.9	The system should communicate to all involved actors of their current status in the diagnosis process.	1	Workflow

R 3.10	The system should be able to interpret and process nonverbal communication from the patient.	1	Collection of data
R 3.11	The system should adapt the level of detail of the information presented depending on the preference of the patient.	1	Presentation of data
R 3.12	The system should motivate the patient to follow through with the treatment.	1	Presentation of data
R 3.13	The system should ensure the patient has understood the diagnosis.	1	Feedback
R 3.14	The system should not hamper human-human discussion and interaction.	1	Ergonomics
R 3.15	The system should be easy to use for the first time.	1	Usability
R 3.16	The system should encourage the practitioner to use all the available functions in the system.	1	Usability
R 3.17	The system should be able to be used efficiently after an extended period of non-usage.	1	Usability

7.4 PROCESSING

R 4.1	The system should aid the practitioner in connecting different symptoms into possible diagnoses.	3	Performance
R 4.2	The system should assist the practitioner in extracting useful data from the anamnesis.	3	Collection of data
R 4.3	The system should allow the practitioner to manually input data into the system and control its dataset.	3	Collection of data
R 4.4	The system should provide diagnosis suggestions.	3	Presentation of data
R 4.5	The system should consider potential diagnosis outliers when following their standard criteria.	2	Assurance
R 4.6	The system should ensure all relevant aspects of the considered diagnosis have been checked.	2	Feedback

R 4.7	The system should be aware of low quality input and notify the practitioner if it might affect the diagnosis negatively.	2	Feedback
R 4.8	The system should assist the practitioner in interpreting input data from anamnesis and examination consistently.	1	Performance
R 4.9	The system should assist the practitioner in computing and understanding statistics and probability.	1	Performance

7.5 TRUST

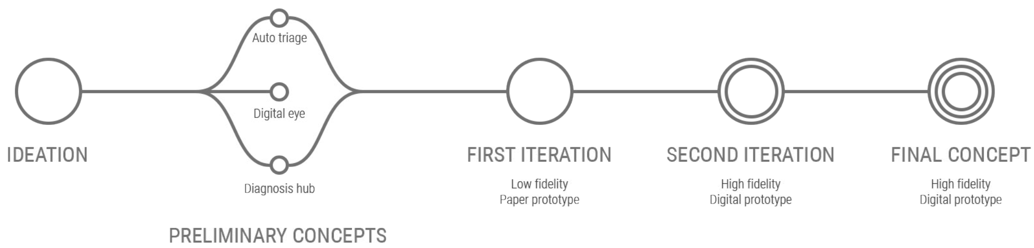
R 5.1	The system should be aware of, and communicate, its own limitations to the practitioner.	3	Performance
R 5.2	The system should communicate its potential bias towards the user.	3	Assurance
R 5.3	The system should facilitate for building trust with the patient to make them feel comfortable giving out all relevant information.	2	Collection of data
R 5.4	The system should encourage the practitioner to validate the system output with reason and intuition.	2	Assurance
R 5.5	The system should be transparent in the reliability of its output.	2	Assurance
R 5.6	The system should notify the practitioner if the selected action is not aligned with the system's recommend procedure.	2	Feedback
R 5.7	The system should be flexible and patient towards its users.	2	Usability
R 5.8	The system should provide a sense of respect and seriousness to its users.	1	Assurance

7.6 OTHER

R 6.1	The system should adhere to Swedish healthcare laws and regulations.	3	Compatibility
R 6.2	The system should be able to recognise and process all ICD-10-CM Diagnosis Codes.	2	Performance

DEVELOPMENT PHASE

This phase utilises the problems and requirements generated in the exploration phase to develop and evaluate solutions.



8 METHODOLOGY
FOR DEVELOPMENT PHASE

In this chapter, the methods and processes for the generation of ideas and the development of concepts are described. The ideation was done using brainstorming sessions and an ideation workshop, while the concept development was done using three iterations of development, each user tested for evaluation.

8.1 IDEATION METHODS

Ideas for concept development were generated through three brainstorming sessions and one ideation workshop. These ideas fed into the construction of three distinct concepts.

8.1.1 BRAINSTORMING SESSIONS

Brainstorming is a method conducted to generate a large number of ideas. Quantity is favoured over quality to have a large set of ideas to choose from when combining them into a concept. A time limit for the session should be set beforehand to motivate the participants not to elaborate on a specific idea. The brainstorming session could address different problem areas or focus on one specific topic (Wikberg Nilsson, Ericsson, & Törlind, 2015).

Brainstorming sessions were held initially to develop a large set of ideas useful later in the concept development. In the initial ideation process, three brainstorming sessions were held; the first to produce general ideas that had grown during the course of the user studies, the second to address specific problem areas and requirements defined, and the third to address specific problems connected to interactions between actors identified in the interaction mapping. The sessions were timed ranging from three to six minutes per subject to facilitate for rapid idea development. Even though the sketching was done individually at first, the suggested ideas were treated as food for thought for discussion. This lead to further enhancements of each idea, bringing elements from separate proposals into more coherent parts, which later could be used in combination to form the concepts. The outcome was several perspectives on how to solve the problems and meet the requirements suggested from the user studies.

8.1.2 IDEATION WORKSHOP

An ideation workshop is a meeting where participants with different competences collaborate to creatively explore a given subject or problem area. It is important to define the purpose of the workshop beforehand to facilitate for a constructive meeting. At the start of the workshop, the participants are introduced to the problem at hand by the moderators, followed by a simple exercise aiming to get the participants in a creative mood. The session is then carried out using creative methods to develop ideas (Wikberg Nilsson, Ericsson, & Törlind, 2015).

The idea workshop was carried out after the initial brainstorming sessions with six students at Chalmers University of Technology with no prior knowledge of the project. The aim was to gain new perspectives on the subject. The session lasted for 60 minutes and was focused on finding novel ideas and new perspectives of the problem areas. The output served as food for thought in the following concept development.

8.1.3 CONSTRUCTING CONCEPTS

All of the ideas from the ideation methods were looked at more critically. Those which seemed reasonable and showing potential were grouped and further developed by asking “how to … the best way?”. These groups of ideas were then considered building blocks for the preliminary concepts. By combining them in different ways and extracting different aspects from them, three distinct preliminary concepts were developed.

8.2 PROTOTYPING METHODS

To evaluate the concepts, developing prototypes was necessary. Three prototypes were made, one with a low fidelity and two with a high fidelity.

8.2.1 LOW FIDELITY PROTOTYPES

Prototypes focused on showcasing key functionality and general structure, often made of paper, are called low fidelity, or lo-fi prototypes. They are often not very detailed, and are used to test content, structure and navigational structure. Given the analogue nature of the prototype, interactivity is limited. Lo-fi prototypes are preferably used early on in the design process, to evaluate ideas and design proposals (Benyon, 2010).

The first prototype was made with low fidelity to gain insights from the users regarding the overall structure rather than specific comments on details not deemed useful this early in the prototyping stage. It consisted of a proposal of a user interface, sketched on paper. Some interactivity was available by adding paper cards representing the user’s choices in the tests. The concept depicted two different patients seeking treatment for different symptoms, one had cold-like symptoms whereas the other had problems associated with their skin.

Low fidelity prototypes provide limited insight in the different processing layers with regards to Norman's design for experience theory. The visceral layer is restricted due to it lacking much of the look and feel elements and can merely be judged by its overall structure. Similarly, usability is greatly constrained by the rudimentary interaction with a paper prototype, but as the general ideas are communicated, discussions on the reflective layer are possible.

One lo-fi prototype was decided to be enough to receive substantial feedback regarding the basic idea to move forward with the design process.

8.2.2 HIGH FIDELITY PROTOTYPES

When a prototype is reflecting the look and feel of the final product, they are said to be high fidelity, or hi-fi. They are produced digitally and include a degree of interactivity. As opposed to lo-fi prototypes, they are used to evaluate, among others, interactivity, functionality and visuals. A problem with hi-fi prototypes is that test users might get the impression that the concept is more developed than might be the case. This brings forth the need of a clear view of what is to be prototyped, making the design coherent (Benyon, 2010).

The second and third prototypes were made with a higher fidelity than the first one, being both digital and interactive, to gather more specific feedback on interactions, user interface, and phrasing of certain elements. The concepts showcased one patient seeking healthcare for cold-like symptoms, along with screens of a patient seeking treatment for a potential skin disease.

High fidelity prototypes enable more extensive analysis of the processing layers with regards to design for experience. The visceral layer becomes fully relevant, while the behavioural facilitate for usability aspects and the test subjects can in a more detailed manner conceptualise on the reflective layer.

Two iterations of hi-fi prototypes were used to facilitate for feedback regarding interaction and functionality. It was required to understand how the users would react to the display of certain elements at specific points in the interaction, why a digital mock-up was deemed the most useful. The screens for the prototypes were made using the software Figma, as it enables designers to collaboratively build an interface. The prototyping was made by importing the screens into the web application proto.io, which is a tool to create rich interactive prototypes.

8.3 EVALUATION METHODS

Verification of the validity of the preliminary concepts was done through a verification against the requirement list. Each iteration of the concepts was then evaluated with user testing combined with questionnaires.

8.3.1 VERIFICATION

A theoretical design verification with respect to the requirement list is a relatively quick way to assess how well concepts meet the defined demands, and subsequently the underlying problems (Society, 2011).

Each of the requirements were rated from 1-3, where 1 was less important and 3 very important, along with the associated problem area from which it was derived. The current solution (Product X) and the three concepts were then compared to each requirement in this list and given a score from 0 to 2 based on how well they met the particular requirement. This score was then multiplied by the inherit rating of the requirement and all of these products were added together for a final verification score of the concept.

The problems were then revisited in the final concept to ensure that the concept solves the defined problems. Each of the problems were systematically processed and compared with the concept to verify whether it was addressed.

8.3.2 USER TESTING

Conducting tests on prototypes with users is called user testing. It is often used to find usability problems with a product. This is typically done by letting a representative user perform tasks in a prototype while the test leader observes what the user does. Focus is on observation rather than asking questions. However, the test subject should be prompted to think aloud regarding what they do and see. Diminishing return in new usability problems is often identified after five tests, why more test subjects is often not worthwhile, and this time should be spent focusing on analysing the data and improving the product for a new iteration of tests (Nielsen, 2012).

User tests were conducted after each prototyping iteration. Two test leaders were present, one who directed the test and the other taking notes on what was said and observed. Each test person received an introduction to the prototype, and then they had the opportunity to use the system while thinking aloud about their impressions. Predefined questions were then asked (guide for first iteration in Appendix 2.1, guide for second and third iteration in Appendix 2.2), to enable comparisons between tests as well as generating more qualitative data. The test ended with a questionnaire, gathering quantitative data regarding the concept (Appendix 3.1). Analysing the outcome led to insights for further developments in the next iteration of the concept development.

The final prototype was evaluated to gather suggestions for future development. The data included information regarding the perception of trust in the system as well as insights regarding the feasibility into the diagnosis process.

The first round of user tests was conducted with six practitioners using a lo-fi paper prototype (Table 3). They were held at an office, remotely from a healthcare centre, which was thought to match the setting in which digital healthcare might be managed. Five of the test users were general practitioners and one held a specialised position at a hospital.

The second round of evaluation was conducted with five users. The test sample consisted of three general practitioners, one specialist at a hospital and one nurse practitioner at an emergency unit. Two of the users, both general practitioners, had participated in the first round of user testing, but in this round, they performed the test remotely using a video call. The third general practitioner performed the test in the office of their healthcare centre. The prototype used in this round was digital and of a higher fidelity than the first iteration and the test was performed on one of the test-leader's computers.

Lastly, the third round of user testing was conducted with five practitioners, four general practitioners and one holding a speciality at a hospital. They had all participated in the first round, one of them had participated in both previous tests. These tests were performed at an office remote from a healthcare centre. The prototype in this round was, as in the second test, digital and of a high fidelity, and the test was performed on one of the test-leader's computers.

Table 3. Participants in the three iterations of user testing.

ITERATION	PARTICIPANTS	TITLE	TYPE OF CARE
FIRST Low fidelity	5	General practitioners	Primary care
	1	Specialist	Healthcare
SECOND High fidelity	3	General practitioners	Primary care
	1	Specialist	Healthcare
	1	Nurse practitioner	Emergency room
THIRD High fidelity	4	General practitioners	Primary care
	1	Specialist	Healthcare

In total, 16 tests were held, with nine different practitioners in three different rounds. The analysis of the data was done using KJ-analysis.

8.3.3 QUANTITATIVE EVALUATION

Gathering quantitative data can be done using questionnaires (Yoland, 2011). They contain a set of questions or statements to which the respondent should answer. The questions can be formulated in either an open or closed fashion, where a questionnaire with closed questions generate quantitative data.

A questionnaire was used in combination with the user tests in order to evaluate the three layers of user experience described by Norman (Appendix 3.1). The statements were formulated to incorporate reactions connected to the visceral level to determine how the user perceived the interface, the behavioural level through questions related to the ease of use and lastly, the reflective level by questions aimed at giving answers regarding the fit of the system into the practitioner's daily work. The scale ranged from 1 to 10, with the participants being prompted to reflect on the solution compared to how their work is done today. 5 meant no difference. The result of the questionnaires enabled comparisons to be made in between the iterations of concept development. All participants but one in the last user test filled in the questionnaire, resulting in six responses in the first round, five in the second and four in the last.

9 IDEATION

This chapter presents the result from the ideation. Ideas from the individual brainstorming focused on the practitioner and existing systems, while the workshop gave additional insights regarding a patient's view on digital healthcare. All ideas were grouped according to similarity in how to solve particular areas of concern as well as where in the process they take effect. They form puzzle pieces which are put together in different constellations in the concept development process. The following areas were defined:

How to...

- Collect data
- Present profile
- Map process
- Access tools
- Document visit
- Use feedback
- Suggest action
- Build trust

9.1 *HOW TO* COLLECT DATA

In order to be able to introduce more advanced digital tools in healthcare, such as advanced algorithms and AI, high quality input is required. Processing fluid and context dependent anamnesis data from the patient into concrete and consistent input is challenging.

This set of ideas explored this by constructing a symptom database from which the system can link individual parts of the anamnesis and symptoms from the patient form [R 3.1; R 4.2]. A practitioner could also input symptoms by searching in the database and ask the patient about them [R 4.3], reducing the need for the system to decipher free text descriptions of symptoms in the chat, as the patient answers whether they experience said symptom or not. When selecting a symptom to ask the patient about, the system provides pre-set, but editable, chat questions which are constructed in an open an unbiased way [R 3.2].

Input could also be generated with voice to text engines where it listens to the patient describing their problems or analysing a video of the patient and compare nonverbal characteristics, such as the patient's movements, posture and facial expressions. This would in part be a data-driven complement to the clinical eye, which was expressed as hard to achieve in treating patients digitally [R 3.3; R 3.10].

The challenges are primarily the technical implementation of these systems. Creating a full-fledged symptom database is hard as the same symptom may play out very differently on different patients, depending on their situation and individual characteristics. The database therefore needs to facilitate for these personalised configurations while at the same time be concrete enough for the system to be able to process it.

9.2 *HOW TO* PRESENT PROFILE

In the beginning of the visit, when the medical practitioner initiates a new patient case, they need to get familiar with the patient's current problem as well as relevant medical history and medical prescriptions.

To mitigate this information threshold, a patient profile could be presented to them in the beginning which provides the most relevant information about the patient's medical history and the current visit to the practitioner to allow for an efficient and effective initiation of the care. It assists extracting the relevant data from the anamnesis form [R 4.2] and from the medical records [R 3.4; R 1.7]. The system applies machine learning to determine which information is most relevant, and presents it to the practitioner in an easily digestible way as to not overload the practitioner with information [R 4.8].

Allowing a quick overview of the patient and its current visit will also help the practitioner to manage several digital patients simultaneously as the time to re-engage in different patient visits will be reduced [R 1.3; R 1.9]. Moreover, should a new practitioner become involved in the case, this overview will allow for efficient sharing of information [R 3.5].

Challenges with this idea mainly revolves around the technical feasibility of the machine to determine which information is relevant in different scenarios. Moreover, the practitioner may want to have immediate access to all available information to be in control of the filtering.

9.3 *HOW TO* MAP PROCESS

Allowing a process view of the care assists in making the procedure more systematic as the practitioner can visually follow predetermined steps [R 1.6]. It will also act as an extension of the profile, in the sense that it simplifies for the practitioner to manage multiple concurrent patients and determine the next step. The process visualisation could also provide the practitioner with a sense of achievement. A stripped down visual process representation could also benefit the patient by letting them know they are making progress towards their common goal, even if the practitioner might appear to take time to answer [R 3.7; R 3.9].

Balancing predetermined systematic process steps and allowing for the practitioner's individual way of conducting care is the main challenge with this idea.

9.4 *HOW TO* ACCESS TOOLS

Relying on textbooks and previously studied knowledge is an outdated way of working for many practitioners. As digital tools, such as checklists, online medical databases, and even simple image search engines are becoming increasingly important in the everyday workflow of the practitioners, this idea aims for them to become better integrated in the systems they are already using [R 2.1; R 6.1].

By providing these tools, or shortcuts to them, contextually aware within the system, the practitioner will not only be more efficient, but also reminded of their use in different situations. Perspectives from different databases could be summarised and provide the practitioner with a more diverse view of the topic, aiding their learning and expansion of their internal knowledge database [R 2.2]. They can also provide access to probability calculations and assist the practitioner in understanding statistics of for example prevalence or risk [R 4.9].

Challenges revolve mainly around the extraction of the necessary tools for this idea, determining which parts are relevant, ensuring the information is updated, and that necessary agreements are made with the owners of the tools and information.

9.5 *HOW TO* DOCUMENT VISIT

The documentation was found to be inconsistent and tedious for the practitioner. Documenting the entire visit retrospectively risks losing details about the visit. These ideas therefore revolved around having continuous and automatic documentation in the background. The objective steps, such as adding a symptom would then be documented automatically, and small text boxes throughout the process would allow for the practitioner to complete it with their individual thoughts or conclusions [R 1.8]. At the end of the visit, the system compiles the automatic documentation as well as the comments from the practitioner and writes it into the medical records [R 1.1].

Enabling this type of automatic documentation would mean that all of the steps which currently resides in the head of the practitioner needs to be transferred into the system. A user interface containing anamnesis, symptoms, examination, test results, diagnosis, and treatment is required. By interacting with the different elements, the practitioner continuously adds their actions and decisions indirectly into the medical records, while at the same time receiving a more structured visual view of the visit. This interaction might take longer than drawing the conclusions in the head of the practitioner, and the change might also be unfamiliar at first, until they get accustomed to this new way of working. However, more detailed and objective documentation facilitates for accurate feedback loops and potentially machine learning of a big dataset of similar patient visits.

9.6 *HOW TO* USE FEEDBACK

Improving any system is dependent on the validation of the output via a feedback loop. Ideas were generated in how to use feedback to improve the patient experience by providing automatic follow-up on the patient to check whether the diagnosis and treatment were effective. This result is then fed back into the system and presented to the practitioner [R 3.8].

Confirming the effectiveness, or, indeed, the ineffectiveness, of the treatment is essential for the system and practitioner to learn from mistakes or inaccuracies. This will prove even more important on a system level as the system adopts increasingly more advanced tool such as AI. By analysing a series of similar cases, the tool has potential to find previously unseen connections and patterns between, for example, symptoms and outcomes.

Findings could be presented in various forms in the user interface, to remind the practitioner of certain steps, or warn them in case they are on the same path that previously lead to a negative outcome. In the future, the system might even be so confident in some specific and predictable cases that it suggests diagnosis and treatment more promptly before the practitioner has even initiated the case. It will proactively guide the practitioner while simultaneously act as a safety net if the practitioner makes a decision the system regards as less than ideal.

The challenges of this idea lie in the details; how the cases with negative outcome should be presented to the practitioner, and whether they should be dealt with a new case or an extension of the first case. Furthermore, the system needs to determine that the patient's answer is indeed related to the treatment they received.

9.7 *HOW TO* SUGGEST ACTION

Years of medical education leads the medical practitioner to develop an intuitive pattern recognition, being able to add symptoms together with the state of the patient and assess different diagnoses. But sometimes a second opinion is valuable to find new angles and to prevent tunnel vision.

Suggestions and second opinions can be artificial. This idea explores using the collected data in combination with symptom and diagnosis databases [R 6.2] to perform filtering of the most probable diagnosis and, indeed, suggest symptoms to ask the patient about [R 4.1]. By asking the right questions, diagnoses can increase or decrease in probability. If the tool is powerful enough, it could even take prevalence and risk into consideration and produce a value of probability for different diagnoses to the practitioner. Should the practitioner decide on a diagnosis that is misaligned with the system suggestion, the system can notify to ensure the practitioner has considered the different possible alternatives [R 4.6; R 4.7].

The ideation found that the interaction between the system and the practitioner could be done in two ways; by either cooperation or comparison. Cooperation means they execute the same task together but manage different parts of it. For instance, the practitioner could perform the anamnesis and extract quantitative symptoms, suitable as input for the system to work with in an algorithm calculating the risk of diagnosis. The output is then further handled by the practitioner. Contrarily, comparison is when the practitioner and the system perform the entire operation, from extraction of input to presentation of output, independently and then compare the results to verify [R 5.4].

Cooperation suggests an interaction much like traditional tools and may therefore have a lower threshold for the practitioner to use. But it means the input and output needs to be managed by the practitioner manually, which may be tedious. Relying too heavily on a system to do the calculation may also affect the practitioner's competence in the long run. Comparison, on the other hand, lets the practitioner perform the operation in parallel, preserving competence and using the system as a second opinion or verification [R 2.2]. However, some may feel this method is unnecessary in the long run as the work is done twice, and if the system is accurate, the practitioner may feel redundant. These are all factors to be considered in the concept development process. Perhaps a combination of the two, where they play different roles in different settings, could be compelling.

9.8 *HOW TO* BUILD TRUST

Introducing advanced tools, such as those which use machine learning, means transferring control from the practitioner to these tools, which in turn requires trust. If the system delivers a result and its internal mechanisms are not fully transparent to the practitioner, as often is the case with for example machine learning and image analysis, they need to be able to trust its result based on the general accuracy of the tool.

These ideas explored introducing more explicit ways of building trust between the practitioner and the system, such as rating systems, accuracy and probability percentage, and giving easy access to peer reviewed studies of the tools [R 5.5].

Suggestions in the system should be presented so the practitioner understands that it is just a suggestion and not a definitive answer, by, for instance, asking: “Have you considered this diagnosis?” [R 4.4]. If the practitioner chooses to opt for the suggestion, the system should allow for altering of parameters and control in how to interpret the result. This means it should be humble and encourage scepticism of its output [R 2.4]. If the system is not confident that the quality of a particular suggestion meets the required level, it should supress it or notify of its low accuracy to the practitioner [R 5.1]. It should also communicate factors which influenced the results to allow for the practitioner to locate potential bias in the system [R 5.2].

