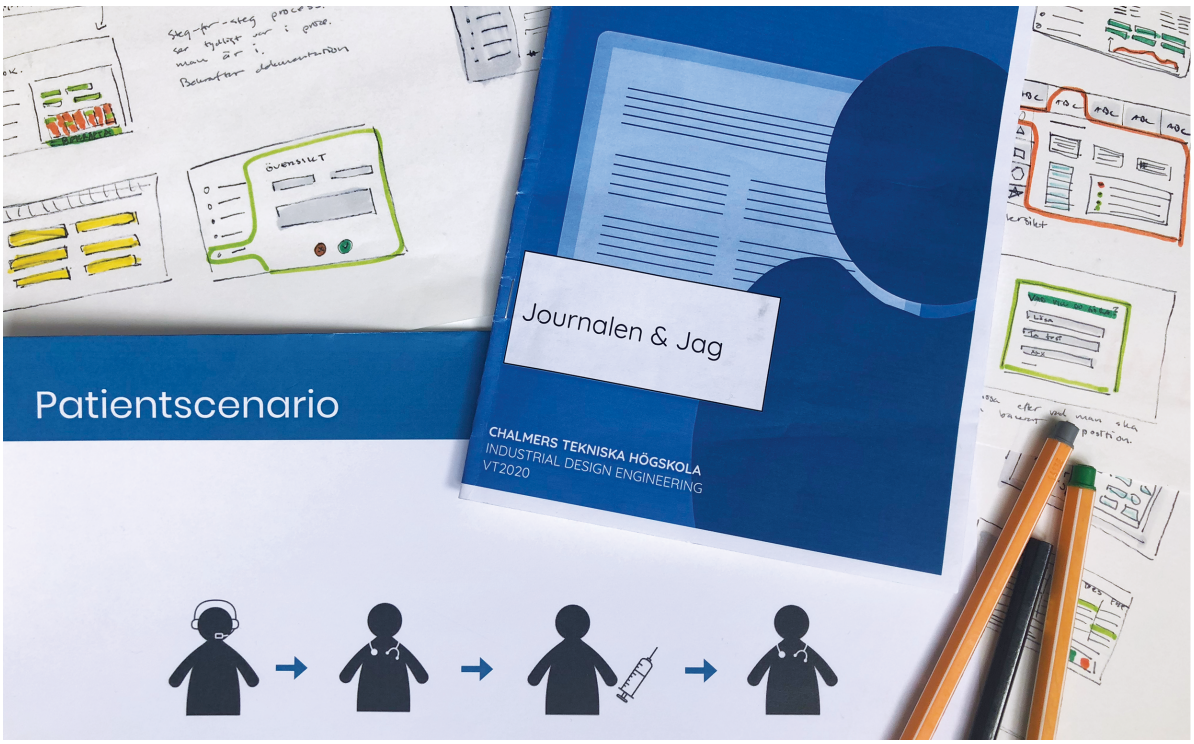
CHALMERS
UNIVERSITY OF TECHNOLOGY



Decreasing the cognitive load within primary care with a human factors approach:

Introducing a user interface design

Master's thesis in Industrial Design Engineering

FREDRIKA ANDERSSON & JOHANNA WENDT
Supervisor & Examiner: Cecilia Berlin

DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020
www.chalmers.se

Decreasing the cognitive load within primary care with a human factors approach:
Introducing a user interface design.

Master of Science Thesis

In collaboration with Närhälsan, Region Västra Götaland

Department of industrial and materials science

Chalmers University of Technology

SE-412 96 Göteborg, Sweden

Phone +46(0) 31 - 772 10 00

Print: Repro Service Chalmers

Publication: Göteborg, 2020

Abstract

This is a master's thesis project performed during the spring semester of 2020 at the Industrial Design Engineering program at Chalmers University of Technology in Göteborg, Sweden. The project was performed in collaboration with the department within the region of Västra Götaland which is responsible for public primary health care, Närhälsan.

Medical harm is a severe consequence of work being performed inadequately within health care and is for the most part caused by high cognitive load on the medical staff, and not due to lack of medical knowledge. If the cognitive load is decreased, actions that can lead to medical harm or medical errors could be limited, consequently decreasing the material, staffing and economical resources within health care. The aim of this master's thesis project is therefore to contribute to decreasing the cognitive load for medical staff at health care centres within Närhälsan.

This project examines the cognitive load at a specific health care centre, assigned by Närhälsan. The cognitive load on the medical staff at the health care centre was investigated through a pre-study and a user study consisting of observations, interviews and booklets with tasks to be performed by the medical staff. All information and data collected were compiled and analysed based on the following cognitive aspects: mental models and expertise; attention, awareness and mental workload; emotion and performance; decision making; and errors and risks.

Several problem cases were identified as having an impact on the cognitive load of the medical staff. The problem case of reading and documenting in the medical record and documentation system was chosen to proceed with, investigating the cognitive load on the medical staff within that problem case. The problem case was chosen since the software was a central part of the medical staff's work and a design solution was possible to implement. The main finding was that all investigated cognitive aspects contribute and affect the cognitive load of the medical staff, not just one or some aspects. As result of the findings, a user interface design for a new medical record and documentation system with a "step-by-step" approach was developed. The interface was validated against compiled guidelines and personas established by the research and data analysis. A final concept was created that supports and guides the user in what should be done, as one solution to decreasing the staff's cognitive load based on the analysed cognitive aspects.

Due to the project being performed during the spring of 2020, the work process needed to be adapted to the global pandemic of COVID-19.

Keywords: human factors, cognitive ergonomics, health care, medical harm, medical errors.

Acknowledgement

Different people have been a part of this master's thesis project, and everyone involved have been vital in making this project possible. Firstly, we would like to thank Dirk Vleugels, *Chefsläkare* at Närhälsan and Cecilia Berlin, Associate Professor at Chalmers University of Technology, who introduced this project. Dirk Vleugels has, throughout the project been very supportive and has been providing the thesis authors with valuable contact and advise needed to perform the project. Constantly providing an optimistic and encouraging approach throughout the project have really been appreciated. Cecilia Berlin has been the supervisor and examiner for the project and has helped and supported the thesis authors in every step of the way throughout the work process. Always been easily accessible and been very supportive in choices made by the thesis authors, and always been very helpful whenever obstacles occurred.

Secondly, we would like to thank all participants involved in the different activities throughout the project. Great thanks to the medical staff at the health care centre where research was performed, and special thanks to the operations manager at that health care centre for being our contact person. Thank you all for welcoming us with open arms and letting us get insights about your work. Thank you to the designers from the master's program Industrial Design Engineering who took time off from their own master's theses and helped the thesis authors by providing visual input to the developed ideas in the ideation process. Thank you to the nurse at the children's hospital in Uppsala who contributed with valuable input regarding the medical record and documentation system Cambio COSMIC. Providing inspiration for the development of a new user interface for a medical record and documentation system.

Lastly, we would like to thank our opponents Gustav Erhardsson and Linnéa Lidander who have supported the thesis authors towards the end of the project and providing a critical point of view on the project and suggesting opportunities of improvements.

Table of contents

1. Introduction ..... **- 1 -**
1.1 Aim ..... - 2 -
1.2 Project setting ..... - 3 -

2. Theory ..... **- 6 -**
2.1 Health care ..... - 7 -
2.2 Human factors ..... - 9 -
2.3 Cognitive ergonomics theory ..... - 12 -
2.4 Cognitive abilities and design principles ..... - 17 -

3. Project procedure ..... **- 19 -**
3.1 Work procedure ..... - 20 -
3.2 Software tools ..... - 21 -
3.3 Data collection methods ..... - 21 -
3.4 Data analysis methods ..... - 24 -
3.5 Methods to state needs and requirements ..... - 25 -
3.6 Ideation methods ..... - 27 -

4. Pre-study ..... **- 29 -**
4.1 First observations ..... - 30 -
4.2 Problem cases ..... - 32 -
4.3 Takeaways ..... - 35 -

5. User study ..... **- 36 -**
5.1 Booklet “My workday” ..... - 37 -
5.2 Medical record and documentation system observations ..... - 39 -
5.3 Description of the medical record and documentation system ..... - 40 -
5.4 Usability testing ..... - 42 -
5.5 Booklet “The Medical record and I” ..... - 44 -
5.6 Cambio COSMIC Interview ..... - 46 -
5.7 Takeaways ..... - 47 -

6. Cognitive ergonomics analysis ..... **- 48 -**
6.1 Mental models and expertise ..... - 49 -
6.2 Attention, awareness and mental workload ..... - 53 -
6.3 Emotions and performance ..... - 56 -
6.4 Decision making ..... - 58 -
6.5 Errors and risks ..... - 60 -
6.6 Takeaways ..... - 61 -

7. Needs and requirements ..... **- 62 -**
7.1 Personas ..... - 63 -
7.2 Guidelines ..... - 65 -
7.3 Takeaways ..... - 68 -

8. Ideation ..... **- 69 -**
8.1 Ideation within the thesis authors ..... - 70 -
8.2 Focus group with medical staff ..... - 70 -
8.3 Workshop with designers ..... - 73 -
8.4 Prototype testing ..... - 74 -
8.5 Takeaways ..... - 75 -

9. Final concept ..... **- 76 -**
9.1 Procedure ..... - 77 -
9.2 Presentation of the user interface ..... - 77 -
9.3 Takeaways ..... - 81 -

10. Project reflection ..... **- 83 -**
10.1 Discussion ..... - 84 -
10.2 Recommendations for future projects ..... - 86 -

11. Conclusion ..... **- 87 -**

References ..... **- 89 -**

Glossary

Word [English]	Word [Swedish]	Definition
Health care centre	Vårdcentral	One of the departments where primary care is provided.
Medical harm	Vårdskada	Illness, damage or death of a patient that could have been avoided, caused by errors and incomplete actions.
Medical error	Behandlingsfel	Actions that can result in medical harm.
Medical record and documentation system	Journalsystem	The software a health care centre uses to schedule appointments and handle patients' medical records.
Medical roles	Vårdpersonal	All employed medical professionals at a health care centre.
Nurses	Sjuksköterska	Assistant nurses (Swedish: *Undersköterska*), district nurses (Swedish: *Distriktssjuksköterska*) and nurse. (Swedish: *Sjuksköterska*)
Prescription	Recept	Medical prescription that has been registered by a doctor to a patient for medication.
Primary care	Primärvård	Most often the first authority within the health and medical care that a patient turns to in need of care.
Referral	Remiss	When a patient is directed to specialists within a certain field.

01.

Introduction

To the project and problem.

This master's thesis project is performed within the public health care sector in Göteborg, Sweden. Care in Sweden can be provided through the public or private sector (Sveriges läkarförbund, n.d.). For the public sector, each region of Sweden is responsible for providing care for the citizens in their specific region. Health care in Sweden is divided into different units, such as special care and primary care. Primary care is where a patient seeks advice, support or treatment for non-emergency cases, most often being the first place the patient comes into contact with medical care (Socialstyrelsen, 2019). The public primary care in the region of Västra Götaland is provided by the department Närhälsan, with health care centres spread out in the whole region (Närhälsan, 2020). The medical staff at a health care centre include doctors, district nurses, assistant nurses, secretaries and personnel within rehab and mental health, who that all contribute with knowledge to provide care and support patients towards a healthy lifestyle.

Medical harm can occur as a consequent of treatment and is when a patient is incorrectly treated, generating suffering, illness or physical or psychological damage that could have been avoided (Socialstyrelsen, 2020a). Seventy percent of actions resulting in medical harm are due to high cognitive load on the medical staff, and are therefore not necessarily caused by a lack of knowledge among the medical staff (Mitchell, 2013). Cognition implies the mental processing a person performs to interpret information, resulting in immediate and/or well-considered actions. The processing of information can easily be affected by for example distractions or stress, which commonly occur in health care, affecting the medical staff's ability of making crucial decisions regarding a patient.

Decreasing the cognitive load and providing safe health care is crucial, and achieving this has mainly been focused on within hospital care (World Health Organization, 2016). The same focus has not been applied to primary care, where the patient's first touchpoint most often is when searching for support or treatment. Primary care patient situations are usually not as severe as within hospital care, but are nevertheless as important. If a case is not discovered at an early stage within primary care, it could cause severe consequences with patient injury, illness or even death.

1.1 Aim

The aim of this master's thesis project is to contribute to decreasing cognitive load for medical staff within Närhälsan, the public primary health care organisation in the region of Västra Götaland, Sweden. The main goal of the project is to contribute with insights about the cognitive ergonomics situation for the staff at a health care centre, so that future work can be carried out more in depth.

Research questions for the master's thesis project, guiding the project forward were:

- What situations at a health care centre result in high cognitive load for the medical staff?
- Which aspects of cognitive ergonomics have an impact on the cognitive load of the medical staff?
- How can a design solution decrease the cognitive load of medical staff at a health care centre?

To be able to answer these questions, one problem case will be investigated further, and a design solution will be developed for that problem case with the intent to decrease the cognitive load, and as a future result possibly decrease medical harm.

The deliverable of this master's thesis project is a design solution intended to decrease the cognitive load on medical staff at a health care centre within Närhälsan, without changing the current health care practices for the worse. In additional to the design solution, a framework of the findings, results and problem cases will be summarised in a manner that supports future work concerning human factors and medical harm within Närhälsan, so that it can be continued and expanded after this project is finalised.

1.2 Project setting

This project is a 30 ECTS master's thesis project at the master's program Industrial Design Engineering at the department of Industrial and Material Science at Chalmers University of Technology. The project was defined and introduced by Närhälsan, the part of the Region Västra Götaland responsible for public primary care. Närhälsan was the actor who guided and helped throughout the process of conducting the project work. One health care centre within the Region of Västra Götaland was assigned by Närhälsan to this project. All research was performed against that specific health care centre, and documented to enable the possibility of applying the insights found to future projects within this area and also to other health care centres within the Region of Västra Götaland.

The people involved in this project, apart from the thesis authors, have been:

- Supervisor as well as examiner.
- Contact person from Närhälsan, who initiated the project.
- Contact person at the health care centre.
- Medical staff at the health care centre.

The project planning focused on involving the medical staff throughout the project as much as possible, because they were the health care experts. Methods planned for use are displayed in Figure 1. Each phase throughout the project should involve the medical staff at the health care centre, so each method within Pre-study, User study and Ideation will be performed by or with the medical staff.

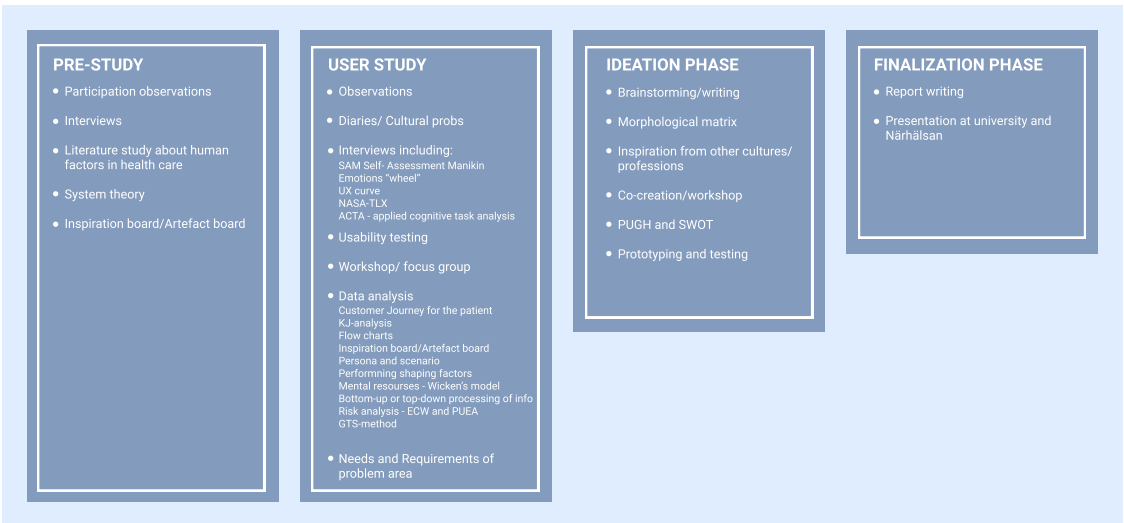


Figure 1. Methods planned to use in the project

1.2.1 Demarcations

Within the health care profession, organisational obstacles have an impact on the cognitive workload of the medical staff overall due to a shortage of staff (Inspektionen för vård och omsorg, 2018). To employ additional medical workers is an aspect that cannot be changed with a design solution, it is therefore not included in this project. The solution that will be developed should be beneficial for the currently existing medical staff and their way of working. The goal of the project is therefore to develop a product, aiding tool or interface that supports the medical staff, and not to change the way of working on an organisational level, while also not changing how the staff act as people and individuals. The project will also, because of the thesis authors' lack of medical knowledge, not focus on the medical aspects of the staff's work, but rather on the human factors aspects of their work. Conclusions regarding how medical acts are performed cannot be made and are therefore not within the scope of the project.

Based on the fact that the project focuses on human factors, and more specifically cognitive ergonomics, the term medical errors, meaning the actions that result in medical harm, is used from here on instead of medical harm.

1.2.2 Ethical aspects

Confidentiality is important when working within health care and with people seeking treatment. It is therefore important to conduct complete professional secrecy throughout the project. Personal information regarding people involved has been handled with great discretion. Throughout the project collecting personal information has been avoided, but any data collected that could be traced back to a specific person has been stored separately from collected data and documents. Information that could identify a person, like names are not stated in documents, everything is instead coded for the thesis authors to understand.

When a person participated in any tests or activites carried out by the thesis authors, this person signed a written agreement before participating. A GDPR template was provided by Chalmers, and signed GDPR documents have been stored separately from the data collected.

1.2.3 Societal aspects

Decreasing the cognitive load for medical staff, and as a possible long-term result decreasing situations that may lead to medical harm, will result in a healthier society, creating a difference on a wide spectrum. A healthy society applies both to the general population but also to the medical staff. With decreased cognitive load the number of burnouts among medical staff could also decrease. Decreasing burnouts can in turn decrease expenses within health care, and the expenses saved can be distributed to other areas of health care instead. A greater number of patients receiving correct treatment will also decrease unnecessary expenses within health care, while it will also increase the general trust in the primary health care.

1.2.4 Ecological aspects

The aim of decreasing the cognitive load within Närhälsan could potentially decrease the amount of unnecessary resources used within the department. Resources that could be decreased are for example materials and electricity used on-site at the health care centre. Less resource usage can generate a positive impact on the environment. The design solution developed as a result of the project could however affect the environment to a lesser or greater extent. The design solution could be a digital or physical solution both of which raise different types of challenges regarding ecological aspects. A digital solution requires a hardware, software and electricity to function properly, as far as consideration to ecological aspects can be taken. A possible physical solution is to a larger extent, compared to a digital solution, including choices where ecological aspects need to be considered, like the materials to use or how the object should be manufactured. Ecological aspects are therefore something that the thesis authors need to take into consideration in the development process of the solution.

02.

Theory

Within the area of this project.

This chapter describes theory, relevant for this thesis. The theory should provide the right setting and context to the project and contribute with basic understanding for the situation. The theory should also provide guidance about what one can investigate and observe and to identify what is already presented to the public regarding medical harm, medical errors and how those occur, and how cognition have an impact on that. Research of already existing literature within those subjects was therefore performed.

2.1 Health care

This section describes information about health care that are within the scope of the project, involving patient safety and software systems.

2.1.1 Patient safety and medical harm

Patient safety is defined by Socialstyrelsen, the National Board of Health and Welfare (2020a) as "*skydd mot vårdskada*", meaning protection against medical harm. It is the caregiver's responsibility to provide safe and qualitative care and should work proactive to prevent medical harm from occurring.

Medical harm is defined by Socialstyrelsen, the National Board of Health and Welfare (Definition av patientsäkerhet och vårdskada, 2020a) as "*lidande, kroppslig eller psykisk skada eller sjukdom samt dödsfall som hade kunnat undvikas om adekvata åtgärder hade vidtagits vid patientens kontakt med hälso- och sjukvården*", meaning that suffering, physical or psychological damage or illness and death that should have been prevented, if the right actions should have been performed on the occasion of the patient's contact with the health and medical care.

Severe medical harm is defined by Socialstyrelsen, the National Board of Health and Welfare (Definition av patientsäkerhet och vårdskada, 2020a) as "*vårdskada som är bestående och inte ringa eller som har lett till patienten fått ett väsentligt ökat vårdbehov eller avlidit*", meaning medical harm that is lasting and not minor, or that the patient now is in need of significantly more medical care or has passed away.

Medical harm that occurs must always be reviewed and investigated by the employer at the health care division where it occurred (1177 Vårdguiden, 2020). For more severe cases, then the situation must also be reported to Inspektionen för vård och omsorg, Health and Social Care Inspectorate. When reporting a severe medical harm, then the registration is referred to as a lex Maria registration. The investigation of that lex Maria registration results in gained knowledge and understanding for why it occurred and what could have been done to prevent the situation from emerging. The investigation is also important in order for the patient to gain clarification of what caused the situation.

Medical errors can occur due to several things, e.g. and incorrect set diagnosis or failure to act on given results, among other things (Always Culture, n.d.). The environment can also vary, medical errors occurring at a hospital or surgery centre or even at a patient's home. The circumstances and situations being the cause of medical errors have however been determined to be the same despite the context. The causes have been established by the Agency for Healthcare Research and Quality to be; *Communication Problems, Inadequate Information Flow, Human Problems, Patient-Related Issues, Organizational Transfer of Knowledge, Staffing Patterns and Workflow, Technical Failures* and *Inadequate Policies*. Communication and the flow of information are crucial within health care for the patient to receive proper care.

Important information can easily get lost if this does not work properly, resulting in the caregiver does not receive all information required to treat a patient.

Inspektionen för vård och omsorg, the Health and Social Care Inspectorate (2018) indicate the importance of good communication between colleagues within primary care in order to avoid medical harm from occurring. Documenting work performed properly is also vital, making it possible for the next person to gain knowledge about the work performed, without misunderstanding and increasing the risk of mistakes. Applying risk prevention to daily work routines is also important, anticipating all possible consequences of an action in order to avoid medical harm from happening.

A good working environment for the medical staff within health care is vital in order to ensure patient safety (Socialstyrelsen, 2020b). When working within health care, decisions sometimes must be made under stressful situations which can result in consequences for the patient's wellbeing. A work environment consisting of a high workload with a great number of patients and information will require the medical staff to multitask, needing to make decisions while simultaneously keeping other information or tasks to perform in their working memory. Under pressure, trying to remember everything while also trying to make proper decisions, some things can be forgotten. During the moment of decision making, it is also crucial that the individual making the decision will not be disturbed or interrupted. If a person is disturbed important steps in the working or decision process can be forgotten. A high workload results, apart from forgetfulness, in exhaustion for the medical staff needing to be constantly alert. Exhaustion can result in the medical staff not being able to make proper decisions or prioritisations between patients or work tasks. In those cases, incorrect decisions and prioritisations can be made, which will have consequences regarding the patient's wellbeing.

2.1.2 Software systems within health care

Different software systems are used on a daily business within health care in order to provide care to patients. Some of these systems are describes in the sections below.

Electronic Medical Record

A patient's medical history, results and diagnosis for example can be displayed in a digital manner through an Electronic Medical Record, EMR (USF Health, n.d.). An EMR can generate improvements of the health care centre's resources of time and finances in comparison to a physical medical record system. Providing easy access to a patient's medical history also improves the patient care since getting a clear understanding of the patient's situation will generate more accurate treatment and diagnosis.

An Electronic Medical Record, EMR, is sometimes used as a synonym with an Electronic Health Record, EHR (USF Health, n.d.). Both electronic medical record systems are to a large extend the same kind of system but differs on some aspects. The major difference is that the information presented about the patient's medical state and history in an EMR is more detailed and mainly shared within the same organisation, whereas an EHR has the possibilities of sharing patient information between different organisations.

Practice Management system

A Practice Management system is a software where medical staff can handle and act on administrative tasks such a billing and time bookings (Uzialko, 2019). A Practice Management system can in some cases be mistaken for an Electronic Medical Record system, which instead handle the medical documentation and not the administrative documentation. One reason for the misunderstanding is that these systems are depending on each other and are used in a closed collaboration since each system contribute with material that the other system needs.

AsynjaVisph

AsynjaVisph (Figure 2) is the software used as electronic medical record and practice management system within public primary care in the region Västra Götaland (Myndigheten för vård- och omsorgsanalys, 2016).

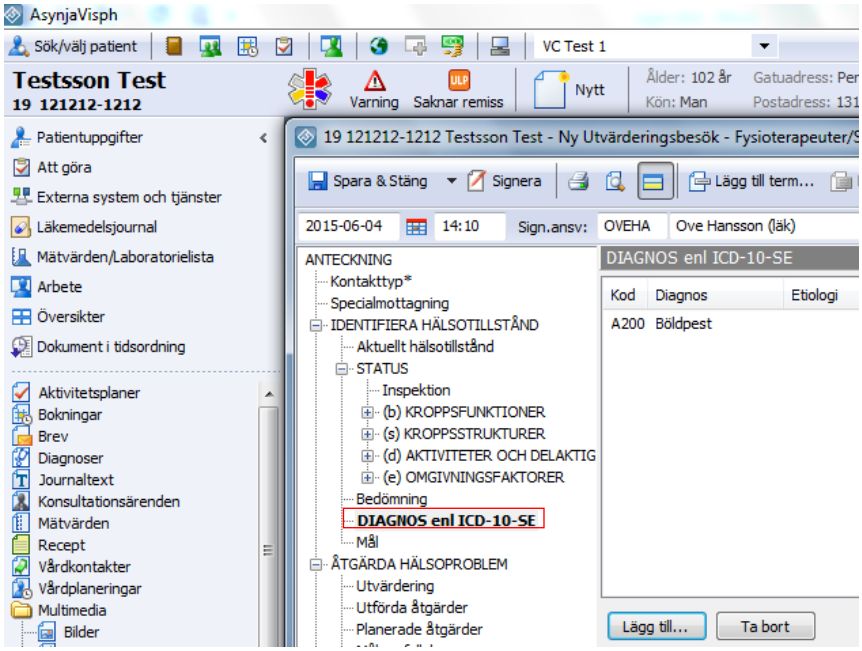


Figure 2. A screenshot of AsynjaVisph's interface (AsynjaVisph förvaltning, 2018, p. 14)

2.2 Human factors

According to the International Ergonomics Association, IEA, (n.d., Definition and Applications) human factors is "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance". Human factors and ergonomics are synonyms and is used as substitute to each other. Human factors involve multidisciplinary fields of subject within physical, cognitive, sociotechnical, organisational and environmental areas, investigated as a whole to understand the interaction between the different fields. The goal with applying human factors to a situation is to achieve sustainable and good working conditions for the individuals in that situation. This is of interest not only for the workers but also for the employers, the government, and organisations working with standardisations and working conditions.

2.2.1 Areas within human factors

Physical ergonomics is an area within human factors that takes consideration to the human body of the operators or users of a machine or a product (Federation of European Ergonomic Societies, n.d). Investigating the area of physical ergonomics involves the physical work conditions of a task with a focus on anthropometry, work posture, movements and safety for example.

Cognitive ergonomics is an area within human factors regarding how the interaction with a product or machine correspond to the available or limited cognitive resources that the user of that product or machine has (Interaction Design Foundation, n.d.-a). This is determined by investigating the attention, human perception, mental processing, memory and perceptual errors of the user that operates in the investigated system. Cognitive ergonomic analysis is most often applied in situations with complex setting with a lot of different actors or tasks. A high level of attention is in those cases needed to make good execution of a task or a good decision that do not result in a severe situation. This is not however a limitation; cognitive ergonomics can be applied to other situations that do not involve high risk situations.

Organisational ergonomics is an area within human factors that is concerning with how the organisational set-up for a task affect the performance of that task (Federation of European Ergonomic Societies, n.d.). Within this area one could investigate the organisation and the processes or policies that are being applied at a workplace and the collaboration and communication within the organisation.

2.2.2 Human factors within health care

Human factors and ergonomic approaches have been applied within health care prior to this project. This has been done in order optimise and increase the wellbeing of the medical staff within health care, while also to detect what existing factors within health care that generate medical errors (Carayon, Xie & Kianfar, 2014). To increase the staff's wellbeing and achieve patient safety, design variables (Table 1) regarding medical staff's working environment have been established by Carayon, Xie and Kianfor (2014).

Table 1. Human factors and ergonomic design principles adapted from Carayon et al. (2014, p. 198)

Focus of HFE	Example of HFE design principles
Physical HFE	
	To minimise perception time, decision time, and manipulation time
	To reduce or mitigate need for excessive physical exertion
	To optimise opportunities for physical movement
Cognitive HFE	
	To ensure consistency of interface design
	To match between technology and the user's mental model
	To minimise the cognitive load
	To allow for error detection and recovery
	To provide feedback to users
Organisational HFE	
	To provide opportunities to workers to learn and develop new skills
	To allow worker control over work systems
	To support worker access to social support
	To involve user in system design

Ergonomics has mainly been used as an evaluation tool in design work within health care, as an external contribution to verify the functionality and usability of the developed product (Zolotova and Giambattista, 2019). Zolotova and Giambattista (2019) discuss a design approach where ergonomic aspects are incorporated within the design work from the beginning, adapting towards ergonomic aspects from the start. Zolotova and Giambattista did, based on research, develop design questions and objectives to use when starting a project with a human factors and ergonomic approach within health care. These questions and objectives are a start towards developing more specific guidelines in the future, as the importance and the knowledge of this design approach only will grow. The questions and objectives are the following:

1. Optimize tasks to perform for the user in terms of balancing the mental workload at the moment and the resources available;
2. Define all the elements of the system in order to evaluate the inputs that the user has to deal with when in a situation of decision-making;
3. Ensure the flexibility of the system in order to make it errors' tolerant;
4. Check the usability and the visual communication of the information through the laws of visual perception;
5. Help users to establish correct relationships by taking into account the subjectivity of people's cognition.

(Zolotova and Giambattista, 2019, p. 472)

Important aspects to observe and investigate, based on these questions and objectives, are therefore the mental workload and resources of medical staff within health care, the circumstances during a decision-making situation and the communication and interaction with surrounding tools (Zolotova and Giambattista, 2019).

2.3 Cognitive ergonomics theory

This chapter describes theory within the field of cognitive ergonomics that are relevant for when investigating and mapping a situation within that area that will used as a base for this project.

2.3.1 System theory

System theory can be applied to understand and analyse situations with users, products and other stakeholders in specific environments (Dul et al., 2011). A system is defined as several parts interacting with each other with a clear goal to achieve, with clear boundaries of what is included in the system. The parts are working as one unit towards the goal, generating something greater than the parts individually. The parts can be humans, products, tasks and organisational factors in a specific environment, where an understanding for the interplay between these actors can be established. A system's complexity is depending on how many parts that are involved and possible changing factors or circumstances (Hollnagel, 2003). The parts within a system affect each other, creating a relationship between them and is dynamically changing and adapting depending on events. Input is retrieved from the parts within the system that affect actions and events, which affect the results of the actions and creates output from the system.

Operators or users plays most often a major part in the performance within systems (Bye, Hollnagel and Brendeford, 1997). The users are depending on the received input and changes of the situation, duration of the tasks, need of mental resources and possible suddenly changes. The operator's knowledge of the processes and how to interpret the presented input is of great importance to the performance.

2.3.2 Mental models and expertise

Mental models are individual and are determined by the experiences and knowledge of the person interacting with their surrounding (Berlin & Adams, 2017). Based on experience and knowledge the person interacting with a surrounding can establish their own way of interaction that are most suitable for the task at hand and for them as a person. Mental models guide the user when interacting with an object or interface and are then based on the user's beliefs rather than facts (Nielsen, 2010). The user makes a prediction of what the outcome will be out of an action, or how an action should be carried out in order to generate a specific outcome. If the interaction generates the result the user predicted, then the object or interface meet the user's mental model of how the interaction should be carried out.

2.3.3 Attention, awareness and mental workload

Attention and awareness are a part of our daily lives since we are using our senses and are taking in information from different situations constantly. Attention helps to highlight some stimuli and information, and to block other information, while also directing appropriate mental resources to the different stages of cognitive processes (Wickens, Hollands, Banbury and Parasuraman, 2012). Wickens' model of information processing is explaining how these cognitive processes are performed when presented with information, in order to carry out a task (Figure 3). The model explains how stimuli is registered and stored during a short period of time in the short-term sensory store, STSS. The sensory input is being processed and the stimuli is giving meaning through the perception by using the short-term memory and long-term memory. This results in a decision of response, followed by the execution of that decided response. When the operator has executed the response, feedback is provided to the operator since that action affected the environment where the task was performed in. The attention plays a central role in the model of information processing and are included in all the different stages of information processing.