10 PRELIMINARY CONCEPTS

Combining the individual solutions from the ideation produced three main concept directions: Auto Triage, Digital Eye and Diagnosis Hub. Given the background of the project, compatibility with Company X's digital product was necessary to keep in mind. As such, the presented concepts are all applied to, or extensions of, Product X.

10.1 THE AUTO TRIAGE

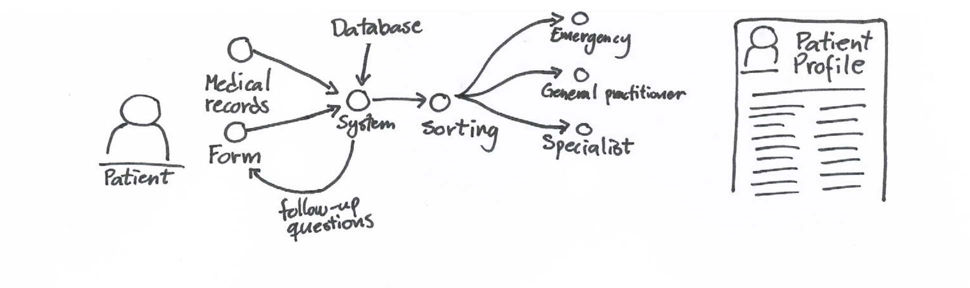


Figure 6. Sketch of the Auto Triage concept.

This concept takes into consideration *how to...*
COLLECT DATA   PRESENT PROFILE   MAP PROCESS   BUILD TRUST

The Auto Triage concept (Figure 6) aims to make the triage process more efficient and less resource demanding by applying AI as a bridge between the initial patient contact and the relevant practitioner. Before the medical practitioner start the diagnosis process in Product X, the patient is triaged to an appropriate level of priority and to a practitioner with suitable competence for that specific case. Instead of having manual triaging, as is standard today, this concept explores triaging done by the system, as well as presenting relevant information to the practitioner in the start of the visit.

The patient initiates the healthcare process by answering form questions about their area of concern. The answers act as an immediate input to the system, which constructs rough hypotheses of what diagnosis it may be. It then uses information and diagnosis criteria from online databases to finetune follow-up questions for the patient to answer, narrowing down to a possible preliminary diagnosis. The system stops when it makes no more dramatic progress and is careful not to overload the patient with questions. It then triages the case to a practitioner with relevant competence.

Upon entering the new case, the practitioner is presented with a profile of the patient with the most relevant information from the form and the medical records. The information is sorted and presented in a process tree structure, so the practitioner gets a quick overview and can start faster.

ADVANTAGES	CHALLENGES
• System triaging and follow-up questions saves time and resources • Patient only tells their anamnesis once • Practitioner gets a quick start with relevant profile and process overview	• Avoid inducing tunnel vision when asking follow-up questions • Determine what information is relevant to show in different cases • Structure input into a quantitative state without losing their nuance • Ensure the practitioner trust the triaging

10.2 THE DIGITAL EYE

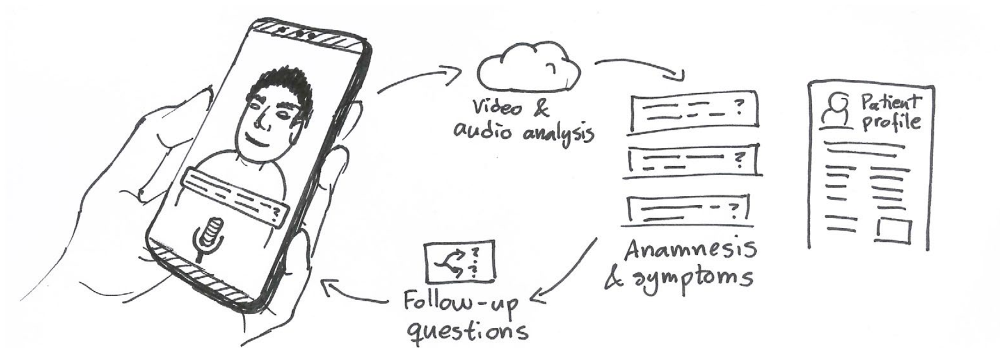


Figure 7. Sketch of the Digital Eye concept

This concept takes into consideration *how to...*
COLLECT DATA PRESENT PROFILE MAP PROCESS DOCUMENT VISIT BUILD TRUST

Anamnesis is considered the most important part of the diagnosis process according to the user interviews. Collecting the patient story as openly as possible is the key to an unbiased diagnosis. Moreover, many tell of the clinical eye as a vital tool to determine the status of the patient nonverbally. As this is something Product X lacks, this concept explores how to reintroduce the clinical eye in a digital environment, through pattern recognition and machine learning.

The Digital Eye (Figure 7) prompts the patient to tell their anamnesis on their smartphone or tablet via video and audio, without any practitioner on the other end. As they record, they are prompted with the form questions on-screen to answer naturally. The verbal answers are transcribed and, concurrently, the video and audio are analysed to interpret patterns in non-verbal cues, such as body language, tone of voice and facial expressions. These are then combined to provide a richer description of the state of the patient. For instance, a symptom of tiredness might be noted, complemented with a verification or a grading from the video and audio analysis as to how tired the patient looked or seemed.

Thus, an anamnesis is constructed, including a list of symptoms. When the patient has finished the anamnesis, the practitioner initiates their work, met by the patient profile, including the recorded video and audio in case they wish to verify the transcribed material.

From this point forward, the concept is quite similar to the Auto Triage concept, featuring a patient profile and process overview.

ADVANTAGES	CHALLENGES
• Video and audio analysis provides a richer description of the symptoms • Catering for the lack of clinical eye in digital anamnesis gathering • Patient does not need to type the answers, but gets a more interactive experience • Practitioner gets a quick start with relevant profile and process overview	• Determine what information is relevant to show in different cases • Structure input into a quantitative state without losing their nuance • Develop models for the system to interpret body language and tone of voice • Some patients may feel uneasy answering questions from a system while being recorded • Technical implementation, such as accurate transcription and pattern recognition

10.3 THE DIAGNOSIS HUB

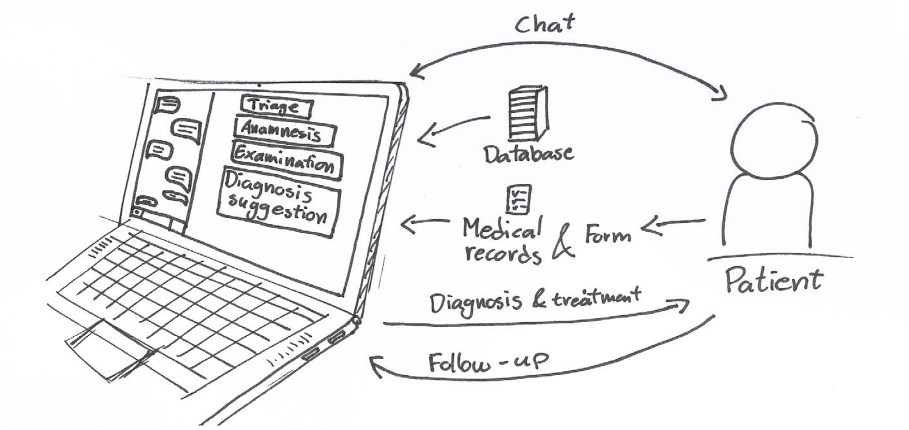


Figure 8. Sketch of the Diagnosis Hub concept.

This concept takes into consideration *how to...*

COLLECT DATA MAP PROCESS USE FEEDBACK DOCUMENT VISIT
ACCESS TOOLS SUGGEST ACTION BUILD TRUST

The Diagnosis Hub concept (Figure 8) focuses on transferring the mental diagnosis process of the practitioner to an extended digital interface in Product X to facilitate automatic documentation, a rich toolbox, suggestions, and feedback.

After triaging and being presented with the information about the patient's visit, the practitioner starts analysing the anamnesis and symptoms from the patient form. Any examination, diagnosis or treatment they explore is managed in the interface, by adding them as interactive modules which communicate with their respective systems. The concept acts like a hub for many systems and present their contents to the practitioner to interact with in one place.

For instance, if the practitioner wishes to perform a strep-A-test for determining the characteristics of a tonsillitis, they add a module in the user interface from which they schedule a visit at the closest healthcare centre for the patient to take the test. The result is then reported back into the system and displayed in the same module.

As the practitioner continues to interact with the interface, they may get contextual aware suggestions and reminders from the system, such as potential allergies the patient has to a specific medication, or a high risk alternate diagnosis that often correlate with a selected diagnosis. This is made possible by the practitioner's interaction which acts like continuous input into the system.

Upon completing the diagnosis, the full practitioner interaction, along with their comments, is documented into the medical records and follow-up is scheduled to the patient after a selected number of days. Depending on what the patient responds in the follow-up determines the next step in the system; a confirmation that the diagnosis and treatment was effective archives the case and sends a positive feedback loop to the system, while the opposite result reactivates the case to analyse what caused the misdiagnosis or treatment. After multiple similar cases, the system will recognise patterns between patient information, symptoms, diagnosis and treatment, which in turn will facilitate for more accurate suggestions in similar future cases.

ADVANTAGES	CHALLENGES
• Information from multiple systems presented in one place • Diagnosis process is shown visually • Hints and reminders • Diagnosis and tool suggestions improves workflow and accuracy • System uses feedback loops to improve accuracy and discover patterns • Automatic and systematic documentation	• Interacting with all user interface elements may be tedious • Structure input into a quantitative state without losing their nuance • How to present the diagnosis and tool suggestions without inducing bias • Ensure the practitioner trust the suggestions but still feel in control

10.4 VERIFICATION AGAINST REQUIREMENTS

A design verification with respect to the requirement list showed the theoretical score of how well the preliminary concepts and the current solution meets the demands (Table 4);(full verification in Appendix 4).

Table 4. Final score of the validation against the requirement list.

VERIFICATION AGAINST REQUIREMENTS			
Current Solution PRODUCT X	Preliminary Concept 1 AUTO TRIAGE	Preliminary Concept 2 DIGITAL EYE	Preliminary Concept 3 DIAGNOSIS HUB
58	106	77	122

A strong focus on systematic tools gave the Auto Triage and the Diagnosis Hub a significant advantage when compared to the current solution. Product X is strong in areas such as collecting data in an open and unbiased way, due to the form, chat and, if needed, added media or even physical patient visit. As the concepts inherit these positive aspects from the current solution, the increase in points is unsurprising. The Digital Eye scores well on aspects such as collection of data and taking subjectivity into account in the anamnesis process. Neither concept was particularly strong in areas where the patient is in focus, which is unsurprising as all concepts are focusing on the work of the practitioner and less on the user experience of the patient.

Relatively low score, in combination with its challenges indicate that the Digital Eye concept is not worth pursuing more in this study. The main challenges regard the technical implementation, as video and audio pattern recognition of this sort is still too immature to provide reliable results. The advantages are not valuable enough to counterbalance the challenges at this point. Still, this technology is interesting to pursue, and perhaps a concept like this will be worth exploring again in future studies.

High marks were achieved by both the Auto Triage and the Diagnosis Hub concepts, in combination with solid advantages in relation to their challenges show promise for further development. Several of the challenges could theoretically be mitigated gradually, and still provide value to the user, indicating these concepts have potential to be relevant in the near future to a certain extent, if not to their full potential. Thus, both the Auto Triage and the Diagnosis Hub were to be further developed in this study.

The preliminary concepts Auto Triage and Diagnosis Hub were effective in two distinctly different areas of the diagnosis process: Auto Triage acts in the pre-phase, when the patient answers to the form to the initial stages of the practitioner's involvement; while the Diagnosis Hub is focused on when the practitioner assesses the anamnesis, to the final step of the diagnosis process. The concepts are therefore compatible with each other in the diagnosis process and the mechanisms behind both concepts are similar. This means the concepts can be merged together into a larger solution.

11 FIRST ITERATION OF CONCEPT

This is the first iteration of the main concept. It is evaluated with a low fidelity paper prototype, the result of which is analysed and put in relation to the theory, to finally generate areas of improvement for the next iteration.

11.1 CONCEPT OVERVIEW

Both Auto Triage and Diagnosis Hub solutions were used to build this concept (Figure 9, more screens in Appendix 5). Triaging is done by having the system analyse the patient's answer to the form, from which the system then creates a profile with the anamnesis completed with relevant information from the patient's medical record. Then, the patient is sorted to either a physical healthcare centre or into a digital visit. The parts involving AI is in this concept related to the triaging process, sorting out symptoms and factors related to the reason for seeking care, and the suggestions for diagnoses and treatment.

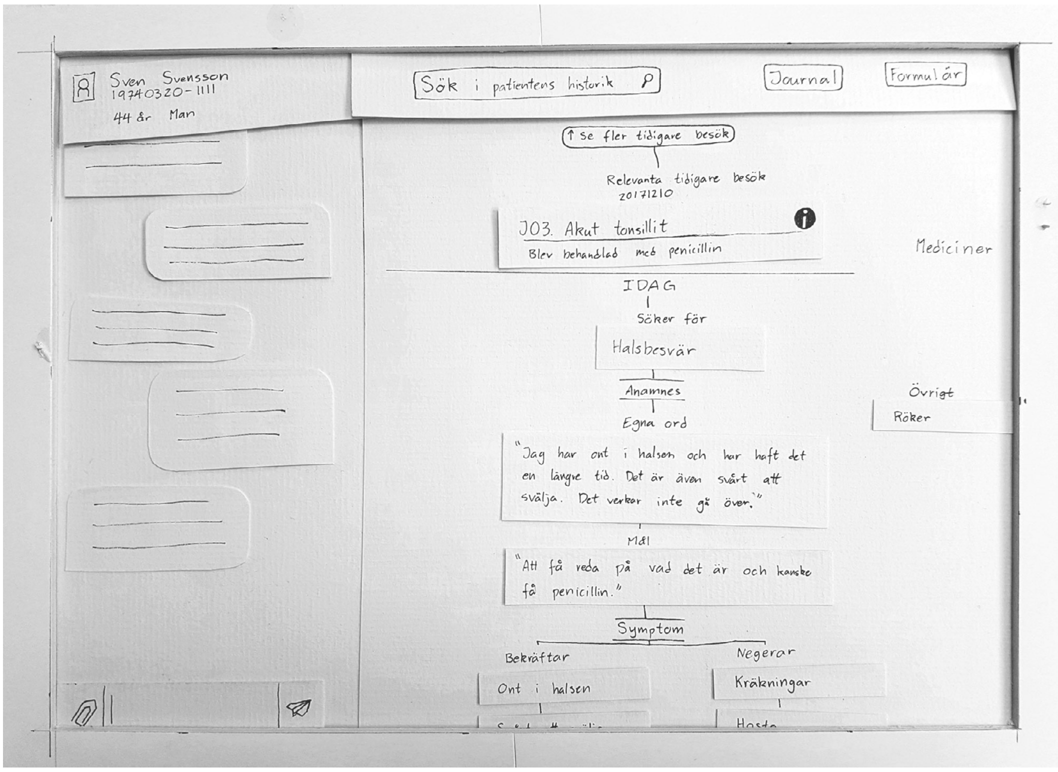


Figure 9. Paper prototype of the first iteration of concept.

When the practitioner opens a digital visit for treatment, they are faced with a view consisting of three distinct parts: a header, the chat and the practitioner's workspace. The header contains a profile of the patient seeking treatment, a search field where they can search in the patient's medical record, as well as shortcuts to the complete medical record and the answers to the form. This element will stick to the top of the screen, thus being accessible at all times.

Communication with the patient is done through the chat, which is located at the left-hand side of the screen. It will stay in place even though the practitioner scrolls through the workspace so communication with the patient is accessible at any given moment.

The workspace is laid out in a linear fashion to resemble the diagnosis process found in the user study. Shown first is the latest relevant healthcare visit related to the reason for the patient seeking healthcare. This was identified as something which might affect the diagnosis by the practitioner of the present visit. This is followed by the reasons for the patient seeking care, with the anamnesis including the patient's goal with, and own thoughts about, the visit. A list of symptoms split into confirmed and negated symptoms follows. The distinctive split between these two categories is done to cater for easier identification of what problems the patient actually has. Noteworthy in this concept is that the symptoms displayed are deemed the most relevant by the system to fulfil a diagnosis, thus utilising a high level of automation and filtering.

The next section allows the practitioner to use digital tools or book clinical tests. They are also presented with diagnosis suggestions. In the concept, the suggestions are available from the start, with the practitioner having the ability to add their own diagnosis as well, should they not agree with the suggestions. The layout of the diagnosis section is done to promote the suggestions and make the practitioners more prone to use the suggestions rather than adding their own diagnoses. Suggestions include criteria fulfilling the diagnosis, represented by checkboxes being filled out if the associated symptom is found in the symptom list. When deciding upon and selecting a diagnosis that suits the list of symptoms, a treatment suggestion appears. This includes displaying a standard dose of a suitable medicine, with the practitioner having the possibility to adjust the dosage.

After settling on a treatment, the practitioner is made aware of that an automated feedback loop is initiated, which will reach out to the patient after seven days, prompting the patient to answer the question of how the treatment has worked out. Should the result of the treatment not be effective, the practitioner will receive information about this, so adjustments can be made. The system then makes the practitioner aware of that the visit has been automatically documented in the patient's medical record.

11.2 EVALUATION

The user testing of the first iteration was conducted with six test users and resulted in discussions regarding areas of concerns and improvements. The most prevalent topics and most important findings are presented and analysed here, sorted after their appearance in the user interface, ending with insights regarding the workflow.

11.2.1 TRIAGE & PATIENT PROFILE

The triaging system was well-received by all the test subjects. However, one of the users raised the topic of providing the care applied for; a patient deemed by the system as not in need of immediate healthcare must not experience that they are rejected digital care. This should be taken into consideration. Apart from this comment, the automatic triage feature was deemed feasible and well-designed by all the users.

11.2.2 SYMPTOMS

A prominent issue identified with the list of symptoms was the system's attempt to sort out symptoms deemed relevant to the reason of seeking care. This was not perceived well by any of the test subjects, as this led to questions regarding rejected symptoms. The users asked for the complete list, as this is something that is provided by the patient through the form. Another issue with the list of symptoms was regarding how the overview would be if a more extensive number of symptoms were presented. The prototype showcased four symptoms, where in reality this list would be much longer, which in turn would affect the possibility to quickly scan them for a quick overview of the problem at hand. Furthermore, questions arose regarding how to add symptoms to the list, which indicates a problem with the alignment of the mental model of the user and the system model.

In the prototype, it was not possible to tell how long a symptom had been prevalent, neither how severe the patient perceived the symptom, something which was pointed out by the test subjects as necessary to conduct an accurate diagnosis. Enabling the patient to grade severity, and visualising the grading appropriately was requested.

The quantitative evaluation (Appendix 3.2) suggested the information presented was not appropriately sufficient (5.8). However, the coupling between the anamnesis and the diagnosis suggestion was perceived better (7.0).

11.2.3 DIAGNOSIS

A prevalent problem regarding the diagnosis suggestions was the complex nature of deciding on a diagnosis. It was pointed out that many diagnoses lack a clear description and criteria needed to be fulfilled in order to confidently diagnose a patient. The examples showcased in the prototype consisted of few criteria, thus leading to the question what would happen with a more extensive and complex illness. In such a case, it was also deemed as more important to the test users to receive support, as the common diagnoses are easier to figure out.

It was also noted that it is important to be able to neglect unusual but dangerous diagnoses early on, to narrow down to the most probable one. This leads to another question posed by two of the test subjects; Should the suggestion be prompted to the user or should it be an active decision to look it up? Prompting the suggestions shows the system is working to assist the practitioner in finding the correct diagnosis efficiently. On the other hand, not prompting the suggestions might make the practitioner reflect more upon the anamnesis and come up with an own theory regarding the diagnosis, thus preserving the competence of the practitioner. One user pointed out that prompting the practitioner with a suggestion might be counterproductive if the practitioner accepts it without a critical mind, potentially leading to an incorrect diagnosis.

In the quantitative evaluation of the concept, the test subjects rated how secure the diagnosis suggestions felt just above the mean value (5.7). On the question regarding improved diagnosis accuracy compare to today, the score was a bit higher (6.3).

Reflecting on the theories of trust described earlier, it is interesting to consider Lee and Moray’s three aspects defining trust. The performance of the system seemed clear to all the test users, as they understood the diagnosis suggestions and what they intended to achieve. However, the purpose did not shine as clearly. Given the simple nature of the prototyped disease, why such a support was necessary seemed unclear. This is enhanced by comments being left regarding the compatibility of the system with a more difficult disease. Furthermore, as three users stated, the transparency of the system is important and something which is not prevalent enough in the concept. This indicate the process of the system is lacking in understanding.

Considering the trust building factors brought up by Ekman, Johansson and Sochor, it seems as if the system is mostly aligned with the users’ mental model regarding the diagnosis process. The suggestions were understood at large. However, noted by all the test subjects was the discrepancy between the practitioners’ vocabulary and the phrases used in the prototype. This indicates that the tone of the system is not that of an experienced agent, which might affect the trust emitted by the system.

11.2.4 TREATMENT

Overall, the treatment panel worked well in the tests. It was deemed positive to receive a standard treatment plan for common diseases. However, as made clear by the test subjects, the treatment is not always in the form of medication. It can also be a surgical operation or self-care. Being able to submit referrals to hospitals or suggestions for self-care was requested. In the case where the treatment is a medicine, however, it is necessary to collect information regarding possible allergies the patient might have towards specific medications. Factors affecting the treatment should also be showed, preferably derived from the patient's medical records.

Sometimes, the patient might be diagnosed with several diagnoses, thus requiring more than one medication. Being able to prescribe a number of medications, as well as indicating what disease a specific medication aims to treat, should be possible.

11.2.5 DOCUMENTATION

It was perceived unclear how the documentation of the patient visit was working. Information regarding the data being stored in the patient's medical records after the visit should be communicated. Questions also arose about the structure of the documentation, it should not be on the same form as the proposed workspace. It also has to be clear what information from the workspace actually ends up in the medical records.

11.2.6 WORKFLOW

Reflecting on the concept's compatibility with the test subjects' workflows, it was pointed out that the solution presented was too linear in its layout. The diagnosis process is seldom as straight forward as the concept suggested. If the case is of an explorative nature, the path from symptoms to diagnosis is not a straight one. Instead it might require more iterations before concluding on a diagnosis, thus the user interface should facilitate for that. Questions also arose regarding how to proceed if the patient required a visit to a physical healthcare centre and how the information collected in the digital visit would be submitted to the physical visit.

On the same note, some test subjects raised the question of a patient revisiting the practitioner, which prompts for more development regarding the continuity of the patient journey. Furthermore, a patient might sometimes be affected by several diagnoses, rather than one single, something which is not catered for in the suggested concept. The possibility to facilitate for different kinds of visits was requested. This also includes extending the list of symptoms to also include perceived problems which might not be a symptom per se, but still something relevant for the practitioner to know to be able to conduct a proper diagnosis.

Three test users had concerns about the presentation of previous visits. Given that the system was said to sort out visits relevant to the current visit, it was expressed that it is more important to see the last healthcare visits, regardless of the reason for seeking care today. Remarks were also made regarding them being displayed without the practitioner actively having to open them, it would have been more attractive had they been opened on demand.

The test subjects gave the concept high scores in the quantitative evaluation regarding the overall structural clarity (8.2), flexibility (8.0) and intuitive use (8.3). They also thought it would reduce the time consumption compared to today's systems (7.7) and fit their workflow well (7.2).

11.3 CONSIDERATIONS FOR SECOND ITERATION

The user testing generated the following key points to consider when developing the next iteration. Some points were considered to be achieved and should be kept in their current state for the next iteration, while others needed more development.

ACHIEVED	DEVELOP FURTHER
• Triage was seen as effective and feasible • Good overview of the information • Coherent feel of the diagnosis process • Diagnosis criteria helped overview and check relevant symptoms • Diagnosis suggestion is an interesting idea • Suggestion of standard treatment was helpful • Automatic documentation was attractive	• Adjust some of the vocabulary to better fit the domain • More control over what symptoms and previous visits are deemed relevant • Clearer how to add new symptoms in the symptoms list • Richer information for the symptoms • Facilitate for multi-diagnosis and a less linear process • Alter the diagnosis suggestions to be less prompting and definitive • Facilitate for non-medication treatment • Simplify how to book a physical visit • More control over automatic features • More satisfying finalising of a visit • Hint about factors that may affect a specific treatment

12 SECOND ITERATION OF CONCEPT

This is the second iteration of the main concept. It is evaluated with a higher fidelity digital prototype than the first iteration, the result of which is analysed and put in relation to the theory, to finally generate areas of improvement for the next iteration.

12.1 CONCEPT OVERVIEW

As in the first prototype, the practitioner is treating a patient applying for care through a web form (Figure 10, more screens in Appendix 6). The AI supplies suggestions regarding diagnoses and symptoms to ask for in an unobtrusive way, prompting the practitioner to come up with a hypothesis before utilising the automated diagnosis support.

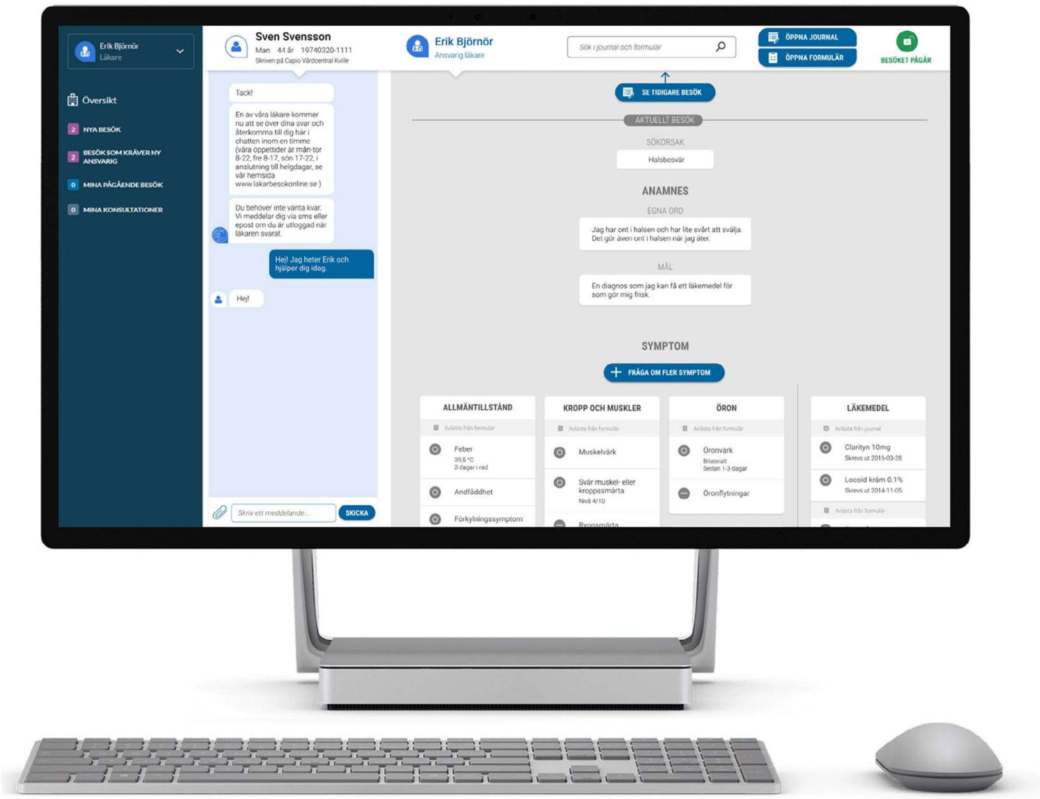


Figure 10. Digital prototype of the second iteration of concept.

The conceptual interface contains four distinct parts: a panel for administrating patient visits, a header, the chat, and the practitioner's workspace. Managing between active patient cases and reaching the menus, is done through the left-hand panel. The header has been expanded to include the state of the visit, either active or finished, and the practitioner responsible for the visit. Much like the previous iteration, there is also the patient profile, search box, and the buttons used to open the form and the medical record.

No changes were made to the chat, and it is still located at the left-hand side of the screen. Navigating both the chat and the workspace is done through scrolling with the mouse. The header sticks to the screen when the practitioner scrolls in the workspace, thus having access to these functions at all time. The workspace is laid out in a linear fashion thought to resemble the diagnosis process. First, the practitioner has the opportunity to look up previous visits, a section which in this concept has been made to attract less attention. Now, the practitioner actively has to press a button to show earlier visits. This was done to cater for having this information presented on demand, rather than forcing the user to read it.

Presentation of the anamnesis is done similarly to the previous iteration, with the patient's goal and own problem description in free text. A noticeable change is the division of symptoms. It is divided into categories of the body where the symptom is present, with confirmed and negated symptoms split vertically. To enhance this separation, icons are used to indicate the state of the symptom. Separated by a line to the right of the symptoms, are the affecting factors shown, in combination with medicines the patient might be on or has tried as self-care. Adding symptoms are made with the button located above the section, which brings up a pop-up suggesting categories of symptoms the system has calculated as useful to receive more information about. The suggestion includes a predefined message the practitioner can send to the patient, formulated in an open manner (Figure 11).

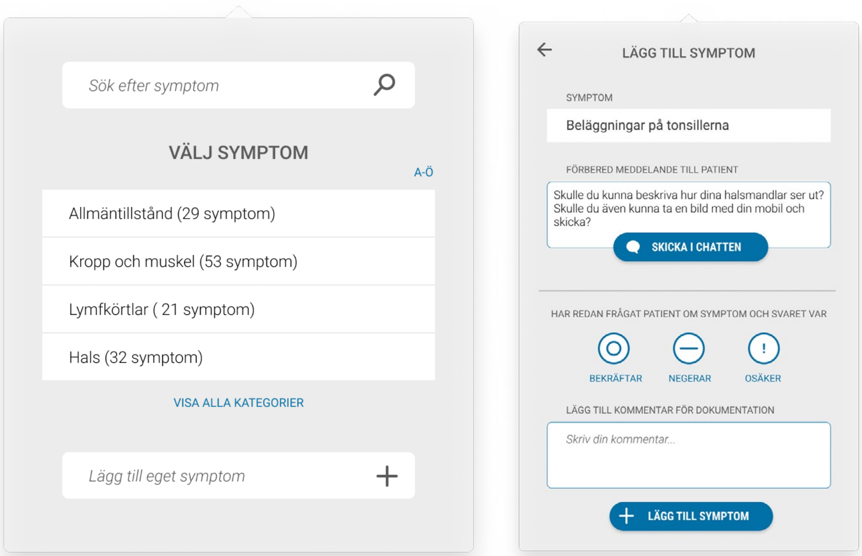


Figure 11. Series of pop-ups building up the adding of symptoms.

Images the patient might have submitted are located below the list of symptoms. They are followed by examinations, which are added through a single button for examinations, clinical tests, and digital tools. The system provides the practitioner with suggestions of suitable examinations related to the specific patient visit. When booking a clinical test, a dialog will prompt the practitioner to choose a healthcare centre and time, which the patient then has to accept or deny. The digital visit will be put on hold until the result from the test is submitted from the physical healthcare centre to the system.

The diagnosis suggestions are accessed by clicking the add diagnosis button below the examination section. The practitioner is faced with the opportunity to either add one or more diagnoses suggested by the system, or search for and add their own. A pop-up containing the criteria, suggestions on tests supporting the diagnosis, as well as diagnose codes for variances of the diagnose is opened. The suggestions are hidden until the practitioner actively opens them, to facilitate for the practitioner forming their own hypothesis regarding the diagnosis, rather than settling for the system's suggestion.

In the diagnosis module, there are criteria for the diagnosis, shortcuts to relevant tests to determine the diagnosis, as well as other information dependent on which diagnosis it is. The criteria act like a checklist for symptoms and the symptoms already established in this visit are checked here. The practitioner can also use this to ask whether the patient has some of these symptoms. When the practitioner has decided on the diagnosis, they click the button in the bottom of the module to choose it for treatment.

After choosing a diagnosis, the user is prompted with a treatment suggestion based on database recommendations. The system uses data from the patient's medical record, and should it include information regarding allergies towards specific medications, this will be prompted and catered for. Apart from choosing the suggested treatment, the practitioner can add their own, should they not accept the suggestion. It is also possible to write prescriptions directly from the system.

When the practitioner has settled on a diagnosis and a treatment plan, they have the opportunity to send an automatically generated summary of the visit to the patient. The feedback is then initiated actively by the practitioner, prompting the user after a set number of days to evaluate how the treatment has worked out. The visit is then ended by the practitioner clicking the finish button, upon which the system automatically saving the visit into the patient's medical record.

12.2 EVALUATION

The user testing of the second iteration was conducted with five test users and resulted in discussions regarding areas of concerns and improvements. The most prevalent topics and most important findings are presented and analysed here, sorted after their appearance in the user interface, ending with insights regarding the navigation.

12.2.1 PATIENT PROFILE

The patient profile displayed information from the initial form and the patient's medical records which were assessed by the system to be relevant in this particular case. However, most test subjects pointed out that they would prefer to see all information, even if it might not be apparently relevant, arguing that sometimes there are implicit connections between different previous visits and seemingly unrelated symptoms that trigger intuition in the practitioner. It was not enough that some of this information was accessible on demand; it should be displayed in its entirety.

12.2.2 SYMPTOMS

Overall, the list of symptoms was understood by the test subjects. However, some problems were identified as critical in the perception and usage of it. Three test users expressed concerns regarding the underlying questions from the form building up the symptoms. Being able to find these questions would be helpful in interpreting the severity and context of the symptom. Another concern expressed by one participant was that some of the symptoms presented would be difficult for a patient to examine or estimate on their own without proper training on how to do it. This could ultimately lead to distrust in the system, why it is important to consider when asking the questions in the form.

Two practitioners also expressed a concern regarding the vastness of the symptom list, which led to a poor overview of the list. Moreover, four of the users had problems identifying which symptoms were negated or confirmed by the patient. The distinction between symptoms, medicines and affecting factors, however, was understood by all test subjects. Observing how the users interacted with the system, it was evident that asking for symptoms was tedious and not completely intuitive. The fact that there was no button to ask explicitly for an image was also hampering the usage, as this was something that the practitioner had to ask for in the chat or in the pre-defined messages in asking for symptoms.

According to the quantitative evaluation (Appendix 3.2), the information presented was perceived less sufficient than in the first iteration (5.6). This was also true for the coupling between the anamnesis and diagnosis suggestion (6.4). These values were perhaps due to the insufficient information displayed in the patient profile, and difficulty overviewing the symptoms list.

12.2.3 DIAGNOSIS

A problem with diagnosing a patient is that there might be more than one diagnosis building up the state of the patient. Being able to detect multiple diagnoses was something expressed as important, and how that was supposed to be done was identified and mentioned as a problem by one user. However, identifying possible differential diagnoses was expressed as a positive effect with the diagnosis suggestions in the system. Overall, having suggestions for a diagnosis was deemed positive and helpful rather than pushing and obtrusive. One test subject expressed a desire to see probability in which diagnose to choose, and that this had to be presented in a transparent way, to make the practitioner trust the suggestion.

Having criteria for a specific diagnosis was expressed helpful, but it was also pointed out by all the subjects that far from every diagnose has such explicit criteria as an acute tonsillitis, which was used as example in the prototype. The question of how the diagnosis suggestion would work in a more complex case was raised. However, two of the test subjects stated that with a criteria-based diagnosis suggestion system, some diagnostic tasks may in the future be transferred from a practitioner to a nurse, permitting the practitioner to spend their time on more difficult cases.

In this iteration, the questionnaire suggested an improvement in how secure the diagnosis suggestions felt (7.2). The increase in suggestions security was dependent on the them being on demand rather than prompting, and thus felt less intimidating.

Returning to the model of trust presented by Lee and Moray, the performance of the system remained intact from the previous iteration. Turning to purpose, it was improved from the first iteration. The submissive nature of the suggestions, prompting the practitioner to actively open them, was appreciated. The intended reason was that this would facilitate for the practitioner coming up with their own hypothesis of the diagnosis instead of directly using the system's suggestion, thus preserving the practitioner's competence, which was understood by the test users. Regarding the process of the system, this factor saw an improvement since the first iteration. Transparency in suggestions was perceived as better, but it still had some way to go. Specifically, how the symptoms were displayed was questioned.

However, regarding the appreciation of the diagnosis suggestions, a theoretically contradictive finding was made. In this round of user testing, the perception of the system's diagnosis suggestion capabilities seemed to have decreased from the first iteration. This question arose from four of the test subjects. Even though hiding the diagnosis suggestions was well received, understanding to the degree of accuracy of the suggestions was low. Relating this to Lee's and See's model of trust alignment in a system, it was evident that there was a mismatch. The four users might have gained a distrust in the system, believing the system was able to perform less actions than actually possible. Furthermore, it suggests a poor resolution of the system's functionality.

This also hints at a mismatch between the mental model and the system, which in turn will affect the trust negatively, according to the framework described by Ekman, Johansson and Sochor. This notion is also strengthened by three users expressing the presented workflow not representing their procedure in a diagnosis process. Looking at the adaptive automation factor, this is something one of the users asked for. They wanted the system to adapt to their preferences, working on their terms, which, is supported by the framework, might increase the level of perceived trust. Although the phrasing of buttons and descriptive texts had been polished for the second iteration, it was still expressed as a reason for concern amongst the test users.

12.2.4 TREATMENT

Regarding the treatment suggestion panel, it was perceived positively to receive suggestions on type of medication based on underlying factors, in this case allergy towards penicillin. One user pointed out that allergies could be clearer. Several points of information to display were also suggested by the test users, for instance interactions with other medicines and the functions of the kidneys if that information is available from the patient's medical record. However, it was noted that the treatment was not always perceived as a suggestion, but rather something forced on to the practitioner, again suggesting a trust alignment problem. In the prototype, it was difficult to assess how to choose the suggested treatment. It was also expressed that not every patient wants to use medicaments, and that the system should facilitate for other types of treatment and self-care.

One test subject expressed the task of prescribing medication in the prototype as just a few of several additional steps, which should be considered when presenting the suggestion. In the prototype, some of the areas were covered, but not all. Two test users stated that more information regarding doses and guidelines considering the medication should be accessible to properly be able to determine if the suggested treatment is suitable.

12.2.5 DELIVERY & FEEDBACK

When it came to deliver the outcome of the diagnosis process to the patient, it was unclear to all test subjects how to proceed. This hints at lacking coherence between the mental model of the user and the interface. Understanding the button labelled "message to the patient" was difficult. The "feedback" panel also faced some problems. Two of the test subjects stated that it should be located before the message to the patient, as the information submitted for feedback should be present in this message. The feedback was also noted as lacking explicitness; how the feedback would work was questioned. It was also suggested that it should include more options, for instance booking tests to verify a treatment.

12.2.6 DOCUMENTATION

The system's ability to automatically document the patient visit into the patient's medical record was attractive to all the test subjects. It was noted as time saving. However, to nurture trust, they requested the ability to preview the automatic medical record before confirming it.

12.2.7 NAVIGATION

When observing the test subjects using the prototype, it was evident that a lot of scrolling was needed to navigate the system. This was expressed by all the participants as tedious and hampering the possibility to quickly scan the different functions provided in the interface. The fact that the prototype lacked a scroll bar on the right-hand side of the screen was also confusing to one test subject, as there was no hint regarding the functions farther down the screen. One test user also stated that a system incorporated into healthcare must be simple to use without too much interaction, as they are used many times a day. It was also noted that the readability of some elements was not enough.

The quantitative evaluation suggested that the overall clarity of the interface had decreased compared to the first iteration (6.4). This was also true for flexibility (6.2), intuitive use (6.0), time consumption (6.4) and how it would fit their workflow (5.4). While this seems surprising at first, it is most likely due to the difference in fidelity of the prototypes, discussed in the chapter "Reflections on concept fidelity".

12.3 CONSIDERATIONS FOR FINAL CONCEPT

The user testing generated the following key points to consider when developing the final concept. Some points were considered to be achieved and should be kept in their current state for the next iteration, while others needed more development.

ACHIEVED	DEVELOP FURTHER
• Prepared messages throughout the system were seen as efficient and helpful • Showing the complete list of symptoms gave users more control • Facilitating for multi-diagnoses • Ability to book a test from the diagnosis module was convenient • Reminder of affecting factors in the treatment module was greatly appreciated • Customisable treatment • Automatic feedback has big potential	• Reduce the amount of scrolling and simplify navigation to allow for overview • Show the previous three patient visits to get a glimpse of the patient healthcare history • Difficult to get an overview of the symptoms list • Enable seeing from which questions a specific symptom is generated for better transparency • Clarify the symbol for confirming and negating symptoms and factors • Adjust for the trust misalignment in suggestions by making them more noticeable • Provide more transparency to the suggestions • Provide control to the practitioner by confirming a suggestion • Simplify how to book a physical visit • Allow for preview of the automatic documentation to assure its accuracy

13 FINAL CONCEPT:
DIAGNOSIS FLOW

This is the third and final iteration of the main concept. It is evaluated with a high fidelity digital prototype, the result of which is analysed and put in relation to the theory, to finally generate areas of improvement for future development.

13.1 OVERVIEW

In the final concept (Figure 12), the medical practitioner can treat a patient remotely with the help of AI based diagnosis support in a digital interface. The practitioner continuously interact with the interface to add each action and result, enabling automatic documentation and a more systematic workflow. AI is introduced in two distinct ways: allowing for the incorporation of specific AI tools as well as a more general, continuous AI in the background. The specific AI tools are accessible like any other traditional tool they already use, lowering the threshold for their use. The general AI uses the continuous input into the system to provide suggestions, hints, and reminders specific to the to keep the practitioner alert and informed.

Figure 12. Diagnosis Flow, assisting medical practitioner throughout the diagnosis process.

13.1.1 WALKTHROUGH OF USAGE

A visit is initiated when a patient seeks care through their mobile phone. They answer a form related to their perceived problem, which answers are then fed into the system. An AI assesses the information and derives information from the patient's medical record, pulling data necessary to the practitioner to diagnose the patient. This information is split up into background information and anamnesis, which the practitioner uses in their assessment. The practitioner performs their diagnosis process in a digital interface, where they can communicate with the patient through a chat and conduct their tasks in a virtual workspace.

Throughout the diagnosis process, the AI analyses the data and prompts the practitioner with suggestions and reminders, for instance with questions for symptoms or diagnosis suggestions. Should the practitioner deem that the patient needs a physical examination or require a clinical test to ensure the diagnosis, this can be booked through the interface. The system supplies the practitioner with probable diagnoses, which can be added to the workspace. Included in the diagnosis suggestion are criteria for the specific diagnosis, which ensures every aspect is covered before settling on a diagnosis. The AI suggests a suitable treatment, based on the patient's background information and the diagnosis chosen. However, this can be rejected by the practitioner, should they deem that another treatment could be more effective. Before finishing the visit, a summary is prepared by the system which can be sent to the patient, including every step taken in the diagnosis process. Furthermore, the practitioner can initiate a feedback loop, which enables the system to reach out to the patient after a set amount of days, to gather information regarding the success of the treatment. This information is used to improve the system's decisions in the future. When the practitioner ends the visit, it is stored automatically to the patient's medical record.

Next, the individual elements building up the interface are described.

13.1.2 WALKTHROUGH OF USER INTERFACE

Five distinct parts are present in the final concept (Figure 13, more screens in Appendix 7). From left to right: the panel for managing patient visits, the chat, the practitioner's workspace, a suggestion panel, and the header. The panel for administrating patients is reduced in size compared to the second iteration; as it is not something that is necessary to treat a patient, but rather something that should be visible on demand.

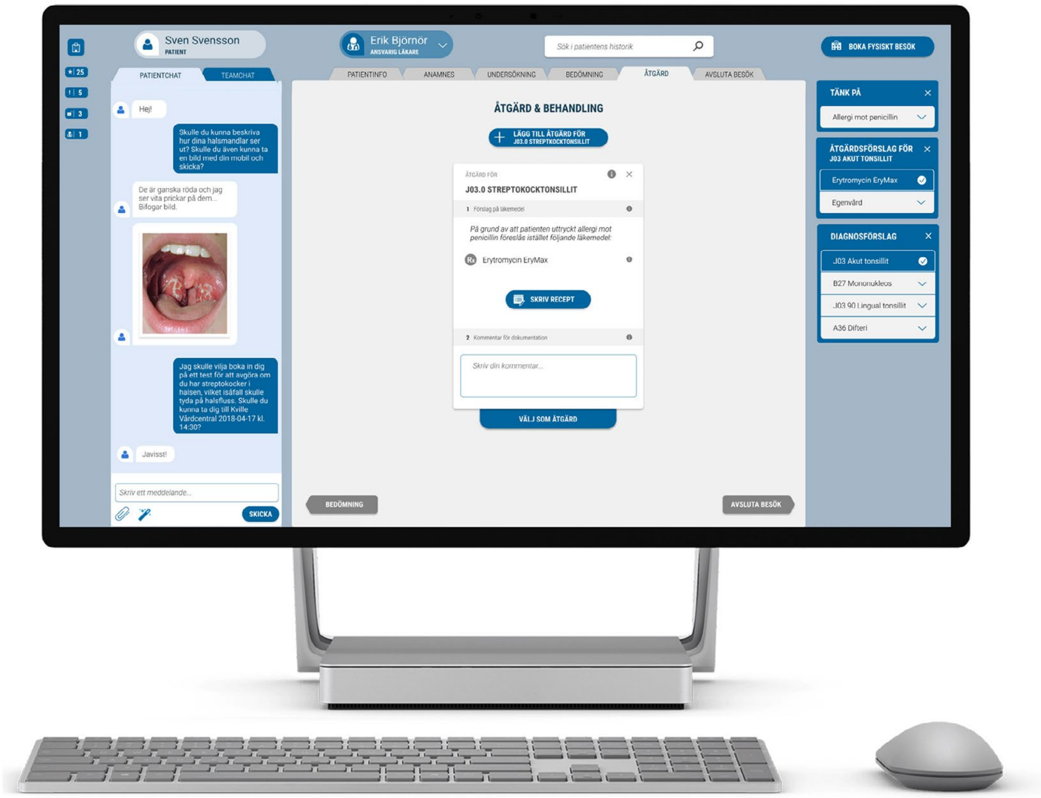


Figure 13. Digital prototype of the final concept.