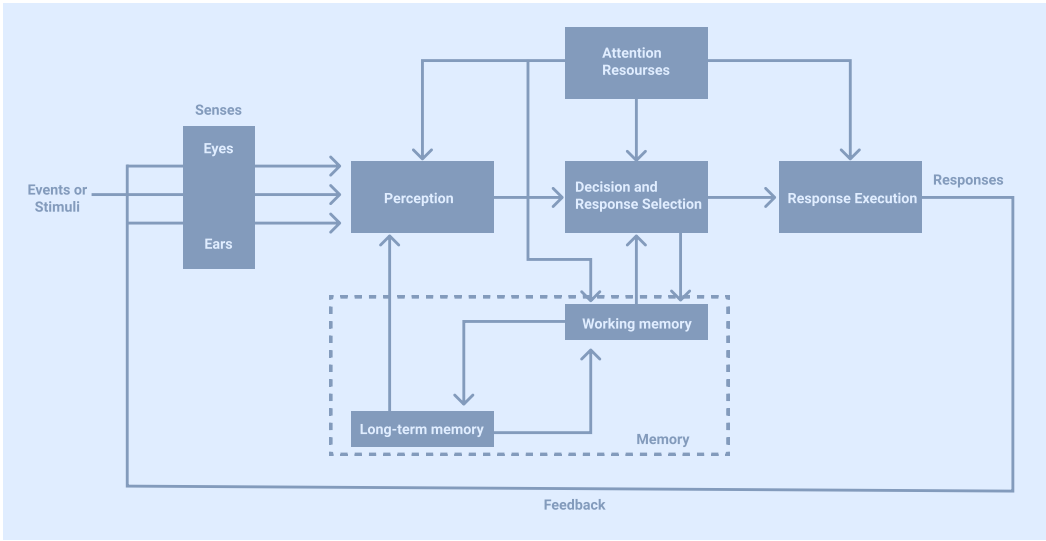


Figure 3. Wickens' Information processing model adapted from Wickens et al. (2012, p.4)

Processing of information can be performed in two different approaches, bottom-up or top-down processing (Berlin & Adams, 2017). Bottom-up processing means that one is reacting to presented stimuli with an automatic response. Top-down processing requires on the other hand analytical thinking based on previous experiences, knowledge and individual goals, in order to create an appropriate response.

As already stated, the memory helps us to store information and to make sense of the world by using previous experience and knowledge. The memory consists of two parts, the working memory and the long-term memory (Berlin & Adams, 2017). The working memory stores recently collected information and is limited in how much information that can be stored simultaneously. Information in the working memory can be retrieved after a short period of time after storage, but it will be lost after a longer period of time if it is not stored in the long-term memory. The long-term memory can hold information that has been processed and stored. The retrieval of information can be affected by how the storing was performed, it can be helpful if there are any connections to the memory and if the individual is in a good state of mind.

The mental state of mind, available resources and limitations, of an operator affects the performance of tasks (Berlin & Adams, 2017). The mental resources of an operator are affected by the individual's cognitive abilities, experience, interpretation of information and skills, but also by the operator's physical state. How a task is performed is depending on the available mental resources, which implicates that mental overload will affect the performance of a task in a negative manner.

Wickens et al. (2012) describes a model of multiple resource where tasks that require same resources and cognitive processes compete with each other, resulting in that the performance of the tasks will be affected in a negative manner. The time that is required to perform the tasks can increase and the difficulty level of the tasks can be raised. Using different senses can generate that the tasks are not being affected by each other to a larger extend compared to if the same senses are being activated.

2.3.4 Emotions and performance

Performing a task that requires a person to make a decision calls for reflection to end up with a solution. The conditions, in the moment of making a decision have an impact on what the outcome will be (Gangemi & Mancini, 2006). Studies show that people are not only influenced by what they read or think when making a decision but also what they feel during that moment in time. Human emotions can in other words more or less have an impact on a person's performance in said moment of decision making. The intensity of the emotion felt during that moment in time also has an impact, with greater intensity, the greater impact that emotion has on behavioural change (Scherer, 2005). Behavioural change also occurs mainly when the duration of the felt emotion is short, while longer duration of an emotion has less impact on behavioural change.

Emotions experienced during an ordinary day and are a cause of something that has happened, or the situation at hand is called discrete emotions (Angie, Connelly, Waples & Kligyte, 2011). Discrete emotions are those of anger, happiness, sadness and fear, among others. These emotions have different ways of influencing judgement and decision making in one way or another. Studies show that people experiencing emotions like anger and happiness has tendencies towards prejudice when making a decision, taking more of a heuristic approach towards a problem, stereotyping events or situations based on previous experience. People experiencing emotions like sadness and fear, on the other hand, has a more detail-oriented

approach towards a situation. Investigating the situation more in detail, takes more personal responsibility for the outcome of the situation and has a greater likelihood of anticipating more negative outcomes of a situation. People experiencing sadness and fear have therefore a more pessimistic approach, taking negative consequences of their actions into consideration, when making a decision (Gangemi & Mancini, 2006). People feeling anger, on the other hand, have the opposite approach, by not investigating or considering the negative consequences of their actions and the decisions they make.

Guilt is also an emotion that takes more negative consequences into consideration when making a decision (Gangemi & Mancini, 2006). When feeling guilt people take more personal responsibility for the situation, while at the same time feeling worry regarding the future and the possibility of experiencing future guilt. Guilt is therefore an emotion that has a great influential impact on decision making, because it makes the individual take more personal responsibility for the outcome, while the feeling of guilt is also wanted to be avoided for their personal sake.

2.3.5 Decision making

According to Miller, Singh, Arnold and Klein (2020) medical decisions are a combination of knowledge and how that is applied to the situation, information processing and identification of evidence. Medical decisions can be made rapidly and automatically or in a more reasonable and analytic manner, where experience, available information, time pressure, attention and awareness can affect the decision.

Decisions can be described by using different frameworks and models. One cognitive model to describe decision making, performance of tasks and possible errors is Rasmussen's Skill, Rule, Knowledge model, SRK-model (Rasmussen, 1983). The model explains three levels of performance and how those actions are being carried out depending on presented stimuli and the operator's previous experience of that task. On the first level, the skill-based behaviour, the operator has a establish routine of how to perform that task. The behaviour is conducted on an unconscious level of the operator and as an automatic behaviour. For the second level, rule-based behaviour, the operator has rules or routines that one follows which has been established by previous experience, with a clear goal of what should be achieved. This level has a higher level of attention from the operator compared to the skill-based level. For the third level, the knowledge-based behaviour, the operator is fully aware and have all attention to the task. The operator knows what the goal with the task is but do not have previous experience, skills or rules of how to perform the task. The operator needs to reason, problem solve and apply trial and error, relying on feedback to investigate which action that takes the operator closer to the goal of the task.

For activities that are being performed on a daily basis, individuals are constantly making decisions about how to carry out that task (Hollnagel, 2009). Trade-offs are made for daily, basic tasks regarding how fast that a task could be performed compared to how accurate the result would be. This is known as the Efficiency-Thoroughness Trade-off, ETTO, principle, where an individual makes a trade-off between efficiency and thoroughness. The ETTO principle can be applied to understand why an individual acts as one does and why that action can generate a success or fail. The ETTO principle includes principles for work related, individual and organisational ETTO rules to understand the task from those different perspectives. The rules can be applied to understand why a certain trade-off is performed. Table 2 is presenting some ETTO rules within all three categories.

Table 2. Relevant ETTO rules for the project

Work ETTO rules	Individual ETTO rules	Collective (organisational) ETTO rules
“It looks fine” - can probably skip.	Scanning style - differences in assumptions.	Negative reporting
“It is no really important” - understands the situation correctly.	Levelling vs sharpening - differences in distinctiveness of memories and the ability to link previous events to one another.	Reduce unnecessary costs
“It is normally ok, no need to check” - great experience.	Reflective vs. impulsiveness - how alternative hypotheses and answers are phrased.	Double bind
“It has been checked by someone else before” - opening for possible mistakes to be made.	Learning strategies - going from no knowledge to knowledgeable by collecting information.	
“Doing like this is much quicker” - working effectively but not performing the task correctly.		

2.3.6 Errors and risks

Errors are something that occur on a daily basis, through interaction with an object or an interface, where an intended goal is not carried out as expected. Errors is a general part of life, and when an act is carried out where the result was not the intended by the user that error is defined as a human error (Bligård, 2012). The consequences of an error can be direct and negative, it can reduce a person’s efficiency, require unnecessary resources, and make someone unsure of the situation. Human errors are according to Reason’s research (1990) divided into five error causes; *slip, lapse, rule-based mistake, knowledge-based mistake* and *violation*. A slip is when a person has a failure in execution, the goal and the intention was correct while the execution was not. A lapse is on the other hand a failure in memory, here the execution or the goal with the execution is simply forgotten. Rule-based mistake is a failure in application, when the execution is well-known and good, but it is used in the wrong situation. Knowledge-based mistake is a failure in problem-solving, when a conclusion is made based on prior knowledge, but that conclusion is incorrect. A violation is separated from the other causes with it being when a person acts incorrectly with the intent of doing so, like cutting corners to save time (Bligård, 2012). Another division of errors is between active and latent errors. Active errors occur when people interact with a system incorrectly, while latent errors are those that occur due to flaws in the system itself. Active and latent errors can sometimes follow each other when an active error occur due to the flaws in the system.

2.4 Cognitive abilities and design principles

This section describes different techniques of how an interface can be designed to direct the user's attention and to manage the user's perception.

2.4.1 Perception attention

Perception attention is the theory of how features within an interface can be displayed to visually and efficiently direct the user's attention when needed (Rensink, n.d). Using features like colour, motion, contrast, curvature, and orientation in the plane in a graphical interface evoke the user to direct their attention to different items depending on how the features are displayed. The attention can be directed in the right moment to items within the interface that is relevant for the action performed. The theory also includes how to offload attention of the user, in order to not direct their attention towards items that are irrelevant.

A human's attention capacity is limited, and an interface should therefore not be too overwhelming for the viewer (Rensink, 2019). In order to visually communicate what is relevant for what should be performed within the interface, the principle of *virtual representation* can be applied. Creating a coherence between different elements within an interface, the user is guided in how a task should be performed, creating attentional shift in the right moment in time. Another way of directing the viewer's attention within an interface is through the use of *lighting level* where some elements are highlighted and other are shaded. The highlighted elements are supposed to draw the viewer's attention, while the shaded elements are irrelevant for the task at hand, offloading the attention of the user. *Featural cues* can also be used to draw the user's attention. The user will draw their attention to elements within an interface that are unique, separating the element from the rest, making it "pop". Uniqueness can be created in several different ways, with the use of different features.

Creating an efficient interaction with an interface also requires for *perception organisation* where the interface in organised, not overwhelming the user with information (Rensink, 2019). *Reduced clutter* is one way of organising an interface, where the number of elements and information are limited, only presenting the most relevant for the situation. Grouping elements together, and even layering different groups are also ways of organising within an interface, which is called *improved selectivity.* An interface can also be organised, avoiding overwhelming the user by using *restricted set of values* which is to limit the amount of coding of the interface that indicates that some elements should be grouped together. The user should not need to reflect on what different element coding is referring to, and this could be avoided by for example limiting the number of colours used within the interface.

2.4.2 Gestalt principles

Gestalt principles are rules of how to coordinate different shapes within an interface to create a unity between the shapes, creating a visual coherence for the user (Soegaard, 2020). The user should be able to understand what they see in an interface, and easily find what they want to do. The gestalt principles are based on the psychology of how the human eye and brain perceive shapes, joining them together, creating a context. Some of those principles are; *similarity*, *common region*, *synchrony*, and *proximity* (Figure 4).

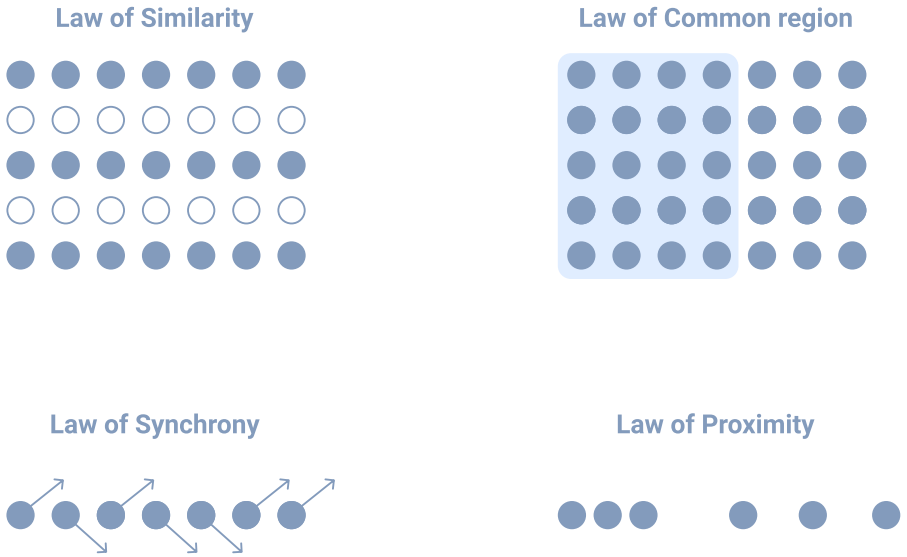


Figure 4. Illustration of some gestalt principles adapted from Soegaard (2020)

The principle of *similarity* within an interface is when the viewer group elements with similar shape, colour and size within the interface together (Chandra, 2019). These elements are interpreted to have similar functions in the system. *Common region* is referred to when the viewer group elements together that are presented within a closed region. The elements are then appeared to have a unity and belong together. When different elements within an interface instead change appearance or shape at the same time, these are also grouped together, and this principle is called *synchrony*. Another grouping principle is *proximity* where the viewer group elements within an interface that are located close together. Elements that are further apart are then separated and interpreted as not belonging together (International Design Foundation, n.d.-b).

03.

Project procedure

About the way of working.

The working process throughout the project has a user-centred and cognitive analysis approach. All methods used have been chosen with the aim to include the medical staff at the health care centre. The importance of collecting information so that analysis of cognitive aspects could be performed has been central throughout the project. The process of analysing cognitive aspects has been carried out continuously and repeatedly throughout the project when collecting data and information.

3.1 Work procedure

In order to achieve the aim, set for the project, the Double Diamond method (Design Council, 2019) with a user-centred approach was used. The Double Diamond is a working process structured by two diamonds where each diamond is examining a situation with an initial wide approach to later compile and conclude the information. The visualisation of the Double Diamond does however imply that the process is linear and that both diamonds are completely separated from each other, which is not the case. One phase does not end another, due to an iterative working process. Ideas can arise early during the discovery process, and the analysis within the Define phase can be included in the second diamond as well.

Figure 5 displays the work process and methods used in this project in a Double Diamond structure. An iterative approach was used throughout the project, going back and forth between different phases.

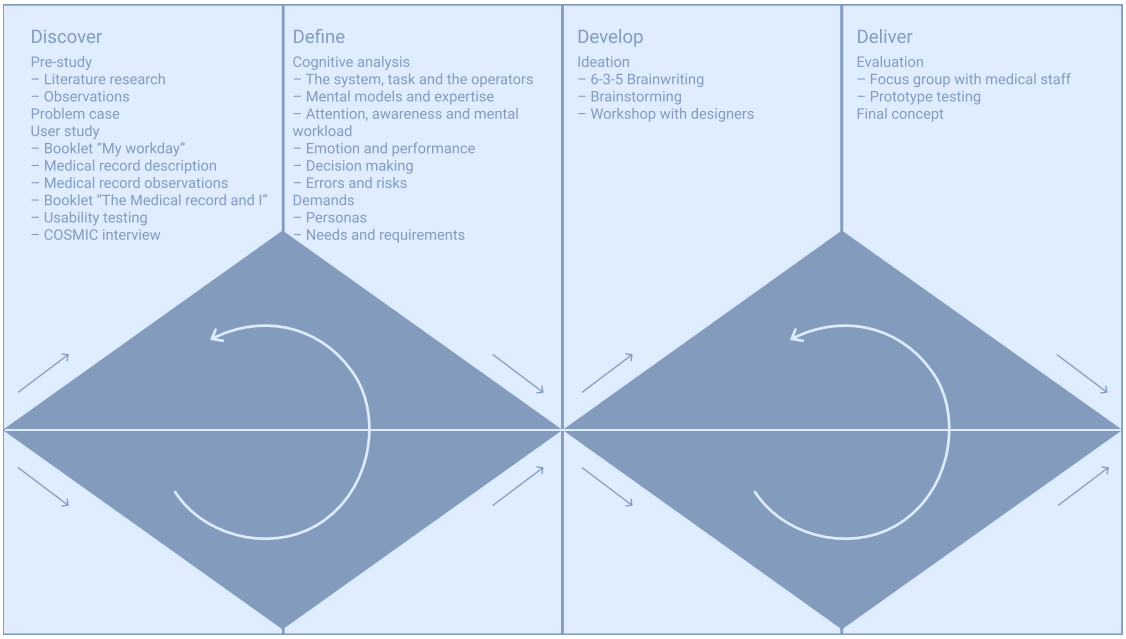


Figure 5. Overview of the work process of the project

The project was initiated by collecting data and information through a literature search and a Pre-study, identifying problem cases at the health care centre regarding the human factors area. All human factors aspects, and not mainly cognitive ergonomics, were taken into consideration in this stage in order to map out the situation and the context. Multiple problem cases could be identified as resulting in cognitive load on the medical staff. One particular problem case was later chosen to proceed with into the user studies. The problem case chosen was based on the possibility of whether a design solution could solve that problem case or not.

The User study focused on qualitative research in order to carry out an analysis of cognitive aspects within the chosen problem case. The methods used for the User study needed to be adapted towards the situation of the COVID-19 pandemic. Because of that, it was not possible for all methods to be carried out together with medical staff at the site of the health care centre. Some user study methods were therefore adapted to be able to collect data at a distance. The insights from the User study were from a cognitive ergonomics perspective and used as a basis to develop a design solution. The design solution, a user interface design, was developed by the thesis authors, together with other design students and the medical staff at the health care centre. The developed user interface was not possible to be further evaluated together with the medical staff as planned, due to the pandemic situation decreasing their availability. The solution was therefore tested and evaluated against the set requirements based on the performed studies.

The different methods used throughout the project are presented and described in the following sections.

3.2 Software tools

Several software tools were used during the project. Working digitally was helpful throughout the project in many ways. For methods requiring a great amount of documentation, a software could be used to limit the amount of paper used during the project. The final concept, being an interface also created a natural reason to use a digital software to create the interface, both visually and as an interactive prototype. More digital approaches were also required due to the pandemic, as it became necessary to perform remote activities to decrease the risk of infection. Different software tools were found to perform those activities digitally. The following software tools were used:

- Figma. A browser-based tool which designers use for designing, prototyping and coding interfaces (Bracey, 2018).
- Zoom. A software-based conference room, used to have meetings with multiple people at different locations with both video and audio (Zoom Video Communications, 2020).

3.3 Data collection methods

The following section describes the methods used during the Pre-study and the User study. In these phases, data was collected to understand and map out the context of a particular health care centre, and the users within that context. The approach was to collect data to understand the situation, but also to later analyse what cognitive aspects have an impact on the cognitive load within the health care centre.

The approach when choosing methods for the Pre-study was to choose something that would enable a wide and open mindset. Having an open mindset was required to not limit the data collecting in an early stage. The approach for the user study was to get a deeper understanding of the users within the context of the health care centre. The methods used were therefore user-centred, involving the user as much as possible in order to understand their thoughts and attitudes.

Some methods were chosen based on the possibility of being performed with the thesis authors present at the health care centre. A health care centre has a high workload and in order to avoid disturbing the medical staff, keeping them from performing their job, so some methods were chosen so that the medical staff could perform the activity whenever they had time.

3.3.1 Observations

Observations are used for user research in order to gain knowledge about either the usability of a product or to understand the user experience of a situation (Interaction Design Foundation, 2020). An observation is conducted by spending time with a user in their natural context, observing the user's behaviour. A clear definition of what should be learned through the observation should be stated before conducting the observation, to know what to look for. Everything observed during the observation is recorded continuously by the observer.

3.3.2 Diary studies

A diary study is a research method used to collect qualitative data about user behaviour that cannot be observed by the researcher (Moran, 2018). This method is a way to collect data from several participants simultaneously over a longer period of time. A diary is handed out to each participant with clear instructions of what they should perform during an established period, which could be several days, weeks or months. Handing out diaries for the participants to complete on their own makes it possible to collect data in the right context, without needing to observe the user. Letting the participant describe their behaviour in their own words also results in the data collected not being biased by the researcher observing the behaviour.

3.3.3 Geneva Wheel of Emotions

The framework Geneva Wheel of Emotions (Figure 6) is based on a two-dimensional space with consideration to the level of control and the variation between negative and positive emotions (Scherer, 2005). Emotions are visualised in the shape of a circle and are graded on the intensity of the felt emotion within the circle. The emotion intensity is low closer to the origin of the circle, and the emotion grows more intense further towards the outer wall of the circle.

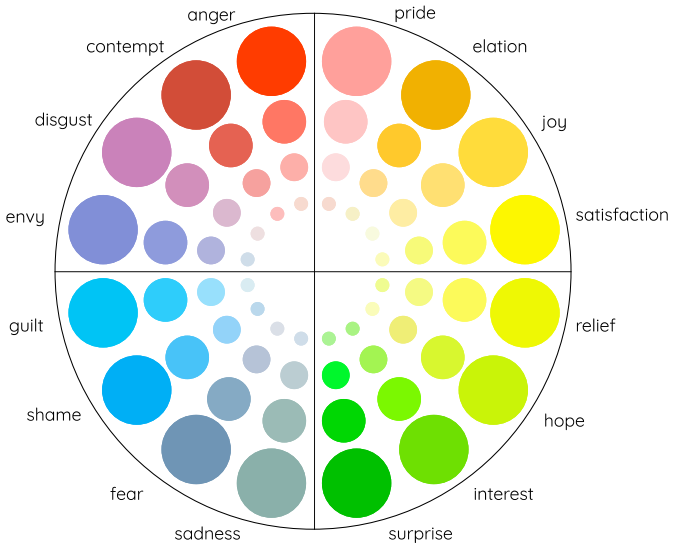


Figure 6. Geneva Wheel of Emotions adapted from Scherer (2005)

3.3.4 Nasa-TLX

Nasa-TLX is a method that subjectively measures mental workload for a specific task, based on six rating scales that affect the workload (Hart & Staveland, 1988). These aspects are described in Table 3.

Table 3. The aspects evaluated in Nasa-TLX adapted from Hart & Staveland, (1988, p.169)

Aspect	Endpoints	Description
Mental demand	Low/High	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical demand	Low/ High	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating. etc.)? Was the task easy or demanding. slow or brisk. slack or strenuous, restful or laborious
Temporal demand	Low/ High	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Performance	Good/ Poor	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Effort	Low/ High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration level	Low/ High	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, con- tent, relaxed and complacent did you feel during the task?

Two different approaches can be applied when analysing the result from the method. The first approach is to analyse each rating values separately, at equal value. The second approach is to apply a weighted value where the participants get to rate the aspects against each other, and therefore gain a better understanding of what mental workload means for the participant. The weighted value is multiplied with the rating value, which generates an adjusted value for the mental workload (Hart, 2006).

3.3.5 Usability testing

Usability testing is a method used to test and evaluate a product or an interface with the help of actual users (Moran, 2019). The method is used to gain insights about problems that the user encounter in the tested object, opportunities of improvements while also to get to know the user. A usability test is performed by a facilitator giving instructions to a user of a task to perform with the object that is being tested. The facilitator then observes the behaviour of the user while performing the task, while the participator provides feedback about the usability, either after the task has been performed or simultaneously while performing the task with a *thinking out loud* tactic. Thinking out loud is when the participant verbalise their thoughts while performing a task (Nielsen, 2012).

3.3.6 Interview

Performing an interview is done in order to get to know the user and their experiences, behaviours, opinions and views (Wikberg Nilsson, Ericsson, & Törlind, 2015). An interview can be structured, semi-structured or unstructured, meaning that the types of interview differs depending on if the questions are clear and concrete only generating one specific answer, or if a more open conversation is provided.

3.4 Data analysis methods

The following section describes the methods used for analysing the data collected throughout the project. Some analysis methods were used to gather and conclude the overall data, while others were used to analyse cognitive aspects in particularly. Some analysis of cognitive aspects was performed early in the project, the methods chosen during that moment in time were then chosen to analyse a small amount of data, creating a general, high-level conclusion. Further during the process of the project more detail-oriented analysis methods could be used instead. The methods used are based on the presented theory and methods within that area and intend to determine a user's cognitive load from different perspectives.

3.4.1 KJ-analysis

A KJ-analysis is a method used for interpreting collected qualitative data, in order to identify specific problems within an observed area (Scupin, 1997). Every thought and observation collected is written down on separate labels with only one thought or observation on one label. The labels are later grouped together, identifying similarities between the different labels, while those groups are later grouped together into families. The grouping is an iterating process, being done multiple times to get it right and through each iteration new groups can occur.

3.4.2 Hierarchy Task Analysis, HTA

A Hierarchy Task Analysis, HTA is performed to understand how an action is carried out and the different steps that are performed for that action (Bligård & Osvalder, 2014). The method breaks down a specific task with an overall goal into sub-goals and sub-tasks to specific actions that are carried out to achieve the overall goal.

3.4.3 Rasmussen's Abstraction Hierarchy Model

The Rasmussen's Abstraction Hierarchy Model (Table 4) is used to break down a complex work environment into different abstraction levels (Bisantz & Vicente, 1994). Higher levels of abstraction state the purpose and the function of the task at hand, while the lower levels states more physical aspects required to accomplish the task.

Table 4. The abstraction hierarchy adapted from Eggleston (2002, p.33)

Functional purpose	Domain Properties Represented
Purposes and Constraints	The purpose for which the system is being designed.
Abstract Functions and Priority Measures	The intended casual structure of the work environment represented in terms of the flow of values an abstract physical property.
General Functions	Description of the basic process of the system in functional language.
Physical Processes and Activities	Characteristics of the physical components associated with these processes and their connections.
Physical Form and Configuration	Characteristics of appearances and spatial distribution of physical components.

3.4.4 Nielsen's Heuristic Evaluation method

Nielsen's (1994a) Heuristic Evaluation model is a way to determine usability problems in user interface design that can result in errors. The method can be performed with the help of a scenario, where former observations have been carried out to understand the user's interaction sequences with the interface. A scenario can, based on observations on how a user performs a certain task be mapped out step-by-step. In order to evaluate the task performed, each step in the process can be graded on a scale based on the severeness of the problem that can occur in each step (Mörner, Strömstedt, Mörkdal, Holmgren, & Månsson Blomqvist, n.d). The grading is from 0 to 4 where 0 is no problem and 4 is usability catastrophe.

An analysis is made on each step of the task in reference to a list of recognised usability principles, also called the heuristics. There exist 10 usability principles; *Visibility of system status, Match between system and the real world, User control and freedom, Consistency and standards, Error prevention, Recognition rather than recall, Flexibility and efficiency of use, Aesthetic and minimalist design, Help users recognise, diagnose, and recover from errors,* and *Help and documentation* (Nielsen, 1994b).

3.5 Methods to state needs and requirements

The following section describes the methods used during the phase of identifying the needs and requirements of a future design solution. The investigated situation was complex with many different actors and aspects to consider. It was therefore valued by the thesis authors to conclude the needs and requirements in a structured manner and in multiple ways. This

approach was taken in order to ensure a comprehensive compilation, generating a graspable way of communicating the needs and requirements. This affected the choice of methods that were applied to compile the needs and requirements, needing it to be possible to evaluate towards when a concept had been created.

3.5.1 Persona

A persona is a fictive person that is used to describe the user in a design project (Wikberg Nilsson, Ericsson, & Törlind, 2015). The description of the persona is based on previously performed studies and research that is compiled into a description of a typical user and their characteristics. It is a way to communicate the needs and requirements of the user in a way that is more associated with a human being instead of through data and statistics. The role of a designer is to develop something that will meet the needs and requirements of people and a persona is a way to get closer to that state of mind, creating more empathy for the user.

3.5.2 Scenario

A scenario is a way to describe a persona in a specific situation (Wikberg Nilsson, Ericsson, & Törlind, 2015). Telling a story describing the situation and the conditions and how the persona would act in that context. This is a way to gain greater understanding of the persona, providing a more living picture of the persona by getting to know how the persona acts and their motivation in a specific situation.

3.5.3 ACD^3-method

The ACD^3-method is a user- and use- centred framework for the development process in design work and is performed to incorporate design decisions made throughout the process into a clear structure (Bligård, 2015). The ACD^3 is a way to communicate design solutions, while it is also used as a guiding tool of what should be done next in the design process at large. Being an activity-centred method, focusing on the interaction between the user and the interface, the design decisions made are described as the constraining of design variables instead of demands. Design variables are described as *how* a design solution can meet needs and requirements from the user, while demands are described as *what* should be achieved.

The ACD^3-matrix consists of three dimensions; *Levels of design, Design perspective* and *Design activities* (Table 5) (Bligård, 2015). The *Levels of design* are the columns in the matrix and defines the different levels of abstraction of the design solution. Moving from left to right, the design solution will be described more and more in detail. The demands on a future design solution is what indirectly connects the different levels of design together, where each step provides the conditions of what should be determined in the next. The *Design perspective* occupies the rows in the matrix and is defined as different approaches towards describing a design solution, moving from a general problem definition to a detailed realisation of a design solution. The *Design activities* are not visualised in the matrix itself but are the work that must be performed in the design process in order to identify the design variables in each box of the matrix.

Table 5. The ACD[3]-matrix adapted from Bligård (2015, p.10)

ACD[3]		Levels of design				
		Effect	Use	Architecture	Interaction	Element
Design perspective	Problem	Main problem	Use problem	Technical architectural problem	Interaction problem	Element problem
	Structure	User, stakeholder and context	Huma-machine system	Mechanical logistic architecture	Detailed divided machine	Logistic architecture element
	Function	Value and ability	System functions	Mechanical functions	Steering and information	Element functions
	Activity	Intended use and life cycle	User tasks	Overall interaction	Detailed interaction	Machine process
	Realisa-tion	Possibilities and limitations	Technical principles and entries	Overall design	Physical shape and user interface	Implementation element

3.6 Ideation methods

The following section describes the methods used during the ideation for a solution to the medical record and documentation system. The ideation methods were performed in several steps, providing iteration and exploration of ideas, followed by developing the generated ideas. It was important when choosing the method, to enable the possibility of involving other people in the ideation phase apart from the thesis authors. Involving other people creates different and new perspectives, thoughts and ideas. Since the thesis authors do not have medical knowledge, it was also of great value to carry out a method together with the user who sorted out important and desired aspects, necessary to be included in a future design solution.

3.6.1 6-3-5 Brainwritning

The method 6-3-5 is a brainwriting method where six participants generate three ideas during five minutes (Wikberg Nilsson, Ericson & Törlind, 2015). Those ideas are then passed counter-clockwise for the next participant to develop further. This is performed until each person has received the ideas that they started with. The ideas are then discussed and categorised.

3.6.2 Brainstorming

Brainstorming is an ideation process focusing on a quantitative creative process, generating a great amount of different ideas not taking feasibility into consideration (Wikberg Nilsson, Ericsson, & Törlind, 2015). The process is based on being inspired by other people's, or previously developed ideas. Ideas are then developed by changing or improving ideas or by combining different ideas together. Generating a great amount of ideas increases the possibility of getting inspired, creating ideas that later can be developed further with another ideation tool.

3.6.3 Focus group

A focus group is a session with invited participants chosen to have a discussion regarding the researcher's project (Parker & Tritter, 2006). The session's topic is decided by the researcher, depending on what kind of data the researcher wants to collect. Open-ended questions are asked, guiding the participants to open up for a discussion between the participants. The participant recruitment for the session should therefore consider the interaction between the participants, whether or not a discussion with good dynamics can be carried out. In the end, the insights from a performed focus group-session is the participants' attitude, opinions and experiences regarding the subject discussed.

3.6.4 Workshop

A workshop is a creative meeting with a group of people being the project's target audience, experts within the project's subject or people that have no connection or knowledge about the project (Wikberg Nilsson, Ericsson, & Törlind, 2015). A workshop is a creative session where the participant's creativity is used during the session to gain insights and get inspiration from the participants. The session generates ideas created by the participants, either based on information provided by the facilitator alone or based on presented ideas that are used as inspiration to develop during the session.