A change has been done to the chat from the previous iterations, it now also includes the possibility to communicate with other practitioners working on the case, by using the chat tab named team chat. However, the location of the chat remains the same. The header now includes the name of the patient, the practitioners working on the case, a search bar to search in the patient's medical record, and a button to book a physical visit at a healthcare centre. It will still stick to the top of the screen when the practitioner navigates the interface.

The workspace is now divided into six distinct tabs reflecting the diagnosis process: patient information, anamnesis, examination, diagnosis, treatment, and finalise visit. Navigation is done either by clicking on the tabs or by using the navigational buttons located at the bottom of each view. In each tab, if the practitioner has not interacted with it yet, a short description of possible actions is offered to provide clues on how the practitioner should proceed.

On the patient information tab, the patient's contact information complemented with previous diseases and affecting factors are shown (Figure 14). The practitioner can access the full medical records with a button.

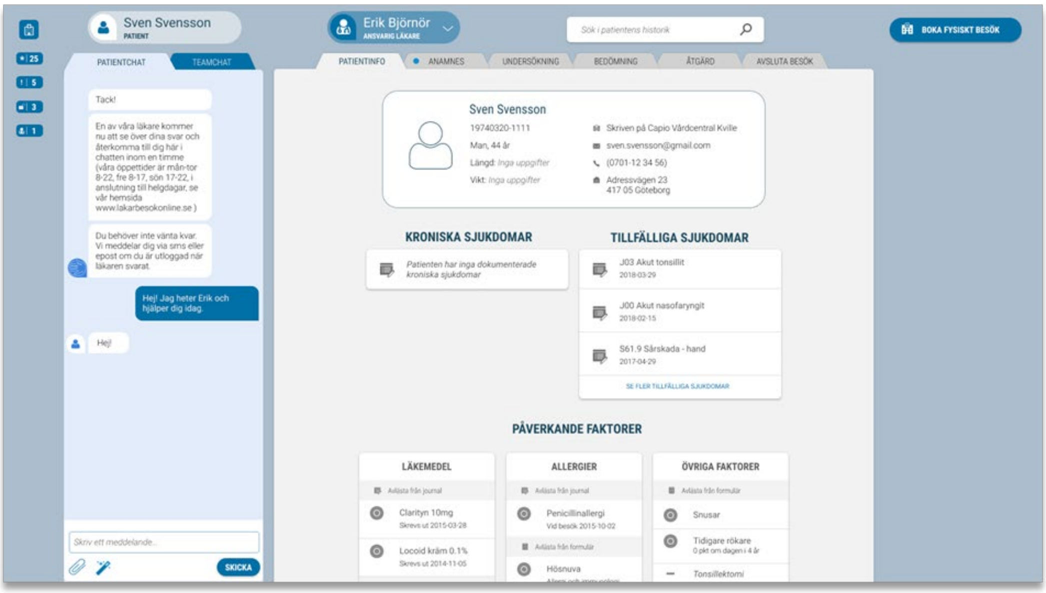


Figure 14. Patient profile, with previous diseases and affecting factors in the workspace.

In the anamnesis tab, the patient's symptoms are displayed. Changes have been made to the icons differentiating negated and confirmed symptoms, to increase visual clarity. The symbols now have distinctly different shapes, and negated symptoms are written in italics, which is standard in many medical record systems (Figure 15). Symptoms are added in the same manner as in the second iteration. Hovering over the symptoms with the mouse opens a pop-up window displaying the underlying questions building up the specific symptom. Should the practitioner require to see the full form including the patient's answers via the "open form" button.

Figure 15. Increased visual clarity in confirming and negating.

Moving on to the examination tab, it is divided into clinical tests and digital tools. Booking a test at a healthcare centre is done in the same way as in the previous iteration, with the system suggesting tests related to the symptoms given by the patient. Digital tools include different checklists being used to determine the probability of a diagnosis, as well as automated tests utilising AI.

Adding a diagnosis to the workspace is done similarly to the previous iteration. However, in this concept, each diagnosis is colour coded, to enhance comparability. This colour coding is also reflected in the symptom tab to see which symptoms are included in a specific diagnosis (Figure 16). This enables the practitioner to asses which symptoms not yet being caught by any diagnose hypothesis.

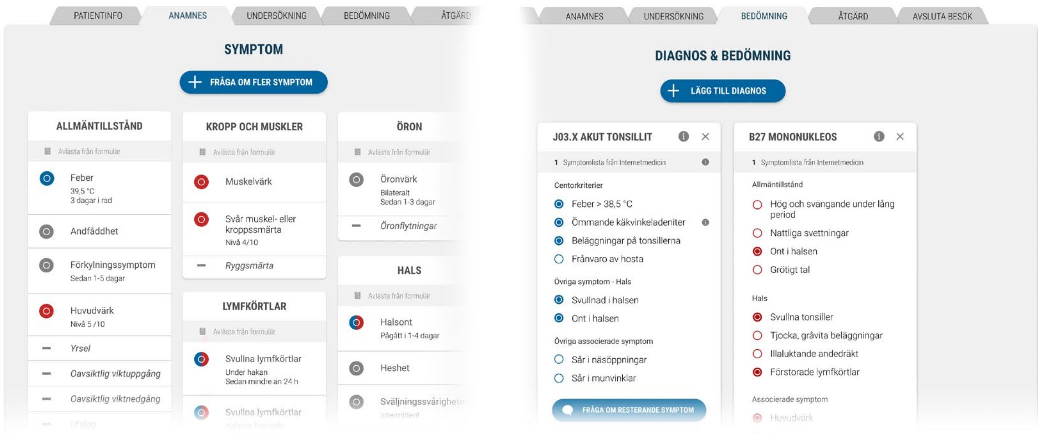


Figure 16. Colour coded symptom list after adding two diagnoses to consider for further assessment.

Choosing a treatment after confirming a diagnose is done in the treatment tab. Should the patient be affected by any factors relevant to consider, for instance allergies, this will show up and be reflected in the suggested treatment.

Wrapping up the visit is done in the finalise visit tab. Activating feedback, including eventual booking of follow-up tests to review the treatment, is offered first in the view. Below the feedback, the practitioner has the opportunity to send a summary of the visit to the patient. To enhance the identification of this section and increase the clarity, a descriptive text is displayed. Closing the visit is done by clicking the button labelled "close and document". Upon clicking, the button is expanded to enable the practitioner to leave a last comment on the visit, as well as previewing the note for the medical record.

A new feature in this concept is how suggestions are presented (Figure 17). Apart from accessing them through the associated button in each tab, the system now shows predictions of the next action for the practitioner to the right of the workspace. Two versions of appearance are present, proactive and retroactive. Suggestions can be retroactive if when the practitioner moves past the anamnesis without asking the patient any questions. Then, the system will prompt the user with questions for relevant symptoms the practitioner might have missed asking for. Proactive suggestions are used when proposing diagnoses, which show up upon entering the diagnosis tab and present a suitable treatment plan for the chosen diagnosis, along with relevant information such as allergies.

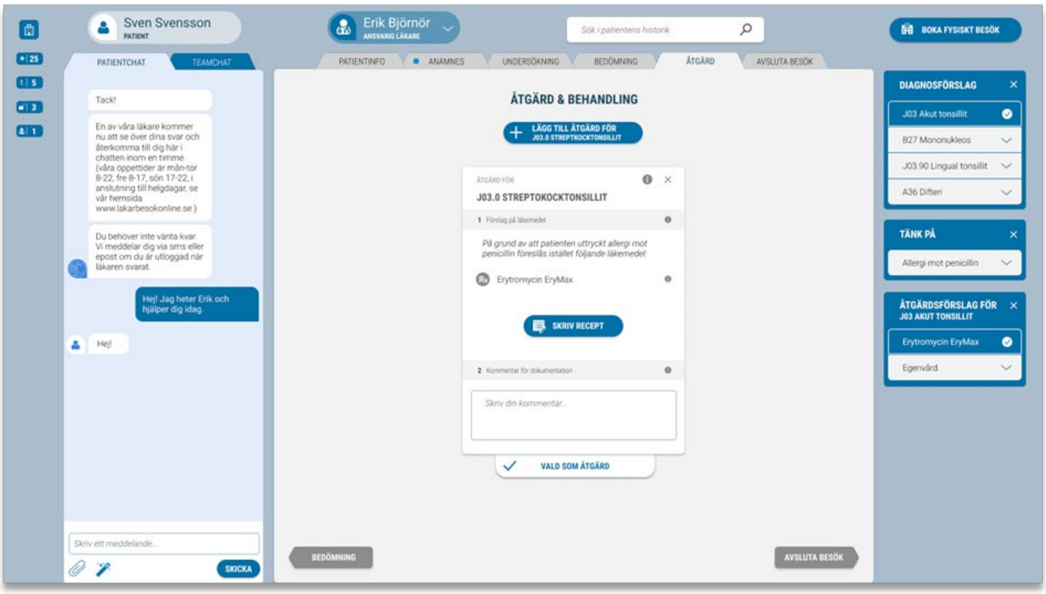


Figure 17. Treatment tab with the suggestion pane on the right-hand side of the screen.

13.2 VERIFICATION AGAINST PROBLEMS

The problem areas were revisited to ensure the final concept solves the problems defined in the explorative phase.

13.2.1 TIME & TASKS

Remote, asynchronous healthcare means the practitioner manages several patients simultaneously, but Diagnosis Flow assists by organising all the components of each visit in the user interface. This is to reduce the time and effort spent to re-engage in a patient's problem, facilitating for efficient multi-patient management [P 1.4]. Moreover, the automatic triage, documentation, and follow-up, as well as prepared chat messages reduce some administrative tasks significantly. As a trade-off, the practitioner needs to continuously interact with the system [P 1.3].

Diagnosis Flow aim to integrate the most used features of different systems to provide convenient access. For example, chronic and the latest temporary sicknesses are automatically extracted from the medical records and presented to the practitioner [P 1.1]. Should there be information from several systems which are redundant, it is combined and displayed only once, but with multiple sources [P 1.2].

13.2.2 COMPETENCE

Introducing automation into healthcare to assist in the diagnosis process might automate certain of the practitioner's work tasks when identifying a diagnosis. It is, therefore, important to ensure the practitioner does not rely too heavily on the system but preserves their competence.

Diagnosis Flow facilitates for this by continuously providing small bits of relevant information to expand the practitioner's internal knowledge by gradual learning, rather than bulk learning. The system is designed to act like an extension of the practitioner, not leaving them in the unknown [P 2.3]. Furthermore, the practitioner always has access to the latest prevalence statistics and recommendations through the system, to ensure the practitioner is always up to date [P 2.1].

13.2.3 COMMUNICATION

There are two types of communication defined in this study: interpersonal and human computer interaction. Although Diagnosis Flow is more focused on the human computer interaction, it lays the foundation for finetuning interpersonal communication in future development.

In the form, the patient can first tell their story in their own words, and is then prompted by further, more quantifiable questions to cater for the subjectivity often prevalent in the anamnesis [P 3.3]. By quantifying the full anamnesis, including symptoms, the system can process the symptoms consistently in the background and assist the practitioner in case they miss a connection deemed significant by the system [P 3.1]. A combination of quantitative and qualitative questions gives the system and practitioner effective ways of complementing each other with their strengths.

A complete anamnesis, told by the patient, is important to establish common needs and expectations between the practitioner and the patient. Diagnosis Flow puts them front and centre in the anamnesis tab for the practitioner to see and ensure they are catered for by the end of the visit [P 3.2].

In any human computer interaction, the transparency is an important component to facilitate for informed trust. Diagnosis Flow caters for this by always providing access to relevant information, with the option to explore more if needed. Moreover, the source is always displayed so the practitioner can assess potential bias [P 3.4]. Good communication between the user and the system is also established through clear presentation of output. For example, showing tangible diagnosis suggestions the user can interact with, rather than simply showing raw data which the practitioner would need to interpret [P 3.5].

13.2.4 PROCESSING

Diagnosis Flow takes advantage of the difference in the internal processing of the practitioner and the system, by using the combination of qualitative and quantitative input in difference ways. The free text anamnesis and the overview of the symptoms allows a holistic perspective for the practitioner, while the system can work systematically in the background to ensure different risk factors and diagnosis are considered [P 4.1; P 4.3]. The data-driven approach is also prevalent in individual tools, such as image analysis using machine learning, where a pre-set algorithm is preferable [P 4.4]. Diagnosis Flow allows the incorporation of these tools to be seamless. From the practitioner's point of view, they are just like any other tools, as they are not required to manage the input manually. This makes the threshold lower to gradually introduce AI in the diagnosis process.

13.2.5 TRUST

To build trust between the practitioner and the system, user tests were used to align their expectations of the automated functions with the actual capabilities. But this balance is not obvious and may change with time. Moreover, due to the tools being seamlessly built into the system, using them feels more natural and in line with tools and clinical tests they already use. To further facilitate for trust building, information is accessible in each of the modules of the system to provide insight in how the function or tool works, and for the user to validate its source [P 5.4; P 5.3].

13.3 EVALUATION

The user testing of the third and final iteration was conducted with five test users and resulted in discussions regarding areas of concerns and improvements. The most prevalent topics and most important findings are presented and analysed here, sorted after their appearance in the user interface, ending with insights regarding the suggestion pane and navigation.

13.3.1 PATIENT PROFILE TAB

The patient profile was expressed as a good asset by four of the test subjects. It was described as a good overview of the patient at hand, and the ability to distinguish between chronical and temporary diseases was deemed useful in constructing a hypothesis of the patient and how inclined it is to seek healthcare. Furthermore, the information presented was said to be sufficient, but at least two of the users asked for the ability to open the full medical record regardless, hinting at a discrepancy in what information is actually necessary to display.

Being able to tell the source of information was positive, but comments regarding the readability of the text presenting this information were made. Some questions were also raised regarding the affecting factors; would the system sort out information it deems useful for the practitioner or would everything show up? If it would not show everything, one of the test users stated that it would be necessary to scan the patient's medical records anyway.

A bigger problem with the patient profile turned out to be in the order which it was presented. In the prototype, it was the opening screen, which led to confusion regarding how the user should proceed. It was not possible to tell the reason for the patient seeking healthcare from this screen, which led to questions about what the patient expected from the visit. One of the test subjects expressively asked for the anamnesis and did not at first figure out how the navigation worked or how the necessary information should be found.

13.3.2 ANAMNESIS TAB

Several problems were found in the anamnesis tab from the user tests. The area with the patient's own words were appreciated by all of the users, but three of the subjects expressed concerns regarding how the symptoms were presented. The list of symptoms did not follow the convention of categorisation in today's medical records. At the same time, the presentation was not neglected as solely negative, but rather something that might be more intuitive after a short learning period. One user pointed out that practitioners are generally inclined to read text consecutively rather than chopped up in chunks, as that is how the information is presented in most medical records.

The pop-ups showing information regarding the questions constructing the specific symptom, were perceived as very good by four of the users, as this led to increased transparency in understanding why the information is present but also to increased awareness of what questions the patient had answered. This could eventually increase the possibilities to identify sources of errors due to the patient not completely understanding the questions. However, it was not evident that this information would show up when hovering over a symptom.

Colour coding appearing in the symptoms list when a diagnose is added for consideration was not appealing to four of the test users. It was expressed as increasing the uncertainty a practitioner might feel towards deciding on a diagnosis, if one specific diagnose fulfils more symptoms in the list than the other, even though this might not be the most probable diagnosis to decide upon. It was also described as too much information to comprehend, with both the unconventional structure of the symptom list in combination with colour coding. Another critique raised was that there was no hint from the diagnosis tab that new information was available at the anamnesis tab. Two of the users stated that they most likely would not revisit the anamnesis upon deciding on a diagnosis.

Comparing the results of the quantitative evaluation (Appendix 3.2), the information presented was deemed as more sufficient than the previous two iterations (7.5), due to the extended patient profile and symptoms. This was also true for the relation between the anamnesis and diagnosis suggestion, it was perceived as clearer than in the two previous concepts (7.5), due to the extra functions of comparing symptoms and diagnoses.

13.3.3 EXAMINATION TAB

The split between clinical examinations and digital tests were perceived well by the testing practitioners. It was noted as a useful feature to be able to book in patients for tests at healthcare centres and receive the result in the digital platform. A concern was raised by one of the subjects, however, that there is a variance between the tests offered at a hospital and a healthcare centre, and that the list of tests for a hospital potentially risked being very extensive, thus offering a bad overview.

13.3.4 DIAGNOSIS TAB

Initially, all of the test subjects expressed a feeling of satisfaction when being faced with the criteria building up the diagnosis. However, upon reflecting on it, two of the users stated that the example used was for a diagnose not too complicated to figure out on their own. Furthermore, concerns were expressed regarding the feasibility of such a system, as not all diagnoses have such clear and well-defined criteria as a tonsillitis. On the other hand, it was stated that in the case of a more complex situation a diagnosis support like this would be the most helpful.

The flexibility to book a test from the tonsillitis diagnosis panel was appreciated by four of the test subjects, as this enabled them to choose in which order a clinical test and diagnosis should be appointed. The same went for the function to ask the patient for remaining symptoms directly from the diagnosis tab, the freedom to conduct the tasks in whichever order the user wanted was deemed positive.

One of the users stated that the information presented on mononucleosis was irritating. Being offered the definition of the diagnosis was expressed as insulting towards a practitioner's competence, since this is something they are expected to know. On a similar note, another test subject expressed the notion that a practitioner could potentially be redundant if the process was too standardised, as basically no medical education was needed to evaluate given symptoms with a check list.

13.3.5 TREATMENT TAB

All of the test subjects appreciated being offered a suggestion for medicine based on the patient's conditions. It was expressed as an improvement in time spent per patient visit being able to write a prescription directly in the system. The possibilities to produce referrals to specialists if for instance a surgical operation was necessary was also perceived as useful.

A problem, however, was the lack of feedback when the practitioner had decided upon a treatment. None of the test subjects intuitively understood what the next step would be.

13.3.6 FINALISE VISIT TAB

The scope of the conclusive tab was not very clear to the test users. The purpose of the feedback module required explanation, but all test subjects were positive towards the function. A common denominator between all the tests was that the practitioners wanted to send the patient a summary of what had been dealt with in the patient's visit. The button to do so was missed by at least two of the users, and for those who found it, the purpose of the button was not clear. Comments were made regarding the phrasing of the text on the button to not be in alignment with the users' mental model of submitting information to the patient.

The button finishing the visit was explicitly stated as easy to find and understand by one of the users, and the rest had no problem using it and comprehending the functionality of it. The possibility to review the final medical record entry was also appreciated. However, one of the subjects stated that the visit should be possible to re-open again once closed.

13.3.7 SUGGESTION PANE

Being presented with suggestions for probable actions in the diagnosis process was generally perceived as something useful to the test subjects. They were referred to as a safety net working to broadening the mind on what diagnosis to consider. However, discussions were held regarding exactly what kind of information should be presented. Should it promote rare diseases, or should it be extensive, ranging from most to least probable, to catch all possibilities? No consensus was reached, as the opinions varied between the users.

Suggesting the practitioner with symptoms potentially missed asked for was also positive. One user did however state that the suggestions never should interfere with the practitioner's agenda, if they had thought about an action, it would be intrusive and irritating if the system suggested it as well. This opposes the view of another test user, as their view was that it would, on the contrary, reaffirm their trust in the system. However, all test subjects stated that it was important that the suggestions were precise and accurate for them to trust the system.

On the trade-off between proactive and retroactive suggestions, it was noted that the function prototyped was well aligned with the users' mental model of how a suggestion should work. Having the system prompting for a missed symptom if the practitioner had moved past the anamnesis tab without asking for a complementing symptom was deemed useful. At the same time, presenting a diagnosis suggestion further in the process, when the practitioner had had the time to come up with a hypothesis regarding a possible diagnosis, would work as an eye opener, that there might be a differential diagnosis which might be more probable.

Treatment suggestions which appeared when a diagnosis was chosen for treatment were appreciated. Prompting of allergy towards penicillin was explicitly regarded as attractive and useful, and the fact that the system adopted to the circumstances was pointed out as very good. Being offered the alternative to also suggest self-care to the patient along with recommendations was welcomed.

The third concept proved less successful in how secure the diagnosis suggestion felt, compared to the second iteration, but better than the first (7.0), perhaps due to it being more prompting. However, the perceived improvement in diagnosis accuracy compared to today had improved from both previous iterations (7.3).

Putting the findings in relation to Lee and Moray's model, the system's behaviour seemed clear to the users. The interface in the third iteration supported more suggestions than the previous, and the users understood suggested courses of actions and reminders on the state of the patient. They also understood that they were supposed to be seen as pointers not mandatory actions, indicating that the purpose was clear as well. The information building up the suggestion was displayed in the interface, merely supporting the practitioner in utilising it, so the users were not confused as to how the system worked. This suggests a good understanding of the system's process. Conclusively, the slight distrust regarding suggestions analysed in the previous iterations were considered to have been mitigated in the final concept, and as the system suggested courses of actions rather than forcing the user in a certain direction, the users felt more in control.

Improvements were also noted regarding the factors presented by Ekman, Johansson and Sochor. The information presented seemed to align with the users' procedure in diagnosing a patient. The tab system represented the steps taken in the diagnosis process, making the users feel familiar with the system. Furthermore, the system's goal of finding an accurate diagnosis was aligned with the goal of the practitioner, which according to the model should further the trust nurtured. The general verbal tone of the system seemed overall to be that of a practitioner, although some phrases need some finetuning, to further build trust. A lacking factor, however, was the feedback as users often seemed lost after conducting the action of proposing a treatment to the patient, indicating that work should be done in improving the system's feedback.

13.3.8 NAVIGATION

The layout with tabs building up the diagnosis process was at a first glance not very intuitive to the test users. Questions were raised regarding what information would be present under each section, but after acquainting themselves with the system it was expressed as logical. The problems mainly revolved around preferences of the phrasing of the tabs, which initially was confusing to at least two of the test subjects. The lack of scrolling through extensive views was much appreciated. However, one of the users stated that having everything on one screen with expandable panels for each category would be even more effective and would more resemble systems practitioners are used to working in today.

A more prominent problem was regarding the lack of feedback between each step in the process. There were few clear hints regarding if the user was actually done with one step and that they should move on to the next in order to continue. It was also evident that some information was lost to the test users, as the contrast on some text fields was too low, leading to questions regarding the text and the icons displayed describing the source of information. Furthermore, the symbol representing a symptom being confirmed by the patient was not intuitively clear to the users, as the icon used resembled a radio button, hinting at pliancy where there actually was none. However, in the context the meaning came across, when the icon was complemented with the more understandable icon for a negated symptom.