3.6.5 Card sorting

Card sorting is a way to evaluate content made in a project, against the users (Sherwin, 2018). Conducting a session of card sorting is made by preparing written topics on cards, for the user to examine and then group together based on what cards they believe belong together. The cards can be either digital or analogue and the topics should be expressed based on the users' mental models and should not be guiding for the project's advantage. The user can *think out loud* while grouping the cards together to reveal the user's thinking process while performing the task. A performed card sorting method generates knowledge about the user's attitude and their expectations. Card sorting is an adaptable method where the approach of the method depends on the project and what should be evaluated.

04.

Pre-study

To create a first understanding.

A Pre-study was carried out to establish knowledge about how a health care centre operates and possible situations that affect the cognitive load of the medical staff, on an overall level. The Pre-study was based on identified theory from the literature search (Chapter 2).

4.1 First observations

To understand how the staff at a health care centre work, observations (Chapter 3) by the thesis authors were performed at the health care centre assigned for the project to perform studies at.

4.1.1 Procedure

The knowledge and insights from the literature review (Chapter 2) was collected and used to establish an observation template (Appendix 1) with guidelines on what to look for when observing medical staff. All human factors aspects were taken into consideration in this stage in order to map out the situation and the context. Aspects to observe were how the individual work at the medical centre, while also how everyone work together and which organisational aspects that affect their work. Observing the use of the physical environment was also beneficial to investigate the physical load of the medical staff and too see if the environment was used to the medical staff's advantage in some way. The cognitive ergonomics was also studied to map the situation, since it is the scope of the project.

The medical staff was at the health care centre shadowed and observed by one thesis author during half a working day or a whole working day. The roles observed were two doctors, one nurse, one emergency doctor, one emergency nurse, one district nurse, one nurse at vaccination, one nurse at the diabetes department, two in reception and two assistant nurses at Lab. During the observations, unstructured interview questions from the thesis authors were asked to get deeper knowledge, and to understand why the staff are working or doing things in a certain way. Everything observed was noted by hand, on paper by the thesis authors and later compiled in a KJ-analysis (Chapter 3). The KJ-analysis was for the project performed digitally in the web-based design platform Figma (Chapter 3) due to the great amount data collected, limiting the amount of post-it used during the process of the project.

4.1.2 Findings

The observation created knowledge of the work being carried out at a health care centre, which roles are involved at the health care centre, and how those collaborate with each other. The work performed is very physical, the staff is most often moving and examining the patients but does also sit still in front of the computer. The staff is very aware of the importance of working ergonomically correct and have routines for that. Organisational factors affect the work carried out at the health care centre to a large extend since that steers the routines and guides the staff in what tasks that should be performed. There are routines for how to document, how to order sample tests and how to send a referral.

A flowchart of how the patient transfers between different roles within the health care centre (Figure 7) and a flowchart of how the medical staff interacts with each other could be mapped out (Figure 8). These flowcharts illustrate the great number of departments involved at a health care centre and how each department is necessary for the health care centre to carry out their work. Critical points, within the health care centre, where a lot of information is collected or sent out is also illustrated in the flowchart.

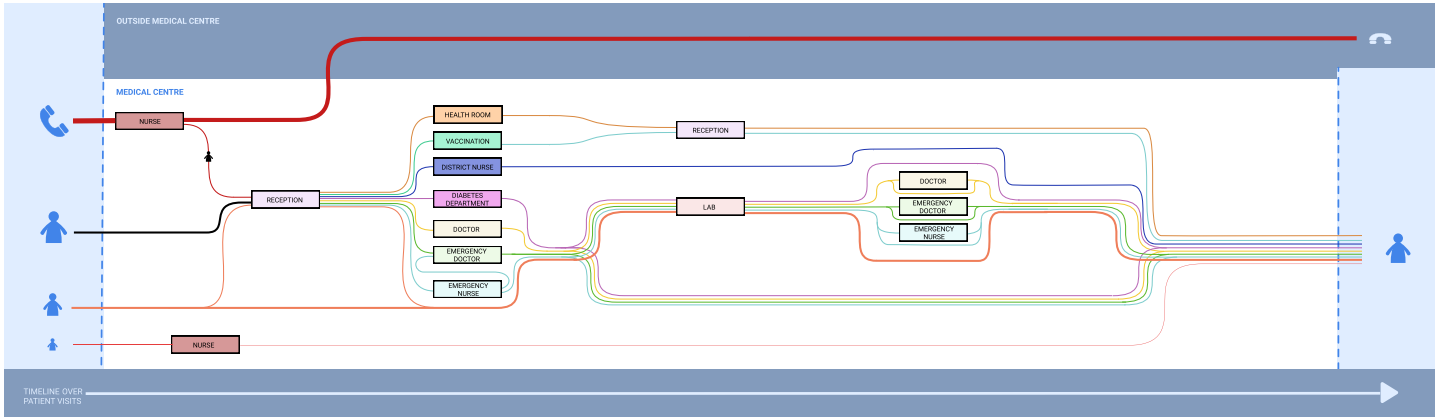


Figure 7. Flowchart over patient's journey at a health care centre

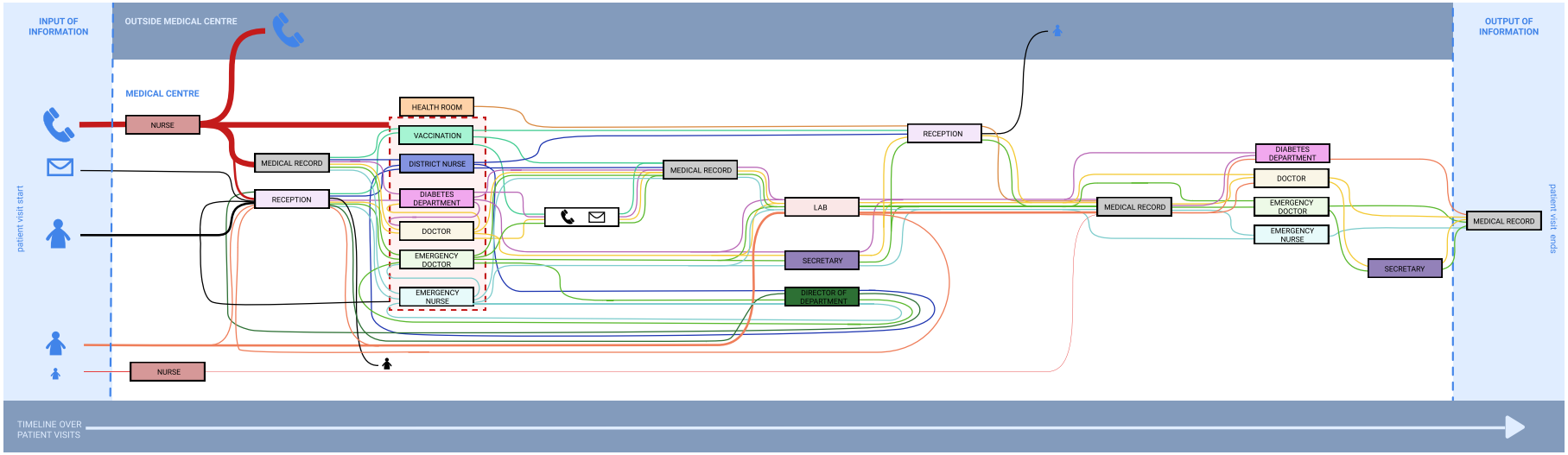


Figure 8. Flowchart over the contact between medical staff

The health care centre is a goal-oriented system that wants to cure and help patients into feeling better. The health care centre is a system with many different actors, routines and tasks, all contributing to the high complexity of the system. The health care centre's complexity is depending on the number of actors involved, the tasks of evaluating and analysing people's conditions and the information flow. The circumstances of a situation can quickly emerge or change. It can therefore be very difficult to foresee what will happened or what the consequences might be, when the same action does not always generate the same result.

The medical staff within the system is working both proactive and reactive when performing their tasks. The medical staff is taking actions from the provided information from patients, colleagues and the medical records when mapping situations. The medical staff is, at the same time, using feed-forward by making assumptions about next steps, possible diagnosis, order test samples or other possible actions to be more effective and efficient, saving time.

4.2 Problem cases

As a result of the flowcharts and the KJ-analysis different problem cases could be established. Each problem case is presenting critical points in terms of cognitive aspects identified by the human factors approach of the observations.

4.2.1 Roles at the health care centre

The roles within the health care centre that stood out as roles with a high cognitive load in one way or the other is presented in Table 6.

Table 6. Problem cases about roles at the health care centre

Problem case	Description
Doctor	A doctor at the health care centre has a lot of in- and output of information to and from multiple channels. The information provided needs to be analysed in several steps, and requires immediate decision making.
Assistant nurse at Lab	The Lab is somewhat of a bottleneck at the health care centre. A lot of information from different channels and roles within the health care centre meets at Lab, to be processed under time pressure and then distributed to the correct location.
Nurses making time bookings	Nurses and district nurses at the health care centre that receives and calls for patients in need of time appointments receives a lot of information, mainly auditive, through the phone. That information needs to be processed a decision has to be made under time pressure, due to the great amount of patients calling the health care centre during a day.
Reception	The reception at the health care centre is the first touch point for the patient visiting the health care centre, affecting the patient flow within the health care centre. The reception is also a crossroad within the health care centre where the personnel has interaction with each role within the health care centre, either digitally or in person, resulting in a lot of information going through the reception.

4.2.2 Information flow

The flow of information within the health care centre is complex, a lot of different roles are communicating between each other, both digitally and verbally. Information can easily be missed or forgotten if it is not communicated properly. The identified information flows are presented in Table 7.

Table 7. Problem cases about information flow

Problem case	Description
Information flow within the health care centre	A health care centre contains a lot of different roles that need to be able to communicate amongst each other. For the staff's work to go as smoothly as possible, and for the patient to have an as smooth journey through the centre as possible information needs to get to the right person at the right time.
Doctor and Lab	A specific flow of information noticed is the communication between a doctor and Lab. A patient is usually sent back and forth between a doctor and Lab, which requires the communication between these roles to go smoothly for each role to know what tasks that has been carried out already and what should be done.

4.2.3 The team

The patterns in terms of staffing and the course of action when each person within the medical staff is not present during a day is a factor that has an impact on the working day at the health care centre, and is further presented in Table 8.

Table 8. Problem cases about the team

Problem case	Description
Staffing patterns and workflows	Each person within the staff at the health care centre has a central role for the health care centre to work smoothly. Whenever some staff within a role is missing, the other people having the same role need to work harder and sometimes overtime. External workforce is also taken into the health care centre when needed, like locum, relay or consult doctors. External workforce limits the possibility of keeping continuity for the patients, while also not always making it possible for a doctor to get to know a patient and their medical history.

4.2.4 Other aspects

Apart from the staff and the information flow other aspects were recognised as influential factors in terms of the cognitive load on the medical staff. These aspects are presented in Table 9.

Table 9. Problem cases about other aspects

Problem case	Description
Reading and documenting in the medical record and documentation system	Meaning the electronic medical record and practice management system. The patient's journey through the centre has a lot of touch points, and depending on the patient's pathway between different roles at the health care centre, several people within the medical staff has to interact with the patient's medical record at multiple occasions. It is therefore important that the information provided in the medical record is correct for the staff to make a correct estimation of the patient and their wellbeing.
The patient's location	The patient's journey through the centre has a lot of touch points, depending on the patient's pathway at the health care centre. There are therefore needs of a clear communication between the different departments, so it is understandable where the patient is going, to whom and why.
Time pressure	A health care centre can be a stressful, high pressure environment to work in with high time pressure and stress for the entire medical staff. The profession itself demands high level thinking, analysing and making fast decisions, and doing that under great time pressure can have the outcome of information being forgotten, easily being distracted and making incorrect conclusions and decisions.

4.2.5 Choice of problem case

One problem case was chosen to investigate further in order to manage within the time limit of the project and to investigate cognitive ergonomics aspects the affect the situation. The problem case chosen was the task of *reading and documenting in the medical record and documentation system*. The medical record and documentation system used at the health care centre, and within the region of Västra Götaland is AsynjaVisph. The choice of problem case was made based on to what extent the different problem cases could result in medical errors, and whether the risk could be decreased with the help of a design solution. However, other aspects from the remaining problem cases could be implemented in the problem case to set the scene of a situation to focus on, to make the problem case more tangible. The choice was therefore made to focus on the reading and documenting in the medical record within the scenario of a specific patient journey. The scenario is set to be that the patient calls the health care centre to book an emergency appointment the same day, gets a doctor's appointment, is being sent to Lab for tests, to later be sent back to the doctor for a follow-up of the test results. This choice of scenario was made to include both the *patient location* and the *information flow* with most cognitive load. Being an emergency appointment that the patient is making is due to the fact that that is the most common scenario when both the patient and information regarding the patient is sent back and forth, between different roles within the health care centre during the same appointment. An emergency appointment is also scheduled with great time limit for the doctor, requiring the doctor to make decisions under high *time pressure*.

4.3 Takeaways

The health care centre is a complex working environment with many different actors, and with a great amount of information and tasks. The overall goal of the health care centre is to make the patient feel better, and the activities at the health care centre surround that goal. The medical staff is aware of the severity of the situation and the importance of performing their tasks correctly.

The work is affected by cognitive and organisational factors to a great extent. Problem cases within cognitive ergonomics areas were identified based on the Pre-study, with the possibility to be investigated further on. The chosen problem case concerns reading and documenting information to the medical record and documentation system, in combination with handling patient location and information flow to set the problem case in a scenario. A design solution, as a user interface design, was judged as possible to be developed in this area to improve the situation.

05.

User study

To deepen the understanding.

A user study was carried out to gain deeper knowledge about the chosen problem case. The theory identified by existing literature (Chapter 2) and findings from the Pre-study (Chapter 4) was applied and used as a base throughout the User study. Several activities were performed to collect data and information. The findings from the user study will be used as input to the Cognitive ergonomics analysis (Chapter 6).

5.1 Booklet "My workday"

With initial understanding of a working day at a health care centre through the Pre-study (Chapter 4), the next step was to get further insights of the medical staff's general experience of a working day.

5.1.1 Procedure

A diary study (Chapter 3) was performed by developing a booklet that was handed to the staff and the health care centre to gain insights about cognitive ergonomics aspects of the medical staff's working situation and tasks (Appendix 2). Handing the medical staff booklets with tasks to do by themselves made it possible for the thesis authors to collect data without being physically present at the health care centre. The purpose with the booklet was to identify the medical staff's attitudes, emotions and working situation identified from the literature review (Chapter 2) and the Pre-study (Chapter 4). The booklet consisted of six different assignments, which were performed during five consecutive days. The assignments in the booklet were:

- How many patients the individual is in contact with during a working day
- An emotional wheel
- A stress level curve
- Map out the interaction between colleagues during a working day
- Imagining the perfect workday
- What one does after finishing a workday

The participants of the diary study were two doctors, one district nurse, one assistant nurse at Lab, and one nurse. The booklets were compiled and summarised, trying to identify patterns and different connections and/or variations between the different roles.

5.1.2 Findings

The findings from the performed booklets "My workday" show that there are differences in how many patients the staff is in contact with, experienced emotions, levels of stress, how much interaction there are between colleagues, their perfect workday and what one does after work. The participants were in contact with anything between a dozen to hundreds of patients during a day. The contact with other colleagues differed from just a few colleagues to a dozen. Their perfect workday and what they do after a workday also differed. It is therefore difficult to draw any general conclusions about these tasks. What can be concluded is that the medical staff's work situations differ from each other, which is reasonable since each person is unique.

Emotions experienced during a working day was established in the booklet with a Geneva Wheel of Emotions and is displayed in Figure 9, where the black dots represent the answers.

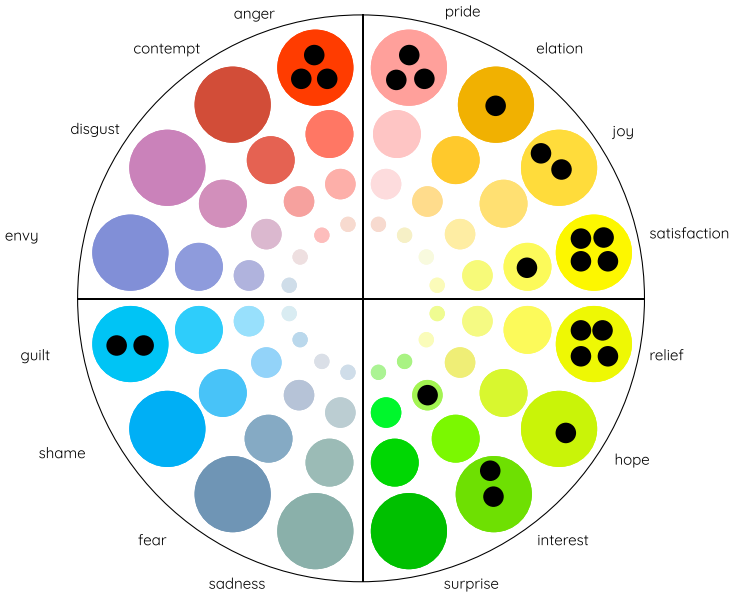


Figure 9. Experienced emotions compiled from all “My workday”-booklets

A lot of emotions were similar between the participants, two at a minimum, showing some cohesion within the medical staff. All emotions were not explained by the participants why they appeared, while some that were explained were not caused by the day-by-day working tasks but more because of an occasion or circumstance that did not occur often.

The level of stress that a person feels during a working day is displayed in Figure 10, where the horizontal axe is the timespan of a working day and the vertical is the experienced level of stress.

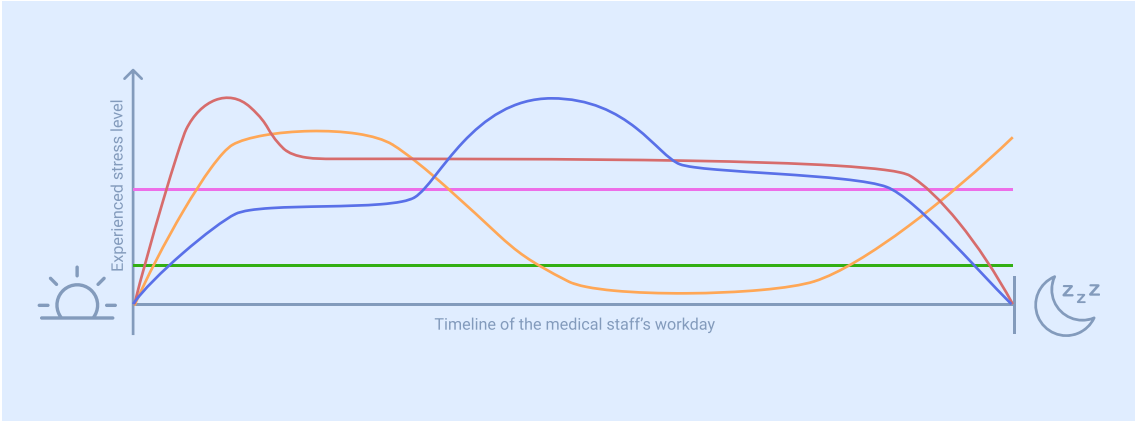


Figure 10. Stress level curves compiled from all “My workday”-booklets

The stress level curve differed depending on the role at the health care centre. The role of a doctor had a flat curve, without any variation in the level of stress experienced. While the other roles that participated had more ups and downs, and a greater amount of variation in their experienced stress levels. The last exercise of the booklet showed that this might have an impact on their life when the working day is over. The task was to describe what they do after a completed working day, and those with more variation in stress level did not have energy left to do more than the most necessary, while those with a flat curve had energy left to do more activities.

5.2 Medical record and documentation system observations

Based on the performed literature review (Chapter 2) and Pre-study (Chapter 4), observations were performed with focus on the chosen problem case, in terms of the medical staff's interaction with the medical record and documentation system.

5.2.1 Procedure

An observation (Chapter 3) was carried out with a template that was developed as guidance for the thesis authors, containing aspects to observe, like the usage of the medical record and documentation system and cognitive ergonomics aspects (Appendix 3). The purpose of this observation was to get deeper understanding of the usage of the medical record system, and attitudes and thoughts regarding the system. The observation was performed by shadowing and observing two doctors, one district nurse, one assistant nurse at Lab and one nurse, by the people in the thesis authors separately. The thesis authors asked questions during the observation with support from the observation template to get deeper understanding and insights. The thesis authors took notes during the observation regarding what was observed and discussed. The notes were later summarised.

5.2.2 Findings

The observations contributed to a basic understanding of how the medical record and documentation system is being used within the problem case scenario. This basic knowledge was used as input to the description of the system in Chapter 5.3 where these findings will be presented in its whole.

The observation also resulted in main conclusions regarding the circumstances for the medical staff and their attitudes when using the system. The attitudes observed were the following:

- The user needs to check a lot of files/documents, both before and after a patient visit, where each file/document is displayed one separate window in the interface.
- The system does not enable direct communication between the users. A chat forum exists, but there is no routine of using it, and information is usually shared verbally.
- Communication of routines and information within the health care centre is lacking.
- The staff are aware that they should document each patient visit/call.
- The staff are aware that they should do a certain task according to the health care centre's routines, but sometimes take short cuts, creating their own ways of doing it.

5.3 Description of the medical record and documentation system

A description of the medical record and documentations system AsynjaVisph with an employee at the health care centre was carried out. The description session was performed to create an understanding of how the system is being used in the chosen problem case scenario.

5.3.1 Procedure

A basic understanding of the medical record and documentation system was established by the observations of the system (Chapter 5.2) and was used as a basis for this description. To get a more detailed picture of the system and to confirm previous findings, a description of the system, going through each action possible to perform in the system, with the thesis authors and an employee of the health care centre was performed. The purpose was for the thesis authors to understand the basics of the system, available functions and how it is used in a calm and quiet setting, compared to during the observations. A template was developed and used with aspects to review and ask during the description (Appendix 4), based on what the thesis authors needed to know to investigate the system further. The description was audio recorded and notes were taken during the meeting. The insights from the walkthrough is input to a Hierarchy Task Analysis, HTA (Chapter 3).

5.3.2 Findings

Every medical role within the problem case scenario uses the medical record and documentation system. Information from the medical record is read and documented by each role. Nurses on the phone and doctors book time slots at the health care centre and at Lab. Each role is using different functions in the medical record and reads different kind of information in the medical record, retrieving the relevant information for their individual tasks. Information is being transferred between the personnel at the health care centre through the system.

The description of the interaction with the medical record and documentation system resulted in one overall HTA and four additional HTAs focusing on each sub-goal in the overall HTA. The overall HTA displays the overall goal and which tasks that are being performed in the chosen problem case scenario (Figure 11). The HTA's for the sub-goals are available in Appendix 5. The mapping of how to perform the different tasks in the problem case scenario shows that there is a great amount of actions required to be performed to reach the goal. Each role works with their own individual work task, but also works as one unit, contributing to achieving the overall goal. The goal for the problem case is to diagnose and cure patients with emergency conditions, helping the patient to feel better.

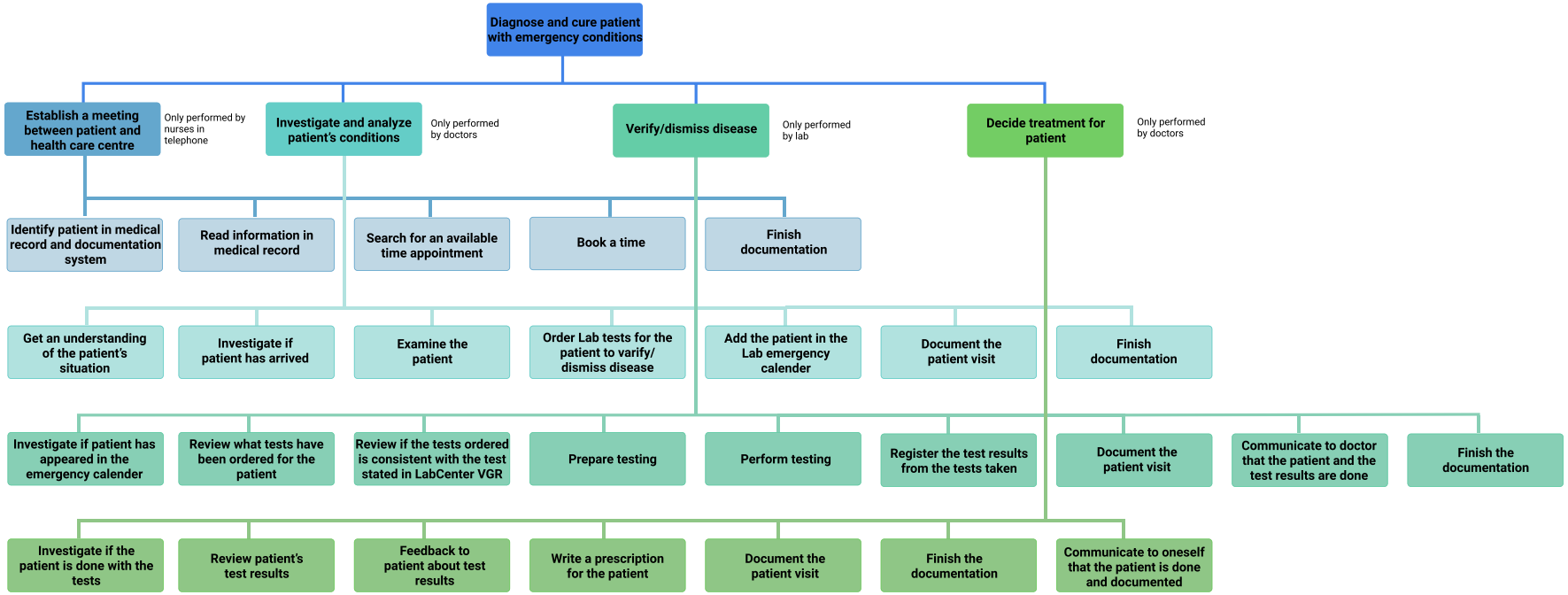


Figure 11. Overall HTA for the tasks performed in the chosen scenario

5.4 Usability testing

A usability test for the medical record and documentation system AsynjaVisph was performed to gain deeper insights about the usage, feelings and thoughts of the identified actions when using the system.

5.4.1 Procedure

The usability test was structured as a thinking out loud session in combination with a semi-structured interview (Chapter 3) (Appendix 6). The purpose was to identify attitudes towards the system within the medical staff and how the system is being used by different individuals. The chosen problem case scenario was presented for the participants in order for them to describe and show how they would proceed and use the medical record and documentation system in that situation. This was followed by a more general interview about their experiences with the system. The end of the session was then finished off by each participant filling out a Geneva Wheel of Emotion (Chapter 3) regarding their emotions when using the medical record, one wheel for when they read and another for when they document something in the system. The session was audio recorded, and later transcribed and was performed separately with two doctors, two nurses on the telephone and two assistant nurses at Lab by one thesis author. The findings were finally summarized as conclusions.

5.4.2 Findings

The findings from the usability test show how the previous stated tasks are being performed and the attitude towards the medical record and documentation system. The tasks of reading and documenting information are facilitated by experience of the software. So, the way of performing the task is influenced by previous experience but also by the situation at hand. Each person has therefore their own approach to the different tasks of reading and documenting in the medical record and documentation system. Shortcuts, routines or tricks are being used by the medical staff in order to ease their workload and to work more efficiently. The staff do sometimes for example prepare themselves before patient visits by reading information in the software. The interaction with the system has sometimes resulted in incorrect actions. Errors are however usually caught early by the person that made the mistake or by a colleague, not going as far as generating negative consequences for the patient.

The emotions experienced when reading respectively documenting in the medical record and documentation system is displayed in Figure 12 and Figure 13, where the black dots represent the answers.

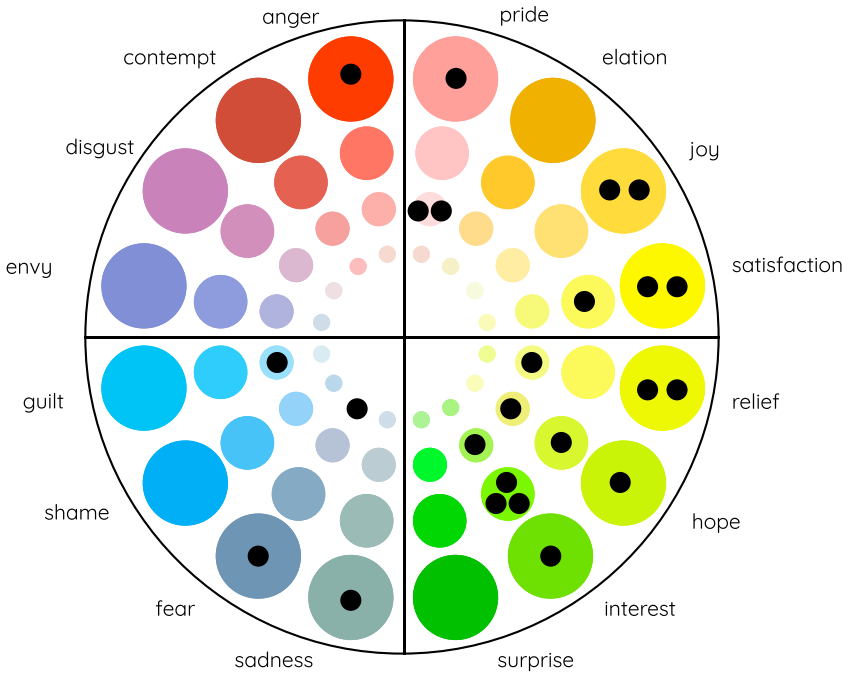


Figure 12. Experienced emotions when reading in the medical record and documentation system, compiled from all usability test

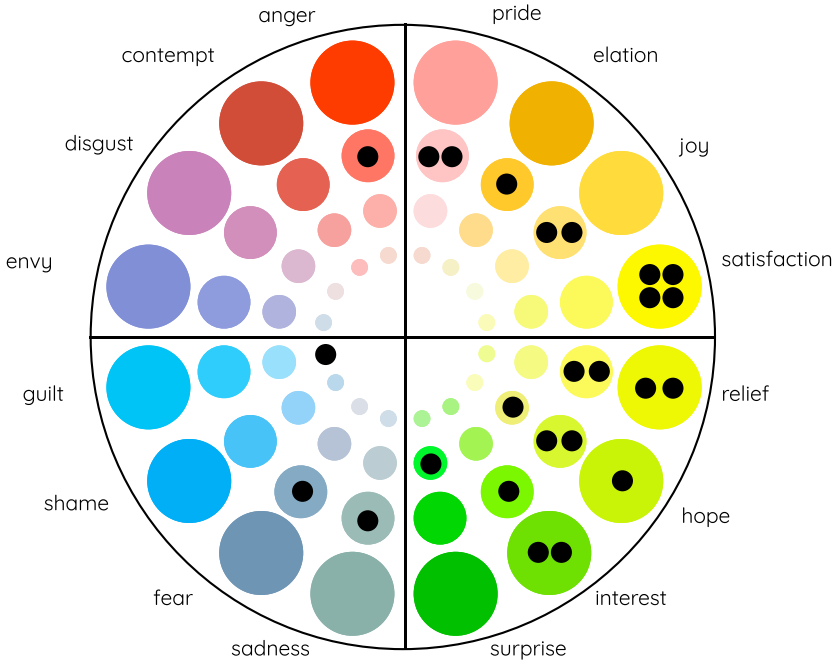


Figure 13. Experienced emotions when documenting in the medical record and documentation system, compiled from all usability test

5.5 Booklet “The Medical record and I”

An activity with focus on the workload in connection to the medical staff’s usage of the medical record and documentation system was carried out. This was done to understand what affects the workload during use.

5.5.1 Procedure

To get a deeper understanding of the medical staff’s workload, a version of Nasa-TLX was carried out. A diary study (Chapter 3) was carried out by creating a booklet with the same structure of the existing Nasa-TLX application to be able to perform the method right after finalising the tasks of reading and documenting in the medical record and documentation system (Appendix 7). The tasks were to be carried out during three working days. One day filling in one Nasa-TLX for both the task of reading and the task of documenting in the medical record and documentation system, and then repeating that for three days. This to create an understanding if the workload regarding the usage of the system differed depending from day to day or not. The booklet included both the rating scales and weighing the aspects against each other.

Four booklets from the individuals at the health care centre were collected and the results from the booklets were transferred to the Nasa-TLX application for iPhone for generating the result of the subjective workload. Both the rating and the adjusted value were analysed to see if there were any differences.

5.5.2 Findings

The result from the NASA-TLX method showed that some aspects affect the task of reading (Figure 14) and documenting (Figure 15) in the medical record and documentation system more than others. The rating and the adjusted value of the tasks were compared and for the most cases the three most impactful aspects of the mental workload correlated. The analysis of the results from the method will from here on be based on the adjusted value because it displays greater differences between the aspects. The results in its whole is available in Appendix 8.

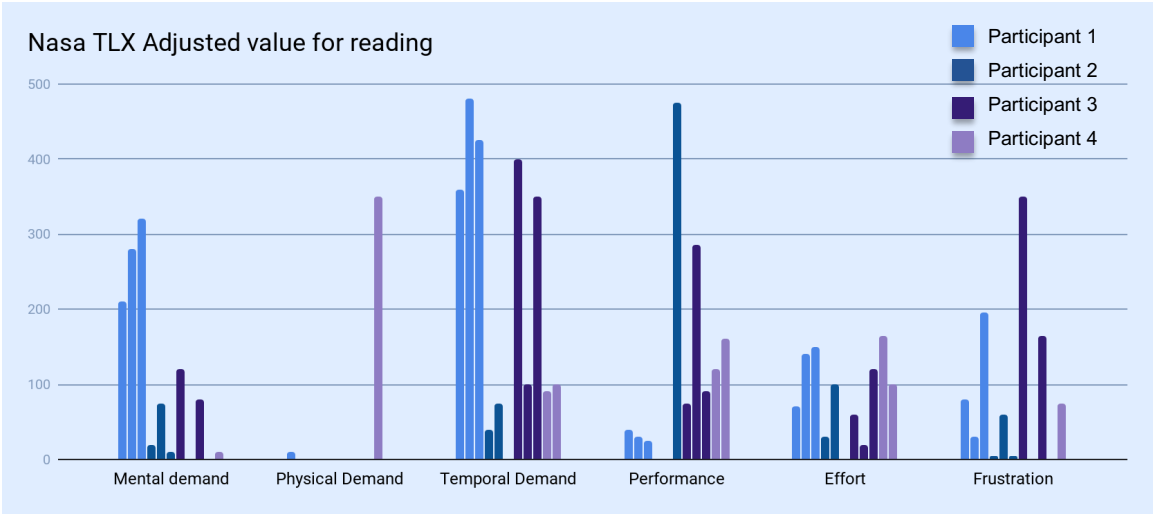


Figure 14. Adjusted Nasa TLX value for reading, for four participants for three days

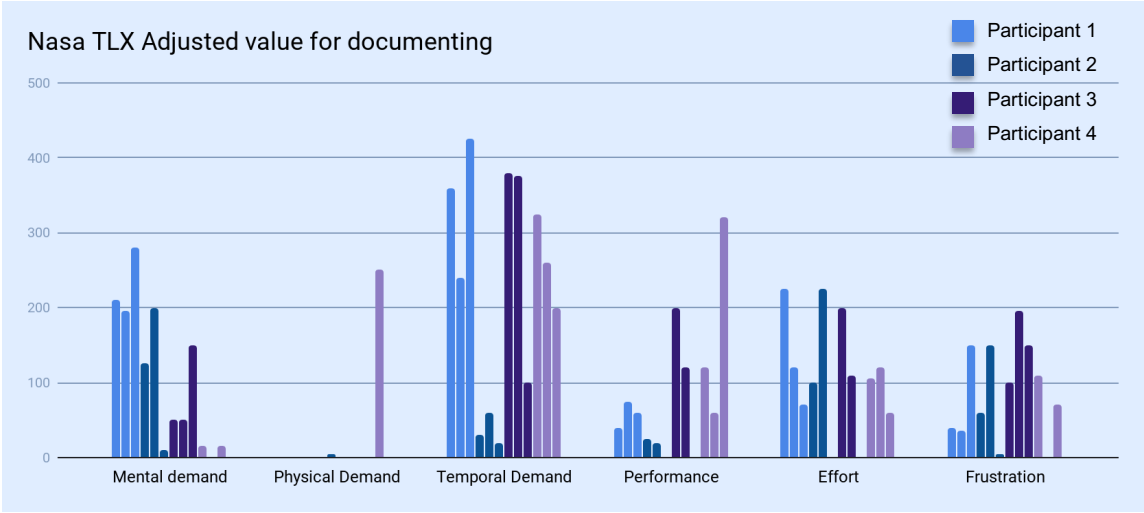


Figure 15. Adjusted Nasa TLX value for documenting, for four participants for three days

One aspect that do not affect the perceived mental workload for reading and documenting by the medical staff is the physical demand, the tasks do not require much physical activity. The performance is also an aspect that do not have an impact on the perceived mental workload, the staff is generally satisfied with their performance and successful with carrying out the tasks. The remaining four aspects; mental demand, temporal demand, effort and frustration level were perceived to contribute to the workload of the participants. There are individual differences between the participants to which extend these aspects affect the mental workload and differences between the task of reading respectively documenting information in the system.

Differences are possible to identify between the different days where the method was performed. This indicate that there are differences in how much mental workload that are required to use the medical record and documentation system, depending on the individual, the task and the day.

5.6 Cambio COSMIC Interview

According to an analysis made by Myndigheten för vård- och omsorgsanalys, the Swedish Agency for Health and Care Services Analysis (2016) the medical record and documentation system that medical employees are most pleased with within primary care all throughout Sweden is Cambio COSMIC. It was therefore of interest to study this software as a benchmark.

5.6.1 Procedure

To get a clear understanding of the benefits with using Cambio COSMIC, a semi-structured interview (Chapter 3) with a nurse at the children's hospital in Uppsala was carried out. The intention with the interview was to get inspiration from the Cambio COSMIC system, both regarding its assets and liabilities, for the development of a new medical record and documentation system.

The interview was carried out digitally through the conference software Zoom (Chapter 3), with a template about what to discuss (Appendix 9). The Cambio COSMIC interface was not used or displayed during the interview due to the interviewee being quarantined at home and did therefore not have access to the software. Information regarding the advantages and disadvantages with Cambio COSMIC was gathered out of the perspective of working as a nurse at a children's hospital. However, during the discussion the interviewee tried to picture themselves working within primary care to get an understanding of what, within the Cambio COSMIC system that would be useful for primary care in particular.

5.6.2 Findings

The interview resulted in conclusions regarding the usage and functions of that system. The conclusion is presented in this chapter.

The Cambio COSMIC medical record and documentation system uses guidance and feedback. Health care plans for new patients are for example already prepared within the system, with different plans having different levels of guidance. One level is locked for cases when the care procedure should be the same for all patients with a particular diagnosis, while the other levels require more decision making by the user but is still guided by the system through headings and lists.

Whenever a deciding task is performed in the Cambio COSMIC system, like making prescriptions, the system reacts whenever a task does not seem accurate. If high dosage prescriptions were carried out, the system questioned the high number, which required the user to double check their action, with the intent of preventing errors.

When reading in Cambio COSMIC the user is mainly presented with the latest updates about the patient and can choose for themselves to read about information documented prior to the latest updates if needed. For reading and getting an understanding of a patient situation within primary care, the interviewee speculated, presenting the latest updates could be applied in an overview. What should be presented to get an overall understanding about a patient's situation

in an overview would then be the latest diagnoses, doctor note and appointments, while also future planned appointments, and readings from test results, according to the interviewee.

Whenever a referral is carried out by the user, that referral can be tracked in the Cambio COSMIC system. It is possible to see the status of the referral, who ordered the referral, when it was ordered, if it is received, under process, or if it is done and can be viewed in the patient's medical record. With this tracking system it is possible to have constant supervision of the referrals, minimising the risk of test results being missed or forgotten.

5.7 Takeaways

The performed User study generated deeper knowledge within the problem case and generated insights that will be used further when mapping the situation and developing the design of a user interface.

An understanding of the preconditions within the health care centre and for the medical staff, both on an individual level, as well on an organisational level, has been established even further. The health care centre depends on each employee to perform their part and provide information in order for the scenario to be carried out. If this does not happen or if it is incomplete, it can be difficult to achieve the overall goal which could lead to the patient not being treated with the most suitable approach. Interplay and collaboration are therefore of great value to be functional and successful.

The results show that there exist different working patterns regarding the usage of the medical record and documentation system. The working patterns depend on the task that should be performed and differs between the medical roles. The patterns are also depending on the individuals within each role and their experiences and knowledge of the medical record and documentation system.

Further insights and inspiration for the user interface design were provided through the study of Cambio COSMIC. The use of guidance and feedback can be used as inspiration when designing a new solution for a medical record and documentation system. Showing the most relevant information for the situation, providing the possibility of getting further information if needed, are also useful aspects to take into consideration for forthcoming ideation.

Considering all presented conclusions from the user study is necessary for the further work in the project. The conclusions contribute to an understanding of the situation at the health care centre and for the medical staff which is beneficial when analysing the findings further. The insights and conclusions from this phase will be deepened and further analysed in Chapter 6 which addresses cognitive ergonomic aspects. The findings from this chapter can also later be used as inspiration when prerequisites to a solution will be stated.

06.

Cognitive ergonomics analysis

Of the identified findings.

An analysis of the collected data and information from the Pre-study (Chapter 4) and User study (Chapter 5) was performed. The collected data was used as input to the analysis of presented theories and methods stated in Chapter 2 and 3 about cognitive ergonomics.

6.1 Mental models and expertise

The approach a person has when interacting with an object, interface, or whatever exists in their surrounding is determined by that person's mental models (Chapter 2). The established mental models of the medical staff within the problem case will be presented in this section.

6.1.1 Procedure

Determining the mental models and expertise of the medical staff at the health care centre was made possible by applying the frameworks of mental model presented in Chapter 2. The mapping was made in two stages throughout the thesis authors' working process. Both analysis occasions were conducted based on the insights from the Pre-study (Chapter 4) and User study (Chapter 5). To support the analysis, Rasmussen's Abstraction Hierarchy Model (Chapter 3) was used as guidance. The aim with this activity was to understand different ways of working by the medical staff.

The first iteration of analysis of the medical staff's mental models was carried out to get a quick overlook and to understand what insights were missing from the previous performed activities. Secondly, further analysis of mental models was conducted, based on new insights from the User study (Chapter 5). More detailed conclusions of the mental models within the health care centre could then be determined. The following sections will present the results from the analysis and the reasoning of the theories and collected data.

6.1.2 First iteration of Mental models

The mental models of the medical record and documentation system determined were during the first iteration of the analysis with the use of the Abstraction Hierarchy Model are displayed in Table 10.

Table 10. The identified mental models with the Abstraction Hierarchy Model.

Hierarchy	Reading	Documenting
Purposes and Constraints	Create a perception regarding a certain patient.	Documenting information perceived regarding a certain patient.
Abstract Functions and Priority Measures	Information flow.	Information flow.
General Functions	Retrieving information and data regarding a certain patient.	Storing information and data regarding a certain patient.
Physical Processes and Activities	Reading, Clicking with mouse.	Writing with keyboard, Clicking with mouse, Dictating with recorder.
Physical Form and Configuration.	Computer, Keyboard, Mouse, Light grey coloured screen, Pen and paper.	Computer, Keyboard, Mouse, Light grey coloured screen, Pen and paper, Recorder.

The main take away from the use of the Abstraction Hierarchy Model was the ability to state what is being used in the situation of reading respectively documenting in the medical record, why that is used and what the general goal is with the task.

6.1.3 Second iteration of Mental models

The mental models observed for when the medical staff is reading in the medical record and documentation system is displayed in Figure 16, and Figure 17 is instead displaying the mental models when the medical staff is documenting. Occasionally the medical staff adapt and changes their way of acting regulated by the situation and circumstances at hand. However, it was clear that most people are more or less prone into choosing one way over the other, and that is how they act during the majority of times.

The overall outlook on reading information the medical record and documentation system is the importance of getting all information needed to acquire an understanding of a patient's situation and history (Figure 16). Reading a patient's medical record provides a lot of important information required for the staff to be able to make well-founded decisions about a patient's situation. Different levels of mental models, and the medical staff's approach when performing the task of reading information in the system is described in Figure 16.

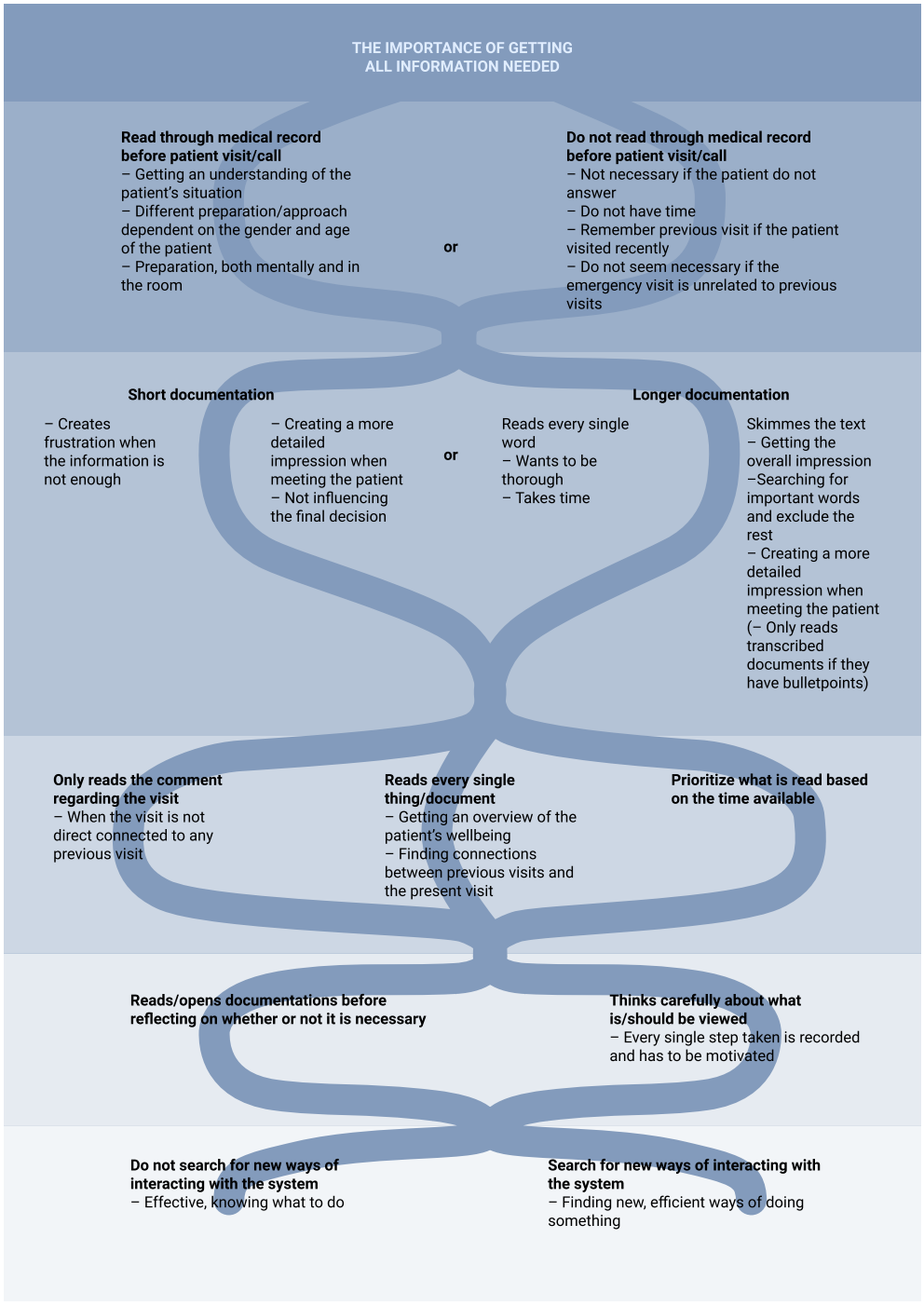


Figure 16. A hierarchy of the mental models when reading in the medical record and documentation system

The overall outlook on documentation information to the medical record and documentation system is the importance of documenting out of providing medical information about the patient for the next person reading the medical record (Figure 17). Different levels of mental models, and the medical staff's approach when performing the task of documenting information in the system is described in Figure 17.

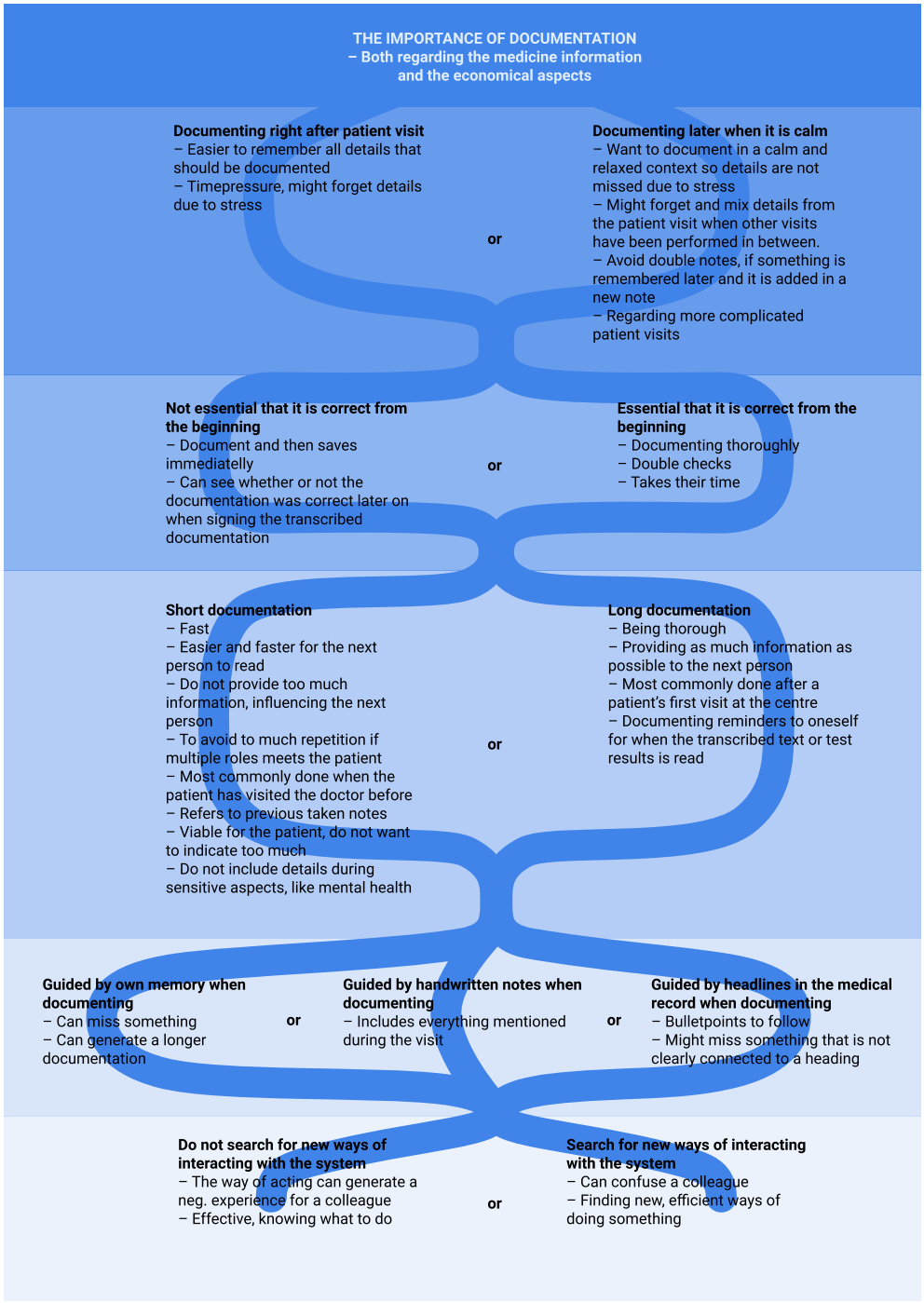


Figure 17. A hierarchy of the mental models when documenting in the medical record and documentation system

6.2 Attention, awareness and mental workload

Attention and awareness are a part of our daily lives since we are using our senses and are taking in information from different situations constantly. How the medical staff handle their attention, awareness and mental workload is discussed and reasoned in this section.

6.2.1 Procedure

To understand how the medical staff cope with their attention, awareness and mental workload and resources, the collected information from the Pre-study (Chapter 4) and User study (Chapter 5) has been applied to the presented theory within these areas (Chapter 2). The theory was used as a starting point and a base for reasoning within the chosen problem case scenario. The method Nasa-TLX (Chapter 3) was performed in the User study (Chapter 5) and the results will be reasoned further in this chapter. The result of the analysis within attention, awareness and mental workload area is presented in the sections below.

6.2.2 Sensory processing

When receiving information from the medical record, for both doctors, nurses on the telephone and Lab, stimuli is being provided at the computer screen, through the visual sense, and by navigation through the system for the medical staff to read. Feeding information to the medical record is also represented by the visual sense by looking at the medical record. When interacting with patients, information and stimuli is presented through the auditory sense, in particular for the nurses on the phone where information is provided verbally from the patient over the phone.

Stimuli and information are mostly retrieved by the visual and auditory sense throughout the whole scenario. This could indicate that those senses are overloaded and over-represented, generating absence of access of mental resources to be able to perform other tasks and actions that require the same resources. However, the tasks of reading and documenting are not always being performed at the same time, which could decrease the load. When interacting with a patient however, reading or documenting information to the medical record and documentation system could be performed simultaneously. These tasks could then interfere with each other, and the performance of the tasks would be affected.

6.2.3 Awareness for the situation

The medical staff's attention and awareness are depending on factors that concern the task itself, the environment that the task is being performed in and to a larger extend also the individual performing the task. A lot of functions in the medical record system require that the personnel update the system oneself, requiring the individual to create awareness about situations themselves. The individual's attitude, sense of responsibility and psychological state could also be aspects that affect an individual's ability regarding attention and awareness. It could also be depending on the individual's inattention, memory failure, fatigue and workload.

Reading information

The awareness of reading information in the medical record is mostly created by the individual, deciding oneself what to read and what to highlight in the medical record. It is the worker's experience and created routines that affects how and what they make themselves aware of during the upcoming patient visit and what the attention should be directed to during the visit. The medical staff read information, interpret the information and draws conclusions about the information, deciding what to do next. The reading itself is not complex but it is of great value

that it is performed correctly so that the right action forward can be taken. The medical staff need to make sure that the most current information for the situation at hand is received and is quickly scanning the documentation for "keywords" that may be relevant for the patient's current situation. This is mostly done right before, or during the contact with the patient. The task is most often performed under time pressure and the reading and interpretation of information needs to therefore be performed quickly. The medical staff is mostly working proactive before visits when reading the medical record, creating awareness about the situation. However, during the patient visit the medical staff is more work reactive depending on information that the patient tells the medical worker.

Documenting information

The awareness of documenting information is a well-established routine of the medical staff's way of working and individuals have created routines of how to perform the documentation. The documentation is performed in an effective and efficient manner with high level of attention to recall the information from the contact with the patient during a short, available period of time, after a visit until the next patient, knowing the importance of making it correctly. There is most often no time to double check the documentation, the attention is during execution fully directed to the task. If one is disturbed, time is required in order to return to the task and reflect upon what one was doing.

The documentation can be performed proactive, forecast what could happened and document that. Documenting information to the medical record is a complex task since it involves a lot of information to process and since a decision must be made of how to move forward.

6.2.4 Processing information

The medical staff has a constant flow of information and is constantly processing that information. The worker must have available mental resources so that the awareness and attention can be directed to the most essential aspects, otherwise essential information can get lost.

The working memory is a central part of the medical staff's work since a lot of information of the patient's situation and condition is stored in the working memory, in combination with information from previous patients and recent cases. The medical staff has created routines and way of working, for both administrative and medical, which is stored in the long-term memory. That knowledge is constantly retrieved from the long-term memory, which affects the individual. A situation that has not been experienced for a long period of time requires more resources to retrieve from the long-term memory compared to if a case has been experienced more recently, since that could be retrieved from the working memory.

The medical workers are using both bottom-up and top-down processing while reading and documenting in the medical record. When a medical worker reads the medical record the attention is directed to reading the presented information and understanding the situation, interpret and make decisions. The worker is reading the information on a computer screen in front of them, and bottom-up processing of information by the worker is performed. The more information the worker reads, the more of analytic thinking is performed and more top-down processing is being performed. The alternation between the different ways of process information is due to the fact that the medical worker has read the information and is then using previous knowledge and experience to analyse and understand the situation. When the medical worker is documenting information to the medical record, it is mainly performed by using top-

down processing, basing the way of working on medical knowledge and previous experience of documenting. Attention has been directed to the information from the contact with the patient and that information is compared with previous knowledge and information to make sence of the situation, to then be documented.

6.2.5 Nasa TLX

The result of Nasa TLX shows that some factors affect the mental workload more than others (Chapter 5). Physical demand is not a factor that affects the medical staff's mental workload while reading and documenting to the medical record and documentation system. That could be because, when reading and documenting, the medical staff is sitting by their desk and uses the mouse and keyboard to perform the tasks, which do not require a lot of physical activity. The staff is most often satisfied with their performance of the tasks, resulting in the performance also not being a factor that affects the medical staff's mental workload. The factors that do affect the mental workload is the mental demand, temporal demand, effort and frustration while performing the tasks.

Mental demand

The mental demand for reading and documenting to the medical record and documentation system can require a lot of mental resources. The medical staff need to decide themself what to read in order to gather correct information about the patient. The staff also needs to analyse information to be able to make the right judgement and draw right conclusions about collected information. The available mental resources can be limited before performing a task depending on the previous performed tasks. This gives implications to reading and documenting information to the medical record and documentation system since it affects the performance of the tasks.

Temporal demand

The task of reading and documenting about a patient is performed during a short period of time. The medical staff is reading about the patient right before or during the contact with the patient and needs to read a lot of information in an efficient and effective manner. In this situation the staff can feel time pressured because there is no available time for preparation and that more time would be beneficial. Documenting is performed as quick as possible and the staff needs to reason and decide what to do to be able to proceed. The way of working is performed in a way where the staff try to finish each patient right away, both in terms of visit and documentation of the visit, before the next patient. Due to time pressure the documentation can be performed later during the day if there is no available time between patient visits.

Effort

The effort that is required to perform a task of reading or documenting information is very dependent on the situation and the medical judgment. Some tasks are performed in an automatic manner which do not require a lot from the worker, while some tasks require more mental resources to complete.

Frustration

Frustration can arise during both reading and documentation in the medical record and documentation system. For reading, frustration can arise due to it being complicated to find the right information, to know if the information is correct, and to analyse the information. Frustration regarding documentation can arise due to not knowing how to perform a certain

action in the system or to analyse the collected information and document to decide on a plan forward. The frustration can depend on the staff not knowing what to do with the patient's situation or because of the patient's attitude and approach to the health care centre.

6.3 Emotions and performance

Emotions is something that is experienced every day. Emotions, how a task is carried out and how those emotions affect the performance within the problem case is described below.

6.3.1 Procedure

To conclude the impact of the emotions that emerge during a working day at the health care centre, all results from the Geneva Wheel of Emotions (Chapter 3) from the User study (Chapter 5) were applied. The analysis of the results from the Geneva Wheel of Emotions was performed according to literature research regarding emotions and how they have an impact on performance (Chapter 2). Emotions were of interest to analyse to understand a person and their emotions behind an action and by that making it easier to design a user interface for that person.

6.3.2 Emotions during a workday

The more predominant emotions for a workday at the health care centre in general, defined from the booklet "My workday" (Chapter 5) were pride, elation, joy, satisfaction, relief, hope, interest, guilt and anger. The intensity of the emotions joy and anger are high, which could have a greater impact on decision making in comparison to if the emotion level was low. These emotions can have an impact on the decisions made by the medical staff if these emotions occur in conjunction with patient interaction in some way due to the stereotype-based approach those emotions will generate. This could affect the conclusions make by a nurse or a doctor regarding if a patient gets an appointment or not, or conclusions made regarding the treatment of the patient. However, not all occasions when these emotions occurred were in relation to interacting with a patient or making decisions regarding a patient.

The emotions of relief and guilt were also expressed in the results from the booklet "My workday" (Chapter 5). This indicate that the medical staff understands the consequences if something would go wrong when making a decision regarding a patient. Because of this understanding, the decisions made are thought through, possibly imagining a worse case than what it actually is, to avoid making a mistake.

6.3.3 Emotions while interacting with the system

The identified emotions through the usability test in the User study (Chapter 5) that occur when reading respectively documenting in the medical record and documentation system differs. These different tasks are therefore analysed separately due to their different ways of interaction with the medical record, while also to be able to see possible differences and similarities between the different tasks regarding the emotional impact.

Reading

The predominant emotions that occur when doing the task of reading in the medical record and documentation system is pride, joy, satisfaction, relief, hope, interest, sadness, fear and anger (Chapter 5).

All emotions that occur are not due to the task itself but rather because of the experience when performing the task of reading, being affected by what is read in the medical record. If the

patient's medical record shows that the situation is severe the feeling of sadness can occur. The feeling of fear and worry can occur due to uncertainty in terms of inexperience, whether their competences are enough to help the patient. The worrying feeling will make the person reading the medical record more focused on making the right decision, being very thorough when interacting with the patient. Worry could also motivate the person to prepare before a patient visit, either by researching the subject beforehand or taking notes on paper to avoid forgetting anything. Worry and anxiety also occur in connection to the actual task of reading because of the fact that each action made by the medical staff in the medical record is documented and saved. This requires that each step taken, and each document opened should be able to be motivated. This feeling of being watched generates a more reflective approach to the interacting with the medical record.

The feeling of interest often occurs when reading in the medical record. Every role at the health care centre have an interest towards medicine, and each patient case that is encountered is therefore interesting in one way or another. This feeling of interest makes the medical staff engaged and curious of the situation and how they can help, performing a thorough investigation to be able to make proper decisions.

Feeling proud and confident about their competence towards helping a patient also occur when reading, but that emotion can vary depending from day to day. Days when the emotion of pride is very dominant could generate more pre-justice where the decisions made are not analysed or double-checked and are based on previous experience. If a patient for example have similar symptoms as a patient that visited the health care centre recently then it is possible that the second patient is diagnosed the same way due to its similarities. However, the other patient could have a completely different diagnosis, but it is not investigated further.

Documenting

The predominant emotions that occur when doing the task of documenting in the medical record and documentation system is satisfaction, relief, hope and interest (Chapter 5).

The emotions are like those for reading in a patient's medical record, but the difference is that some are less dominating while the feeling of satisfaction is more notable dominating while documenting. This change in emotions is a result of that the worry felt when reading has disappeared because the task is done and a decision has been made, with the hope of it being a correct one. Being able to finish a task and do a proper documentation generates the emotion of satisfaction throughout the medical staff. Whether or not the decision actually was correct and whether or not the next person reading the documentation will be satisfied with the work carried out is however not possible to know in the documentation situation. This generates the feeling of hope that everything was done correctly, which also then have the effect of the performance in terms of the person being thorough when completing the documentation to avoid any mistakes.

6.4 Decision making

Decisions are being made constantly at the health care centre, both medical related decisions and non-medical related decisions. These decisions are being analysed and discussed in this section.

6.4.1 Procedure

The insights identified from the User study (Chapter 5) was used as a starting point for the reasoning about decision making. The presented frameworks within decision making (Chapter 2) was applied to the findings in combination with the method Efficiency-Thoroughness Trade-off, ETTO (Chapter 3). This was performed to create understanding for how decisions are being performed, what those decisions are depending on and the consequences of made decisions.

6.4.2 Medical related decisions

Many of the decisions that the medical staff make during a working day is related to medical aspects and judgments. Medical decisions are depending on the individual's expertise and experience, available information about the patient and the individual's mental state of mind. The mental state of mind can be affected by all the analysed cognitive aspects. The individual is most often taking decisions regarding medical aspects by oneself but can ask a colleague for advice or a second opinion. Medical decisions are taken rather quickly by the medical staff to solve the situation effectively and efficiently, to be able to continue with their work.

Medical decisions are one part of the medical staff's decision making during a workday at the health care centre, but other decisions are also performed. It is however not possible for the thesis authors to identify why a certain medical decision was taken due to the thesis authors' lack of medicine knowledge. The analysation of decision making will therefore hereafter focus on decisions in connection to reading and documenting information in the medical record and documentation system.

6.4.3 Action related decisions

Decisions are made all the time at the health care centre. Some decisions are made on an automatic level, but some decisions are performed on a level of problem solving. This means that decisions are made on all three levels of the behavioural skill-rule-knowledge model, SRK model.

When the medical staff read in the medical record and documentation system it is done in a very automatic manner, just acting and making automatic decisions. The individuals have established their own routines that they follow for how the reading is being performed. The reading is therefore performed on a skill-based level but also on a ruled-based level. The staff recognise and make associations to some stimuli from previous experience.