The third iteration was perceived better than the second in the qualitative evaluation, but worse than the first in overall clarity (7.5), flexibility (6.8), intuitive use (6.8) and how it would fit the practitioner’s workflow (6.3). While this seems surprising at first, it is most likely due to the difference in fidelity of the prototypes, discussed in the chapter “Reflections on concept fidelity”. Furthermore, the time consumption was experienced as worse than both previous concepts (5.0), likely due to the perceived tediousness of the navigational tab structure.

13.4 CONSIDERATIONS FOR FUTURE DEVELOPMENT

The user testing generated the following key points to consider when developing the final concept. Some points were considered to be achieved and should be kept in their current state for future development, while others needed more development.

ACHIEVED	DEVELOP FURTHER
• Minimised amount of scrolling was appreciated • The overall division between tabs was deemed logical • Diagnosis suggestions are aligned with the trust of the practitioner • Contextually aware suggestions were appreciated • Patient profile provided sufficient information • Ability to see the source information deemed positive • Division between clinical and digital tools felt logical • Writing a prescription in the treatment module felt efficient and coherent	• Improve navigation as the tab structure resulted in confusion in how to proceed to the next step • Improve pliancy and readability of individual elements, such as the symptoms icon • Reconsider the colour coding feature, as it was perceived overwhelming and partly misunderstood • Reflect on the value of showing the diagnosis criteria immediately, as the importance of criteria is dependent on the diagnosis • Rethink the finalise tab, as its purpose was not obvious

CONCLUSIVE PHASE

This phase discusses the study at large, poses considerations for future work, and states its conclusion.

DISCUSSION — FUTURE WORK — CONCLUSION

14 DISCUSSION

To evaluate the success of the thesis, returning to the research question is needed.

How should AI be introduced in the diagnosis process to improve efficiency and effectiveness, while ensuring that the medical practitioner remains in control?

Introducing AI into healthcare generates a multitude of changes due to its different way of working. AI requires quantifiable quality input which somehow has to be provided. This study suggests that an interactive workspace for the practitioner is a way to do it without invoking distrust from the practitioner. The workspace allows for a gradual introduction of AI, and acts much like a platform for housing different AI diagnosis tools where the practitioner and the AI can work in union, their responsibilities potentially shifting in individual areas as one becomes consistently more accurate than the other.

The final concept provides a more systematic way of managing the diagnosis process than in healthcare today. Reminders and suggestions in combination with feedback loops has potential for improving diagnosis accuracy and improve the system with time. The evaluation of the suggestions shows that hinting at actions and reminding of factors is an effective way of making the practitioner feel in control. Moreover, by relieving the practitioner from mundane tasks such as documentation and looking up information and tools in different systems, the practitioner can become more effective and focus on the patient. The practitioner needs to interact more in a visual user interface, which may cause for a learning curve and take more time initially, but the projected saved time in automatic documentation in combination with suggestions and easily digestible information will outweigh the loss and result in a more efficient diagnosis process.

14.1 REFLECTIONS ON THE DESIGN PROCESS

Tackling something as complex as healthcare requires a holistic view, as many factors affect the outcome and can thus be considered a wicked problem. This motivated the extensive user study conducted in the beginning of the project. Defining the problem area in one step was difficult, calling for the need of an iterative process. The user study provided insights to conduct concept development, but the emerging data from the user tests also fed in to the consecutive iterations. Should the process have been linear with only a single concept, lots of insights would have been lost. Looking back at the state of the first concept and the improvements in the consecutive ones, the final proposal would not have been as extensive as it turned out if the process had been linear, ending after the first iteration.

It was perceived that saturation was achieved regarding insights in the diagnosis process through the interviews, as little new information was gained in the last interviews. However, quantitative data on attitudes towards diagnosis support and new technology in healthcare could have proven useful. Constructing a well-composed questionnaire aimed at solving a wicked problem is, however, difficult to do in the beginning of a research phase, but perhaps it could have been used to verify the interviews. This could have broadened the problem definition and suggested which level of automated suggestions to use in the concepts. However, it was evident in the interviews that the answer was found in the discussion, rather than in the answer first thought of by the practitioner, why questionnaires might have offered a skewed view of the problem area.

During the development process, the focus was narrowed down even further to the practitioner's perspective during the development process, causing some of the identified problems from the human support and patient perspective to be represented less in the final concept. However, this should be considered in future development subsequent to this study. Furthermore, there were some requirements and ideas which were disregarded due to difficulties in their technical implementation and due to it not being any obvious way of gradually phasing them in, most notably requirements about nonverbal anamnesis collection and accordingly the preliminary concept Digital Eye. These aspects are still considered important and should be included in future studies in this field.

14.2 REFLECTIONS ON USER PARTICIPATION

Six of nine user test participants were practitioners employed by Company X. This might have affected the result in that they potentially were more positive to new technology, as they work at a tech company. Furthermore, their perception of AI as a tool in healthcare might be more positive than that of the average practitioner. However, the participants working in the physical healthcare also shared the notion that new technology in general and AI in particular should be incorporated to improve healthcare.

The reason for involving the practitioners at Company X to the extent as they were, also derives from the strain the healthcare in Sweden is under. Recruiting test users from healthcare centres proved difficult, as little time was available to spare to participate in a user test. Could this problem have been mitigated by applying design methods such as personas or scenarios? Possibly, but this would have resulted in a loss of user insights, which was deemed vital to the viability of the proposed design. It was concluded that the trade-off between recruiting test users from Company X, holding potential bias versus the involvement of users tipped over to involvement's favour. Furthermore, specialists in different fields participated in the test, and they provided feedback related to their area of expertise, giving more insights regarding features for future implementation. Aligned with Nielsen's proposal of the size of the test sample, at least five test subjects tried the prototype in every iteration, leading to sufficient data to effectively evaluate the proof of the developed concepts.

A factor potentially affecting the outcome of the evaluation of the concepts could have been the choice of sickness prototyped for treatment. Tonsillitis is one of the more common diseases in Sweden and something a practitioner has little problem with finding. The criteria are straight forward, and the test used to ensure the diagnosis is fairly secure. Remarks were made by the test users that they would probably be able to diagnose the patient without any support. However, positive comments were left on suggestions for treatment and alerts regarding allergies towards specific medicines, pointing at the usefulness and convenience of such a system even in rather simple cases. The strict criteria of tonsillitis acted as a good example of how the system should work, which might not have been possible with a rare disease built up by less clear symptoms.

14.3 REFLECTIONS ON CONCEPT FIDELITY

The first iteration prototype intentionally lacked look and feel, as it was meant to evaluate the structure and the idea at large. However, this meant a significant loss in the visceral layer and ended up producing some unexpected answers of questions of the quantitative evaluation concerning said layer. It seems the participants filled in this layer in their heads, imagining a variant of a user interface which they thought pleasing and gave marks accordingly. Then, when the high fidelity was introduced, a divergence between their imagined user interface and the one presented occurred, perhaps influencing their marks for the high fidelity prototype. Naturally, this analysis is only applicable to the test subjects who participated in both the first iteration and the second or third.

Although Norman’s theory of design for experience was not strictly guiding the development process, it was a useful tool to break down different mechanisms that steered the perception of certain elements in the prototypes, such as at what level a particular problem arose or played out. It contributed mainly in the evaluation of the different prototypes. A certain level of fidelity was needed to analyse the three layers of user experience, why the first prototype did not provide as much insights on this topic as the second and third.

Nielsen’s usability guidelines acted as a checklist from which to take both inspiration for the requirement list and development process, but also to analyse against in the evaluation of the prototypes. However, as the task of diagnosing a patient is heavily dependent on the reasons for seeking healthcare, evaluating the usability of a system aimed at handling all diagnoses is difficult as the needs for every given situation might vary greatly. Although more detailed evaluations of usability could be assessed given more examples of healthcare visits to test along with additional time and resources, the result is in line with what Harrison, Sengers and Tatar suggests regarding a system situated in the third paradigm. The usability guidelines were considered, but did not play a significant part in the user tests. Prominent was instead the notion of trust and user experience, which feeds in to the context-based nature of a third paradigm system. This further strengthens the notion that the proposed design is indeed placed in this realm.

14.4 REFLECTIONS ON BUILDING TRUST

An unexpected finding with the first concept was that the trust for the system went down when the system only presented the information it deemed relevant to the practitioner. This can be put in relation to the theory presented by Lee and See, that the word of another, in this case the system, could not be properly relied on. Perhaps, should the users have worked with the system for a longer period of time, realising that the system actually presented only the relevant information, this trust issue would have been eliminated. Furthermore, how the suggestions were presented was important in the perceived trust. In the first concept, the suggestions were perceived as too prompting, not giving enough room for the practitioner to make their own hypothesis. However, in the second iteration, the suggestions turned out too subtle, resulting in the practitioner not finding them. In conclusion, the third iteration struck a balance between the two, being suggestive rather than pushing, which was perceived as natural and effective to the test subjects, suggesting an alignment of trust and automation.

The theory concerning building trust gave insight in why distrust appeared and what parameters should be adjusted to align the user expectation of automation with the actual delivered automation. Having different theories concerning the issue of trust was helpful in creating a rich understanding of the implications of trust in different scenarios, but became cumbersome at times in the evaluation as the same problem could be explained from different perspectives with some overlapping. Perhaps only theories concerning distinctly separated areas should have been used to avoid this confusion and enable fewer but more in-depth analyses.

14.5 IMPLICATIONS

Reflecting on the consequences of implementing the proposed system, it is necessary to consider some concerns raised by the test users. It could facilitate for resource saving in healthcare, should a nurse be able to diagnose patients instead of a practitioner. Two practitioners stated that following the checklist of the diagnosis suggestion does not require the competence of a practitioner. This could potentially lead to the practitioners having more time to spend on more difficult diagnoses. However, this leads to another question regarding the future of the healthcare. What would happen to the diagnostic work tasks of the practitioner, should more and more diagnoses receive clear requirements, thus enabling a nurse or a less educated person to treat patients? Sure enough, the practitioner would still be needed to conduct surgeries, but the majority of the healthcare work force is not educated to do this. Continuing this trail of thought even further, into the distant future as this type of technology evolves, would an institutionalised healthcare aimed at diagnosing patients even be necessary? Could the patients not do this on their own with a fully automated system?

Introducing a system like this one involves significant development of other conjoined systems, such as a database for symptoms and diagnoses generated from medical knowledge databases, and access to different medical journals. Moreover, the system might not be as capable in the initial period of use as the databases are not finetuned, but as continuous diagnoses are made in the system, feedback loops will improve the system and strengthen the databases. A workspace of this sort does imply a significant shift in the practitioner workflow as well, and thus a learning curve is to be expected. As the evaluations have showed, introducing an AI to enhance rather than replace the practitioner is an appropriate way of taking advantage of the different strengths of each separate entity. Combining the holistic view of the practitioner with the systematic approach of the AI could potentially make them reach further than the sum of their parts. However, the timing is important. As the introduction of AI in healthcare and digital solutions are beginning to change how healthcare in general is conducted and distributed, now is a suitable time to also introduce a system that facilitates these tools of the future.

15 FUTURE WORK

Apart from the considerations for future development proposed in the final concept chapter, these are some points for future work regarding feasibility, implementation and design.

To further ensure the proposed concept's viability, technical feasibility analyses have to be made, as development of an AI able to conduct the proposed automation is of utmost importance for the system's success. However, the suggestion system could be gradually introduced to facilitate for a smoother transition period from no support to the diagnosis support suggested in this study, which should not require an AI too advanced from what is present today.

Incorporating information from third party sources requires investigations regarding the willingness of said sources to collaborate. Necessary to the concept is the information supplied by medical journals and medical knowledge databases. As these instances are not managed by Company X, agreements have to be made on how this information can be used.

Further testing regarding usability has to be made to ensure an effective usage of the system in cases more difficult to diagnose than the prototyped disease. Development on aligning the visual language with the graphical profile of Company X should also be made.

One perspective not covered in this study is that of the patient. Gathering insights regarding the patients' views on an automated healthcare is crucial before implementing the proposed system.

16 CONCLUSION

Introducing the data-driven approach of an AI system in the diagnosis process, which relies heavily on intuition, poses problems of trust, effectiveness and efficiency.

The suggested concept offers the practitioner support when diagnosing a patient digitally, giving them suggestions on diagnoses and alerting them on affecting factors from the patient. User testing of the system showed that the practitioners trust the delivery of the AI based features, indicating this is a viable way of introducing an AI in the diagnosis process.

This study shows that introducing AI in a digital diagnosis process should be done gradually with the practitioner at its centre, to build trust and take advantage of their respective strengths.

17 REFERENCES

Ahlzén, R., Berggren, L., Metsini, A., Olsson, L., & Tegelberg, Å. (2018, 04 18). DN Debatt. "Vetenskapligt stöd saknas för digitala diagnoser". Retrieved 05 23, 2018, from Dagens Nyheter: https://www.dn.se/debatt/vetenskapligt-stod-saknas-for-digitala-diagnoser/

Bengtsson, K. (2017, 02 07). Sök vård på rätt mottagning. Retrieved from 1177 Vårdguiden: https://www.1177.se/Vastra-Gotaland/Regler-och-rattigheter/Hitta-ratt-i-sjukvarden/

Bennett, C. C., & Hauser, K. (2013). Artificial intelligence framework for simulating cilinical decision-making: A Markov decision process approach. Artificial Intelligence in Medicine vol 57, 9-19.

Benyon, D. (2010). Designing Interactive Systems: A Comprehensive Guide to HCI and Interaction Design. Addison-Wesley.

Berthold, M. (2009). The coming of age of artificial intelligence in medicine. Artificial Intelligence in Medicine, 5-17.

Chang, A. C. (2016). Bid data in medicine: The upcoming artificial intelligence. Progress in Pediatric Cardiology vol 43, 91-94.

Ekman, F., Johansson, M., & Sochor, J. (2018). Creating Appropriate Trust in Automated Vehicle Systems: A Framework for HMI Design. Transactions on Human-Machine Systems, 95-101.

Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2017, 2 2). Dermatologist-level classification of skin cancer with deep neural networks. Springer Nature, 542, 115-118.

Forestier, G., Petitjean, F., Riffaud, L., & Jannin, P. (2017). Automatic matching of surgeries to predict surgeons' next move. Artifical Intelligence in Medicine vol 81 , 3-11.

Halevy, A., Norvig, P., & Pereira, F. (2009). The Unreasonable Effectiveness of Data. IEEE Intelligent Systems , 24(2), 8-12.

Harrison, S., Sengers, P., & Tatar, D. (2007). The Three Paradigms of HCI.

Hassenzahl, M., & Tractinsky, N. (2006). User Experience - A Research Agenda. Behaviour & Information Technology, 91-97.

Hojo, T. (2004). Quality Mangement Systems - Process Validation Guidance. The Global Harmonization Task Force.

IVO. (2017). Hur upplever patienter och närstående vården? - Sammanställning av klagomål som kommit in till patientnämnderna under 2016 . Inspektionen för Vård och Omsorg.

Kaulio, M., Karlsson, M., Rydebrink, P., & Klements , M. (1996). PRE - Att skapa ett företagsspecifikt arbetssätt för att hantera kundkrav. Göteborg: Chalmers Tekniska Högskola och Institutet för Verkstadsteknisk Forskning.

Krey, J. (2018, 04 19). Diagnos via nätet liknas vid "experimentell verksamhet". Retrieved from Dagens Medicin: https://www.dagensmedicin.se/artiklar/2018/04/19/digitala-vardbesok-maste-betraktas-som-experimentell-verksamhet/

kry.se. (2018, 05 22). Det här är KRY. Retrieved from Kry: https://kry.se/om/

Kushniruk, A. W. (2001). Analysis of Complex Decision-Making Processes in Health Care: Cognitive Approaches to Health Informatics. Journal of Biomedical Informatics, 365-376.

Läkemedelsverket. (2014, 10 20). Introduktion till regelverket. Retrieved from Läkemedelsverket : https://lakemedelsverket.se/malgrupp/Foretag/Medicinteknik/Introduktion-till-regelverket/

Lee, J. D., & See, K. A. (2004). Trust in Automation: Designing for Appropriate Reliance. Human Factors, 50-80.

Lee, J., & Moray, N. (1992). Trust, control strategies and allocation of function in human-machine systems. Ergonomics, 1243-1270.

Mayer, R. C., Davis, H. J., & Schoorman, D. F. (1995). An Integrative Model of Organizational Trust. Academy of Management Review, 20(03), 709-734.

McGlynn, E., Asch, S., Adams, J., Keesey, J., Hicks, J., & DeCristofaro, A. (2003). The quality of health care delivered to adults in the United States. New England Journal of Medicine, 2635-2645.

mindoktor.se. (2018, 05 22). Så funkar det. Retrieved from mindoktor: https://www.mindoktor.se/sa-funkar-det/

Nielsen, J. (2012, January 4). Usability 101: Introduction to Usability. Retrieved May 3, 2018, from Nielsen Norman Group: https://www.nngroup.com/articles/usability-101-introduction-to-usability/

Norman, D. A. (2004). Emotional Design - Why We Love (or Hate) Everyday Things. Cambridge: Basic Books.

Olzon Schultz, S. (2017, 12 05). Malignt melanom - hudcancer. Retrieved from 1177 Vårdguiden: https://www.1177.se/Vastra-Gotaland/Tema/Cancer/Cancerformer-och-fakta/Cancerformer/Hudcancer-malignt-melanom/

Palmgren, M., & Eklund, F. (2014). Att mäta och planera för en välfungerande sjukvård. Stockholm: Sveriges Kommuner och Landsting (SKL), och Rådet för främjande av kommunala analyser (rka).

Patel, V. L. (2009). The coming of age of artificial intelligence . Artificial Intelligence in Medicine, 5-17.

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in General Theory of Planning. Policy Sciences, 155-169.

Sågänger, J. (2018, 05 03). Växande antal privata vårdgiare på nätet. Retrieved from Dagens Medicin: https://www.dagensmedicin.se/artiklar/2018/05/03/vaxande-antal-privata-vardgivare-pa-natet/

Shortliffe, E. H. (2009). The coming of age of artificial intellience in medicine . Artificial Intelligence in Medicine , 5-17.

SKL. (2007). Hälsa, Arbete och Kön. Stockholm: Sveriges Kommuner och Landsting.

Socialdepartementet. (2017, 02 09). Hälso- och sjukvårdslag (2017:30). Retrieved from Sveriges Riksdag: https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/halso--och-sjukvardslag_sfs-2017-30

Socialstyrelsen. (2017). Tillståndet och utvecklingen inom hälso- och sjukvård. Stockholm: Socialstyrelsen.

Society, I. C. (2011). IEEE Draft Guide: Adoption of the Project Management Institute (PMI) Standard: A Guide to the Project Management Body of Knowledge (PMBOK Guide)-2008 (4th edition). IEEE P1490/D1, 1-505.

Spool, J. M. (2004, May 11). The KJ Technique: A Group Process for Establishing Priorities. Retrieved from UIE: https://articles.uie.com/kj_technique/

Stefanelli, M. (2009). The coming of age of artificial intelligence in medicine. Artificial Intelligence in Medicine, 5-17.

Stephenson Smith, S. (2014). New International Webster's Comprehensive Dictionary of the English Language, Deluxe Encyclopedic Edition. Standard International Media.

Szolovits, P. (2009). The coming of age of artificial intelligence . Artificial Intelligence in Medicine, 5-17.

Vårdanalys. (2016). Vården ur befolkningens perspektiv 2016 - en jämförelse mellan Sverige och tio andra länder. Stockholm: Myndigheten för vård- och omsorgsanalys.

von Hippel, E. (1988). Sources of Innovation. New York: Oxford University Press.

Wikberg Nilsson, Å., Ericsson, Å., & Törlind, P. (2015). Design - Process och Metod. Lund: Studentlitteratur AB.

Yoland, W. (2011). Do it Yourself Social Research. Routledge.

APPENDICES

APPENDIX 1
INTERVIEW GUIDES

1.1 AI INTERVIEW GUIDE

Interview - AI

Basics about AI

Can you combine different inputs to form the diagnosis? For instance, images complemented by text

How fast is the analysis?

Diagnosis

What parameters forming the diagnosis can be derived from the AI?

How consistent is the analysis?

How does the input correlate to the output?

A bad quality image could result in a false negative diagnosis?

Using AI in healthcare

How accurate does the diagnosis have to be to be considered positive?

How accurate is the diagnosis, could it potentially be used in its current state to form a solid diagnosis today?

Security

How is personal security addressed in the AI? Can personal data be derived from the algorithm or is it anonymous?

1.2 DIAGNOSIS INTERVIEW GUIDE

STÖD VID DIAGNOSTISERING

Under våren skriver vi vårt examensarbete där vi undersöker hur vårdpersonal ställer diagnoser samt hur stöd kan underlätta.

Denna intervju är ett verktyg för att lära oss så mycket som möjligt om era rutiner vid diagnostisering och vilka metoder och verktyg som används idag.

Informationen från era anonyma svar kommer att användas till förstudien och kartläggningen av problembilden, som utgör grunden för konceptutvecklingen.

Intro

Ålder

Professionell titel

Ev. specialisering

År inom vården

Vad är viktigast för dig i läkaryrket?

Diagnostisering

Hur ser ett normalt diagnostiseringsförlopp ut för dig?

Från anamnes till uppföljning. Punkta gärna upp det i olika steg. Hur vet du att diagnosen är färdig?

Vilka flaskhalsar upplever du i processen? Vad tror du att dessa beror på?

Vilken typ av beslutsstöd använder du dig av idag vid diagnostisering?

Ex. om du rådfrågar kollegor, jämför med tidigare studier, använder dig av digitala tjänster etc.

Vad gör du om de kliniska testerna motsäger din patientundersökning?

Ex. om du litar mest på din egen kunskap/omdöme eller om du värderar externt stöd högre.

Datadrivet vs intuition

Denna del undersöker på vilket sätt, datadrivet eller intuitivt, som sjukvården jobbar samt vilken riktning du vill att den ska ta. En kort definition av termerna följer:

Datadrivet: ”Bottom-up”, beslut baserat på data som behandlas systemastiskt.

Intuition: ”Top-down”, beslut baserat på erfarenheter och intuition.

Hur ser arbetssättet ut inom sjukvården vid diagnostisering idag?

	1	2	3	4	5	6	7	8	9	
Datadrivet										Intuition

Vilket arbetssätt tror du är optimalt?

	1	2	3	4	5	6	7	8	9	
Datadrivet										Intuition

Hur ska man jobba för att nå dit?

Hur många år tror du att det tar att nå dit? [siffra]

Teknisk utveckling i vården

Vilka teknologier och metoder har förändrat sjukvården och ditt arbetssätt under tiden du har jobbat inom vården?

Ex. digitaliserade journaler

Vilka teknologier och metoder tror du kommer göra stora avtryck i framtidens sjukvård?

Känner du till begreppet ”artificiell intelligens” (AI)?

Din definition av AI

Hur skulle du definiera AI med en mening?

Vet du om AI används inom sjukvården idag?

Om ja, hur används AI inom sjukvården idag?