Documenting to the medical record and documentation system is performed on all three levels of the SRK-model. How to perform the documentation is on a skill-based level since it is performed very quickly, especially for the nurses on the phone where the documentation needs to be finished quickly in order to take the next call. The staff has routines to work after, with developed individual ways of working and with the knowledge of all the necessary steps to perform when facing different scenarios. This means that decisions regarding documentation is performed on a rule-based level. Decisions are also made on a knowledge-based level if the medical staff is faced with an unfamiliar situation, not knowing how to act. The person is then

using previous experiences and knowledge, searching for more information or asking a colleague for advice on how to act.

6.4.4 Efficiency-Thoroughness Trade-offs

Efficiency-Thoroughness Trade-offs, ETTO, are performed while reading and documenting information in the medical record and documentation system and presented in Table 11.

Table. 11. Efficiency-Thoroughness Trade-offs while reading and documenting.

Task	Trade-offs
Reading	
	The medical staff can be under time pressure before or during contact with the patient. This means that the staff must do a trade-off between prioritising working according to schedule or to read/scan through the information, or not read information about the patient at all.
	The medical staff can quickly read through the information, only highlighting the most relevant aspects to the patient's current reason for contacting the health care centre. Which can affect how much or relevant information the medical staff retrieved.
	The medical staff has own ways of working regarding what to highlight while reading and analysing the retrieved information, based on previous experience, to minimise the reading time. The staff is working in a very routinely manner to make their work more efficient.
	Signing or to authenticate notes or test results can be approved without being properly reviewed due to time pressure.
Documenting	
	The medical staff is for the majority of visits documenting information as a short summary, only including the most essential aspects regarding the current visit to save time. This result in a more effective and efficient reading of the information for the next occasion. There are exceptions, for example when a patient visits the health care centre for the first time, then a more thorough documentation is performed to include background information.
	The documentation of a patient could be put on hold in order to succeed working according to schedule of patient visits. The documentation is later resumed when the individual has the time to perform the documentation. This could generate that some details regarding the patient visit are forgotten.
	Details of information when documenting can sometime not be included or are compromised due to time pressure.
	The documentation is performed as the individual is used to, based on previous experience, even though that may not be the most correct way of acting. It would however take too much time for the individual to investigate how one should do it correctly and that is therefore not prioritised as long as the goal of the task is achieved.
	Some documentation is performed more rarely resulting in the staff most often performing trial and error to find their way forward.

6.5 Errors and risks

The results of an action can sometimes not be as one expected or be performed incorrectly. How errors and risks is coped with in the scenario of the medical staff interacting with the medical record and documentation system is described in this section.

6.5.1 Procedure

Information and insights regarding errors and risks has been collected in the User study (Chapter 5). The reasoning about possible errors that could occur when interacting with the medical record and documentation system has been performed with Nielsen's Heuristic Evaluation, HE, method (Chapter 3). The previous performed HTA (Chapter 5) was used when grading steps in the task analysis to evaluate the problem case scenario with all steps included. Relevant theory within this area (Chapter 2) has in addition to the performed HE been applied to the findings from the User study. This is done to gain understanding of possible errors that could occur and why.

6.5.2 Error evaluation

The actions having the possibility of creating large problems were those that could result in the medical staff missing important information or accidently documenting incorrect information. Solely looking at the Nielsen's Heuristic Evaluation, possible errors that could occur were active errors that were more or less a cause of latent errors (Appendix 10). The errors defined were associated with the interface's ability to provide the *visibility of the product's status*, *prevent errors* and regarding the *aesthetic and minimalistic design of the interface*.

Active errors also occur when interacting with the medical record and documentation system, in terms of the user executing an action incorrectly, slip, or forgetting what they are supposed to do, lapse. Recurring errors were due to forgetting something, either in terms of documentation while also in terms of sending out instructions or results for the next person in line to see. Errors did also occur regarding failure in execution in terms of documenting information in the wrong place, while also in terms of typing the wrong number or word when documenting results, receipts, or similar.

Rule-based mistakes do also occur when interacting with the medical record and documentation system. Rule-based mistakes were mainly caused by of the user's mental model, and their approach to the task at hand. Each person has their own way of working and their own approach towards a task, so if that do not correlate with the mental model of the next person in the scenario, an error can occur. Some people do not want to document a great amount of information while the next person does, making the next person feel like they have a lack of information needed for the situation. The same goes for the other way around, when a person wanting short documentation reads a great amount of information, then information can be missed when the person does not want to read every word written.

Rule-based mistakes could also occur when one role at the health care centre carried out a task thinking that it was performed correctly, and the mistake is detected when the next person receives the task. One example of this is sending for a request to Lab regarding taking tests, when some tests cannot be analysed locally at the medical centre, resulting in Lab needing to correct that mistake. Knowledge-based mistakes was not explicitly observed during the research, but the medical staff expressed that those mistakes could occur when they for example encounter situations that they are not familiar with. The cause of violation is mainly due to time pressure and a high workload. Sometimes shortcuts were taken in terms of not documenting

properly, or not documenting at all which could result in the next person reading the documentation, or lack thereof, not knowing what to do.

6.6 Takeaways

The cognitive analysis of reading and documenting information to the medical record and documentation system indicates that all the investigated aspects affect the cognitive load of the medical staff. The medical staff are working together as one unit to help the patient but are simultaneously working with individual tasks. There are strong mental models for how to perform the tasks of reading and documenting information to the medical record and documentation system. Each individual has their own personal way of interacting with the system, but alters their way of interaction, if the situation requires it.

The individual steers and manages a lot of their own attention and mental resources. The tasks are sometimes performed during a short period of time, which affects the workload, and the user to direct their full attention to the task at hand. Performing each task well is important and carries great responsibility when making decisions of what to do next and what to direct attention to. Decisions are often made with a trade-off between speed and thoroughness of the task is performed. Many decisions are made automatically based on routines and knowledge, while some are instead based on reasoning and problem solving.

Sometimes errors occur when interacting with the medical record and documentation system, but those are most often noticed by the user or by a colleague. Errors can depend on slips, lapses, or lack of awareness, thinking one is performing a task correctly. The emotions felt during a day affect how the medical staff act and react. Interest for the patient is shown and the staff want to do their part, contributing to curing the patient. The medical staff are aware of the consequences their actions can have which also impacts their way of acting.

Previous experiences and knowledge can contribute to the cognitive load decreasing for the individual user. Routines and working patterns could be established to a larger extent so that the individual can make use of them when coping with the cognitive load and the time pressure. The health care centre is however a dynamic workplace, differing from day to day, and even from patient to patient, which also affects the cognitive load of the medical staff. All stated aspects and factors are important to be aware of and take into consideration when designing a user interface, to support and decrease the medical staff's cognitive load instead of adding to it.

07.

Needs and requirements

To determine guidelines for a design solution.

In this chapter, all data and information collected throughout the project are compiled in different ways to determine guidelines for a future design solution of the medical record and documentation system.

7.1 Personas

Needs and requirements can be communicated in several different manners. One approach to do that is to define personas (Chapter 3), fictive characters that describes the needs and requirements of the users. The personas and their characteristics are described further in this section.

7.1.1 Procedure

The collected insights from the performed Pre-study (Chapter 4), User study (Chapter 5) and Cognitive analysis (Chapter 6) was used to compiled to understand a specific user's need and requirement. A methodology of persona and a scenario (Chapter 3) was therefore applied to communicate the needs and requirements in this situation in an accessible manner. Two different types of users where identified through the analysis of insights and a scenario was created to each user.

7.1.2 Specific user needs and requirements

The analysis of different cognitive aspects (Chapter 6) at the health care centre made it possible to state recurring patterns of different behaviours and personalities. Two different paths of cognitive approaches were clearly established, one being for a newly graduated medical student, new to the usage of the medical record, and the other for a more experienced medical staff, both in terms of medicine and with the use of the medical record. These paths could then be stated as two different personas; *Alex* and *Kim*. Each persona covers the main cognitive aspects observed as the mental models, attention and awareness, mental resources and workload, emotions, decision making and possible errors that could occur for that persona.

7.1.3 Persona Alex

Alex is 26 years old and has recently graduated from medical school and has just started working within primary care at a health care centre in town. Alex is a part of the generation who has grown-up with computers and IT-systems and is therefore comfortable with using different computer systems and is easily learning new systems. Being new into working in health care, Alex is very excited and eager to learn while also being a bit nervous and anxious, not knowing what to expect. What kind of patient will I meet? Are the colleagues nice? And what kind of routines do they have? Not studying anymore also means a lot more responsibility for Alex, there are no teacher or supervisor there to correct their mistakes, which is a bit scary especially when the consequences of a mistake will affect another human being.

Scenario

During the first days at the health care centre Alex has to learn the medical record system that are used at the site. The health care centre has a high workload, and no one has therefore time to perform a proper walkthrough of the system together with them, and Alex does therefore have to learn on their own. Alex finds it easy to operate the system but knowing where to find things that are needed is not quite as simple, which generates a high mental workload for them, not being able to keep up with the high pace at the health care centre. Luckily Alex's colleagues are for the most part close by, making it possible to ask questions whenever they cannot find

something or needs help with something. After a while, the most important functions are clear to Alex and operating the system is now manageable.

When working with the system Alex is very thorough, reading most documents about a patient word by word. When documenting, they always take the time to make sure that all details are included, and double checks the documentation in a calm setting, possibly saving documentation for later to be able to go through the documentation before saving it. Whenever getting too little information due to previous short documentation Alex gets nervous, feeling that more information is needed for them to do the work with confidence. So whenever finishing a task, they feel a great level of relief, thankful that the task is done, and hopefully done correctly. Not receiving any immediate feedback regarding the task always makes Alex concerned that something might be wrong, but in the end they are just really happy, likes the job tasks and the fact that people are being helped.

7.1.4 Persona Kim

Kim is 56 years old and has been working within health care since graduation at the age of 25, and has been working at the health care centre for 20 out of those 31 years in the business. With a lot of experience working at the health care centre, they are the one person people turn to when they need to ask questions, regarding both medical and administration aspects. Kim also turns to colleagues for consultation whenever a question appears, but the final decision is always theirs to make. By experience, they know how to be selective and know what tasks and aspects to put more or less energy on, and can therefore come to a relevant solution for the problem quickly without it taking too much energy.

Scenario

When using the medical record and documentation system Kim works fast to be as effective as possible, knowing that it will benefit them in the long run during the workday. Kim has their own way of working within the system, and even though it might not be the most efficient way of working, it is the way they have always been doing things since the system was implemented. Kim knows that short-cuts exists but by operating the system in their own way makes it still effective because they know exactly what to do, and do not have to reflect upon actions. By knowing what to do Kim also knows what to search for within the system for different situations. When presented with a great amount of text, they know what to look for and does therefore only need to skim through the text. Kim can therefore make a judgement of what information is relevant to provide whenever documenting something in the system, keeping it short and informative, making it possible for the next person to read it efficiently, getting all information needed in a short amount of time.

Even though Kim has been around for a while they still get stressed when perceiving a high workload, that have not changed with time. Therefore, they make all assignments and tasks as soon as possible, getting them out of the way, and tasks are only put on hold if they are more extensive and need more focus than usual. However, the feeling of stress for Kim is usually temporary and specifically for the task at hand, and whenever that task is completed the stress level decreases. So, whenever a task is finished, they feel relieved for it being out of the way so that all energy and focus can be put on the next task. Whenever a task is finished, that task is not returned to or double checked later on, because Kim is confident that the task was carried out correctly.

7.2 Guidelines

Another way to present needs and requirements is through guidelines. The compiled guidelines are described in this section.

7.2.1 Procedure

All information collected from the Pre-study (Chapter 4), User study (Chapter 5) and Cognitive ergonomics analysis (Chapter 6) compiled to communicate the needs and requirements of the user. To make a clear structure of the user's needs and requirements was the ACD^3-method applied (Chapter 3). Support was provided from the framework of the matrix for compiling the situation, breaking down the situation into smaller pieces and demands in a detailed and systematic manner. The three first levels of design in the ACD^3-method were determined to be based on the existing interface of the medical record and documentation system. The two remaining levels of design, interaction and element, were identified through the previously performed activities.

The aspects determined through the ACD^3-matrix were later summarised as a list of guidelines for a new medical record and documentation system. The guidelines are based on minimising the cognitive load on the medical staff at the health care centre, while also solving the problems identified from previous studies in the project. Each statement in the list was rated 1-5 where 5 is most important and 1 is the least important, based on the importance of the guideline, which in turn was based on the prior research.

7.2.2 Findings

The ACD^3-matrix, as a whole with all design variables is displayed in Appendix 11. The guidelines set for a new medical record and documentation system within the chosen problem case scenario, stated based on the ACD^3-matrix, is presented in Table 12.

Table 12. The guidelines for a new medical record and documentation system within the chosen problem case scenario

Guideline	Description	Rating [1-5]
Functions [medical focus]		
Enable search function to find a specific patient in the system		5
State what tasks that should be performed	For yourself as well as for other colleagues at the health care centre.	5
State what tasks that had been performed	For yourself as well as for other colleagues at the health care centre.	3
Provide real time information of a patient's status within the health care centre	Should present information of what actions and decisions have been made for the patient during their visit at the health care centre.	2
Provide real time information of a patient's location within the health care centre	Should present information of who the patient has visited and where they are going, at the health care centre.	2
Enable access to an individual calendar	A calendar stating your individual appointments and tasks.	5
Enable access to another colleague's calendar	A calendar stating your colleague's individual appointments and tasks.	5
Enable access to a group calendar		5
Enable access to an emergency calendar	A calendar for emergency appointments.	5
Should enable communication between colleagues	Communication within the medical record and documentation system without it being visible for the patient.	3
– Reading in the medical record		
Enable access to information regarding the reason for the time booking		5
Enable access to notes from previous appointments		5

Enable access to test results		5
Enable access to a summary/overview of information regarding a patient		4
Provide the most essential information for the situation		3
Enable access to more information in the system when an action is performed		2
Enable guidance of where to find information needed for the situation		2
Provide pedagogical described information regarding a patient's situation	For the patient to read and understand their situation.	1
– Documenting to medical record		
Enable possibility to add information to a patient's medical record		5
Provide guiding headings of information to document		4
Provide more information/headings to be documented depending on previous documentation/action		3
Handling of the system		
Enable usage for a new user	Should be intuitive for a new user who has gotten a short introduction to the system.	5
Enable usage for an experienced user		5
Enable usage for all mental models	Should support and not limit different ways of working.	3
Communication of usage through guiding icons		3
Communication of usage through guiding text		4
Communication of usage through guiding buttons	Supporting and describing buttons in the interface to let the user know how the interface should be used.	5

Enable visual communication of available appointments for time booking	Should provide visual guidance of time slots that are available when booking an appointment for a patient.	3
Feedback		
Enable visual communication that an action is performed		5
Provide verification of a performed task	Giving feedback to the user when the user has performed an action, that the action has been performed and been registered by the system.	5
Acknowledge an action that is performed incorrectly	Question an action by the user if the action generates questionable results.	4
Provide automated tasks	Tasks that should not be needed to be performed by the user and are made automatically by the interface.	3
Should be able to regret an action		3
Should be able to correct an action		5

7.3 Takeaways

The needs and requirements for the problem case scenario are described through the two compiled personas and the design variables identified through the ACD^3 framework. The personas describe guidelines for typical users within the problem case, personified as Alex and Kim. The stated list of guidelines is instead a more objective, concretised way of communicating the prerequisites.

The summarized needs and requirements for a new user interface should, decrease the cognitive load, provide feedback, guidance and adaptability to the person using the system. Feedback should be given to confirm that an action has been performed, and that it is performed correctly to prevent errors. Guidance should be provided to decrease the demand on mental resources, to direct the user's attention to the right thing in the right moment, and to help in moments of decision making. Finally, adaptability should be achieved, considering emotions that can occur and enable usage of all mental models.

The results from both activities will be taken into consideration when developing a user interface design of a new medical record and documentation system within the chosen problem case scenario. When a new user interface design is developed, the personas can be used to verify the concept, regarding whether or not it would be desirable and useful for both personas identified. In addition to that, the stated list of guidelines can also be used to verify whether every demand set for a medical record and documentations system is met.

08.

Ideation

To start creating ideas.

Based on research performed (Chapter 4, 5 & 6) and the identified guidelines for the medical record and documentation system (Chapter 7), the ideation phase was initiated. The intention of this phase is to find ways to develop the existing medical record and documentation system to improve the medical staff's cognitive ergonomics situation.

8.1 Ideation within the thesis authors

The performed research and the design variables stated was used as a basis for the thesis authors to start developing and visualise ideas for a medical record and documentation system, by the thesis authors alone.

8.1.1 Procedure

The ideation methods 6-3-5 brainwriting and brainstorming (Chapter 3) was used to generate ideas of how to develop the medical record and documentation system by the thesis authors. This to be able to generate many different ideas and to then develop those ideas further.

For 6-3-5 brainwriting was instead of using six people for the activity, as the method signifies, the method was performed by the thesis authors, consisting of two people. The method was performed with two different approaches. For the first round three concept directions was determined as reading, documenting and booking a time in the medical record and documentation system. The second round consisted of three concept directions focusing on the medical roles of a nurse, a doctor and an assistant nurse at Lab.

Brainstorming ideas was carried out individually by the thesis authors. Inspiration was taken from research and the ideation method 6-3-5 performed prior to this. The approach while brainstorming was to developed functions and ideas from a visual and graphical perspective, while also brainstorming on how those ideas and functions could interact with each other since the 6-3-5 brainwriting method generated separately ideas.

8.1.2 Findings

The generated ideas from the thesis authors were used as a starting point for the whole ideation phase. All ideas, from both ideation methods were compiled and visualised with the same visual expression, describing the function of the idea (Appendix 12).

8.2 Focus group with medical staff

To evaluate the generated ideas from the thesis authors, input was received from the medical staff through a focus group.

8.2.1 Procedure

To be able to know if the generated ideas by the thesis authors would be relevant and useful for the staff at the health care centre, a focus group with medical staff was performed (Chapter 3).

The focus group session was divided into three parts. The first activity was a card-sorting method (Chapter 3) were different functions within the medical record and documentation system where presented. A function was defined as a feature the medical staff could use in their interaction with system focusing on reading and documenting information. This was performed to identify which functions the medical staff use and desire in their work. For the next step in

the focus group session, different ideas generated by the thesis authors were presented. The ideas were 22 in total divided into three different categories; reading, documenting and specific aspects like feedback and guidance. Each category was presented one at a time, with a visual concept sketch and verbal description of each idea and the function and goal behind them. The participants could then have a discussion of which ideas that could be useful and helpful for them in their role at the health care centre. At the end of the session, a video describing a futuristic scenario of health care was presented. A discussion followed the video on whether or not the scenario would be useful or helpful and how that would have an impact on their work.

The participants of the focus group were a doctor and an assistant nurse working at Lab since those medical roles are involved in the chosen problem case. A nurse working with taking phone calls could not attend the focus group session. The other roles present tried to imagine what kind of input a nurse would have had throughout the session.

8.2.2 Findings

The results from the focus group with the medical staff is presented here, divided based on the three different activities during the session.

Card sorting

The cards chosen during the card-sorting method for each role when reading respectively documenting in the medical record and documentation system is presented in Table 13. Chosen cards for the roles of the nurse and Lab was the same both when reading and documenting, while the doctor required different functions depending on the task. All roles had some similarities between one another regarding getting an understanding of the situation in some way, either of what should be done or of the patient situation. A common denominator is also shown to be the need of feedback regarding performed tasks and of the working day.

Table 13. Result from card sorting from the focus group with medical staff

	Nurse	Doctor	Lab
Reading			
	See already booked time slots.	See the status of the patient visit.	Get knowledge about the reason for patient's contact and visit.
	See available time slots.	Get an understanding of the patient's emergency condition.	Get guidance/suggestion on what should be done.
	See suggested time slots.	Get access to relevant information	Get access to relevant information.
	Document reason for the patient's contact and visit.	Get an understanding of the reason for the patient visit.	Get an understanding of what should be done.
	Get an understanding of the patient's medical history.	Get feedback on performed tasks.	
	Get feedback regarding the working day.		
Documenting			
	See already booked time slots.	Document the patient visit/contact.	Get knowledge about the reason for patient's contact and visit.
	See available time slots.	Document the future treatment and plan for the patient.	Get guidance/suggestion on what should be done.
	See suggested time slots.	Document the monitoring of the patient.	Get access to relevant information.
	Document reason for the patient's contact and visit.	Get access to all information simultaneously.	Get an understanding of what should be done.
	Get an understanding of the patient's medical history.	Get an understanding of the patient's general condition.	
	Get feedback regarding the working day.	Use suggested procedures for tasks to be performed.	

Preferred ideas

For the discussion regarding the ideas presented for the participants, some ideas were more preferred than others. These ideas are available in Appendix 13. The input from the medical staff generated greater understanding by the thesis authors regarding what could be suitable or not for a future solution.

The main take away from the discussions regarding the movie of a futuristic health care scenario was the value of including the patient more in the process, guiding them more in how they can deal with a situation on their own. An idea was also initiated of the possibility of letting the patient fill in some information about themselves before calling the health care centre to book an appointment. In this way the nurse managing the phones can get a quick understanding of the situation based on what the patient has filled in, which will help the nurse to determine if the patient needs an emergency time or not.

8.3 Workshop with designers

The next activity in the ideation phase was a workshop with design students. This is described in this section.

8.3.1 Procedure

The ideas preferred by the medical staff during the previous workshop (Chapter 3) was collected and presented to five designers studying their last semester at the master Industrial Design Engineering at Chalmers Technical University. The intention with the workshop was to collect visual and graphical inspiration to the thesis authors of how different ideas could be visualised.

The workshop was performed digitally in the design platform Figma (Chapter 3), where all designers could work simultaneously. The communication and guidance from the mediator were performed through the conference software Zoom (Chapter 3), not requiring gathering everyone at the same place. The six ideas preferred by the medical staff, were presented one at a time by a basic visualisation of the function and a short description of the aim and the reason for that particular function. The designers had seven minutes for each idea to visualise the idea in a different way, working individually on different frames.

As a warm-up, for the beginning of the workshop, the same procedure was performed for a website. A screenshot of a website was presented with a short task description followed by seven minutes where the designers were supposed to make a quick redesign of that website. Not all designers were familiar with Figma before the workshop, so the warm-up task was mainly a way for them to get to know the software.

8.3.2 Findings

Some created visualisations were highlighted by the thesis authors due to their potential in being applied to a future concept to decrease the cognitive load of the medical staff. These visualisations are displayed in Appendix 14 and will be used as a base for the creation of the future concept.

8.4 Prototype testing

In order to determine whether or not the ideas developed would be useful or not for the medical staff at the health care centre, a prototype of the medical record and documentation system was made and tested.

8.4.1 Procedure

The ideas from the focus group with the medical staff were combined together, creating an interactive prototype in the design tool Figma (Chapter 3). Visual inspiration was taken from the workshop with designers with guidance of a theoretical ground regarding perception attention and gestalt principles (Chapter 2). Three parts of the prototype were developed, one for the role of a nurse that makes time booking for patient appointments, one for the role of a doctor, and one for the role of personnel working at Lab. The prototype was divided into three parts, not including all roles within one sequence, to avoid developing a large prototype that would be too heavy to work on. The different roles' actions within the prototype did not correlate and therefore did not need to be included in one whole sequence.

Each part of the prototype was tested and evaluated against the different personas, Kim and Alex and also the guidelines (Chapter 7). The thesis authors impersonated the two different personas, one at a time and tried the prototype with the set problem case scenario in mind for both nurses on the telephone, doctor and Lab. The thesis authors had a discussion about the believed identified insights based on the persona's experience of the prototype between the different medical staff roles. The prototype was then evaluated against the established guidelines. The evaluation was performed in this manner because of lack of access to medical staff.

8.4.2 Findings based on the personas

The insights from the persona evaluation is presented below, divided between the different roles and in the order of the problem case scenario; *nurse on telephone*, *doctor* and *Lab*.

Nurses on telephone

The ability of adapting the amount of information presented to the user of the medical record and documentation system is important for both personas, avoiding the feeling of being overwhelmed by the presented information. The usage and the amount of confirmation when an action is performed within the system needs to be balanced. The amount of confirmation should not be too much, slowing Kim down, while it should also not be too limited making Alex feel uncertain if the system is used correct or not. Applied confirmation steps should therefore be weighted depending on if they are necessary, for both personas. Whether the confirmation should require an action to confirm or not should also be weighted. The amount of guidance within the system should also be balanced, where Alex needs guidance and Kim wants to do tasks and use the system in their own way. However, if Kim performs tasks in their own way, information can go lost, which indicate that some guidance can be useful. Guidance of tasks being performed also leads to that tasks are performed uniformly between the staff at the medical centre. This could generate that documentation by one colleague is comparable with documentation by another colleague. The person reading the information in the next step of the scenario will then be provided by similar amount of information independently of which nurse performed the time booking.

Doctor

Kim's and Alex's way of working and their need of support and guidance differs. They are both in need of support, but to different extend, where one person's way could limit the other. Alex could for example get to a point of not knowing what to do next, where Kim instead cannot proceed as quickly as wanted. Alex is in need of more support, as well as more information which could inhibit Kim and create frustration. A future solution needs therefore to take consideration of them both, keeping unnecessary information hidden with the possibility of making it available if it is desirable. Both Kim and Alex could however benefit from clearer notifications and reminders to get the right information and support of what one should do next.

Lab

The most important aspects for both Alex and Kim are to be able to see a schedule of which patient to meet, view what samples that should be performed and report the results of those samples for the right patient. The other functions and information in the medical record and documentation system is not important for them and could be unnecessary. Alex is in need of more support and information about samples compared to Kim. It is therefore of great importance to find a good balance between Kim's efficient way of working and Alex's need of information. Alex and Kim are not taking many decisions within the scenario, which indicates that they are not in need of any additional support for making decisions. It could however be beneficial to provide awareness about test results that are out of the ordinary, just as support.

8.4.3 Finding based on the guidelines

Most concluded guidelines (Chapter 7) set in this project for a new medical record and documentation system are met in the prototype. All functions necessary to perform the tasks for the problem case scenario are included. The guideline of enabling communication between colleagues is however not included in the prototype. This could be depending on the fact that communication between colleagues is not a function required for the problem case scenario.

When evaluation the prototype against the guidelines it was found that additional changes was needed to meet the guidelines to a greater extent. Clearer verification and feedback could be presented when a task had been performed. The possibility of correcting an action could also be needed to be adjusted in the prototype in order to meet the guideline better.

Some factors within the list of guidelines are difficult to evaluate whether or not they are met without including the actual users or through performing extensive evaluation testing. The possibility of determining whether or not the guideline of the prototype is providing the most essential information can mainly be determined by a person with medical and primary care knowledge. The evaluation to the guidelines was performed towards the personas and gained knowledge by the thesis authors as base for the evaluation.

8.5 Takeaways

The ideation phase shows the development from separate ideas into a prototype of a user interface design that was evaluated theoretically against the personas and the set guidelines. The work process included several perspectives from the thesis authors, designers and the medical staff. The evaluation against the personas and guidelines showed possibilities of improvements regarding presented information, feedback and guidance/ support, and the importance of adaptability to the user's level of experience. This will be used as input to the final concept where the prototype will be updated based on the received input.

09.

Final concept

Of medical record and documentation system

The result and insights from the project are compiled into a final concept of a user interface. The final concept is based on the performed literature study (Chapter 2), Pre-study (Chapter 4), User study (Chapter 5), Cognitive ergonomics analysis (Chapter 6), stated Needs and requirements (Chapter 7) and the performed Ideation (Chapter 8).

9.1 Procedure

The created prototype was evaluated and tested against the compiled personas and stated guidelines (Chapter 8). The result from that evaluation was used as input to the final design concept where changes and adjustments were performed to correspond better to the situation and the medical staff. The prototype was modified in Figma (Chapter 3) and is presented in this report as an interactive prototype.

9.2 Presentation of the user interface

The final concept is divided into three different parts, one for each medical role involved in the problem case; *nurse on the phone*, *doctor* and *assistant nurse at Lab* (Chapter 8). The final concept, regardless of the medical role, follows the same structure and principles of having a step-by-step approach (Figure 18, 19, 20, 21& 22) throughout.

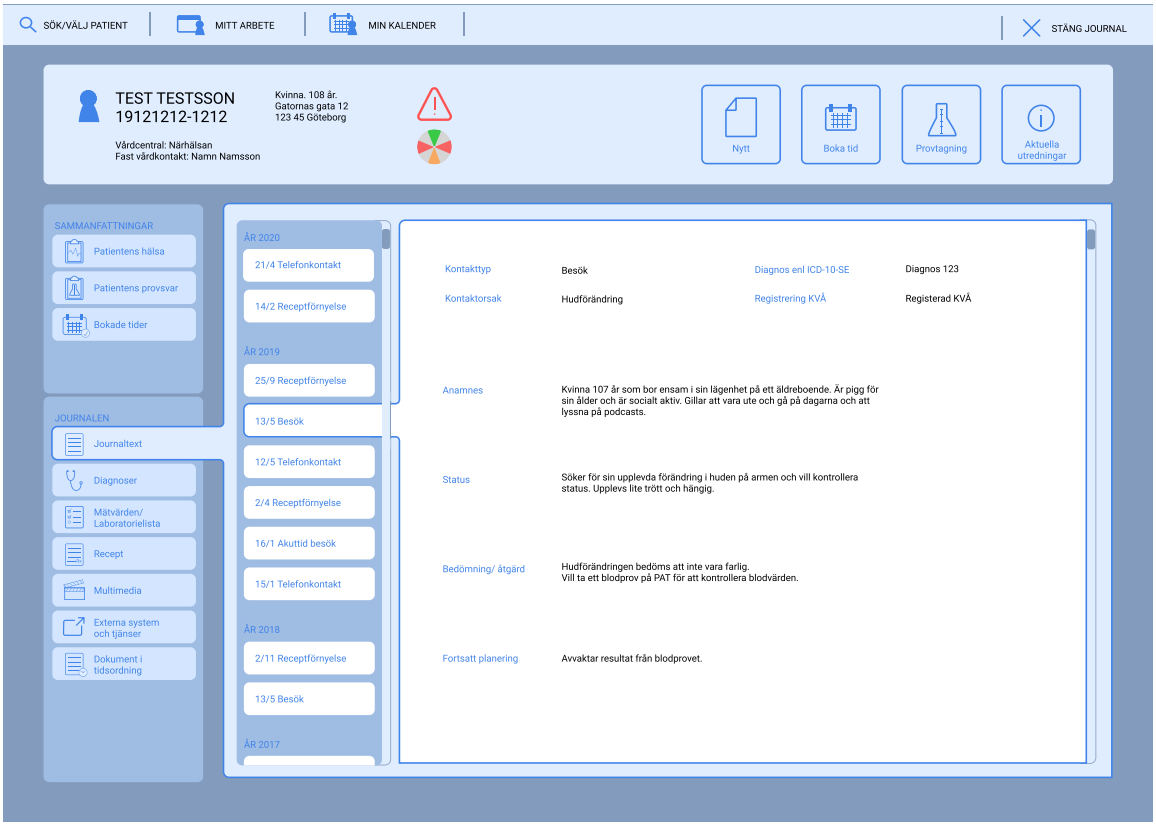


Figure 18. A frame of the final concept showing the concept's step-by-step approach

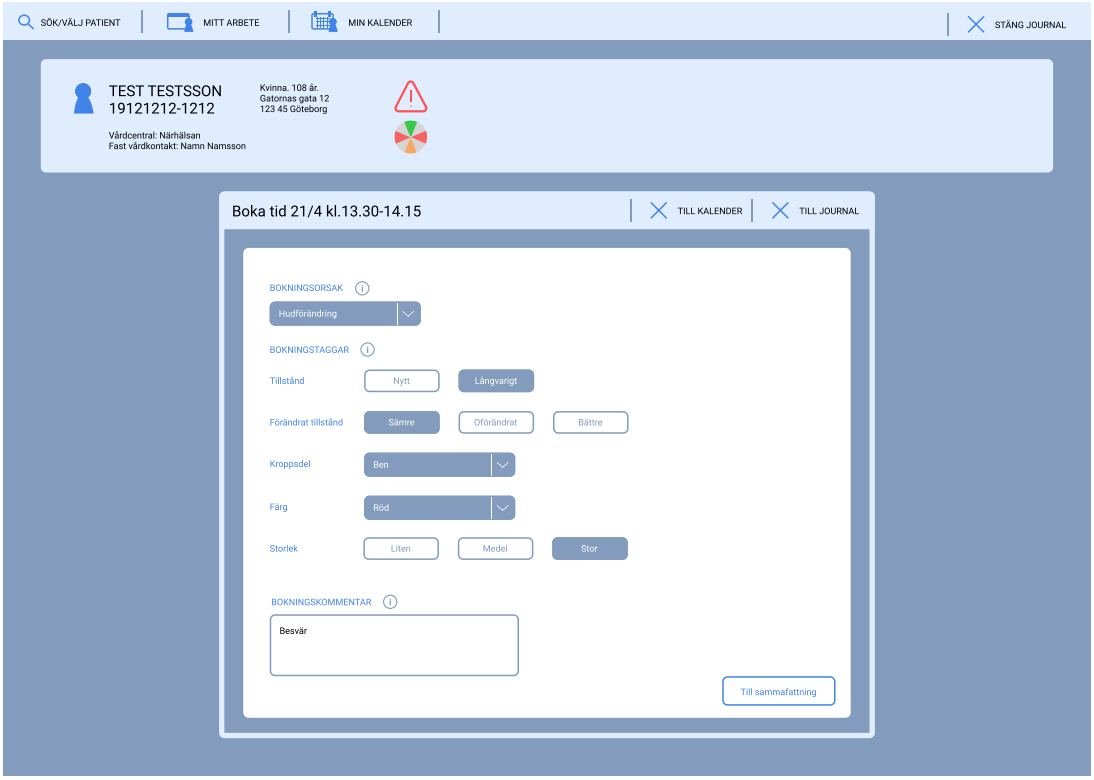


Figure 19. A frame of the final concept showing a nurse's view when booking a time slot

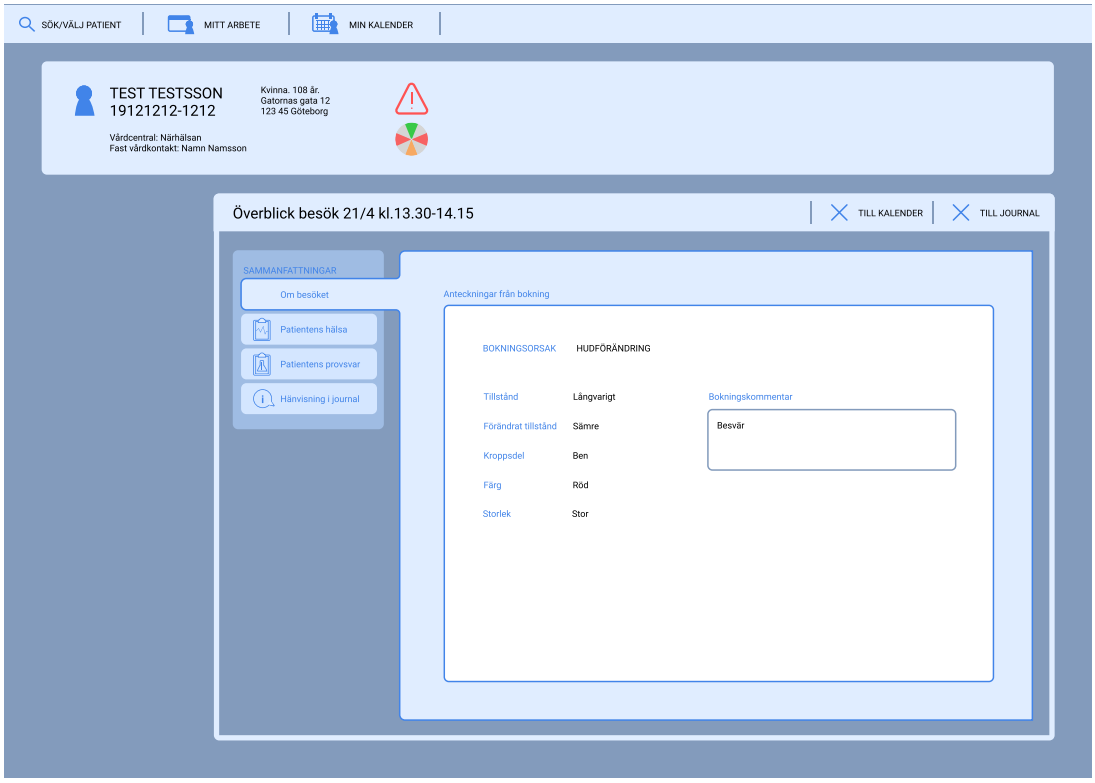


Figure 20. A frame of the final concept showing a doctor's view of a booking for a patient that the nurse has documented

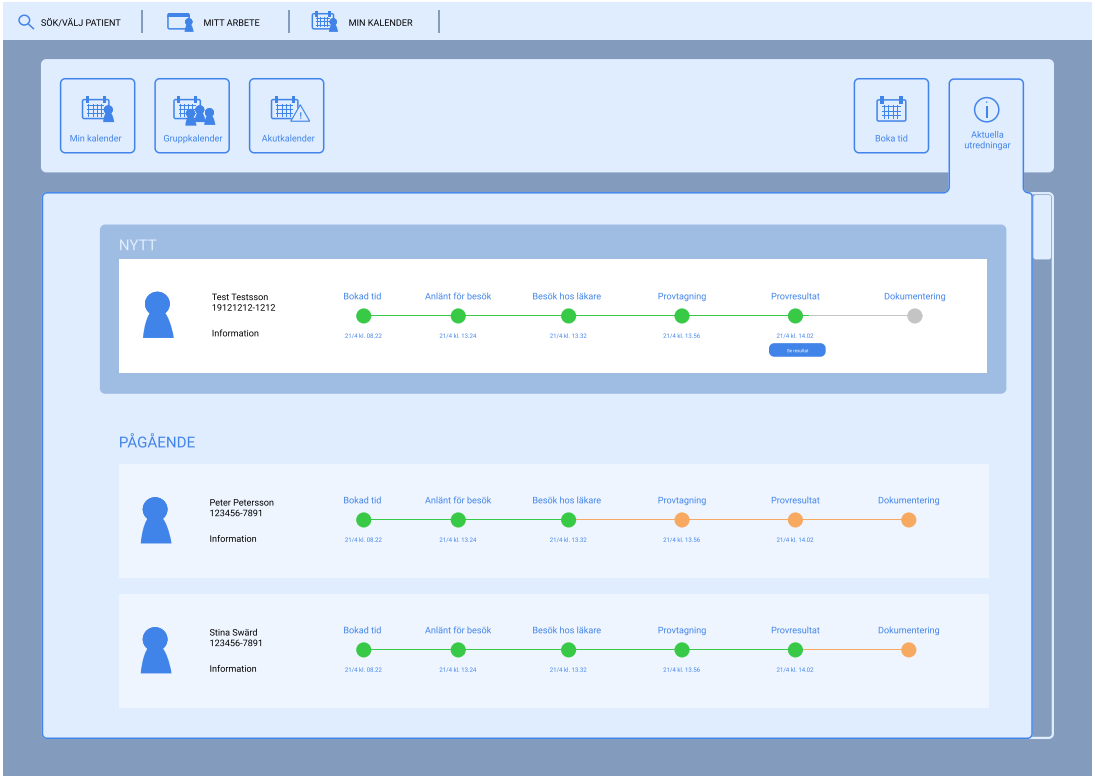


Figure 21. A frame of the final concept showing updates about a doctor's patients and investigations

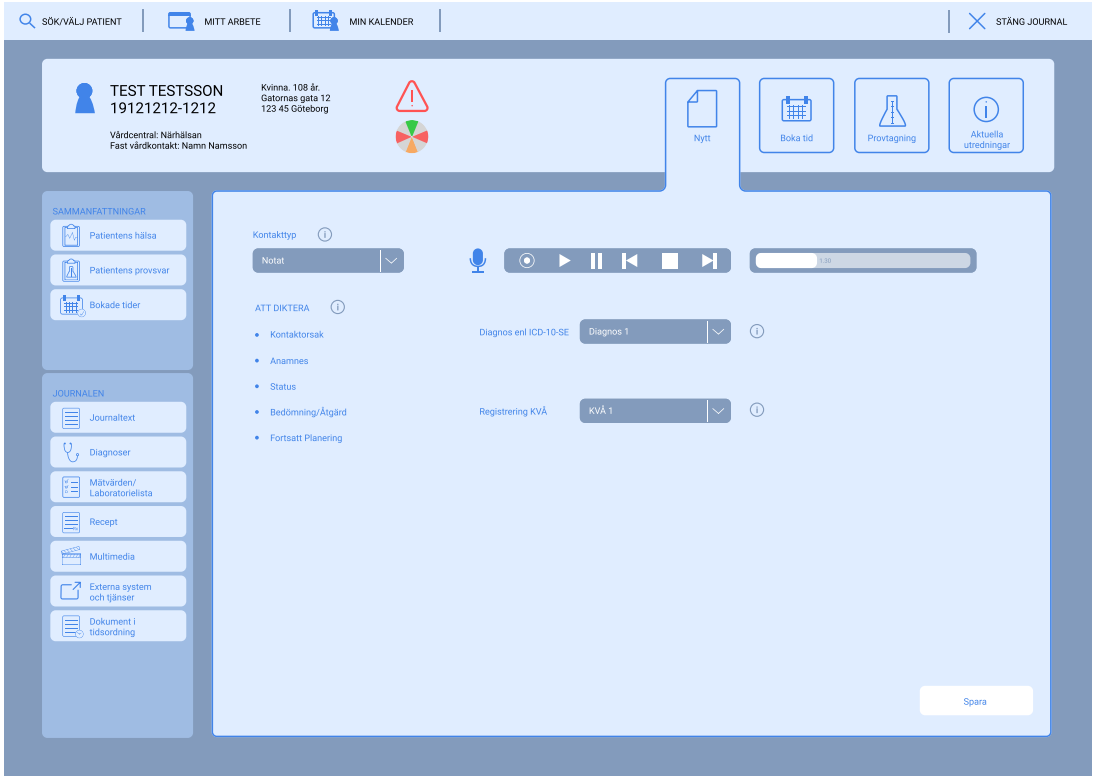


Figure 22. A frame of the final concept showing a doctor's view when documenting a patient visit

The main aim of the final concept is to decrease the cognitive load of the medical staff, based on the findings and ideation of the project. A central foundation in the concept is the presentation of feedback and confirmation to its user about status and performed actions. The user does not need to keep themselves updated, the system supports the user and provides the latest information automatically. The user then gets support regarding what to direct their attention to and highlight, generating that user's mental resources are unburdened and the user do not need to remember everything one is required to do.

The final concept is based on the selected problem case scenario and of the flow of actions that will be carried out. Guidance and directions regarding which order tasks should be performed in are provided, supporting both experienced and inexperienced users. Relevant information is available, if one wants, during situations in the problem case scenario where additional help and guidance could be needed.

The three parts of the final concept are presented and described more in detail, part by part, in the following sections.

9.2.1 Nurse's user interface

The part of the final concept for nurses on telephone is available, following the link:
Nurse on telephone. The prototype is in Swedish since the project has been conducted in Sweden and the users of the user interface are Swedish-speaking.

The nurse's part of the final concept is mainly focusing on how the documentation will be performed when booking an emergency time slot (Figure 19). When opening the patient's medical record, a summary of the patient's health is presented, providing an overall understanding of the patient's situation. A nurse gets informed of the situation, and does not have to search for the most relevant information and decide what to highlight while talking to the patient on the telephone.

The interface provides a step-by-step process for the documenting part of the booking of an emergency time slot. Different health conditions are presented for the nurse to choose from depending on the patient's situation, where relevant statements with alternatives are displayed depending on the chosen condition. The process is predetermined, supporting the nurse in what to document and what to ask the patient. A summary of the booking with the chosen time slot and the performed documentation is shown in the last step in order to provide feedback to the nurse before confirming the booking.

The work process for documentation must be performed efficiently and effectively for the nurse to progress to the next call. For an inexperienced nurse, time is saved based on the guidance of what to document, while more information can be provided if needed. For the experienced nurse, only necessary information and options for the situation are provided. The step-by-step documentation also supports the doctors in the next step of the problem case scenario, providing information to understand the patient's situation.

9.2.2 Doctor's user interface

The part of the final concept for doctors is available, following the link:
Doctor. The prototype is in Swedish since the project has been conducted in Sweden and the users of the user interface are Swedish-speaking.

The doctor's part of the final user interface concept focuses on several different functionalities where the interface provides guidance for what to do (Figure 20, 21& 22). When preparing for the visit, summaries of the reason for the visit and the patient's health are presented together with references to additional information in the patient's medical record, if needed. This provides prerequisites for getting a basic understanding of the situation, while the option of searching for more information is given, supporting different working patterns. When documenting a request for a sample test at Lab, this is also provided with a step-by-step process guidance and more optional information available if needed. Guidance is also provided when performing the documentation of a patient visit, by presenting a checklist of what to include and acknowledge.

The second aspect for the doctor's part of the final concept concerns how to keep track of what is happening within current investigations of patients. The interface will notify to the doctor when the patient has arrived for the visit. When a sample has been ordered, the doctor will get notified when results have been registered after the sampling process. New events are visually presented in the list where current investigations of patients are displayed and provides reminders to the doctor of what one should do and the status of the different investigations. The doctor is provided automatically with updates, not need to direct awareness to remind oneself to manually look for updates, is instead for provided to them. The attention could then be directed to the task in front of them, instead of keeping track of all ongoing events simultaneously. This should decrease the mental workload, and support the doctor in directing their attention appropriately.

9.2.3 Lab's user interface

The part of the interface final concept for Lab is available, following the link:
Lab. The prototype is in Swedish since the project has been conducted in Sweden and the users of the user interface are Swedish-speaking.

The part of the interface regarding the tasks performed at Lab in the final concept focuses on making the Lab personnel's tasks easily accessible and effective. When a new emergency time slot has been booked, the Lab will be notified about that incoming patient in the calendar. When opening the patient's medical record, a notification is provided immediately in conjunction to sample testing, stating which test should be taken. The assistant nurse is then presented only with relevant information for them and their tasks.

The verifying of samples requested for LabCenter and the reporting of test results follow the same structure and sequence of actions. The procedures are performed in the same manner and in the same location in the interface. This supports the assistant nurse to not forget any actions and also decreases the amount of information to process.

9.3 Takeaways

The final concept suggests a user interface design for a new medical record and documentation system, including the functions necessary for the selected problem case scenario. The identified insights and conclusions from the Pre-study (Chapter 4), User study (Chapter 5) and Cognitive ergonomics analysis (Chapter 6) in combination with the compiled Needs and requirements (Chapter 7) were used to develop the final concept. The presented user interface is therefore not a comprehensive solution for an entire medical record and documentation system, only to the problem case.

The final concept presents a design approach for decreasing previously identified aspects of cognitive load for the medical staff at a health care centre. One central foundation in this user interface is the presentation of feedback and confirmation to the user about status of the task and performed actions. The user does not need to keep themselves updated, because the system supports the user through visual notifications to guide and correct the user, directing their attention to the right element at the right moment. The user is also guided through the interface by the step-by-step approach, guiding the user one step at a time, decreasing the mental resources needed to perform a task. The user interface also enables usability for all mental models observed at the health care centre, making the interaction with the interface possible to adapt depending on the person using the system. The most relevant information is provided for the situation, enabling the possibility of getting more information, if wanted and needed. The additional information can both be regarding information about a patient, but also in terms of providing more theoretical information regarding what to document and medical knowledge in moments of decision making.

10.

Project reflection

On the procedure and results.

10.1 Discussion

Throughout the project, the work process has been to explore, define and verify in iterations. This way of working provided great understanding by the thesis authors for the situation. The work process has however been adjusted along the project and adapted after the COVID-19 pandemic during the spring of 2020. This had an impact on how present the thesis authors could be at the health care centre and whether or not activities and evaluations of ideas and concepts could be performed with the staff at site.

The work process of this project has been directed, from the start, towards cognitive ergonomics. The perspective was broadened in the first phase of the project by the thesis authors to human factors in order to map the situation using a more holistic approach. The human factors approach was favourable since it enabled a general understanding about of the situation before focusing on mainly cognitive ergonomics. However, the findings from the human factors' perspective indicate that a lot of situations were due to poor cognitive ergonomics, but also organisational ergonomics. An alternative for this project would then have been to study organisational aspects further instead of cognitive ergonomics. The thesis authors do however have more knowledge regarding cognitive ergonomics, which made the decision to focus on cognitive ergonomics a favourable choice in this project setting.

The choice of problem case led to that three medical roles were included, out of all available roles that were mapped out in the beginning of the project. The thesis authors have during the project had access to individuals within these roles to different extend, where the number of participants in some activities have been low. This means that the result of the performed activities could then reflect individual opinions and point of views, not representing a general perspective of that role. The individuals that participated in the activities have on the other hand varied between the different activities, which could neutralise individual opinions.

The methods used throughout the project have for the most part generated a lot of information valuable for the project. Applying the methods of distributing booklets to the medical staff did however have both advantages and disadvantages. The advantage was that the thesis authors did not have to disturb the medical staff when working and the staff could perform the task whenever they had time, as mentioned before. The disadvantage was however that the booklets were easily forgotten about or misplaced by the participants. All booklets distributed were therefore not returned to the thesis authors, resulting in data being collected from a lower number of participants than originally planned for. This problem mainly occurred for the second booklet "The Medical record and I", which was distributed in the beginning of the COVID-19 pandemic outbreak. The data collected was therefore based on a low number of participants. The results were however reasonable and could be verified through the studies performed prior to distributing the booklet.

The project presents a user interface of the medical record and documentation system. The concept is a new approach of how to perform the tasks, meaning that it is of great importance to validate the concept with real users of the existing software when evaluating the new solution. A more theoretical approach was however applied during evaluation of the concept due to the disruption caused by COVID-19. The knowledge gathered by the thesis authors throughout the project has however created a great understanding for the medical staff's work and their cognitive ergonomics load. Based on that experience, a valid evaluation could be performed given the circumstances.

The stated needs and requirements for a medical record and documentation system are developed with focus on cognitive ergonomics, not taking medical aspects into consideration, due to the lack of medical knowledge by the thesis authors. The project has taken consideration to functions and actions that are used today by the medical staff in the problem case scenario, in order to not change existing and relevant functions and actions. A next step could have been to phrase needs and requirements from a medical point of view as well, generating more overall guidelines and a possibility of changing the medical functions as well. Another step could be to involve additional medical roles and situations outside the problem case scenario.

10.2 Recommendations for future projects

In the initial phase of the project several problem cases were stated that could be investigated further to analyse the work situation at a health care centre from the medical staff's perspective, with a human factors approach. Future projects can therefore be inspired and make use of the identified problem cases in this project to investigate on further. It is however important to stress that these cases where identified at one health care centre and that variations between health care centres can occur.

Spending time at the health care centre gives the observer an understanding of the context, daily routines and performed tasks. A basic understanding of the situation is very useful as a first step in a design process, to later be able to investigate the situation more in detail. The activities performed at site should however be well prepared beforehand to gain the most out of the time spent at the health care centre. Knowing the main goal of one activity makes it easier to state beforehand what aspect to investigate and what to do. Make sure to ask questions during the activities, preferably directly in connection to the event, in order to obtain a more detailed understanding of the situation. Asking questions in the right context can be a mediated tool for the interviewee to tell the observer more and feel more comfortable than if the interview would have been in a staged context.

The access to the medical staff was very dependent on the workload on the staff at the health care centre. If that aspect is taken into consideration, activities can be adapted and adjusted to better match the work and schedule at the health care centre. In this project, the workload was lower during the afternoon of the workday, resulting in some activities being more applicable to be carried out during that time of the day. Activities could also be adapted and performed in a manner where the thesis authors did not need to be present at the health care centre. In that way, the medical staff could perform the task whenever they had the time to and the thesis authors did not influence or disturb the medical staff's work.

It is of great importance to understand the whole situation surrounding a task when analysing cognitive ergonomic aspects. Analysing each cognitive ergonomic aspect is therefore necessary to gain an overall understanding. The combinations of the cognitive ergonomic aspects can affect the cognitive load to a greater extent compared to one aspect separately. The reasoning for each aspect is based on a theoretical framework and different theories within that area. It is therefore important, as always, to understand the theory within the different the areas to be able to create a valid reasoning and analysis of the cognitive load. The drawn conclusions will otherwise risk being incomplete or incorrect.

It is beneficial to enter a project within healthcare with an open mind and an approach to be able to adjust the project to the current setting. It is also favourable to map the situation from several perspectives, explore, define and validate information throughout a project.

11.

Conclusion

Of the project
and findings.

The aim of contributing to decreasing the cognitive load for medical staff within Närhälsan, the public primary health care in the region of Västra Götaland, has been met through the presented user interface design of a new medical record and documentation system. The stated research question *what situations at a health care centre result in high cognitive load for the medical staff?* is answered through the several stated problem cases, which are concern *roles at the health care centre*, *information flow*, *the team* and *additional aspects*. One problem case, in combination with a scenario, was chosen to investigate further and develop a design solution. The chosen problem case referred to the task of reading and documenting in the medical record and documentation system with the scenario of a patient calling to book an emergency appointment with a doctor. This scenario includes the different roles of a *nurse on the telephone*, a *doctor* and an *assistant nurse at Lab*.

The answer to the second research question, *which aspects of cognitive ergonomics have an impact on the cognitive load of the medical staff?* was determined through a wide set of different user-centred methods and a data analysis of different cognitive aspects. Individual approaches, routines and previous experience have notable influence on the medical staff's cognitive load. All cognitive aspects have been acknowledged to have an impact on the cognitive load in one way or another. Analysing different cognitive aspects made it possible to map out the whole situation, taking all aspects into account when developing a design solution.

The findings from the cognitive analysis were applied to the problem case of reading and documenting in the medical record and documentation system. It was in this time possible to answer the research question *how can a design solution decrease the cognitive load of medical staff at a health care centre?*. A design solution for a medical record and documentation system was developed as a user interface design. The user interface was developed with an iterative process and was evaluated against determined needs and requirements of providing feedback, guidance and adaptability to its user, validating whether the interface decreases the cognitive load or not. The interface can be used by all observed mental models at the health care centre. The system also decreases the required mental resources to perform tasks within the system by guiding the medical staff's attention through the interface, and by providing help in moments of decision making. The interface is also designed with features intended to limit the risk of errors occurring during interaction. The user interface design is decreasing the medical staff's cognitive load, through guidance and intuitive interaction, making it possible to perform tasks in an effective and thorough manner even during moments of time pressure.

Developing a new user interface for a medical record and documentation system is only one way to decrease cognitive load for medical staff, but the work to decrease the cognitive load does not end here. With the help of this project, human factors could be further to investigate within primary care, continuing to help medical staff and decrease their cognitive load.

References

1177 Vårdguiden. (2020). Anmälan om vårdskada - lex Maria. Retrieved 2020-05-08 from https://www.1177.se/Vastra-Gotaland/sa-fungerar-varden/lagar-och-bestammelser/anmalan-om-vardskada--lex-maria/

Always Culture. (n.d.). The 8 Most Common Root Causes of Medical Errors. Retrieved 2020- 05-07 from https://alwaysculture.com/hcahps/communication-medications/8-most-common-causes-of-medical-errors/

Angie, A. D., Connelly, S., Waples, E. P., & Kligyte, V. (2011). The influence of discrete emotions on judgement and decision-making: A meta-analytic review. Psychology Press. DOI: http://dx.doi.org/10.1080/02699931.2010.550751

AsynjaVisph förvaltning. (2018). Vårdcentralsspecifik dokumentation. Användarmanual för AsynjaVisph, version 5.0. Göteborg: Västra Götalandsregionen.

Berlin, C. and Adams, C. (2017) Production Ergonomics: Designing Work Systems to Support Optimal Human Performance. London: Ubiquity Press. DOI: https://doi.org/10.5334/bbe.

Bisantz, A. M. & Vicente, K. J. (1994). Making the abstraction hierarchy concrete. International Journal of Human - Computer Studies. 83–117. DOI: https://doi.org/10.1006/ijhc.1994.1005

Bligård, L-O. (2012). Predicting mismatches in user-artefact interaction. Development of an analytical methodology to support design work. (Doctoral thesis, Chalmers University of Technology, Gothenburg). Retrieved from http://publications.lib.chalmers.se/records/fulltext/162717/162717.pdf

Bligård, L-O. (2015). *ACD³ Utvecklingsprocessen ur ett människa-maskinperspektiv.* Göteborg: Chalmers Tekniska Högskola.

Bligård, L-O., & Osvalder, A-L. (2014). Predictive use error analysis – Development of AEA, SHERPA and PHEA to better predict, identify and present use errors. *International Journal of Industrial Ergonomics.* (p.153-170). DOI: https://doi.org/10.1016/j.ergon.2013.11.006

Bracey, K. (2018). What is Figma? Retrieved 2020-05-14 from https://webdesign.tutsplus.com/articles/what-is-figma--cms-32272

Bye, A., Hollnagel, E., & Brendeford, T. S. (1997). Human–machine function allocation: a functional modelling approach. *Reliability Engineering and System Safety, 64*(2), 291-300. doi: 10.1016/S0951-8320(98)00069-6

Carayon, P., Xie, A., & Kianfar, S. (2014). *Human factors and ergonomics as a patient safety practice.* (p. 196–205). USA: University of Wisconsin-Madison. DOI:10.1136/bmjqs-2013-001812

Chandra, S. (2019). Gestalt Principles — Learn how to influence perception. Retrieved 2020-05-19 from https://medium.com/ringcentral-ux/gestalt-principles-learn-how-to-influence-perception-83112932d0bc

Design Council. (2019). *What is the framework for innovation? Design Council's evolved Double Diamond.* Retrieved 2020-05-11 from https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W. S., … van der Doelen, B. (2011). A strategy for human factors/ergonomics: developing the discipline and profession. *Ergonomics*, *55*(4), 377-395. doi: 10.1080/00140139.2012.661087

Eggleston, R. G. (2002). Cognitive Systems Engineering at Twenty Something: Where do we stand? In M. D. McNeese & M. A. Vidulich (Eds.), *Cognitive systems engineering in military aviation environments: Avoiding cogminutia fragmentosa* (p.15-78). Wright-Patterson Air Force Base, OH: Human Systems Information Center.

Federation of European Ergonomic Societies. (n.d). What is ergonomics?. Retrieved 2020-05-07 from http://ergonomics-fees.eu/node/7

Gangemi, A., & Mancini, F. (2006). Guilt and Focusing in Decision-making. John Wiley & Sons, Ltd. DOI: 10.1002/bdm.536

Hart, S. G. (2006). Nasa-Task Load Index (NASA-TLX); 20 Years Later. *SAGE Journals. 50*(9), 904-908. DOI: https://doi.org/10.1177/154193120605000909

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. Advances in Psychology, 52, (p. 139-183). DOI: https://doi.org/10.1016/S0166-4115(08)62386-9

Hollnagel, E. (2003). Handbook of Cognitive Task Design. [Electronic resourse] (1). eISBN: 9781410607775

Hollnagel, E. (2009). The ETTO Principle: Efficiency-Thoroughness Trade-Off [Electronic resource] (1). eISBN: 9781317033615.

Inspektionen för vård och omsorg. (2017). *Varför händer det igen? Om patientsäkerhetsarbete i primärvården* (IVO Series No. 9). Retrieved from https://www.ivo.se/globalassets/dokument/publicerat/rapporter/rapporter-2017/varfor-hander-det-igen.pdf

Inspektionen för vård och omsorg. (2018). *Vad har IVO sett 2018? Iakttagelser och slutsatser om vårdens och omsorgens brister för verksamhetsåret 2018.* (IVO Series No. 6). Retrieved from https://www.ivo.se/globalassets/dokument/publicerat/rapporter/rapporter-2019/vad-har-ivo-sett-2018-digital.pdf

Inspektionen för vård och omsorg. (2020). *Lex Maria och lex Sarah*. Retreived 2020-05-05 from https://www.ivo.se/publicerat-material/statistik/lex-maria-och-lex-sarah/

Interaction Design Foundation. (2020). How to Conduct User Observations. Retrieved 2020-05-14 from https://www.interaction-design.org/literature/article/how-to-conduct-user-observations

Interaction Design Foundation. (n.d.-a) Cognitive Ergonomics. Retrieved 2020-05-07 from https://www.interaction-design.org/literature/topics/cognitive-ergonomics

International Design Foundation. (n.d.-b). Gestalt principles. Retrieved 2020-05-19 from https://www.interaction-design.org/literature/topics/gestalt-principles

International Ergonomics Association. (n.d). What is Ergonomics?. Retrieved 2020-05-07 from https://iea.cc/what-is-ergonomics/

Mitchell, P. (2013). Safer Care—Human Factors in Healthcare: Course Handbook. London: Swan & Horn.

Moran, K. (2018). Diary studies: a quick primer. Retrieved 2020-05-14 from https://uxdesign.cc/diary-studies-cd65a61a4f89

Moran, K. (2019). Usability Testing 101. Retrieved 2020-05-14 from nngroup.com/articles/usability-testing-101/

Myndigheten för vård- och omsorgsanalys. (2016). *Ändamålsenliga journalsystem i primärvården – lärdomar från läkarnas perspektiv.* (PM 2016:7) Retrieved from https://www.vardanalys.se/wp-content/uploads/2017/12/PM_2016-7-%C3%84ndam%C3%A5lsenliga-journalsystem-i-prim%C3%A4rv%C3%A5rden_webb.pdf

Mörner, C., Strömstedt, B., Mörkdal, V., Holmgren, O., & Månsson Blomqvist, Z. (n.d). *Uppgiftsanalys, granskning och användbarhetstest av Skistars bokningssystem*. Linköping: Linköpings universitet

Nielsen, J. (1994a). How to Conduct a Heuristic Evaluation. Nielsen Norman Group. Retrieved 2020-04-06 from https://www.nngroup.com/articles/how-to-conduct-a-heuristic-evaluation/

Nielsen, J. (1994b). 10 Usability Heuristics for User Interface Design. Nielsen Norman Group. Retrieved 2020-04-06 from https://www.nngroup.com/articles/ten-usability-heuristics/

Nielsen, J. (2010). Mental Models. Nielsen Norman Group. Retrieved 2020-05-20 from https://www.nngroup.com/articles/mental-models/

Nielsen, J. (2012). Thinking Aloud: The #1 Usability Tool. Retrieved 2020-05-14 from https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

Närhälsan. (2020). Låt oss få bli din vårdcentral. Retrieved 2020-05-07 from https://www.narhalsan.se/vard-och-rad/vardcentral/

Parker, A., & Tritter J., (2006). Focus group method and methodology: current practice and recent debate. *International Journal of Research & Method in Education*. *29*(1), 23-37. DOI: 10.1080/01406720500537304

Rasmussen, J. (1983). Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, *13* (3), 257-266. DOI: 10.1109/TSMC.1983.6313160

Rensink, R. A., (n.d). *The Management of Visual Attention in Graphic Displays*. Canada: University of British Columbia.

Scherer, K. R. (2005). What are emotions? And how can they be measured? Social Science Information. DOI: http://dx.doi.org/10.1177/0539018405058216

Scupin, R. (1997). The KJ Method: A Technique for Analyzing Data Derived from Japanese Ethnology. *Human Organization. 56*(2). 233-237.

Sherwin, K. (2018). Card Sorting: Uncover Users' Mental Models for Better Information Architecture. Retrieved 2020-05-15 from https://www.nngroup.com/articles/card-sorting-definition/

Socialstyrelsen. (2019). Who does what in the Swedish National Healthcare services. Retrieved 2020-05-14 from https://www.socialstyrelsen.se/en/about-us/healthcare-for-visitors-to-sweden2/where-to-go-for-medical-care-in-sweden/who-does-what-in-the-swedish-national-healthcare-services/

Socialstyrelsen. (2020a). Patientsäkerhetslagen. Retrieved 2020-05-07 from https://patientsakerhet.socialstyrelsen.se/lagar-och-foreskrifter/centrala-lagar/patientsakerhetslagen/

Socialstyrelsen. (2020b). Riskområden. Retrieved 2020-05-08 from https://patientsakerhet.socialstyrelsen.se/risker-och-vardskador/riskomraden/

Soegaard, M. (2020). The Law of Similarity - Gestalt Principles (1). Retrieved 2020-05-19 from https://www.interaction-design.org/literature/article/the-law-of-similarity-gestalt-principles-1

Sveriges läkarförbund. (n.d.). Swedish healthcare system. Retrieved 2020-05-14 from https://slf.se/in-english/swedish-health-care-system/

Uzialko, A. (2019). The Best Medical Practice Management Software of 2020. Retrieved 2020-05-07 from https://www.business.com/categories/best-medical-practice-management-software/

Wickens, C. D., Hollands, J. G., & Banbury, S. (2012). Engineering Psychology and Human Performance [Electronic resource] (4). Ebook ISBN: 9781315665177.

Wikberg Nilsson, Å., Ericsson, Å., & Törlind, P. (2015). Design: Process och metod (1:1). Lund: Studentlitteratur AB.