AI vid diagnostisering

Den definition vi använder oss av är att AI är en dator som har möjligheten att fungera som den mänskliga tankeprocessen, att den kan lära sig saker på egen hand, bedöma om den gjort rätt eller fel och om ett fel har begåtts, lära sig av misstaget så att det inte upprepas.

I praktiken skulle detta innebära att denna AI kan användas i ett datorprogram som ett komplement vid diagnostisering.

Hur är din allmänna inställning till AI som ett kompletterande verktyg vid diagnostisering?

	1	2	3	4	5	
Mycket negativt inställd	◯	◯	◯	◯	◯	Mycket positivt inställd

Vilka fördelar ser du med AI som ett kompletterande verktyg vid diagnostisering?

Vilka nackdelar ser du med AI som ett kompletterande verktyg vid diagnostisering?

Till sist...

Har du några övriga tankar och synpunkter?

Har du några synpunkter på intervjun?

Vad tycker du om intervjun?

APPENDIX 2

USER TEST GUIDES

2.1 TEST GUIDE FOR FIRST ITERATION

Test - Prototyp 1

Scenario

Det här konceptet arbetar med att triagera patienter in i Product X och potentiellt även till en vårdcentral baserat på hur de svarar på formuläret. De olika alternativen vi tänker oss är sjuksköterska, läkare, fysisk mottagning om tester behövs samt specialist.

Systemet skapar en profil över patienten med data dels från formuläret, men även data från journalen som baserat på svaren från formuläret bedöms relevant av systemet. Patienten sorteras därefter till en pool av patienter som är kopplad till rätt vårdgivare beroende av komplexiteten i anamnesen. Vårdgivaren väljer sen patient som i Product X idag.

Här har du nu öppnat en patient, och du möts av den här vyn. Vi skulle vilja höra dina tankar om de olika ingående delarna, och vad du tänker att de fyller för syfte eller visar.

Vi skulle nu vilja att du går igenom vårdprocessen och hjälper patienten genom att interagera med systemet.

Tänk gärna högt och förklara vad du tänker i varje steg.

Funktionalitet

Vad tänker du är målet med systemet?

Kan du förklara vad produkten gör?

Vad kan du säga om patienten utifrån vad systemet visar?

Finns det någon funktionalitet som du saknar?

Struktur

Vad tycker du om systemets struktur?

Vad tycker du om de olika delarna i arbetsvyn?

Är informationen som presenteras relevant? Har du tillräckligt med information för att kunna ställa en diagnos? Vilka delar fattas?

Workflow

Hur känner du att den passar in i ditt arbetsflöde?

Vad tror du om tidsåtgången i systemet jämfört med idag?

Hur känner du inför att arbeta med diagnosen i ett system?

Kan du komma åt relevant information från huben? Behöver du ytterligare verktyg som komplement?

Tankar om att arbeta i ett digitalt, systematiskt stöd? (för de som inte jobbat i Product X)

Tillit

Vad behöver du för att lita på att systemet lyfter fram relevant information i ett specifikt ärende?

Hur upplever du kontrollen du har över informationen som visas? Tex. lägga in egna parametrar

Finns det utrymme för skepticism? Känns det som att systemet är definitivt i sina förslag?

Hur ska tilliten byggas upp, tills systemet är allmänt accepterat som ett pålitligt system?

Övrigt

Skulle du vilja använda systemet?

Vilka positiva effekter ser du i detta system?

Vilka negativa effekter ser du i detta system?

Vad ska vi fokusera på i den fortsatta utvecklingen?

2.2 TEST GUIDE FOR SECOND & THIRD ITERATION

Test - Prototyp 2 & 3

Scenario

- Patient svarar på formulär kopplat till problematik den upplever
- Systemet presenterar anamnesen till läkaren, baserat på svaren i formuläret och data kopplad till formulärsvaren från journalen
- Systemet kopplar ihop läkaren och patienten digitalt

Det du gör dokumenteras automatiskt i journalen

Frågor

Vad tycker du om systemets struktur?

Hur känner du att den passar in i ditt arbetsflöde?

Vad tror du om tidsåtgången i systemet jämfört med idag?

Kan du komma åt den information du behöver för att kunna ställa en diagnos?

Tankar om att arbeta i ett digitalt, systematiskt stöd?

Vad behöver du för att lita på att systemet lyfter fram relevant information?

Hur upplever du kontrollen du har över informationen som visas? Tex. lägga in egna parametrar

Finns det utrymme för skepticism? Känns det som att systemet är definitivt i sina förslag?

Vad tänker du är målet med systemet?

Finns det någon funktionalitet som du saknar?

APPENDIX 3
QUANTITATIVE QUESTIONS & EVALUATION

3.1 QUESTIONNAIRE

Utvärdering av Prototyp 2

Form description

Gränssnittet känns överlag...

	1	2	3	4	5	6	7	8	9	
Otydligt	○	○	○	○	○	○	○	○	○	Tydligt

Systemet känns...

	1	2	3	4	5	6	7	8	9	
Omständigt	○	○	○	○	○	○	○	○	○	Smidigt

Systemet känns...

	1	2	3	4	5	6	7	8	9	
Svårtytt	○	○	○	○	○	○	○	○	○	Intuitivt

Informationen som visas om patienten är...

	1	2	3	4	5	6	7	8	9	
Otillräcklig	○	○	○	○	○	○	○	○	○	Tillräcklig

Kopplingen mellan anamnes och diagnosförslag känns...

	1	2	3	4	5	6	7	8	9	
Otydlig	○	○	○	○	○	○	○	○	○	Tydligt

Diagnosförslag känns...

	1	2	3	4	5	6	7	8	9	
Osäkert	○	○	○	○	○	○	○	○	○	Säkert

Systemet passar in i mitt arbetsflöde...

	1	2	3	4	5	6	7	8	9	
Dåligt	○	○	○	○	○	○	○	○	○	Bra

Hur kommer det här systemet påverka träffsäkerheten i diagnosen jämfört med idag?

	1	2	3	4	5	6	7	8	9	
Negativt	○	○	○	○	○	○	○	○	○	Positivt

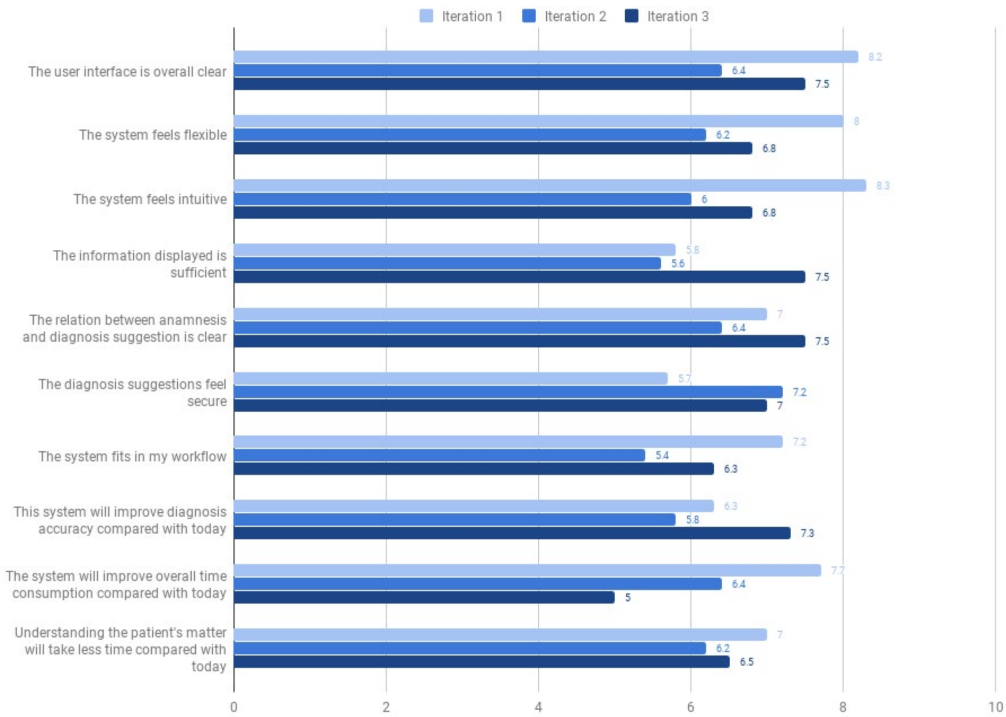
Hur tror du tidsåtgången generellt kommer förändras med systemet jämfört med idag?

	1	2	3	4	5	6	7	8	9	
Ta mer tid	○	○	○	○	○	○	○	○	○	Ta mindre tid

Hur tror du tidsåtgången är för att sätta dig in i patientens ärende, jämfört med idag?

	1	2	3	4	5	6	7	8	9	
Ta mer tid	○	○	○	○	○	○	○	○	○	Ta mindre tid

3.2 QUESTIONNAIRE RESULT



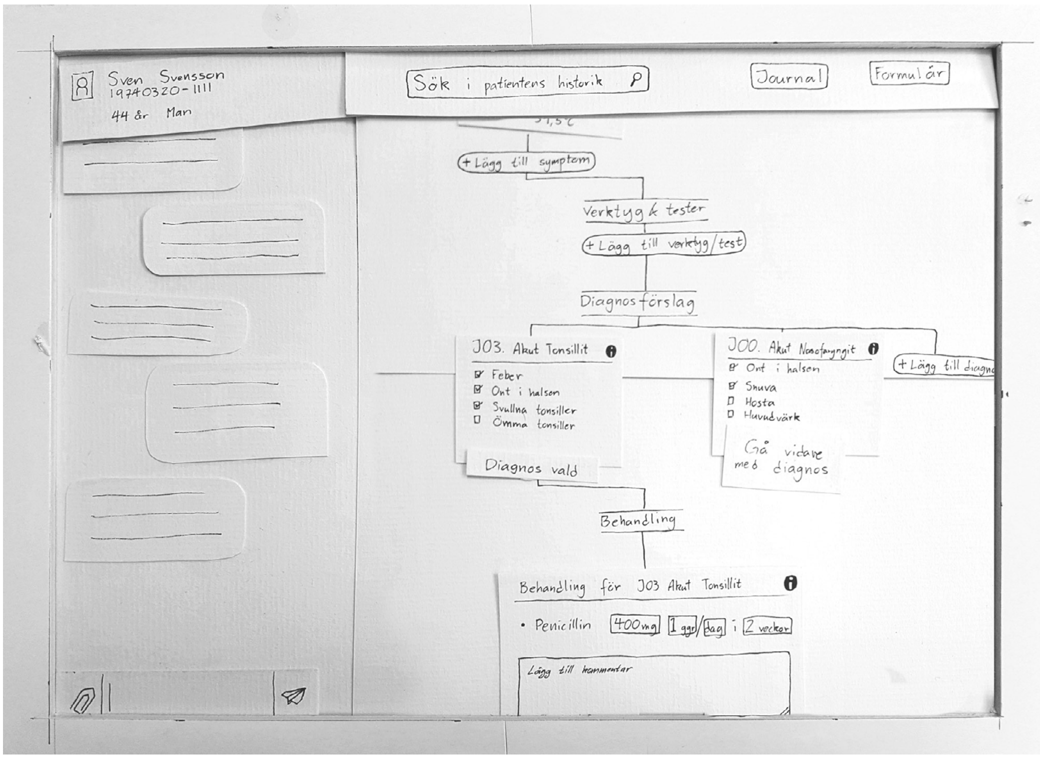
APPENDIX 4
REQUIREMENT LIST WITH VERIFICATION OF CONCEPTS

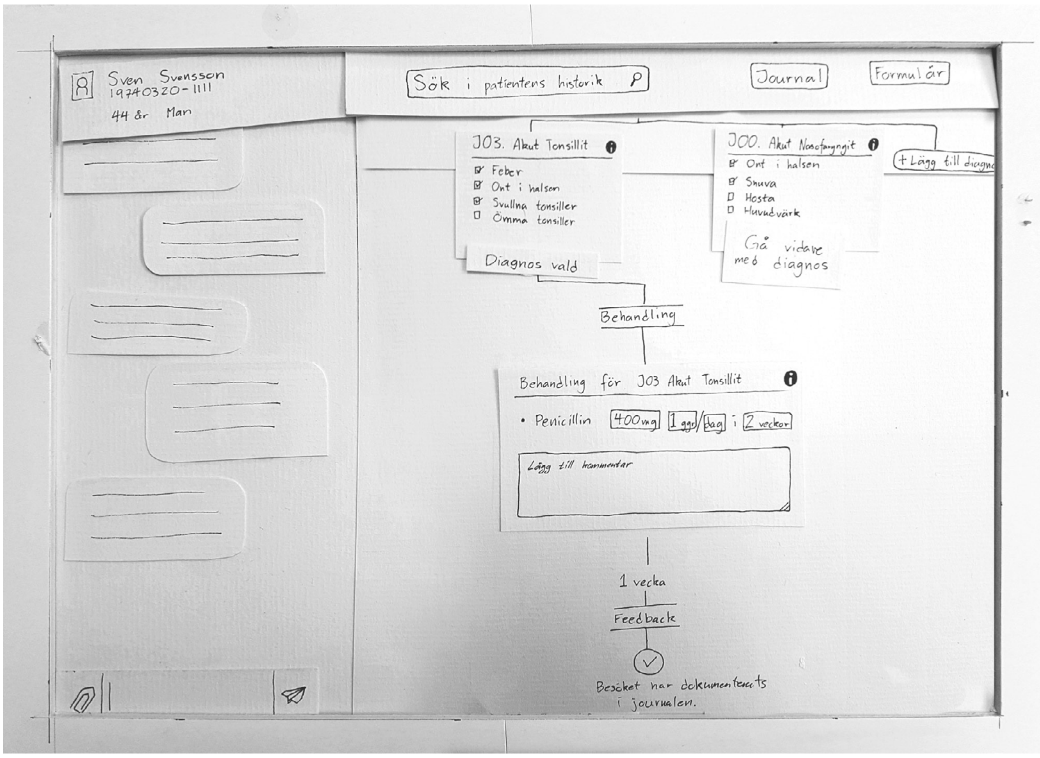
	REQUIREMENT	RATING	TYPE	PRODUCT X	AUTO TRIAGE	DIGITAL EYE	DIAGNOSIS HUB
	1 Time & Tasks			58	106	77	120
R 1.1	The system should facilitate for efficient and effective documentation.	3	Documentation	1	1	1	2
R 1.2	The system should cooperate with other healthcare systems.	3	Compatibility	0	1	-	1
R 1.3	The system should assist the practitioner in keeping track of multiple patients simultaneously.	3	Ergonomics	1	1	1	1
R 1.4	The system should ensure that the patient only meets the most relevant practitioners.	2	Performance	1	2	-	-
R 1.5	The system should not disrupt the workflow of the practitioner.	2	Workflow	1	2	2	1
R 1.6	The system should encourage the practitioner to work systematically so as to develop routines.	2	Workflow	1	1	1	2
R 1.7	The system should enable the practitioner to access information about the patient's previous visits.	2	Compatibility	0	2	2	2
R 1.8	The system should encourage documentation of the practitioners thought-process.	1	Documentation	0	-	-	2
R 1.9	The system should provide a perceived decrease in workload for the practitioner.	1	Ergonomics	0	2	1	0
	2 Competence						
R 2.1	The system should be able to access and extract information from online medical knowledge databases.	3	Collection of data	-	2	-	2
R 2.2	The system should facilitate for the practitioner to preserve and develop knowledge and competence.	3	Assurance	0	-	-	1
R 2.3	The system should highlight the risk of a practitioner's potential bias due to their field of research.	1	Assurance	0	1	1	0
R 2.4	The system should encourage a certain degree of skepticism to the system so the practitioner stays vigilant.	1	Assurance	1	1	1	1
	3 Communication						
R 3.1	The system should cater for patient subjectivity in the anamnesis and interpretation of symptoms.	3	Collection of data	0	0	2	0
R 3.2	The system should encourage open questions in the anamnesis.	2	Collection of data	1	2	2	1
R 3.3	The system should facilitate for both text and media input by the patient.	2	Collection of data	2	2	2	2
R 3.4	The system should present relevant information from the medical records to the practitioner.	2	Presentation of data	-	2	2	2
R 3.5	The system should strive for an unambiguous presentation of output from tests and processes, regardless of the practitioner.	2	Presentation of data	1	1	2	2
R 3.6	The system should be easy to learn how to operate.	2	Usability	2	2	2	1
R 3.7	The system should ensure that the involved actors' goals and expectations are aligned.	1	Workflow	1	1	1	1
R 3.8	The system should ensure that the established goal is fulfilled.	1	Workflow	0	1	1	2
R 3.9	The system should communicate to all involved actors of their current status in the diagnosis process.	1	Workflow	0	2	2	2
R 3.10	The system should be able to interpret and process nonverbal communication from the patient.	1	Collection of data	-	-	2	-

R 3.11	The system should adapt the level of detail of the information presented depending on the preference of the patient.	1	Presentation of data	0	2	0	0
R 3.12	The system should motivate the patient to follow through with the treatment.	1	Presentation of data	0	-	-	1
R 3.13	The system should ensure the patient has understood the diagnosis.	1	Feedback	1	-	-	1
R 3.14	The system should not hamper human-human discussion and interaction.	1	Ergonomics	2	2	0	1
R 3.15	The system should be easy to use for the first time.	1	Usability	2	2	2	1
R 3.16	The system should encourage the practitioner to use all the available functions in the system.	1	Usability	0	2	2	1
R 3.17	The system should be able to be used efficiently after an extended period of non-usage.	1	Usability	2	2	2	1
	4 Processing						
R 4.1	The system should aid the practitioner in connecting different symptoms into possible diagnoses.	3	Performance	0	2	0	2
R 4.2	The system should assist the practitioner in extracting useful data from the anamnesis.	3	Collection of data	1	2	2	1
R 4.3	The system should allow the practitioner to manually input data into the system and control its dataset.	3	Collection of data	0	-	-	2
R 4.4	The system should provide diagnosis suggestions, not definite diagnoses.	3	Presentation of data	-	-	-	2
R 4.5	The system should consider potential diagnosis outliers when following their standard criterias.	2	Assurance	0	-	-	2
R 4.6	The system should ensure all relevant aspects of the considered diagnosis have been checked.	2	Feedback	-	-	-	2
R 4.7	The system should be aware of low quality input and notify the practitioner if it might affect the diagnosis negatively.	2	Feedback	-	1	-	1
R 4.8	The system should assist the practitioner in interpreting input data from anamnesis and examination consistently.	1	Performance	1	2	2	2
R 4.9	The system should assist the practitioner in computing and understanding statistics and probability.	1	Performance	0	1	-	1
	5 Trust						
R 5.1	The system should be aware of, and communicate, its own limitations to the practitioner.	3	Performance	1	0	1	1
R 5.2	The system should communicate its potential bias towards the user.	3	Assurance	0	1	0	1
R 5.3	The system should facilitate for building trust with the patient to make them feel comfortable giving out sensitive information.	2	Collection of data	2	2	2	2
R 5.4	The system should encourage the practitioner to validate the system output with reason and intuition.	2	Assurance	2	1	1	1
R 5.5	The system should be transparent in the reliability of its output.	2	Assurance	2	1	-	1
R 5.6	The system should notify the practitioner if the selected diagnosis is not aligned with previous successful cases of this diagnosis, (ie is in risk of being misdiagnosed).	2	Feedback	-	-	-	2
R 5.7	The system should be flexible and patient towards its users.	2	Usability	2	2	1	2
R 5.8	The system should provide a sense of respect and seriousness to its users.	1	Assurance	2	2	2	2
	6 Other						
R 6.1	The system should adhere to Swedish healthcare laws and regulations.	3	Compatibility	0	1	1	1
R 6.2	The system should be able to recognise and process all ICD-10-CM Diagnosis Codes.	2	Performance	0	2	-	2

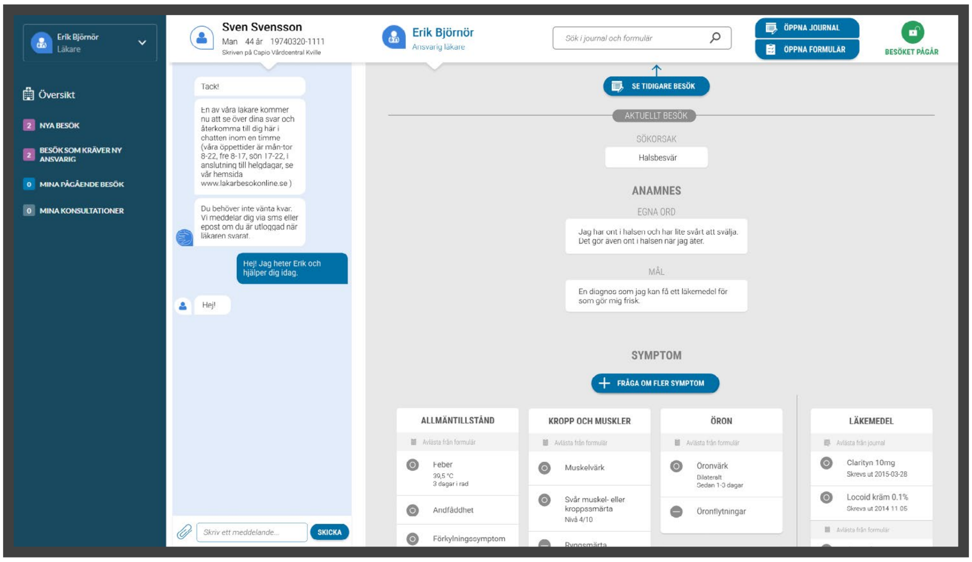
APPENDIX 5

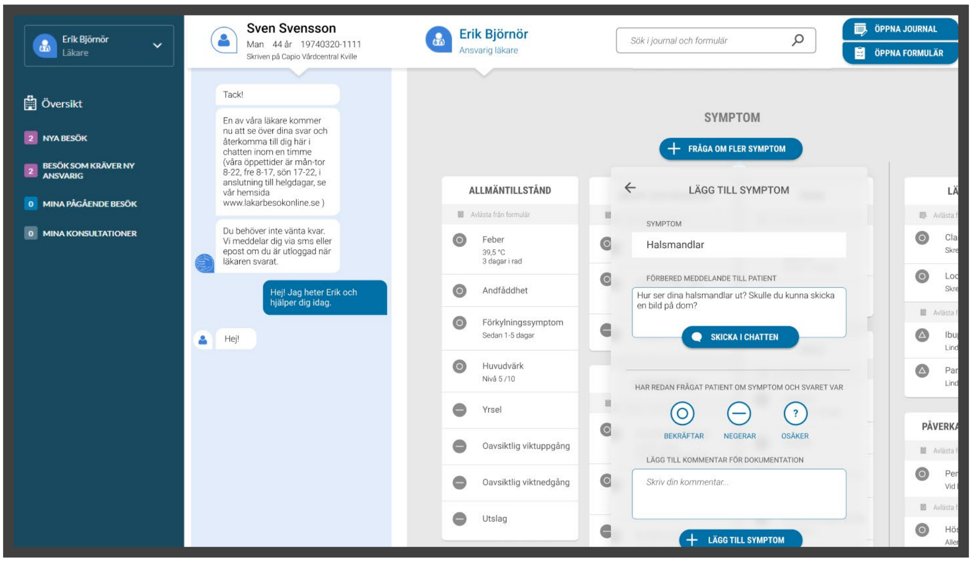
FIRST ITERATION - SCREENS

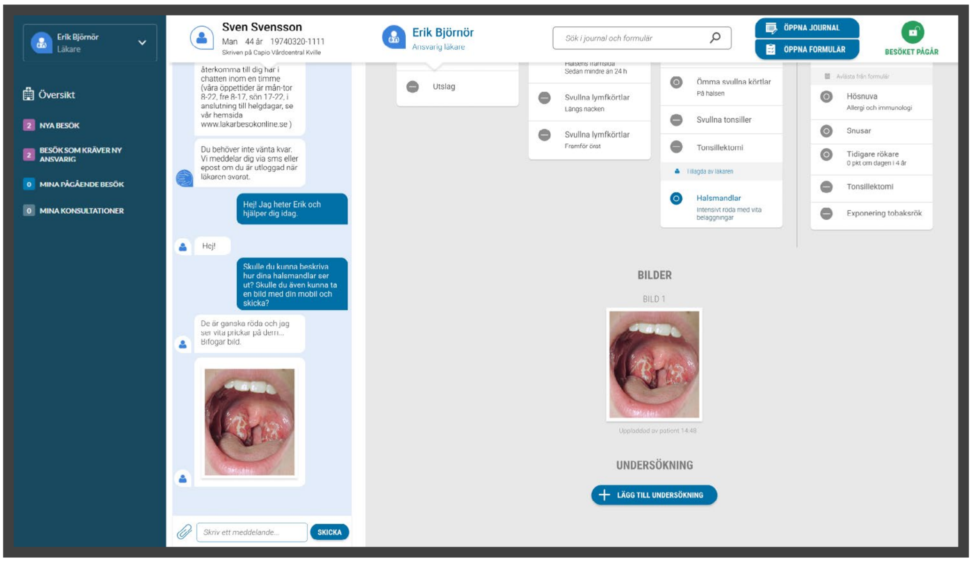


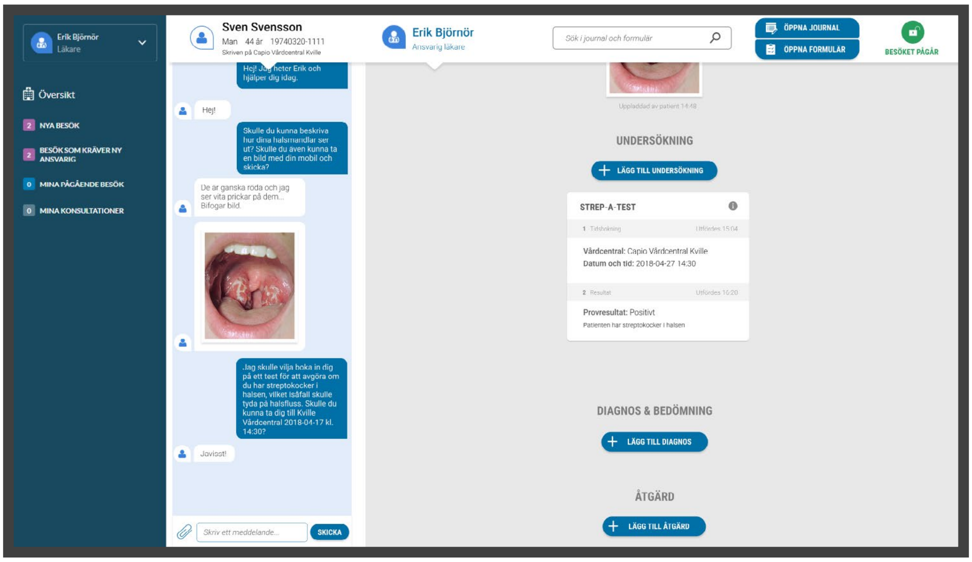


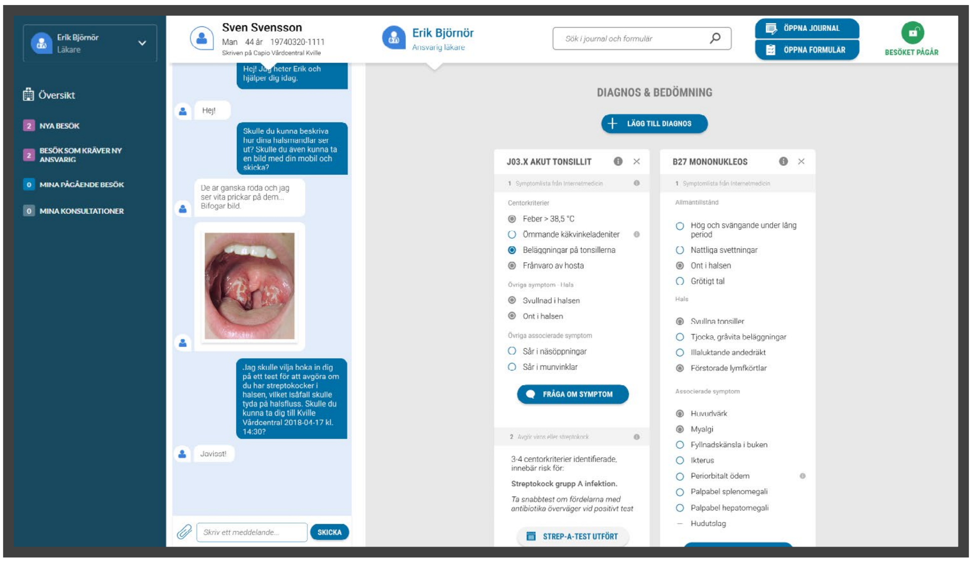
APPENDIX 6
SECOND ITERATION - SCREENS

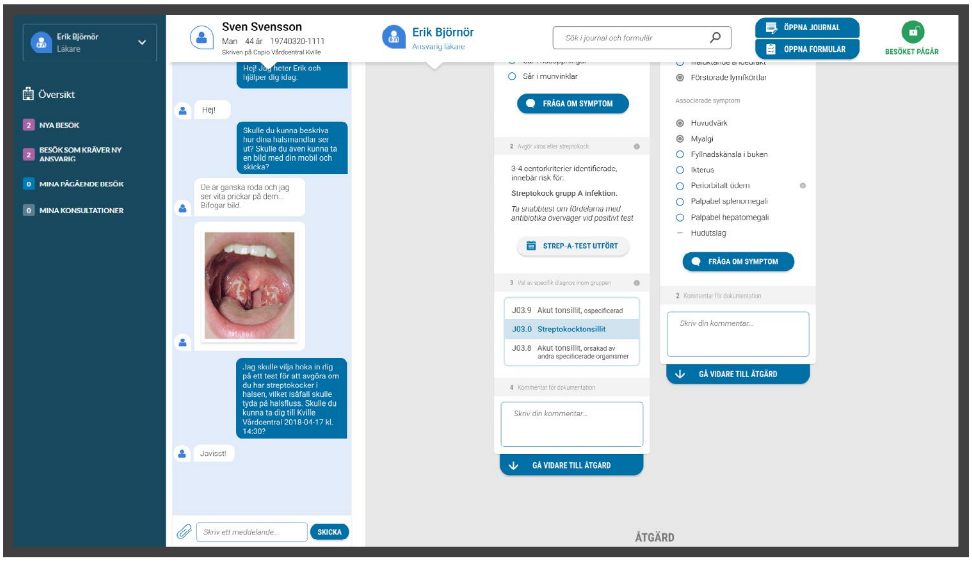


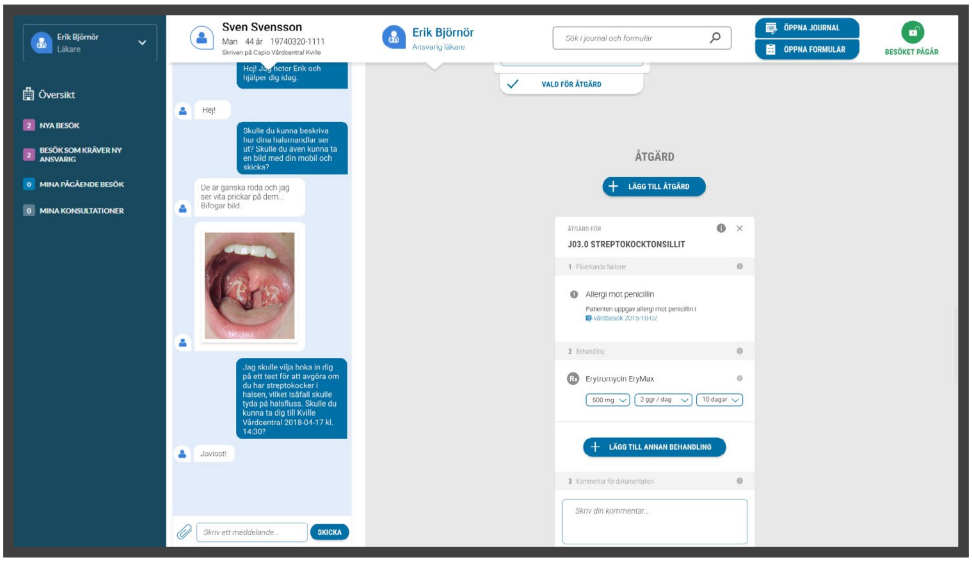


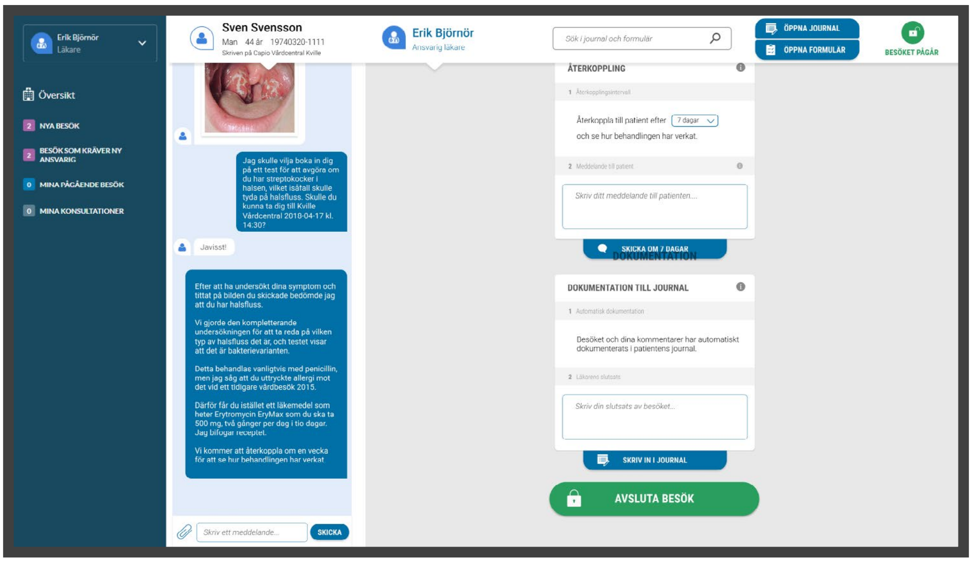

Erik Björnör
Läkare
Översikt
NYA BESÖK
BESÖK SOM KRÄVER NY ANSVARIG
MINA PÅGÅENDE BESÖK
MINA KONSULTATIONER
Sven Svensson
Man 44 år 19740320-1111
Erik Björnör
Ansvarig läkare
Sök i journal och formulär
ÖPPNA JOURNAL
ÖPPNA FORMULÄR
BESÖKET PÅGÅR
Hej! Jag heter Erik och hjälper dig idag.
Hej!
Skulle du kunna beskriva hur dina halsmandlar ser ut? Skulle du även kunna ta en bild med din mobil och skicka?
De är ganska röda och jag ser vita prickar på dem... Bifogar bild.
Skriv ett meddelande...
SKICKA
Utslag
Svullna lymfkörtlar
Ömma svullna körtlar
Svullna tonsiller
Tonsillektomi
Halsmandlar
Hösnuva
Snusar
Tidigare rökare
Exponering tobaksrök
BILDER
BILD 1
UNDERSÖKNING
LÄGG TILL UNDERSÖKNING


Erik Björnör
Läkare
Översikt
NYA BESÖK
BESÖK SOM KRÄVER NY ANSVARIG
MINA PÅGÅENDE BESÖK
MINA KONSULTATIONER
Sven Svensson
Man 44 år 19740320-1111
Erik Björnör
Ansvarig läkare
Sök i journal och formulär
ÖPPNA JOURNAL
ÖPPNA FORMULÄR
BESÖKET PÅGÅR
Hej!
Skulle du kunna beskriva hur dina halsmandlar ser ut? Skulle du även kunna ta en bild med din mobil och skicka?
De är ganska röda och jag ser vita prickar på dem... Bifogar bild.
Jag skulle vilja boka in dig på ett test för att avgöra om du har streptokocker i halsen, vilket isåfall skulle tyda på halsfluss. Skulle du kunna ta dig till Kville Vårdcentral 2018-04-17 kl. 14:30?
Javisst!
Skriv ett meddelande...
SKICKA
UNDERSÖKNING
LÄGG TILL UNDERSÖKNING
STREP-A-TEST
Vårdcentral: Capio Vårdcentral Kville
Datum och tid: 2018-04-27 14:30
Provresultat: Positivt
DIAGNOS & BEDÖMNING
LÄGG TILL DIAGNOS
ÅTGÄRD
LÄGG TILL ÅTGÄRD

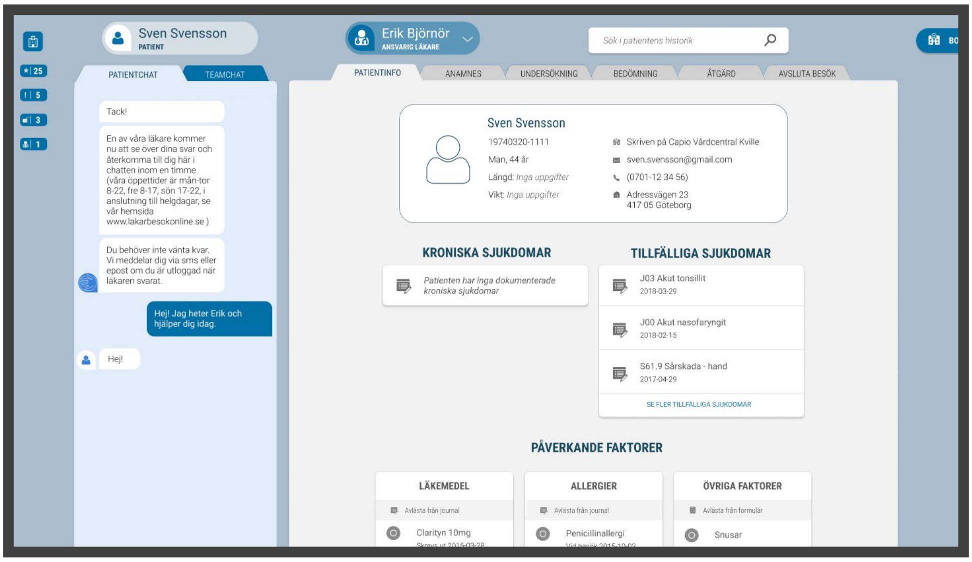

Erik Björnör
Läkare
Översikt
NYA BESÖK
BESÖK SOM KRÄVER NY ANSVARIG
MINA PÅGÅENDE BESÖK
MINA KONSULTATIONER
Sven Svensson
Man 44 år 19740320-1111
Erik Björnör
Ansvarig läkare
Sök i journal och formulär
ÖPPNA JOURNAL
ÖPPNA FORMULÄR
BESÖKET PÅGÅR
Javisst!
Skriv ett meddelande...
SKICKA
DIAGNOS & BEDÖMNING
LÄGG TILL DIAGNOS
J03.X AKUT TONSILLIT
Feber > 38,5 °C
Ömmande käkvinkeladeniter
Beläggningar på tonsillerna
Frånvaro av hosta
Svullnad i halsen
Ont i halsen
Sår i näsöppningar
Sår i munvinklar
FRÅGA OM SYMPTOM
Streptokock grupp A infektion.
STREP-A-TEST UTFÖRT
B27 MONONUKLEOS
Hög och svängande under lång period
Nattliga svettningar
Ont i halsen
Grötigt tal
Svullna tonsiller
Tjocka, gråvita beläggningar
Illaluktande andedräkt
Förstorade lymfkörtlar
Huvudvärk
Myalgi
Fyllnadskänsla i buken
Ikterus
Periorbitalt ödem
Palpabel splenomegali
Palpabel hepatomegali
Hudutslag

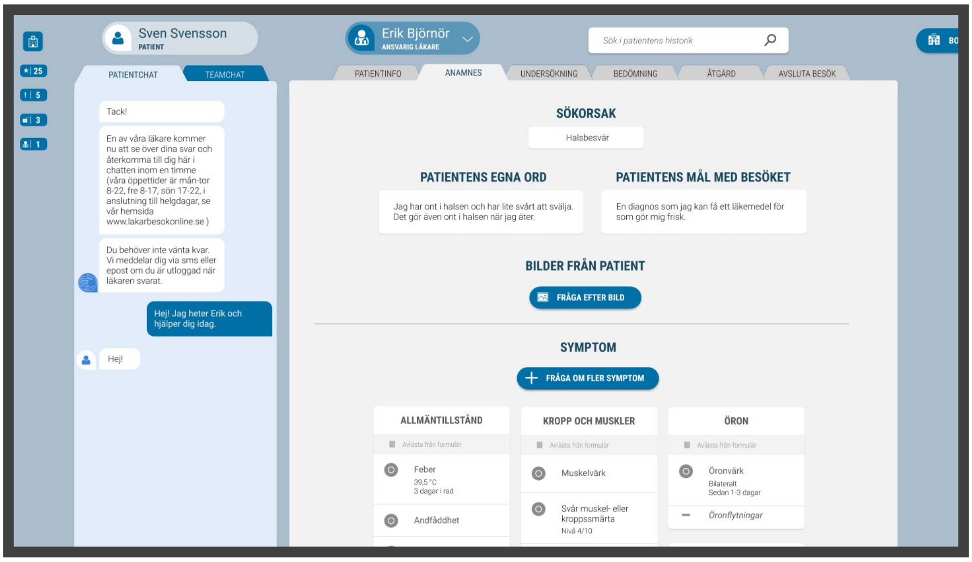

Erik Björnör
Läkare
Översikt
NYA BESÖK
BESÖK SOM KRÄVER NY ANSVARIG
MINA PÅGÅENDE BESÖK
MINA KONSULTATIONER
Sven Svensson
Man 44 år 19740320-1111
Skriven på Capio Vårdcentral Kville
Erik Björnör
Ansvarig läkare
Sök i journal och formulär
ÖPPNA JOURNAL
ÖPPNA FORMULÄR
BESÖKET PÅGÅR
Hej!
Skulle du kunna beskriva hur dina halsmandlar ser ut? Skulle du även kunna ta en bild med din mobil och skicka?
De är ganska röda och jag ser vita prickar på dem... Bifogar bild.
Jag skulle vilja boka in dig på ett test för att avgöra om du har streptokocker i halsen, vilket isåfall skulle tyda på halsfluss. Skulle du kunna ta dig till Kville Vårdcentral 2018-04-17 kl. 14:30?
Javisst!
Skriv ett meddelande...
SKICKA
Sår i munvinklar
FRÅGA OM SYMPTOM
Streptokock grupp A infektion.
STREP-A-TEST UTFÖRT
J03.9 Akut tonsillit, ospecificerad
J03.0 Streptokocktonsillit
J03.8 Akut tonsillit, orsakad av andra specificerade organismer
Skriv din kommentar...
GÅ VIDARE TILL ÅTGÄRD
Förstorade lymfkörtlar
Associerade symptom
Huvudvärk
Myalgi
Fyllnadskänsla i buken
Ikterus
Periorbitalt ödem
Palpabel splenomegali
Palpabel hepatomegali
Hudutslag
FRÅGA OM SYMPTOM
Skriv din kommentar...
GÅ VIDARE TILL ÅTGÄRD
ÅTGÄRD


VALD FÖR ÅTGÄRD
ÅTGÄRD
LÄGG TILL ÅTGÄRD
J03.0 STREPTOKOCKTONSILLIT
Allergi mot penicillin
Erytromycin EryMax
500 mg
2 ggr / dag
10 dagar
LÄGG TILL ANNAN BEHANDLING
Skriv din kommentar...

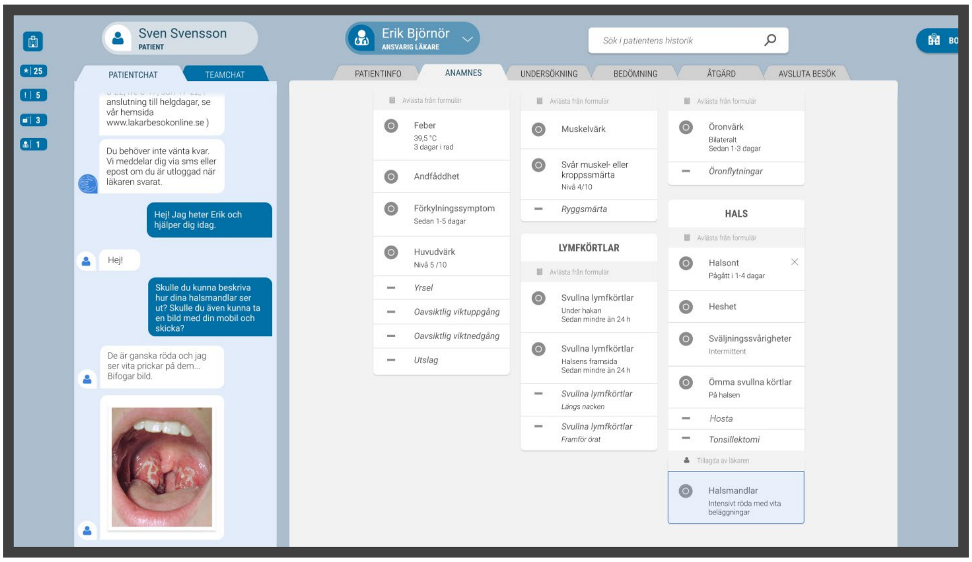

ÅTERKOPPLING
Återkoppla till patient efter 7 dagar och se hur behandlingen har verkat.
Skriv ditt meddelande till patienten...
SKICKA OM 7 DAGAR
DOKUMENTATION TILL JOURNAL
Besöket och dina kommentarer har automatiskt dokumenterats i patientens journal.
Skriv din slutsats av besöket...
SKRIV IN I JOURNAL
AVSLUTA BESÖK
Efter att ha undersökt dina symptom och tittat på bilden du skickade bedömde jag att du har halsfluss.
Vi gjorde den kompletterande undersökningen för att ta reda på vilken typ av halsfluss det är, och testet visar att det är bakterievarianten.
Detta behandlas vanligtvis med penicillin, men jag såg att du uttryckte allergi mot det vid ett tidigare vårdbesök 2015.
Därför får du istället ett läkemedel som heter Erytromycin EryMax som du ska ta 500 mg, två gånger per dag i tio dagar. Jag bifogar receptet.
Vi kommer att återkoppla om en vecka för att se hur behandlingen har verkat.

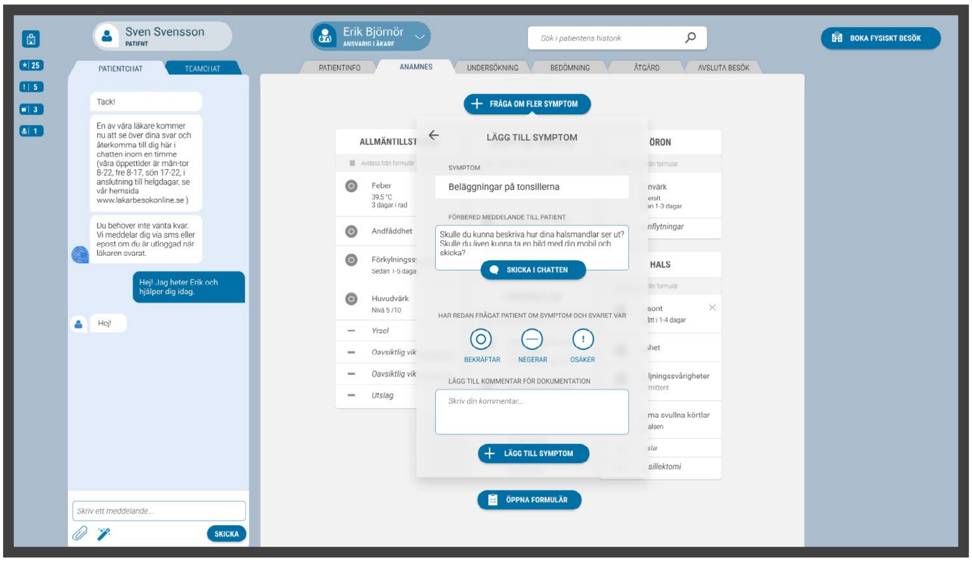
APPENDIX 7
DIAGNOSIS FLOW - SCREENS

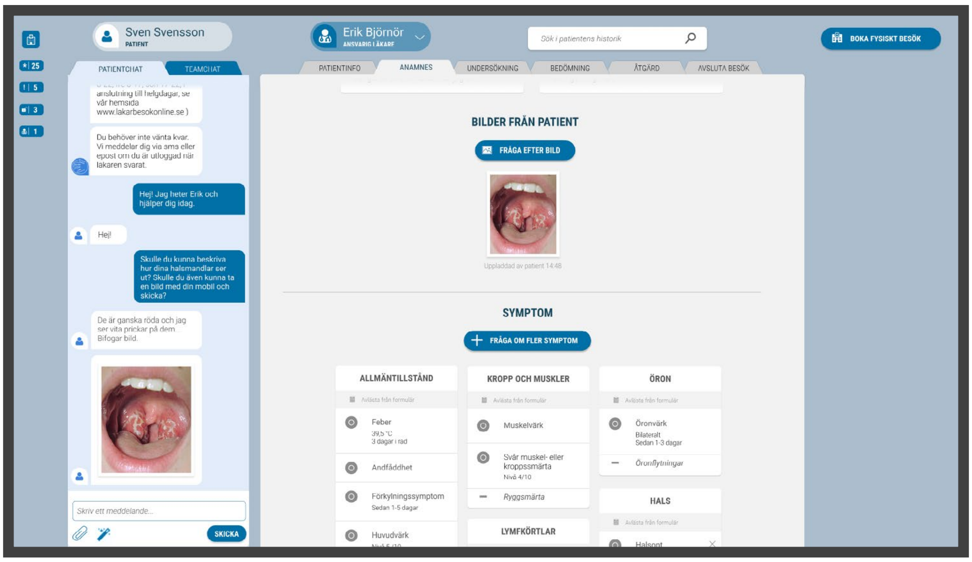


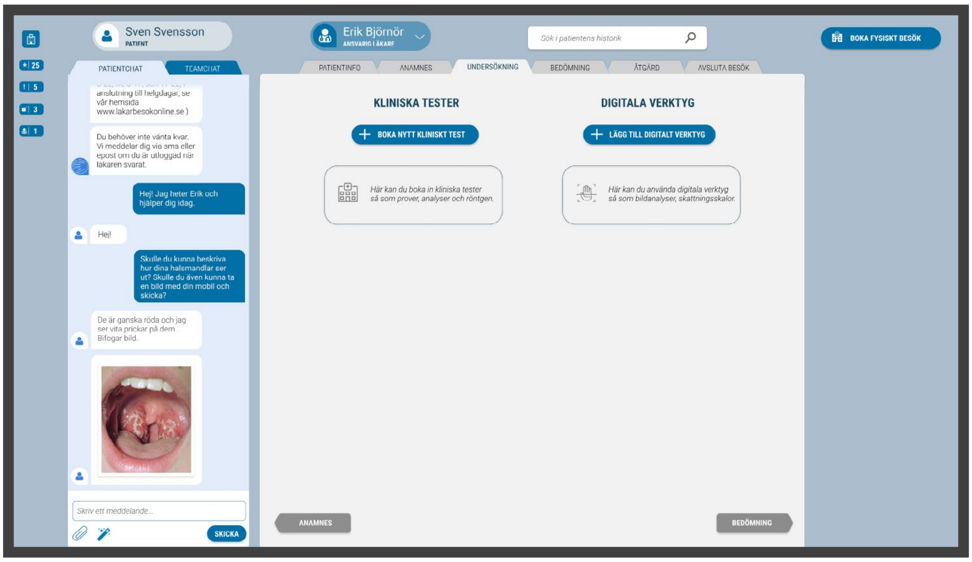


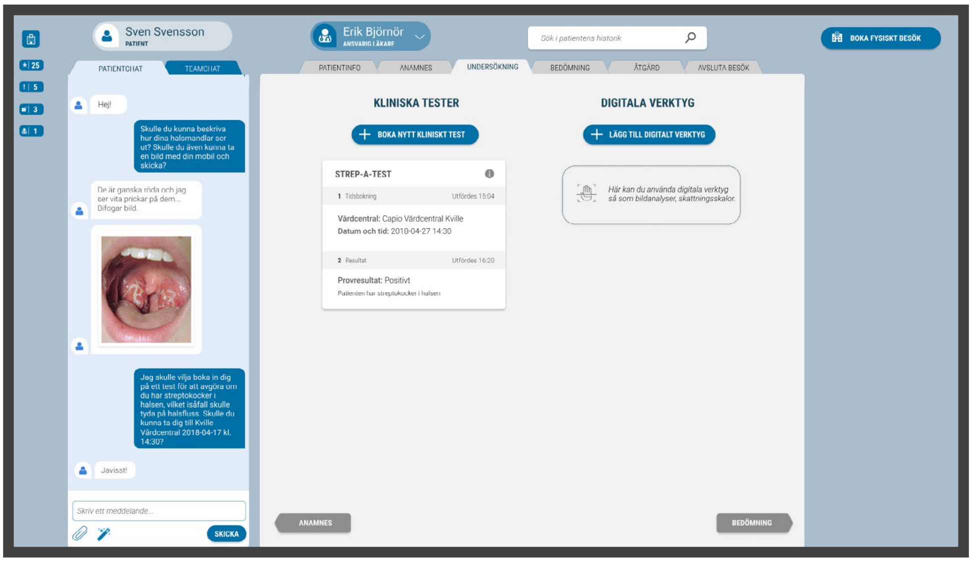
DIAGNOSIS FLOW - SCREENS

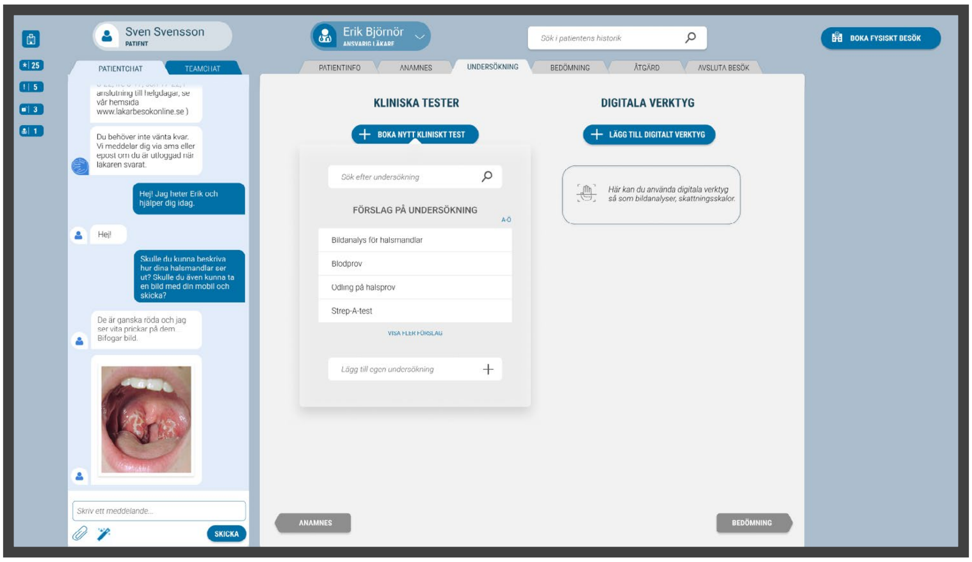




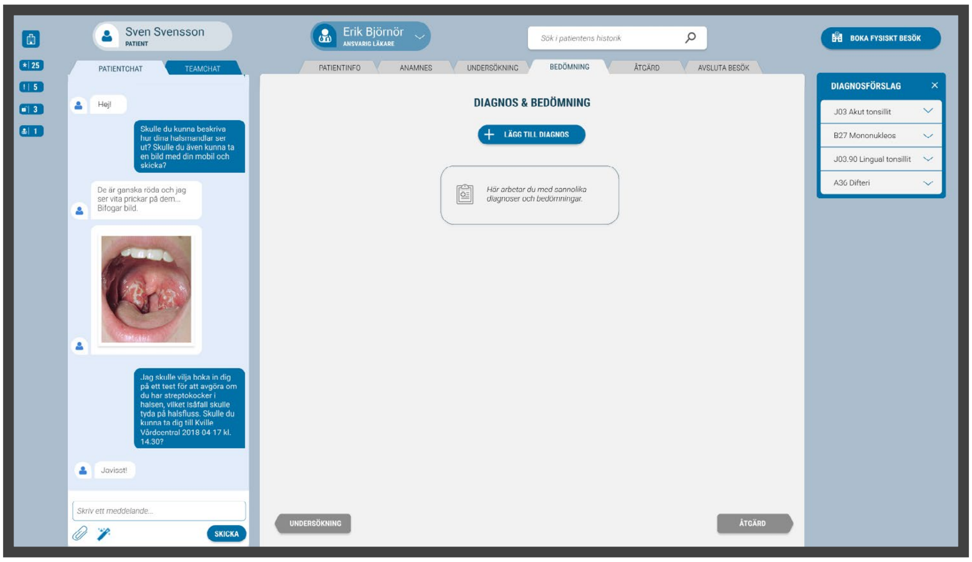


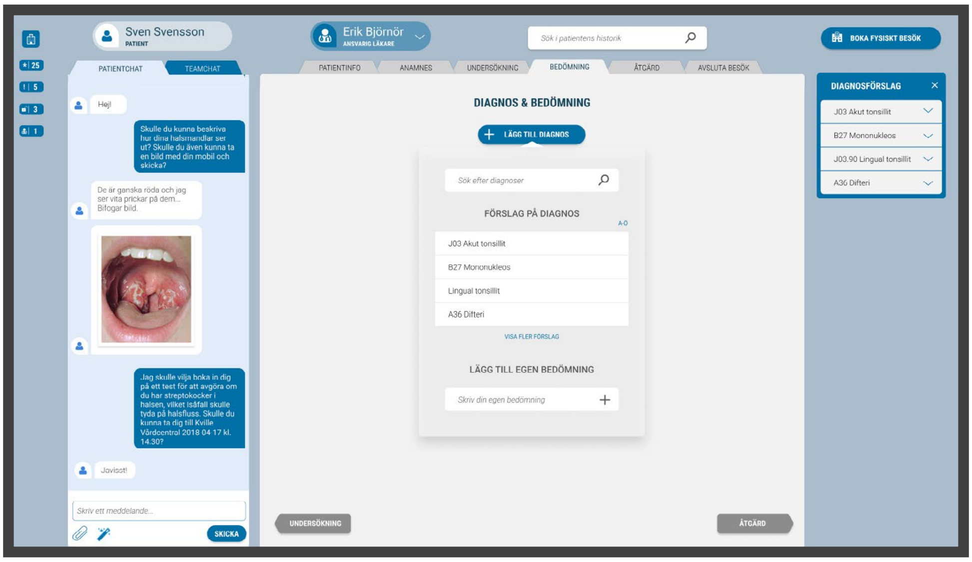


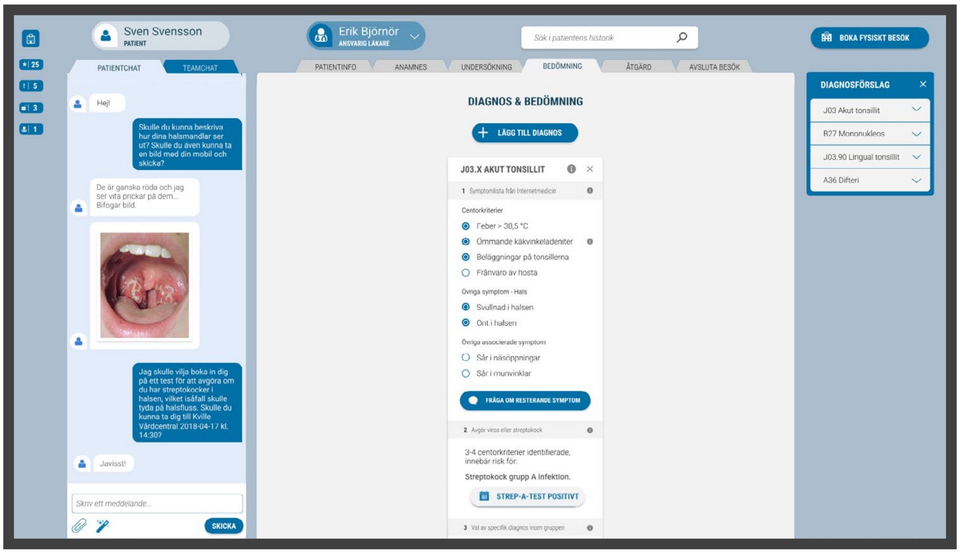


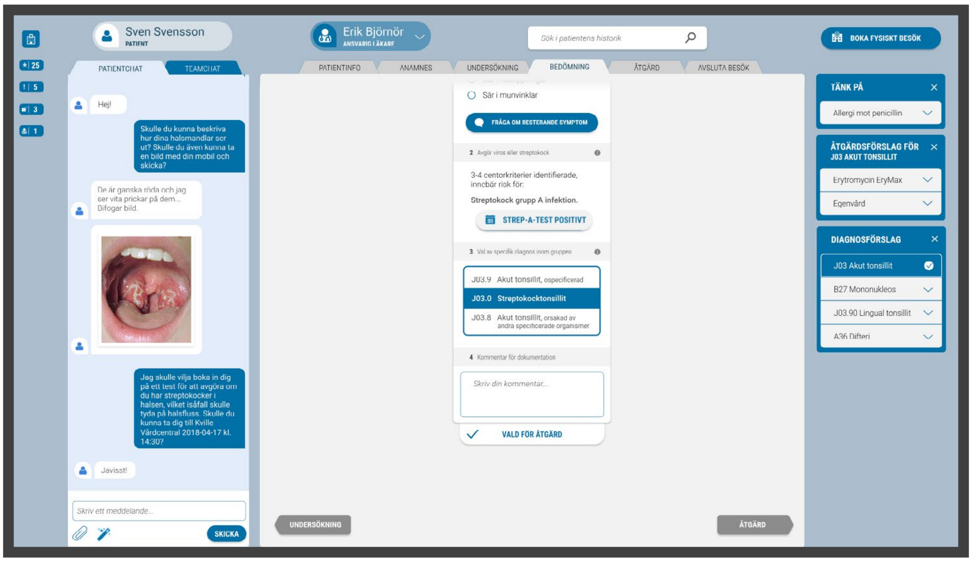


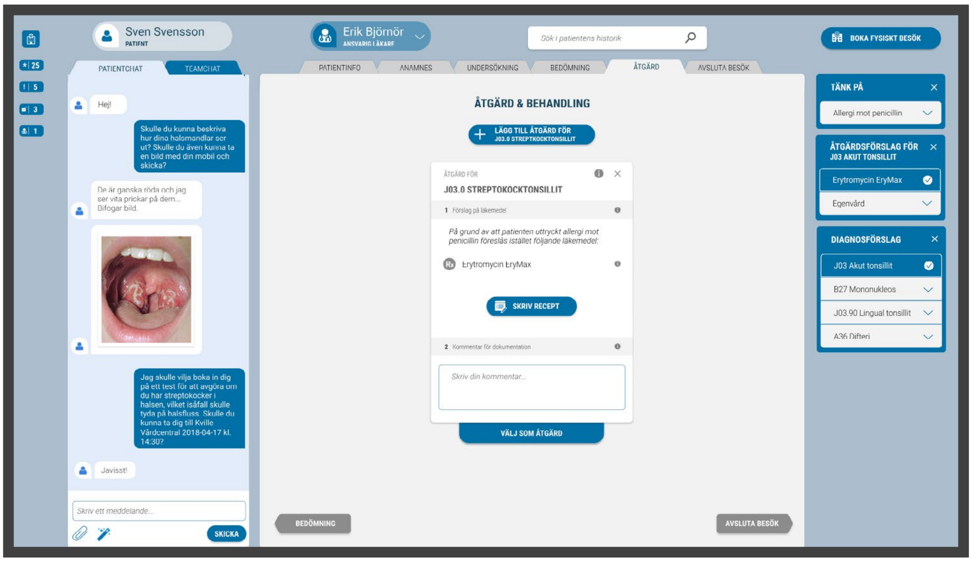
DIAGNOSIS FLOW - SCREENS

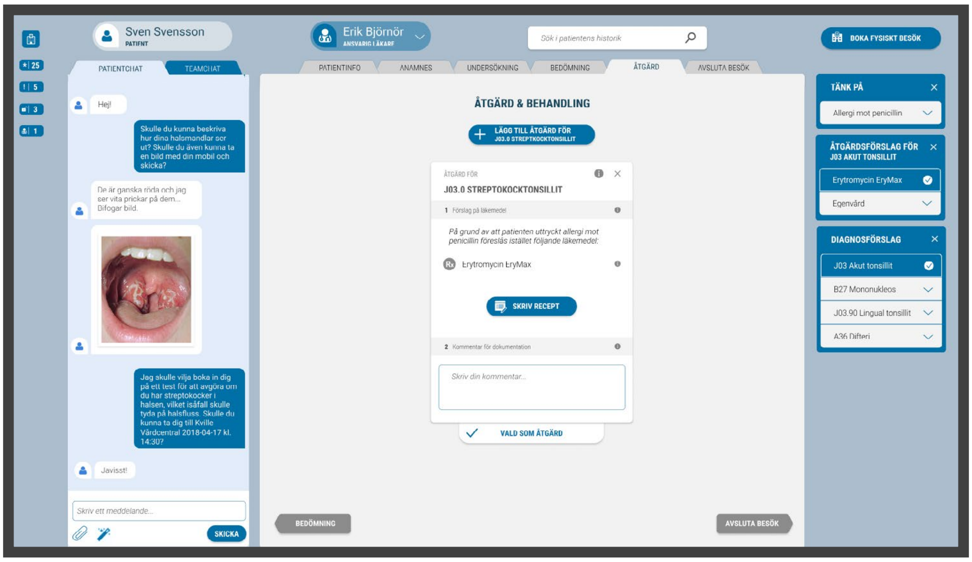







Sven Svensson
PATIENT
Erik Björnör
ANSVARIG LÄKARE
Sök i patientens historik
BOKA FYSISKT BESÖK
PATIENTCHAT
TEAMCHAT
PATIENTINFO
ANAMNES
UNDERSÖKNING
BEDÖMNING
ÅTGÄRD
AVSLUTA BESÖK
Hej!
Skulle du kunna beskriva hur dina halsmandlar ser ut? Skulle du även kunna ta en bild med din mobil och skicka?
De är ganska röda och jag ser vita prickar på dem... Difogar bild.
Jag skulle vilja boka in dig på ett test för att avgöra om du har streptokocker i halsen, vilket isåfall skulle tyda på halsfluss. Skulle du kunna ta dig till Kville Vårdcentral 2018-04-17 kl. 14:30?
Javisst!
Skriv ett meddelande...
SKICKA
Sår i munvinklar
FRÅGA OM RESTERANDE SYMPTOM
3-4 centorkriterier identifierade, innebär risk för:
Streptokock grupp A infektion.
STREP-A-TEST POSITIVT
J03.9 Akut tonsillit, ospecificerad
J03.0 Streptokocktonsillit
J03.8 Akut tonsillit, orsakad av andra specificerade organismer
Skriv din kommentar...
VALD FÖR ÅTGÄRD
UNDERSÖKNING
ÅTGÄRD
TÄNK PÅ
Allergi mot penicillin
ÅTGÄRDSFÖRSLAG FÖR J03 AKUT TONSILLIT
Erytromycin EryMax
Egenvård
DIAGNOSFÖRSLAG
J03 Akut tonsillit
B27 Mononukleos
J03.90 Lingual tonsillit
A36 Difteri


Sven Svensson
PATIENT
Erik Björnör
ANSVARIG LÄKARE
Sök i patientens historik
BOKA FYSISKT BESÖK
ÅTGÄRD & BEHANDLING
LÄGG TILL ÅTGÄRD FÖR J03.0 STREPTOKOCKTONSILLIT
ÅTGÄRD FÖR
J03.0 STREPTOKOCKTONSILLIT
På grund av att patienten uttryckt allergi mot penicillin föreslås istället följande läkemedel:
Erytromycin EryMax
SKRIV RECEPT
Skriv din kommentar...
VÄLJ SOM ÅTGÄRD
BEDÖMNING
AVSLUTA BESÖK


ÅTGÄRD & BEHANDLING
LÄGG TILL ÅTGÄRD FÖR J03.0 STREPTOKOCKTONSILLIT
ÅTGÄRD FÖR
J03.0 STREPTOKOCKTONSILLIT
På grund av att patienten uttryckt allergi mot penicillin föreslås istället följande läkemedel:
Erytromycin EryMax
SKRIV RECEPT
Skriv din kommentar...
VALD SOM ÅTGÄRD
BEDÖMNING
AVSLUTA BESÖK

DIAGNOSIS FLOW - SCREENS