World Health Organization. (2016). Human Factors: Technical Series on Safer Primary Care. Geneva: World Health Organization.

Zolotova, M., & Giambattista, A. (2019). *Designing Cognitive Ergonomics*
Features of Medical Devices. Aspects of Cognitive Interaction, The Design Journal,
(p. 463-474). DOI: 10.1080/14606925.2019.1595432

Zoom Video Communications. (2020). Zoom Meetings & Chat. Retrieved 2020-05-14 from
https://zoom.us/meetings

Appendix

Appendix 1 - Observation template to first observations

Objective questions

Organizational system design

- **Transitions of care**
  Proper handovers? *Korridorskonsultation?*
  How do you transfer all information needed to the "right" person?
  How, when and where?
  About what?
  How often?
  What does the flows look like?
    - How is everything connected?
- **Policy and planning**
  When do they eat lunch?
  When do they take breaks?
  When are the working hours?
- What different types of departments are there?
- Possible systems? Subsystems? Open/closed?

Subjective questions

- **Communication and teamwork**
  Teams, team roles and responsibilities?
  Cultural norms? People's mental state, interest and motivations.
  Are they in a team together with the patient?
  The patient's relatives and their involvement

- **Co-workers**
  Is there any authority?
  Hierarchy?
  Any particular person?
- Decision making
- Personal attributes and personalities.

How is the patient's visit at the care centre? What kind of "journey" does the patient have?
Do they take care of children or only adults? If both, does the "journey" differ?

Physical system design

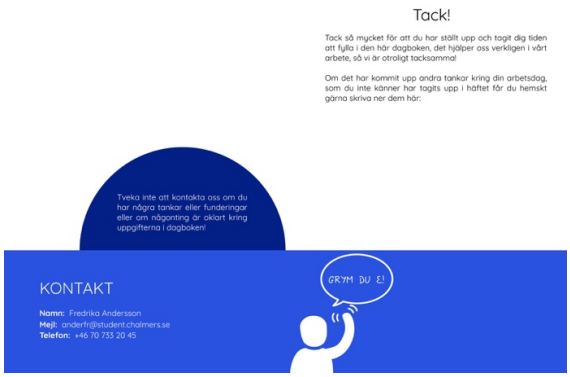
- **Environment:** Distribution, Distractions and so on! When, where and how?
    - lighting
    - sounds
    - motions
    - distractions
    - time pressure
    - Ergonomic aspects (bending, reaching, lifting)(aids to perform their work?)
    - How is the staff working with the furnitures and the "machines"?

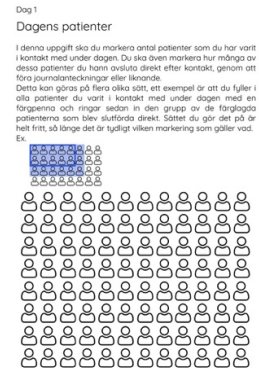
Cognitive system design

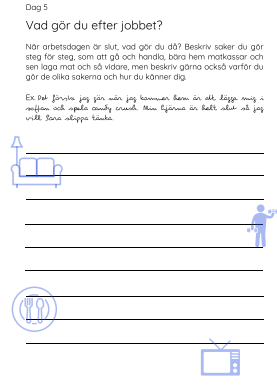
- **Work patterns**
  Automatic? What/when?
  Analytic thinking? What/when?
  Complexity of tasks?
  Do they have any own solutions?
  Where do they take shortcuts and risks regarding different tasks?
  What kind of information do they rely on themselves and their knowledge and what do they have to look up?
- **Data management and completeness of medical records**
  Manage time pressure, mental workload and interruption:
  Information underload/overload?
  Information scatter?
  Conflicting information?
  Duration of information?
  Intensity of information?
  Electronic records/programs?
  What kind of tools do they use?
  What type of systems?
  How do they use them? Usability?
- **Ordering and interpretation of diagnostic and laboratory test results**
  Three phases: pre-analytic, analytic and post-analytic? Information flow?
- **Cognitive abilities:** skills, expertise, pattern recognition, attention, memory, ability to focus (Situation awareness), expectations and associations.
- **Tunnel vision**
- **Fatigue/Stress**
  What the end of the day like? (when you're the most tired)
  How and when does that affect the work?
  How do they keep track of the time when they have a meeting with a patient?
  How does their "agenda" look? When do they know how their day will be?

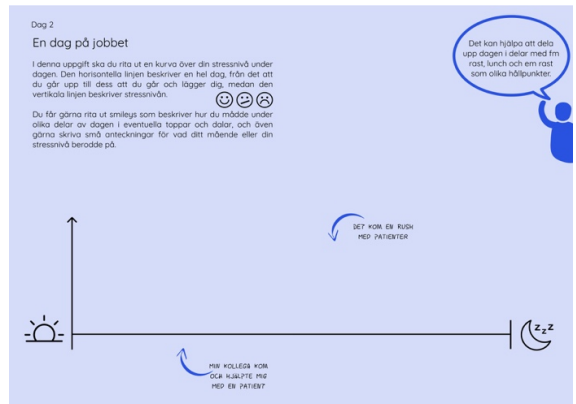
Appendix 2 - Booklet “My workday”

This illustrate the booklet “My workday” as it was printed.









Appendix 3 - Observation template to Medical record and documentation system observations

The use of medical record and documentation system

Handling of system

What is documented?
- What kind of info/functions are used?
- How detailed? How much?
- How much time is spent on this? Preparation before?
- Is any documentation performed during visit?

What is interpreted?
- What kind of info/functions are used?
- What is observed in the system?
- Key words? Numbers? Notes? Test results?
- How much time is spent on this?
- Preparation before meeting patient? Or during visit?
- During visit: times for reviewing the medical record?
  what? results/notes?

Started/finished documentation
- How many patient visits during the observation?
- What is required for them in order to start the documentation?
  - Time? Prioritizing? Routine?
- How many of these are documented directly? or semi-finished?
- How many of these are documented later during the day?
- Any "own" system for reminder which patients that are/are not documented?
- Returning to already "finished" documentation?
- How sure are they of being completed finished? Confident of including all aspects?

Control of documentation/ Miss in documentation
- Is any incorrect documentation discovedered? incorrect from the beginning?
  - By whom? When? How? How many times?
- Is any incomplete documentation discovered?
  - By whom? When? How? How many times?
- Is anybody checking/controlling documentation?
  - By whom? When? How? How many times?

Supporting tools
- Is any aids used during visits to remember? How much? What kind of info?
- How is used after visits?
- Any other aid for correct documentation?

Other software
- Is the medical record and documentation system separately or not?
- Other used software? Calendar? Is everything connected or separated?
- Is any documentation performed multiple times in different softwares?

Other aspects
- shortcuts?
- clicks? writing? clicks vs. writing?
- how fast/slow?
- Is medical staff in the same medical record? How often? How do they act if it happens?

Attitude and emotions
- Attitude towards documenting?
- Attitude towards interpretation/reading?
- Acting regarding dication/documentation? (pausing, doing everything at once/gradually, reading at the same time, looking at notes)

- What are the mental states during the day?
  - What affects? When?
  - Thinking? Engaged? Critical? Autopilot?
- How confident are they in their professional role?
  - Knowledge about medicine? Double checking? When/what/with whom?
  - Knowledge about "rounties"? Double checking? When/what/with whom?
- Mental models in general?
  - For handling softwares/computer?
  - Acting?

Time
- How much time for each visit?
  - How is that decided? Who decide number of cases/visits?
- Time for documentation?
- Stressed because of time?
- Own solutions for handling time pressure/falling behind?
- What is prioritized? Why? Who decides that?

- How much do they have to do during the observation?
  - How many patients? How it should be or not?

Patient

Where is the patient?
- Any support for knowing where the patient is?
- How is the staff notified about the patient's arrival/results/dictation or similar?
- Need of additional notification about the patient?

Relation to patient?
- How do they act toward "new" patients/regular patients?
- Are they are a team? Patients involvement? Helping/hindrance?

Appendix 4 - Template Walkthrough of medical record and documentation system

Can we take pictures?

Want to know:

The different ways of documenting throughout a patient journey.

1. Booking a scheduled time over the phone.
2. Visiting doctor, and the preparations before the visit.
3. Going to Lab.
4. Back to doctor, and the documentations post visit.

Headings.

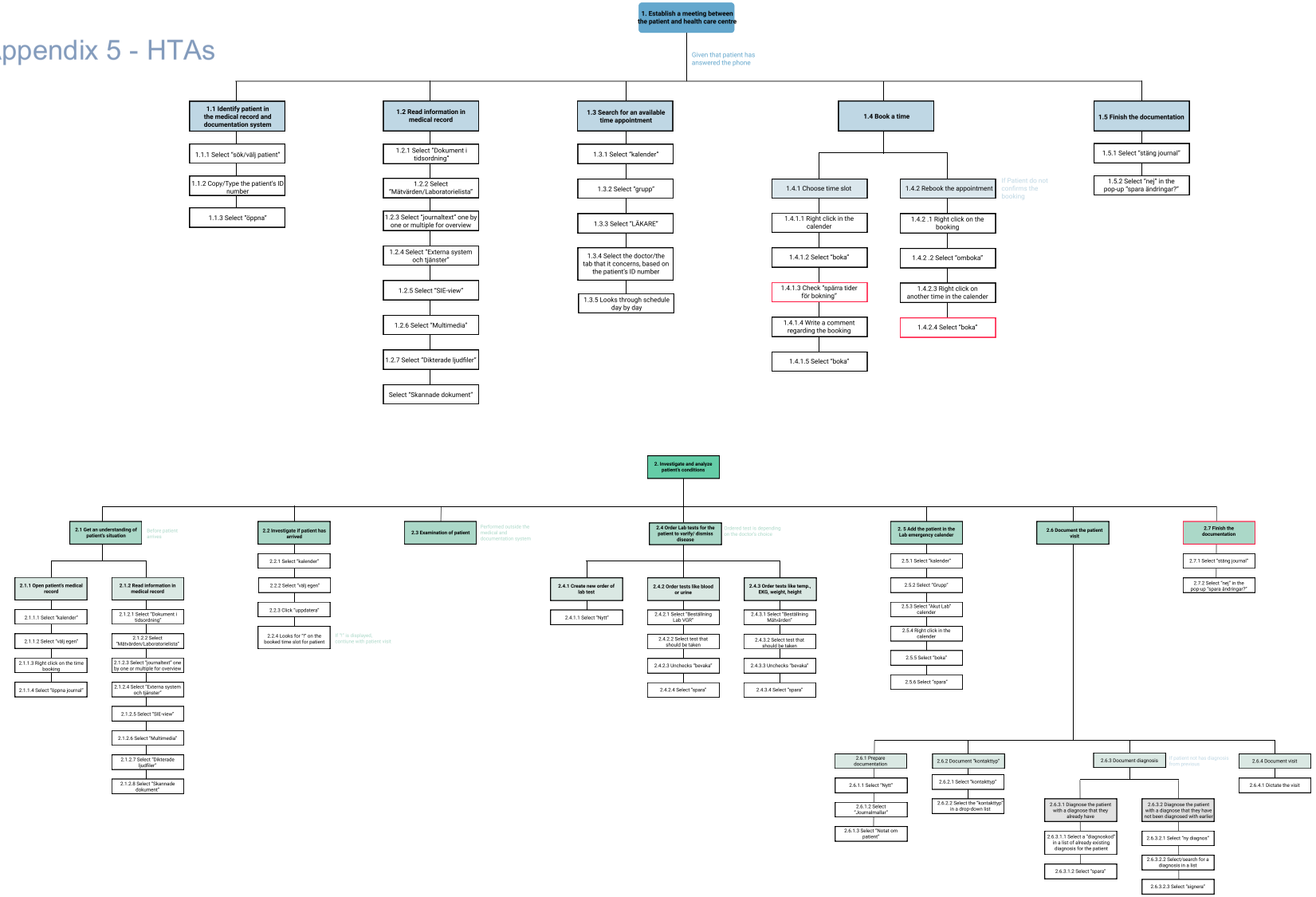
- What are they? where are they going? what are they used for?

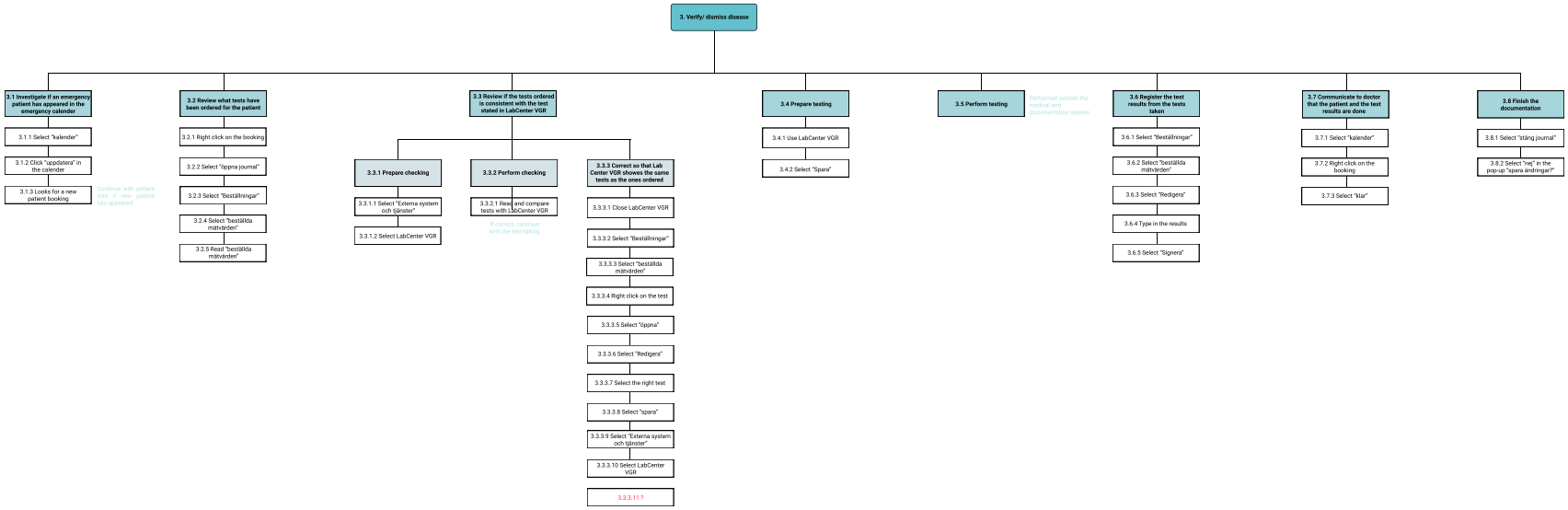
What subjects is noted in the patient medical record dependent on the role?
What/how much should be noted? Is there any regulations?
Have you had any education/course regarding the system?
    How do you teach a new employee?
Do any functions exist that is not used?

Shortcuts

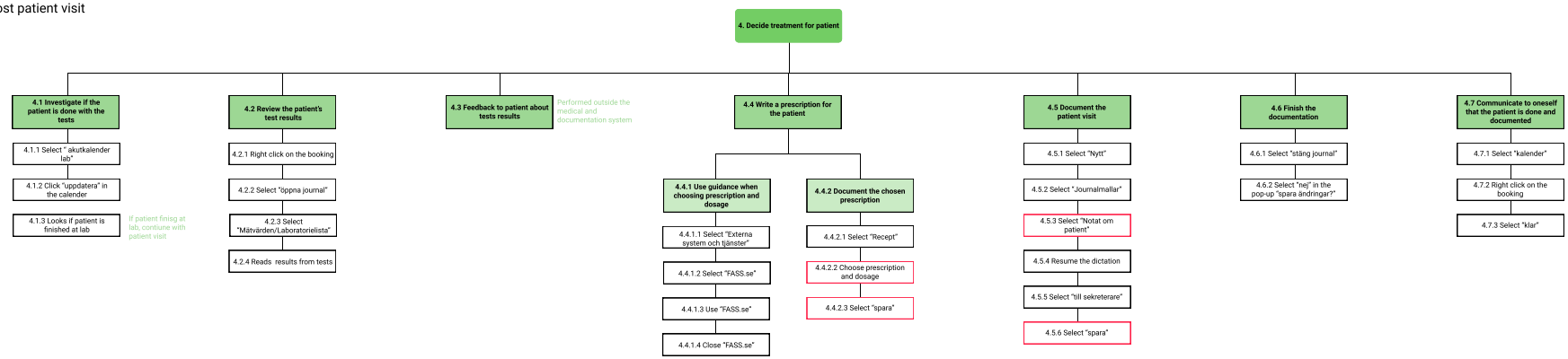
- What are they? Where are they going? What are they used for?
- How many are there?
- Do they exist in every role/task?

Appendix 5 - HTAs





Post patient visit



Appendix 6 - Usability test template

Intro till deltagarna 5 min

Hej,
Vad roligt att du kunde tänka dig att ställa upp!
Nu när vi har observerat en del så har vi lagt märke till att journal- och dokumentationssystemet är en aspekt som återkommer många gånger under en arbetsdag, *och att avläsningen och dokumentering in i journal- och dokumentationssystemet är väldigt väsentligt, samtidigt som det kräver mycket tid och koncentration, vilket man inte alltid kan få när det är mycket att göra.* Vi har därför valt att titta lite närmare på journal- och dokumentationssystemet och fördjupa oss mer inom just det området. Så, med den här intervjun så vill vi framför allt få lite mer förståelse för användningen av journal- och dokumentationssystemet, hur det fungerar men också hur tankarna går under hanteringen av journal- och dokumentationssystem.

Försäkring om känsliga frågor…..

Vi kommer börja med att gå igenom hur du gör när du läser igenom en journal och en bokning inför ett besök och hur du dokumenterar ett besök eller samtal. Och sedan kommer vi avsluta med några frågor. Vi tror att det inte kommer ta mer än 30 minuter.

Innan vi börjar så ska du få kolla över ett avtal kring vad vi kommer prata om nu. Så läs igenom och känns det okej får du skriva under.

Då kör vi!

Scenario Nurse:

Nurse

1. Scenario: Du har en patient som du ska ringa.

Förbereder du dig något inför samtalet?

Om nej: Gäller det alltid?

Om ja: Hur kommer det sig?

Gör du något under samtalet för att skapa dig en uppfattning om situationen?

Kan du visa och berätta hur du tänker när du skapar dig en uppfattning om situationen under samtalet?

Hoppa till nästa scenario.

Om nej: Vilka samtal förbereder du dig för?
Fortsätt nedåt.

Om ja: Kan du visa och berätta hur du tänker när du förbereder dig inför ett samtal för att läsa av journalen och bilda dig en uppfattning om situationen?

Hur tänker du när du kollar igenom dokumentationen?
Vad brukar du kolla på?
Varför?

Är det något du oftast inte kollar på?
Varför?

Förbereder du dig inför varje möte?
Om ja, Hur?
Varför/varför inte?
Skiljer det beroende på om du har träffat/har haft kontakt med patienten tidigare?

2. Scenario: Du ska dokumentera vad du har fått höra av patienten.

Görs detta under samtalet eller efter samtalet, då patienten har lagt på?
Varför vill du göra det då?

Kan du visa och berätta hur du tänker när du dokumenterar ett patientbesök om vad som hände/ vad ni pratade om?

Hur tänker du när du journalför?
Vad är viktigt att ha med?
Tänker du på hur mycket/lite du skriver in?

Vad journalför du inte?
Varför?

Journalför du varje kontakt med patient?
Varför/varför inte?

Skiljer det hur du dokumenterar beroende på om du har träffat/har haft kontakt med patienten tidigare eller inte?

Scenario Doctor:

Doctor

1. Scenario: Du har ett patientbesök om 5 minuter som har bokat en akuttid. Du har inte träffat inte denna patienten tidigare.

Skulle du förbereda dig på något sätt inför besöket?

Om nej: Gäller det alltid?

Om ja: Hur kommer det sig?

Om nej: Vilka besök förbereder du dig för?
Fortsätt nedåt.

Om ja: Kan du visa och berätta hur du tänker när du förbereder dig inför ett patientbesök för att läsa av journalen och bilda dig en uppfattning om situationen?

Hur tänker du när du kollar igenom dokumentationen?
Vad brukar du kolla på?
Varför?

Är det något du oftast inte kollar på?
Varför?

Förbereder du dig inför varje möte?
Om ja, Hur?
Varför/varför inte?
Skiljer det beroende på om du har träffat/har haft kontakt med patienten tidigare?

2. Scenario: Du har precis träffat din akutpatient och du ska dokumentera besöket.

Brukar du dokumentera direkt eller brukar du vänta med det?

Om direkt: Varför vill du göra det direkt?

Om inte: Varför vill du vänta och göra det senare?

För båda: Kan du visa och berätta hur du tänker när du rapporterar in ett patientbesök för att dokumentera vad som hände/ vad ni pratade om?

Hur tänker du när du journalför?
Vad är viktigt att ha med?
Tänker du på hur mycket/lite du dikterar in?

Vad journalför du inte?
Varför?

Journalför du varje möte/kontakt med patient?
Varför/varför inte?

Skiljer det hur du dokumenterar beroende på om du har träffat/har haft kontakt med patienten tidigare eller inte?

Skiljer det hur du dokumenterar beroende på om du har skickat patienten till labb eller inte?

Scenario Lab:

Lab

1. Scenario: Du har en akutpatient som kommer om 1 min och som du inte har träffat innan.

Skulle du förbereda dig på något sätt inför besöket?

Om nej: Gäller det alltid?

Om ja: Hur kommer det sig?

Gör du något under besöket för att skapa dig en uppfattning om situationen?

Kan du visa och berätta hur du tänker när du skapar dig en uppfattning om situationen under besöket?

Hoppa till nästa scenario.

Om nej: Vilka besök förbereder du dig för?
Fortsätt nedåt.

Om ja: Kan du visa och berätta hur du tänker när du förbereder dig inför ett patientbesök för att läsa av journalen och dokumentation och bilda dig en uppfattning om situationen och vad du ska göra?

Hur tänker du när du kollar igenom dokumentationen?
Vad brukar du kolla på?
Varför?

Är det något du oftast inte kollar på?
Varför?

Förbereder du dig inför varje möte?
Om ja, Hur?
Varför/varför inte?
Skiljer det beroende på om du har träffat/har haft kontakt med patienten tidigare?

2. Scenario: Du har precis träffat din akutpatient och du ska dokumentera besöket.

Gör du någon annan uppgift medans du väntar på att provsvaren ska bli färdiga?

Kan du visa och berätta hur du tänker när du rapporterar in ett patientbesök för att dokumentera vad som hände/ vad ni pratade om?

Hur tänker du när du journalför?
Vad är viktigt att ha med?

Vad journalför du inte?
Varför?

Journalför du varje möte/kontakt med patient?
Varför/varför inte?

Skiljer det hur du dokumenterar beroende på om du har träffat/har haft kontakt med patienten tidigare eller inte?

Interview questions to all:

Intervju

Nu kommer jag ställa lite frågor till dig.

Första erfarenhet av journal- och dokumentationssystem

Hur lärde du dig systemet?
- Try and error?
- Strukturerad genomgång med kollega?
- Lära av varandra successivt under tidens gång?

Var det lätt eller svårt att använda den i början?
- Blev det lätt fel?
- Vad för typ av fel?

Stötte du på problem eller frågetecken regelbundet?
- Vad gjorde du då?
- I vilka sammanhang?

Användning av journal- och dokumentationssystemet

Har du några knep som du använder dig utav?
- Genvägar för att effektivisera?

Söker efter nya sätt att göra saker på?
- Lär man sig själv och testar? Får hjälp/tips av kollegor?

Vad skulle du vilja kunna göra/se i journal- och dokumentationssystemet samtidigt som du läser information eller skriver in i journal- och dokumentationssystemet?

Saknar du något i journal- och dokumentationssystemet?

När det går fel…

Hur ser du på följderna av din dokumentation?
- Hur ser du att din dokumentation påverkar framtiden?

Hur bekväm är du i utförandet av journal- och dokumentationssystemet?
- Dokumentera/läsa "rätt/relevant" information?

Har du något sätt för att säkerställa att saker blir rätt?
- läser igenom anteckningar en extra gång?

Har det någon gång blivit fel när du använder journalen?
- Läst fel? Rapporterat fel?
- Vem upptäcker felen?

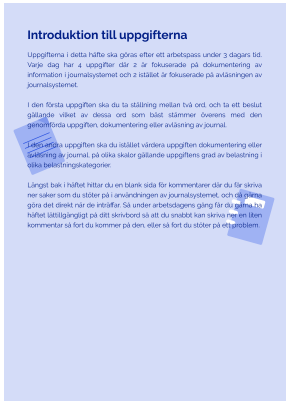
Emotional wheel

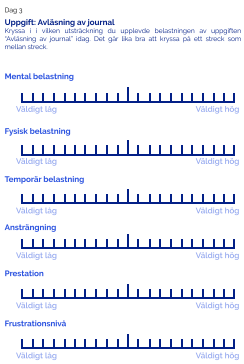
Här har vi olika känslor, som du kanske känner igen sen innan så då vill jag att du kryssar i några känslor som du upplever, och på vilken skala du upplever dem, prata gärna högt när du kryssar i. Vi börjar med när du läser i en journal och sedan tar vi för när du dokumenterar?

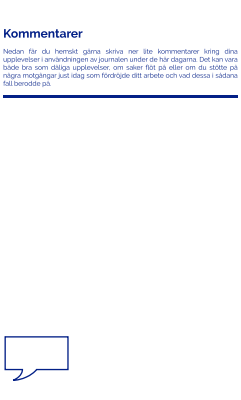
- Varför känner du så?
- När upplever du det?
- Vad bidrar till att du ska känna/inte känna så?
- Vad hade behövts för att du inte ska känna så?
- Påverkar det ditt arbete?

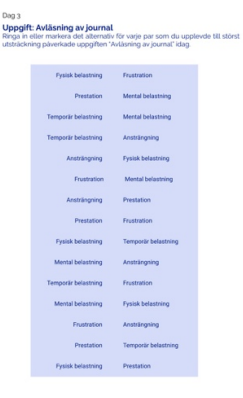
Appendix 7 - Booklet “The Medical record and I”

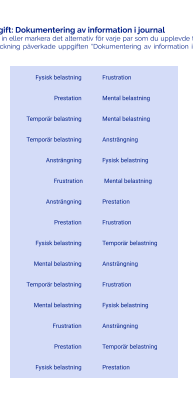
This illustrate the booklet “The Medical record and I” as it was printed.

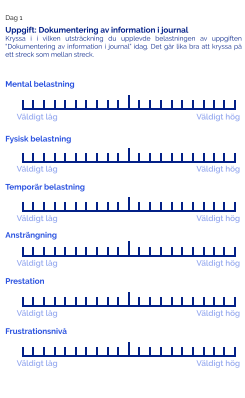












Dag 1

Uppgift: Avläsning av journal

Ringa in eller markera det alternativ för varje par som du upplevde till störst utsträckning påverkade uppgiften "Avläsning av journal" idag.

Fysisk belastning	Frustration
Prestation	Mental belastning
Temporär belastning	Mental belastning
Temporär belastning	Ansträngning
Ansträngning	Fysisk belastning
Frustration	Mental belastning
Ansträngning	Prestation
Prestation	Frustration
Fysisk belastning	Temporär belastning
Mental belastning	Ansträngning
Temporär belastning	Frustration
Mental belastning	Fysisk belastning
Frustration	Ansträngning
Prestation	Temporär belastning
Fysisk belastning	Prestation

Dag 2

Uppgift: Avläsning av journal

Kryssa i i vilken utsträckning du upplevde belastningen av uppgiften "Avläsning av journal" idag. Det går lika bra att kryssa på ett streck som mellan streck.

Mental belastning

Väldigt låg — Väldigt hög

Fysisk belastning

Väldigt låg — Väldigt hög

Temporär belastning

Väldigt låg — Väldigt hög

Ansträngning

Väldigt låg — Väldigt hög

Prestation

Väldigt låg — Väldigt hög

Frustrationsnivå

Väldigt låg — Väldigt hög

Dag 2

Uppgift: Avläsning av journal

Ringa in eller markera det alternativ för varje par som du upplevde till störst utsträckning påverkade uppgiften "Avläsning av journal" idag.

Fysisk belastning	Frustration
Prestation	Mental belastning
Temporär belastning	Mental belastning
Temporär belastning	Ansträngning
Ansträngning	Fysisk belastning
Frustration	Mental belastning
Ansträngning	Prestation
Prestation	Frustration
Fysisk belastning	Temporär belastning
Mental belastning	Ansträngning
Temporär belastning	Frustration
Mental belastning	Fysisk belastning
Frustration	Ansträngning
Prestation	Temporär belastning
Fysisk belastning	Prestation

Dag 1

Uppgift: Avläsning av journal

Kryssa i i vilken utsträckning du upplevde belastningen av uppgiften "Avläsning av journal" idag. Det går lika bra att kryssa på ett streck som mellan streck.

Mental belastning

Väldigt låg — Väldigt hög

Fysisk belastning

Väldigt låg — Väldigt hög

Temporär belastning

Väldigt låg — Väldigt hög

Ansträngning

Väldigt låg — Väldigt hög

Prestation

Väldigt låg — Väldigt hög

Frustrationsnivå

Väldigt låg — Väldigt hög

Dag 2

Uppgift: Dokumentering av information i journal

Ringa in eller markera det alternativ för varje par som du upplevde till störst utsträckning påverkade uppgiften "Dokumentering av information i journal" idag.

Fysisk belastning	Frustration
Prestation	Mental belastning
Temporär belastning	Mental belastning
Temporär belastning	Ansträngning
Ansträngning	Fysisk belastning
Frustration	Mental belastning
Ansträngning	Prestation
Prestation	Frustration
Fysisk belastning	Temporär belastning
Mental belastning	Ansträngning
Temporär belastning	Frustration
Mental belastning	Fysisk belastning
Frustration	Ansträngning
Prestation	Temporär belastning
Fysisk belastning	Prestation

Dag 2

Uppgift: Dokumentering av information i journal

Kryssa i i vilken utsträckning du upplevde belastningen av uppgiften "Dokumentering av information i journal" idag. Det går lika bra att kryssa på ett streck som mellan streck.

Mental belastning

Väldigt låg — Väldigt hög

Fysisk belastning

Väldigt låg — Väldigt hög

Temporär belastning

Väldigt låg — Väldigt hög

Ansträngning

Väldigt låg — Väldigt hög

Prestation

Väldigt låg — Väldigt hög

Frustrationsnivå

Väldigt låg — Väldigt hög

Dag 1

Uppgift: Dokumentering av information i journal

Ringa in eller markera det alternativ för varje par som du upplevde till störst utsträckning påverkade uppgiften "Dokumentering av information i journal" idag.

Fysisk belastning	Frustration
Prestation	Mental belastning
Temporär belastning	Mental belastning
Temporär belastning	Ansträngning
Ansträngning	Fysisk belastning
Frustration	Mental belastning
Ansträngning	Prestation
Prestation	Frustration
Fysisk belastning	Temporär belastning
Mental belastning	Ansträngning
Temporär belastning	Frustration
Mental belastning	Fysisk belastning
Frustration	Ansträngning
Prestation	Temporär belastning
Fysisk belastning	Prestation

Dag 3

Uppgift: Dokumentering av information i journal

Kryssa i i vilken utsträckning du upplevde belastningen av uppgiften "Dokumentering av information i journal" idag. Det går lika bra att kryssa på ett streck som mellan streck.

Mental belastning

Väldigt låg — Väldigt hög

Fysisk belastning

Väldigt låg — Väldigt hög

Temporär belastning

Väldigt låg — Väldigt hög

Ansträngning

Väldigt låg — Väldigt hög

Prestation

Väldigt låg — Väldigt hög

Frustrationsnivå

Väldigt låg — Väldigt hög

Appendix 8 - Results Nasa-TLX

Participant: 1

Dag 1 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	70	3	210
	Physical Demand	20	0	0
	Temporal Demand	90	4	360
	Performance	10	4	40
	Effort	75	3	225
	Frustration	40	1	40
			Weighted rating	58,33

Dag 1 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	70	3	210
	Physical Demand	10	1	10
	Temporal Demand	90	4	360
	Performance	10	4	40
	Effort	70	1	70
	Frustration	40	2	80
			Weighted rating	51,33

Dag 2 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	65	3	195
	Physical Demand	5	0	0
	Temporal Demand	60	4	240
	Performance	15	5	75
	Effort	60	2	120
	Frustration	35	1	35
			Weighted rating	44,33

Dag 2 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	70	4	280
	Physical Demand	10	0	0
	Temporal Demand	80	5	480
	Performance	10	3	30
	Effort	70	2	140
	Frustration	30	1	30
			Weighted rating	58,67

Dag 3 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	70	4	280
	Physical Demand	5	0	0
	Temporal Demand	85	5	425
	Performance	20	3	60
	Effort	70	1	70
	Frustration	75	2	150
			Weighted rating	65,67

Dag 3 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	80	4	320
	Physical Demand	10	0	0
	Temporal Demand	85	5	425
	Performance	25	1	25
	Effort	75	2	150
	Frustration	65	3	195
			Weighted rating	74,33

Participant: 2

Dag 1 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	25	5	125
	Physical Demand	0	0	0
	Temporal Demand	15	2	30
	Performance	25	1	25
	Effort	25	4	100
	Frustration	20	3	60
			Weighted rating	22,67

Dag 1 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	10	2	20
	Physical Demand	0	0	0
	Temporal Demand	10	4	40
	Performance	0	5	0
	Effort	10	3	30
	Frustration	5	1	5
			Weighted rating	6,33

Dag 2 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	50	4	200
	Physical Demand	25	0	0
	Temporal Demand	30	2	60
	Performance	20	1	20
	Effort	45	5	225
	Frustration	50	3	150
			Weighted rating	43,67

Dag 2 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	25	3	75
	Physical Demand	0	0	0
	Temporal Demand	15	5	75
	Performance	0	1	0
	Effort	25	4	100
	Frustration	30	2	60
			Weighted rating	20,67

Dag 3 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	5	2	10
	Physical Demand	5	1	5
	Temporal Demand	5	4	20
	Performance	0	5	0
	Effort	0	2	0
	Frustration	5	1	5
			Weighted rating:	2,67

Dag 3 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	5	2	10
	Physical Demand	0	0	0
	Temporal Demand	0	3	0
	Performance	95	5	475
	Effort	0	4	0
	Frustration	5	1	5
			Weighted rating:	32,67

Participant: 3

Dag 1 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	75	2	150
	Physical Demand	0	0	0
	Temporal Demand	50	2	100
	Performance	0	5	0
	Effort	0	3	0
	Frustration	50	3	150
			Weighted rating	26,67

Dag 1 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	0	1	0
	Physical Demand	5	0	0
	Temporal Demand	20	5	100
	Performance	95	3	285
	Effort	5	4	20
	Frustration	0	2	0
			Weighted rating	27

Dag 2 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	50	1	50
	Physical Demand	5	0	0
	Temporal Demand	95	4	380
	Performance	50	4	200
	Effort	50	4	200
	Frustration	50	2	100
			Weighted rating	62

Dag 2 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	60	2	120
	Physical Demand	0	0	0
	Temporal Demand	100	4	400
	Performance	25	3	75
	Effort	60	1	60
	Frustration	70	5	350
			Weighted rating	67

Dag 3 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	50	1	50
	Physical Demand	50	0	0
	Temporal Demand	75	5	375
	Performance	30	4	120
	Effort	55	2	110
	Frustration	65	3	195
			Weighted rating:	56,67

Dag 3 aviäsning Trail: OKLAR2-OMTAG 006

		Rating	Weight	Adjusted
Rating scale	Mental demand			
	Physical Demand			
	Temporal Demand			
	Performance			
	Effort			
	Frustration			
			Weighted rating:	

Participant: 4

Dag 1 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	15	1	15
	Physical Demand	10	0	0
	Temporal Demand	65	5	325
	Performance	30	4	120
	Effort	35	3	105
	Frustration	55	2	110
			Weighted rating	45

Dag 1 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	40	2	80
	Physical Demand	15	0	0
	Temporal Demand	70	5	350
	Performance	45	2	90
	Effort	40	3	120
	Frustration	55	3	165
			Weighted rating	53,67

Dag 2 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	20	1	20
	Physical Demand	15	0	0
	Temporal Demand	50	5	250
	Performance	65	4	260
	Effort	30	2	60
	Frustration	40	3	120
			Weighted rating	47,33

Dag 2 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	20	1	20
	Physical Demand	5	0	0
	Temporal Demand	40	5	200
	Performance	75	4	300
	Effort	15	2	30
	Frustration	35	3	105
			Weighted rating	43,67

Dag 3 dokumentering

		Rating	Weight	Adjusted
Rating scale	Mental demand	15	1	15
	Physical Demand	10	0	0
	Temporal Demand	40	5	200
	Performance	80	4	320
	Effort	20	3	60
	Frustration	35	2	70
			Weighted rating	44,33

Dag 3 aviäsning

		Rating	Weight	Adjusted
Rating scale	Mental demand	10	1	10
	Physical Demand	5	0	0
	Temporal Demand	20	5	100
	Performance	80	2	160
	Effort	25	4	100
	Frustration	25	3	75
			Weighted rating	29,67

Appendix 9 - Interview COSMIC template

Introduktion

Berätta om oss och vårt arbete

- valt att fokusera på journalsystemet Asynja Visph och en viss patientresa.
- beskriv lite hur journalen används i det scenariot.

Intervju

När och hur använder du dig av COSMIC? Och använder du dig av en padda eller en dator eller båda delarna?

Hur går du tillväga när du ska läsa i en patients journal?
Hur går du tillväga när du ska dokumentera en patientkontakt?
Hur går du tillväga om du ska dokumentera resultat från en provtagning?

Vad i journalsystemet är det som bidrar till att du får förståelse för patientens situation innan ett besök? Layout? Flöde? Funktioner?
Vad i journalsystemet gör att du tycker det är enkelt att dokumentera en patientkontakt eller resultat från en provtagning? Layout? Flöde? Funktioner?

Vad gillar/uppskattar du med journalsystemet?
Vad gillar/uppskattar du inte med journalsystemet?

Får du någon stöttning eller feedback kring ditt arbete? Både för dokumentering och läsning av journalen.

Fick du ordentligt stöd/utbildning i hur systemet skulle användas i början eller har du lärt dig systemet på egen hand?

Egen hand: Var systemet tillräckligt intuitivt för att lära sig det?

Kände du att du lärde dig allt direkt eller har du lärt dig nya saker allt eftersom?

Stöd/utbildning:
Kände du att du lärde dig allt direkt eller har du lärt dig nya saker allt eftersom?

I samband med dina arbetsuppgifter, finns det något i hanteringen av journalsystemet som du skulle vilja ändra på för att underlätta ditt arbete?

Om ja: Vad skulle du vilja ändra på?

Om nej:
Vad vi har läst på så tycker folk att det är för mycket klick, att man inte får ordentlig feedback, att vissa tar omständiga omvägar som inte är effektivt för att man inte riktigt förstår hur systemet ska hanteras och att det är svårt att navigera och få en överblick över en situation.

Inget där som du håller med om?

Uppkommer det någonsin fel vid hanteringen av COSMIC?

Om ja: Vad för slags fel?
I vilka tillfällen och varför brukar dessa fel uppkomma?
Vem upptäcker felen?

Om nej: Gå vidare till nästa fråga.

Appendix 10 - Results Nielsen's Heuristic Evaluation method

Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
1. Book a time for the patient						0	No problem
1.1.1	Select "sökväljl patient	8. Aesthetic and minimalistic design	Where to start and search for a patient is not graphically clear. However, based on standards (Windows) the user knows to start in the upper left corner.	1		1	Cosmetical problem
1.1.2	Copy/Type the patient's ID number	5. Prevent errors	The system do not correct the user when typing a wrong digit in a patient's ID number.	2		2	Small problem
1.3.1-1.3.3	Select right calender	4. Coherent with standards and 8. Aesthetic and minimalistic design	Different ways of chosing a command right after each other. One is a symbol, one is a list and one is a drop-down list.	1		3	Large problem
1.3.4	Select the doctor/the tab that it concerns, based on the patient' s ID number	5. Prevent errors	The system do not correct the user if a calender regarding a doctor that it does not concern are chosen.	2		4	Catastofical problem
1.3.5	Looks through schedule day by day	7. Flexibility and efficiency	Have to search a lot before finding a time available. Possible to miss a time. Takes time to search.	2			
1.4.1.3 - 1.4.1.5	Make commands regarding the booking.	8. Aesthetic and minimalistic design	A lot of information in the appearing window.	1			
1.5.1	Select "stäng journal"	8. Aesthetic and minimalistic design	Where to finish and close a patient's medical record is not graphically clear. However, based on standards (Windows) the user knows to finish in the upper right corner.	1			
1.5.2	Select "nej" in the pop-up "spara ändringar?"	2. Similarities between the product and reality	If the user choses another command, all work that has been carried out are lost.	3			
2. Help and diagnose the patient visiting the medical centre							
2.1.1.1	Select "kalender"	8. Aesthetic and minimalistic design	Do not visually know where to go to select the calender. Tiny icon for the calender and not clear the intension with the symbol.	1			

Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
2.1.2	Reading information in the medical record	1. The visibility of the product's status 7. Flexibility and efficiency 8 Aesthetic and minimalistic design	No support in what to look at, what they should look at. There is a lot to choose from. No feedback on what is "right". Which makes it possible to miss important information.	3			
2.2.3	Click "uppdatera"	1. The visibility of the product's status	An update of the system has to made manually, making it possible to miss important information if the update is forgotten/do not have the time.	2			
2.2.4	"I" appears on the booked time slot if the patient has arrived	8. Aesthetic and minimalistic design 1. The visibility of the product's status	Hard to see the symbol in the calender because it is very tiny. If the user updates the system they do however look for that symbol (if experienced).	1			
2.4.1.1	Select "Nytt"	8. Aesthetic and minimalistic design	Where to start and writes notes regarding a patient is not graphically clear. However, based on standards (Windows) the user knows to start in the upper left corner.	1			
2.4.2.2 + 2.4.3.2	Select test that should be taken	5. Prevent errors 8. Aesthetic and minimalistic design	A lot of information. Possible to chose the wrong test by mistake in the list.	2			
2.4.2.3 + 2.4.3.3	Unchecks "bevaka"	3. User control and freedom	The "bevaka" box is checked as a default and if it is not unchecked that result in additional, unnecessary work when signing off test that are under supervision even though they should not.	3			
2.5.1-2.5.3	Select right calender	4. Coherent with standards 8. Aesthetic and minimalistic design	Different ways of chosing a command right after each other. One is a symbol, one is a list and one is a drop-down list.	1			

Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
2.6.1.1	Select "Nytt"	8. Aesthetic and minimalistic design	Where to start and writes notes regarding a patient is not graphically clear. However, based on standards (Windows) the user knows to start in the upper left corner.	1			
2.6.2.2	Select the "kontakttyp" in a drop-down list	5. Prevent errors	Possible to chose the wrong "kontakttyp" by mistake in the drop-down list.	2			
2.6.3	Select "diagnos enl ICD10-SE"	8. Aesthetic and minimalistic design	The headlines to the left in the window are competing with each other in gettin attention. However, "diagnos enl ICD10-SE" is written in uppercase to attract the user's attention.	1			
2.6.3.1.1	Select a "diagnoskod" in a list of already existing diagnosis for the patient	5. Prevent errors 8. Aesthetic and minimalistic design	A lot of information. Possible to chose the wrong diagnosis by mistake in the list.	2			
2.6.3.2.2	Select/search for a diagnosis in a list	5. Prevent errors 8. Aesthetic and minimalistic design	A lot of information. Possible to chose the wrong diagnosis by mistake in the list.	2			
2.7.1	Select "stäng journal"	8. Aesthetic and minimalistic design	Where to finish and close a patient's medical record is not graphically clear. However, based on standards (Windows) the user knows to finish in the upper right corner.	1			
2.7.2	Select "nej" in the pop-up "spara ändringar?"	2. Similarities between the product and reality	If the user chooses another command, all work that has been carried out are lost.	3			
3. Takes tests for an emergency patient							
3.1.1	Select "kalender"	8. Aesthetic and minimalistic design	Do not visually know where to go to select the calender. Tiny icon for the calender and not clear the intension with the symbol.	1			

Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
3.1.2	Click "uppdatera"	1. The visibility of the product's status	An update of the system has to made manually, making it possible to miss important information if the update is forgotten/do not have the time.	2			
3.2.3	Select "Beställningar"	5. Prevent errors 8. Aesthetic and minimalistic design 4. Coherent with standards	A lot of different headlines presented to the user, headlines that are also similar to each other. Difficult to know which "beställnings" related headline to choose.	1			
3.3.1.1	Select "Externa system och tjänster"	8. Aesthetic and minimalistic design	A lot of different headlines presented to the user. Tiny text, have to visually search for a specific headline – have to know what you are looking for.	1			
3.3.3.2	Select "Beställningar"	5. Prevent errors 8. Aesthetic and minimalistic design 4. Coherent with standards	A lot of different headlines presented to the user, headlines that are also similar to each other. Difficult to know which "beställnings" related headline to choose.	1			
3.3.3.9	Select "Externa system och tjänster"	8. Aesthetic and minimalistic design	A lot of different headlines presented to the user. Tiny text, have to visually search for a specific headline – have to know what you are looking for.	1			
3.6.1	Select "Beställningar"	5. Prevent errors 8. Aesthetic and minimalistic design 4. Coherent with standards	A lot of different headlines presented to the user, headlines that are also similar to each other. Difficult to know which "beställnings" related headline to choose.	1			
3.6.4	Type in the results	5. Prevent errors	The results is required to be typed manually – possible to type in the wrong result. The result which is written down by hand on paper that can go missing.	3			

Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
3.7.1	Select "kalender"	8. Aesthetic and minimalistic design	Do not visually know where to go to select the calender. Tiny icon for the calender and not clear the intension with the symbol.	1			
3.8.1	Select "stäng journal"	8. Aesthetic and minimalistic design	Where to finish and close a patient's medical record is not graphically clear. However, based on standards (Windows) the user knows to finish in the upper right corner.	1			
3.8.2	Select "nej" in the pop-up "spara ändringar?"	2. Similarities between the product and reality	If the user choses another command, all work that has been carried out are lost.	3			
4. Make a decision on what actions to make depending on the patient's wellbeing and test results							
4.1.1	Select "kalender"	8. Aesthetic and minimalistic design	Do not visually know where to go to select the calender. Tiny icon for the calender and not clear the intension with the symbol.	1			
4.1.2	Click "uppdatera"	1. The visibility of the product's status	An update of the system has to made manually, making it possible to miss important information if the update is forgotten/do not have the time.	2			
4.2.3	Select "Mätvärden/Laboratorielista"	8. Aesthetic and minimalistic design	A lot of different headlines presented to the user. Tiny text, have to visually search for a specific headline – have to know what you are looking for.	1			
4.4.1.1	Select "Externa system och tjänster"	8. Aesthetic and minimalistic design	A lot of different headlines presented to the user. Tiny text, have to visually search for a specific headline – have to know what you are looking for.	1			

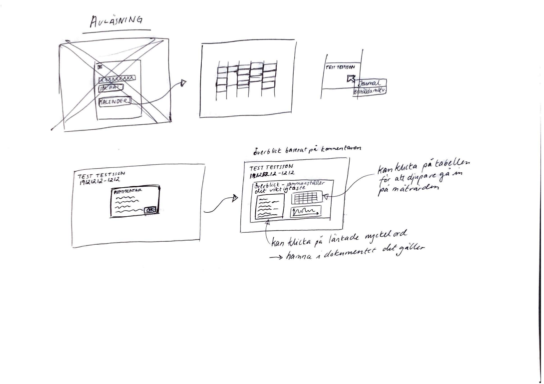
Location in HTA	Task description	Hierarchy – Nielsen	Error description	Degree of seriousness		Rating	Rating description
4.4.2.1	Select "Recept"	8. Aesthetic and minimalistic design 4. Coherent with standards 6. Recognition instead of display	A lot of different headlines presented to the user. Tiny text, have to visually search for a specific headline – have to know what you are looking for. "Receipt" can also be chosen elsewhere, in the note for the patient – have to know which one is relevant for which situation.	1			
4.4.2.2	Choose prescription and dosage	5. Prevent errors 8. Aesthetic and minimalistic design	A lot of information. Possible to chose/type the wrong prescription by mistake in the list.	2			
4.5.1	Select "Nytt"	8. Aesthetic and minimalistic design	Where to start and writes notes regarding a patient is not graphically clear. However, based on standards (Windows) the user knows to start in the upper left corner.	1			
4.5.5	Select "till sekreterare"	5. Prevent errors 8. Aesthetic and minimalistic design 4. Coherent with standards	Have to know that this command has to be chosen before "spara", possible to by mistake choose "spara" instead when the user is stressed and operates on Window standards.	2			
4.6.1	Select "stäng journal"	8. Aesthetic and minimalistic design	Where to finish and close a patient's medical record is not graphically clear. However, based on standards (Windows) the user knows to finish in the upper right corner.	1			
4.6.2	Select "nej" in the pop-up "spara ändringar?"	2. Similarities between the product and reality	If the user choses another command, all work that has been carried out are lost.	3			
4.7.1	Select "kalender"	8. Aesthetic and minimalistic design	Do not visually know where to go to select the calender. Tiny icon for the calender and not clear the intension with the symbol.	1			

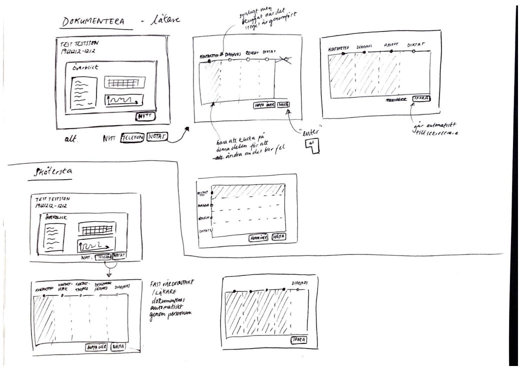
Appendix 11 - Result ACD3-matrix

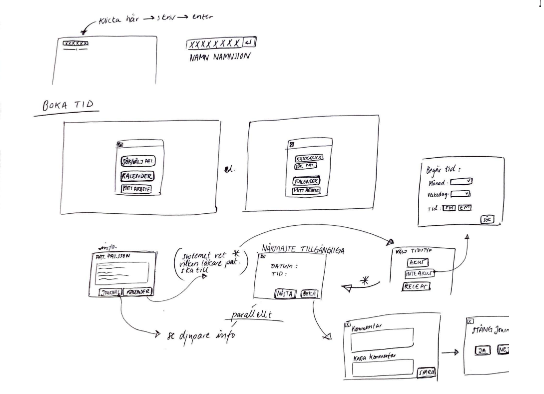
LEVELS OF DESIGN

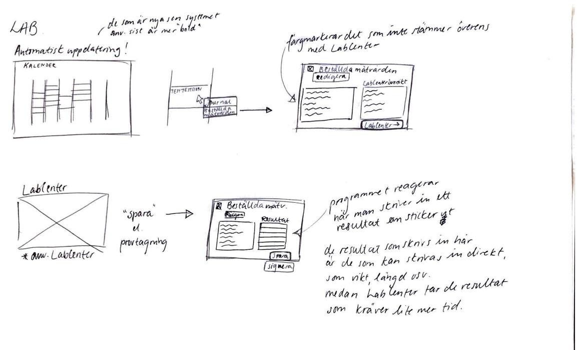
DESIGN PERSPECTIVE	EFFECT	USE	ARCHITECTURE	INTERACTION	ELEMENT
PROBLEM	**Problem statement:** The medical record contributes to the medical workers' cognitive workload which affects the staff's performance at the health care centre.	**Q1:** Does the usage of the medical record unburden the cognitive workload of the medical staff? **Q2:** Does the usage of the medical record has any implications of the staff's medical work? **Q3:** Is any support provided while using the medical record?	**Q1:** How does the interface affect reading and documenting in the medical record? **Q2:** How does the interface affect: – the system, the task and the operators? – mental models and expertise? – attention and awareness? – mental resources and mental workload? – emotions? – decision making? – errors and risks? when reading and documenting in the medical record. **Q3:** How does the interface affect the effectiveness and efficiency of the usage of the medical record when reading and documenting in the medical record?	**Q1:** What interface benefits reading and documenting in the medical record the most? **Q2:** What interface is most beneficial in supporting: – the system, the task and the operators? – mental models and expertise? – attention and awareness? – mental resources and mental workload? – emotions? – decision making? – preventing errors and risks? when, in reading and documenting in the medical record. **Q3:** What interface benefits the effectiveness and efficiency in the usage of the medical record the most when reading and documenting in the medical record?	**Q1:** What elements should be present when reading and documenting in the medical record? **Q2:** How should the elements in the medical record work together to support the medical staff when reading and documenting in the medical record?
STRUCTURE	**Intended context:** The medical centre. **Intended users:** Medical workers at the health care centre. **Additional stakeholders:** The patient.	**Intended context:** The rooms and equipment of the assistant nurses in lab, district nurses /nurse on the telephone and doctors. – Computer – Keyboard – Mouse – Desk – Notebook / Paper **Intended users:** Assistant nurses in lab, district nurses /nurse on the telephone and doctors. **Additional stakeholders:** The patient.	**Reading...** – about a patient to be able to book a time for the patient – about a patient to understand the patient's situation. – to know what tasks to perform. **Documenting...** – booking a time. – testresults from Lab. – information regarding the patient visit.	**Reading...** – about a patient to be able to book a time for the patient – journalblad – mätvärden/laboratorietests – dokument i tidsordningen – externa system och tjänster – multimedia – about a patient to understand the patient's situation. – comment regarding the reason for the time booking – journalblad – mätvärden/laboratorietests – dokument i tidsordningen – externa system och tjänster – multimedia – to know what tasks to perform. – beställda mätvärden – LabCenter **Documenting...** – booking a time. – calendar – testresults from Lab. – beställda mätvärden – LabCenter – information regarding the patient visit. – notat om patient	**Reading...** – about a patient to be able to book a time for the patient Different, varying information from a number of previous visits within each segment: – journalblad – mätvärden/laboratorietests – dokument i tidsordningen – externa system och tjänster – multimedia – A summary/overview with the possibility of searching for more information if needed. – about a patient to understand the patient's situation. Different, varying information from a number of previous visits within each segment: – comment regarding the reason for the time booking – journalblad – mätvärden/laboratorietests – dokument i tidsordningen – externa system och tjänster – multimedia – A summary/overview with the possibility of searching for more information if needed. – to know what tasks to perform. All tests that should be taken during the patient visit is stated in: – beställda mätvärden – LabCenter **Documenting...** – booking a time. Search for/get guidance to the right doctor and a time available in: – calendar – testresults from Lab. Type the results from different tests in: – beställda mätvärden – LabCenter – information regarding the patient visit. Document the information with guidance from headings in: – notat om patient
FUNCTION	**Ability:** Enable the ability to retrieve the correct information. Enable the ability to document information retrieved. **Value:** Easy to provide correct medical care. Easy intuitive interaction. Easy to get a quick overview of the information. Easy to document the visit. Easy to provide a correct communication between different stakeholders.	**Main function:** Retrieve the correct information. Document information retrieved. **Part function:** Store information. Provide different types of information in the medical record. Find the right information for the occasion in the medical record. Add information regarding a patient in the patient's medical record. Edit / update information regarding a patient in the patient's medical record.	**Machine function:** Provide readable text and information. Provide storage of documentation from previous patient visits from multiple users. Provide saving possibilities of new information added. Provide intuitive interaction with the interface. – to enable effective work. – to enable efficient work. – to enable quick decision making.	**Guiding and information:** Interaction guidance and information through... – text. – icons. – buttons. Additional information or steps described through text, icons or buttons when interacting with guiding elements. Add additional information when an action by the user has been carried out. Change in visual interface when carrying out an action, communicating that the action is carried out. Change in visual interface when an action is carried out incorrectly. Display a visual indication of actions that has been carried out and actions that are to be carried out next. Deplay list/history of previously made documentation.	**Element functions:** Interaction guidance and information through text. – Named heading associated with the information provided when clicking on that heading. Interaction guidance and information through icons. Icons have meaning what information is provided when clicking on that icon, based on common, culturally known icons. – Added information displayed in text when hovering the arrow on the icon. – Icons with following text of what it stands for. Interaction guidance and information through buttons. – Buttons located on well-known locations in the window to facilitate perception attention. – Numbered and coloured buttons to clearly state the function of the button. Displaying previously made documentation in a summary/overview. Displaying the order of previously made documentation in the user's preferred way – date – alphabetical. – among others.
ACTIVITY	**Main usage:** Getting and providing information about a patient. **Secondary usage:** – Viewing information for different patients. – Viewing different kinds of information regarding each patient. – Booking a visit for a patient. – Documenting different kinds of information regarding a patient. **Additional usage:** The patient is striving to understand their own situation.	**The user's main role:** Book a time for a patient visit. Read information about a patient. Document information about a patient. Navigate in the interface by clicking with a computer mouse.	**The user and machine's overall interaction:** Find an available booking time in the interface Find the medical record of the patient that a task concerns in the interface. Clicking with computer mouse – to find right information. – to guide through the tasks performed. Read information provided. – Document reason for the appointment. – Document information needed to be documented. Dictate information needed to be documented. Choose information needed to be documented in a list of suggestions. Search for information needed to be documented in a list.	**The user and machine's detailed interaction:** Clicking with computer mouse – to find right information. – through guiding text, icons and buttons. – to guide through the tasks performed. – through guiding text, icons and buttons Find an available booking time. – Make an action indicating that a time should be booked. – Choose the correct calendar. – Get guidance in finding available appointments. – Book that time. – Document reason for the appointment. – Displayed headings with aspects to be documented. – Provides more information/headings to be documented depending on previous documentation. Find the medical record of the patient that a task concerns. – Type the patient's personal ID-number and search. Read information provided in: – comment regarding the reason for the time booking – journalblad – mätvärden/laboratorietests – dokument i tidsordningen – externa system och tjänster – multimedia – A summary/overview with the possibility of searching for more information if needed. Document information regarding the appointment: – Displayed headings with aspects to be documented. – Choose or search for information needed to be documented in a list of suggestions for: – kontaktlogi – Diagnos enl ICD10-SE – Provides more information/headings to be documented depending on previous documentation. – Dictate information needed to be documented.	**Machine processing:** Provides calendar for – one day. – weeks. – one specific person. – different groups/roles. – different appointment types. – dealing with different time slots, (unavailable). Knows which doctor the patient is registered to. Visually indicates when a time slot is available. Adds a time block when a patient visit is booked. Visual change in interface, when an action is performed. Provides additional information through text when an action is performed. Provides guidance/direction on where to find more information. Provides additional steps to perform, if required, after an action is performed. Letters or numbers typed appears in the interface when using the keyboard to type information. Provides suggestions of phrases to use, based on previously used phrases, when a word/phrase is being typed with the keyboard. Enable displaying the order in a list of suggestions in the user's preferred way – date – alphabetical. – among others.
REALIZATION	**Possibilities & Limitations:** Needs to be usable for both experienced and new users. Needs to be handled efficiently. Needs to enable proper, thorough performance of task. Needs to enable clear communication. Should not limit people in how they want to perform tasks within the interface.	**Use requirements:** Intuitive usage. Provide guidance of how the interface can be used. Clear communication of what should and has been done. Limit the amount of mouse clicks needed to make the interaction efficient.	**Machine requirements:** Automated tasks within the interface. Possibility to add personal shortcuts. Guidance on – where to find correct information for the situation. – what to document. Communication/Feedback – to prevent errors – to make aware of patient status – of own status – of test results Provide information relevant for the situation at hand.	**(Chapter 7)**	**(Chapter 8)**

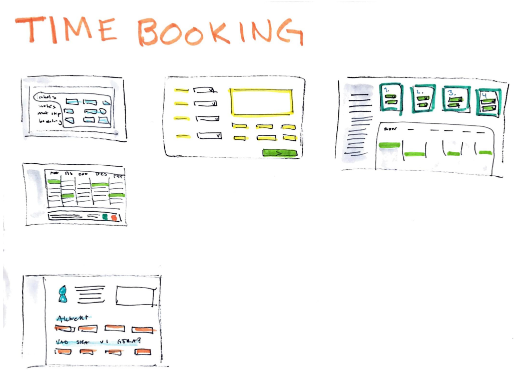
Appendix 12 - Ideation Design team

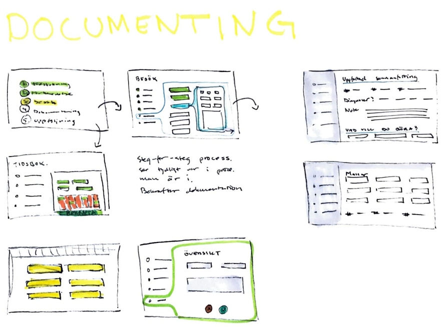


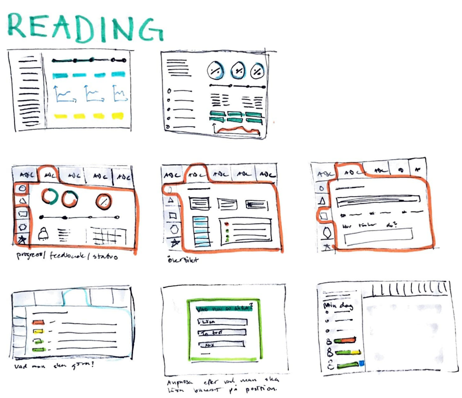






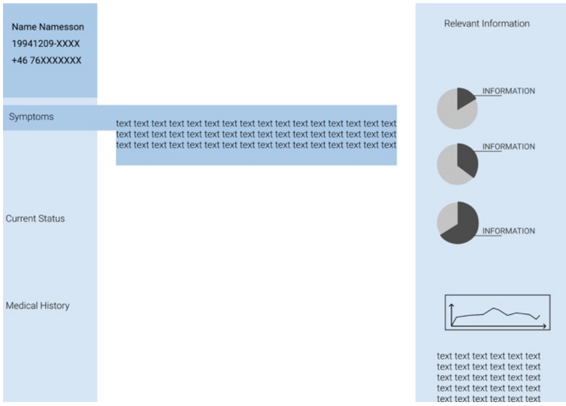


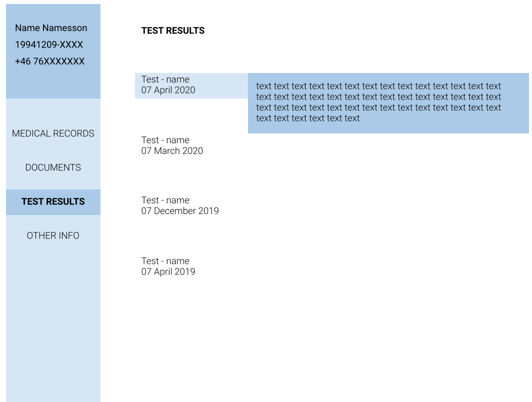


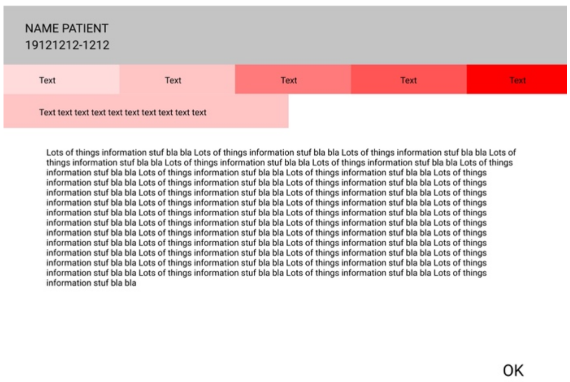


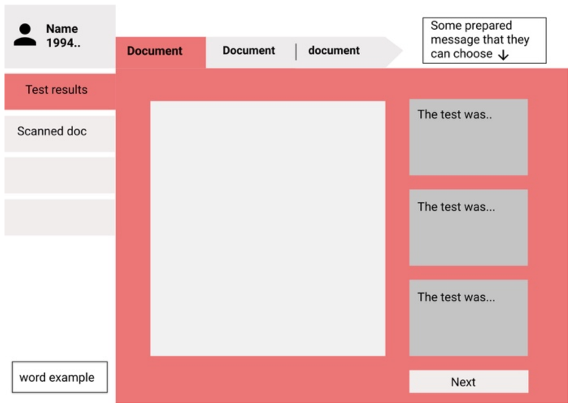
Appendix 13 - Ideas from workshop with medical staff

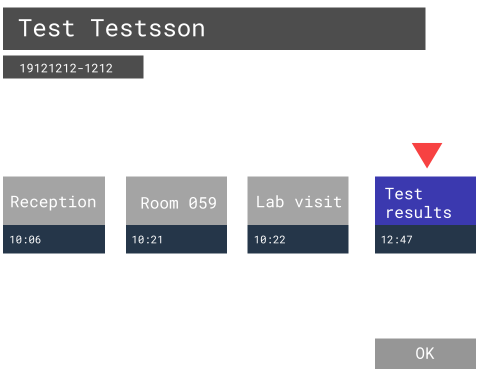
Appendix 14 - Ideation workshop with designers











DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY