CHALMERS
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ICT as a tool to improve workflow and teamwork at a medical ward

A concept study

Master of Science thesis in the master degree programme Biomedical Engeineering

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Gothenburg, Sweden 2015

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Preface

This report is the final outcome of a master's thesis; the final examination in my master of science studies in Biomedical Engineering at the Signals and Systems department at Chalmers University of Technology in Gothenburg, Sweden. The project was carried out at Domitor Consulting AB during late September 2014 to the end of February 2015.
I would like to thank Domitor Consulting AB and everybody who have contributed with their time, energy, experience and skills to major support me throughout the project, specially the CEO Nicklas Björklund for a highly dedicated guidance from the start. I thank Karl Niklasson for contributing with his knowledge and supporting me with his skills, vital parts of the final steps in the project would not have been possible without him. The outcome of this project would have been impossible to reach without these two individuals and their corresponding contributions. Also big thanks to the Domitor employees Johan Filipsson and Magnus Jägmark for a warm welcome and making me feel as one of their own. I would also like to thank my supervisor and examiner Professor of Practice Bengt-Arne Sjöqvist at Chalmers University of Technology for all the help with academic issues and his highly dedicated guidance throughout the writing of the report and project in whole. I would like to share my appreciation for all the participants involved in the researching phase, providing me with feedback where all embraced the tasks with an excitement and were highly engaged.
Last but the best, thanks to my family for all the major support throughout studies at Chalmers University of Technology. You are my true fantastic four!

Abstract

This masters thesis was carried out at Domitor Consulting AB, a consulting company which today mainly delivers IT solutions towards the healthcare sector. The objective was to investigate how a concept based on an ICT platform including mobile devices can improve and support todays workflow and processes in healthcare. The term eNursing has been used to describe this application domain within eHealth in general. The resulting concept, named eNurse, was tailored to fit the workflow and processes within one medical ward at a hospital.
The following main research questions were addressed from an analytical and use context point of view:

- What are the benefits, if any, from introducing a eNursing concept through a mobile ICT solution?
- How can the concept improve rounding and handovers for the healthcare department HLAVA
- How should an eNursing concept, partly implemented on a mobile ICT platform, be designed to reach those potential benefits?

The project was divided into four phases: data gathering, low-fidelity prototyping, high-fidelity prototyping and usability testing.
Observations and interviews were carried out in the first phase to identify information flow and different needs around a healthcare professionals daily work. The first phase resulted in several identified problems to solve such as inefficient information handling and lack of decent communication tools adapted to the current situation. An initial design suggestion, as a low functioning prototype, was constructed and evaluated in the second phase. A more detailed and thorough prototype underwent the same procedure in the subsequent phase. Redesigns were made iteratively throughout these phases, leading to a final design concept which underwent a usability test in the fourth phase to conclude the concept.
eNursing is an eHealth solution adapted towards a medical wards' needs for ICT support and focuses on care processes and care giving. The proposed concept, eNurse, integrates information from existing solutions such as a decision support system and sensors into a mobile ICT device. In this master thesis, eNurse uses care plans, labresults etcetera and communication tools to irrespective of location and time provide access, documentation and sharing of information. eNurse also allows healthcare professionals to continually form an impression on both a patients and a wards current state. The interface has a high degree of usability and is intuitive to assure a usable product.

Contents

Chapter 1

Introduction

1.1 Background

Stories in media and studies regarding quality care and patient safety indicate significantly that the amount of adverse events need to decrease. SKL (2014) (Sveriges kommuner och landsting) presented in a report that circa one tenth of all patients are exposed to care injuries where 50-70 % could be avoided by improved work routines and docility. Swedish media reported in late december 2014 a case where lack of documentation, communication and accessibility of information between healthcare professionals resulted in a patient getting decubitus (Ulander and Grill, 2014). In the associated interview with a nurse of the hospital staff it was reported that reconciliation with the patient often becomes actively neglected. According to the nurse, a combination of the above and lack of staff results in little or no time for reconciliation which became the underlying reason for the patients injury. The commonly referred publication "To err is human" by Kohn et al. (2000) confirmed the above arguments early and furthermore implies that errors in healthcare are caused by faulty processes and conditions which lead healthcare professionals to make mistakes like the above or fail to prevent them. Patients and healthcare professionals in general have experienced a lack of quality in healthcare which has been partially confirmed through the few interpersonal meetings with patients that occur today. on Quality of Health Care in America and of Medicine (2001) argues that healthcare in general needs to become more:

> **Safe:** That is, avoiding patients to get injured from the care that is intended to help them.
>
> **Effective:** Providing correct services and information to all who could benefit at the right time, location, moment and with little time consumption.
>
> **Patient-centered:** Providing respectful care which meet each individual patients' preferences, needs and values whilst ensuring that the patients values guide all clinical decisions.

Timely: Reducing waits and delays for both those who receive and those who give care.

Efficient: Avoiding all types of waste such as waste of equipment, supplies, ideas and energy.

Equitable: Providing care that is equal in quality irrespective of any factor.

Different eHealth solutions have today been produced towards the healthcare sector to solve these issues. The idea has been to use mobile information and communication technology (ICT) allowing mobile work. Mobile work means the possibility to access and communicate vital information about a patient irrespectively from location at a hospital. Cerner have their award winning product called the PowerChart Touch, a mobile solution built for Apples' iPad where healthcare professionals e.g. can:

- Review diagnostics clinical results, patient charts
- Address routine requests such as simple orders
- Document allergies, problems histories
- Create and sign progress notes

It can be argued from this that PowerChart focuses on mobilizing documentation, communication and to provide decision support. Ascom have their smartphone solution called the Myco (short for My companion). Myco serves as a communication assistant designed specifically for nurses. Myco has a number of sensors, which detects the surrounding circumstances and adapts the modality of call- and alarm signals from both your work companions and patients. . Myco can also be used for information sharing and communication between nurses. Future work aims on extending the device such that you can handle information in the same way as e.g. the PowerChart. To be noted is that this smartphone indicates possibilities in improvement in teamwork and workflow between healthcare professionals.

The examples on existing solutions show that focus is mainly applied on solving documentation requirements and providing some decision aids from a medical diagnosis perspective rather than informing the users on how the care process is progressing and evolving. Cambio Healthcare Systems have their own take on this with their tablet product called Cosmic Nova Ward Tablet. What the Nova Ward Tablet is still lacking however is the fact that it mainly concerns the care process' progress and does not, in a suitable way, include or look into how the patient herself is progressing in the care process. These solutions are in general terms of information and functionality not fully adapted to the actual context of a healthcare professional which is the treatment of a patient. They do additionally still lack both required functions and information. Hence, existing solutions do not fully serve as an aid for all healthcare professionals in their everyday work with patients.

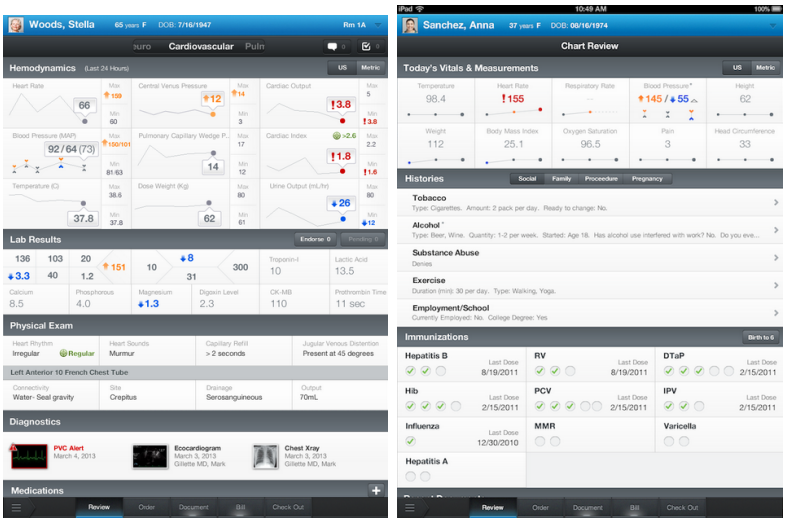


Figure 1.1: Cerner PowerChart

Figure 1.2: Ascom MyCo

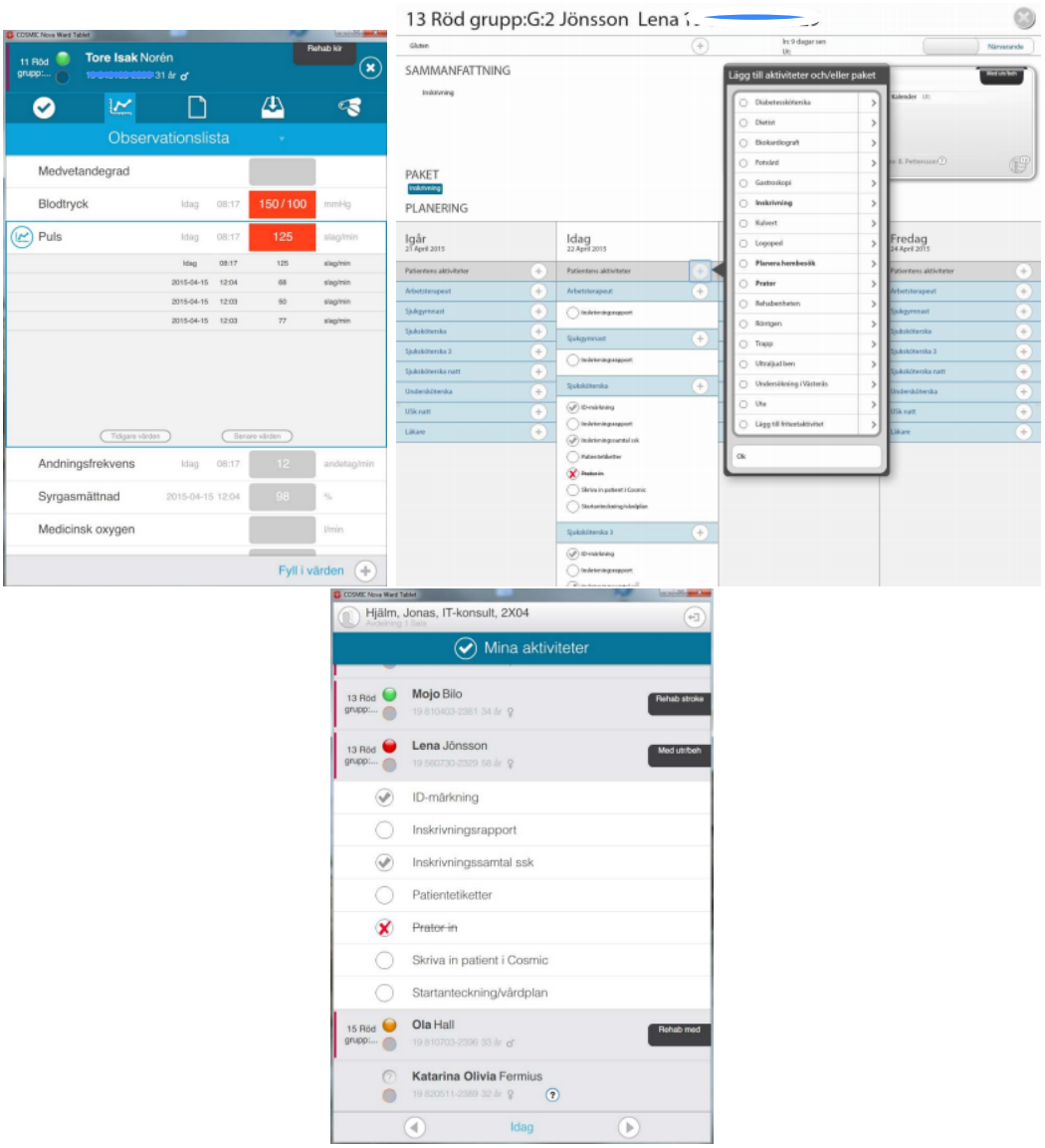


Figure 1.3: Cosmic Nova Ward Tablet

Domitor Consulting AB is an IT consulting company, based in Borås, who has mainly focused their business towards creating IT solution software for the healthcare sector. Domitors' most recent software which they deliver to hospitals cardiac departments over the whole Västra Götalands Regionen (VGR) is named Mequal. Mequal is a quality- and process supporting IT solution that for simplifies and complements the daily healthcare processes and documentation. Mequal allows the user to define basic care plans, so called E-SVP (Enkel-StandardVårdPlan), for a certain group of patients which describes what activity is to be done, at what time and by whom. An individual care plan can then be tailored manually from this E-SVP by adding and removing activities. Mequal provides also a decision support which supports with keeping track of a patients present state of health, compliance with guidelines on medication etc. Mequal thus also serves as a process- and quality assurance system for the daily routines and patient record documentation, ensuring compliance with defined guidelines during the treatment of a patient. Eriksson et al. (2014) argues that the use of care plans simplifies todays planning and the daily care but also the communication between healthcare professionals and allows carrying dialogues with patients to involve them further in their treatment.

Individual care plans and more thorough decision support are examples on utilities that are almost absent in todays existing solutions. The cardiac department named Hjärt & Lung Akutvårds Avdelningen at Södra Älvsborgs Sjukhus (HLAVA at SÄS) use Mequal which has simplified and improved their work as Mequal intends to. However, the absence of a system that support mobile work has made their everyday work as restricted as the described above with lack of time, information when needed etcetera. According to staff at HLAVA, rounding and handovers are two majorly time-consuming activities. Staff at HLAVA also experience problems with keeping track of their patients state of health and the general situation at the ward. Healthcare needs thus

- Higher quality assurance
- Increase and improvement of interpersonal meetings with patients
- Involve patients in their treatment, both the process and the progress

Having access to Mequal and the above addressed needs forms furthermore a strong foundation for introducing an eNursing concept at HLAVA to demonstrate and motivate how eNursing, through a concept, can support healthcare with the three issues above.

1.1.1 What is eNursing

eNursing is an application domain, defined at Chalmers University of Technology by this studys' author and examiner together, applicable within healthcare practice. eNursing is a subdomain to eHealth which aims on supporting wards with tools which are directly applied and adapted toward the different needs for mobile ICT support and emphasizing teamwork, patient encounters and pliability in the care process. In general, it is a sub-

domain to eHealth which transfers the eHealth theory towards the above three through the usage of mobile units i.e. delivering correct patient information at the right time to the correct responsible individual. eNursing focuses thus on the care process and caring of a patient in comparison to the above mentioned focus areas of existing solutions. eNursing does grant with healthcare professionals with additional information through including the usage of todays advancement in sensors such as smart wearables and smart home solutions. There are no restriction on whether this additonal information is to be on e.g. patients or the work environment.

1.1.1.1 eNurse - an eNursing concept

An eNursing concept has been developed accordingly to this definition and is named eNurse. eNurse focuses on adressing the mentioned on Quality of Health Care in America and of Medicine (2001) and Kohn et al. (2000) issues by

- Simplifying the documentation process
- Release more time for caring of patients
- Increase the care-quality (right actions are made at the right time, accordingly to the plan)
- Enhancing and simplify collaboration and communication within a medical team
- Improve care outcome
- Improve the patient experience
- Focus on patient care and care processes

This is to be reached by providing healthcare professionals the opportunity to retrieve, document and report correct information on corresponding related patients they are responsible for during their shift, at any arbitrary moment and location. The main idea of eNurse is to achieve the above through integrating existing solutions such as Mequal and sensors (e.g. wearable devices) collect all needed information, i.e. care plans, labresults, vitals etcetera and present it in a mobile device (tablets, big touch screens etcetera) to provide the opportunity to reach the above irrespective of location. Healthcare professionals are to be able to, through the eNurse, continually form their own impression on their corresponding patients. eNursing can thus hypothetically also increase interpersonal meetings with patients and support healthcare professionals with information to use during these meetings for encouraging patients to become more involved in their treatment. eNurse can additionally, through the usage of different technical or sensor solutions, provide healthcare professionals with information on the wards current state. eNurse has thus the opportunity to improve teamwork through tracking compliance with the wards' patients and state.

1.2 Purpose/aim

The aim of this study is to investigate the possibility to, through the introduction of a mobile ICT platform and an application, improve and simplify:

- Information and communication needs
- Handovers and rounding in general
- A healthcare professionals' everyday activities (typically a nurses')

The purpose is to look into if using these platforms as tools for documentation, information source and communication can improve the above. A mobile web application will be designed which is related to this investigation and designed according to what role these mobile platforms should play. Mimicing a real life situation at HLAVA is possible with Mequal being used at HLAVA and available at Domitor. Mequal is thus suitable to use for demonstrating the ideas of the eNursing concept eNurse. Also, HLAVA will be the ward that this study works towards due to the choice of Mequal and the concept eNurse will thus be designed towards only this ward to demonstrate the concept in general. The study will thus not investigate a concept which is adapted to all types of wards or a unique concept for all types of wards. The study will not exclude investigating needs to integrate other types of data from other systems together with Mequal data to reach the aim.

1.3 Delimitations

This study focuses on building a physical software prototype of eNurse which will be tested and evaluated by healthcare professionals in the HLAVA department where Mequal is already available and thus can be used as a starting point. In a longer time perspective, eNurse is intended to be used by all titles of HLAVA. This study will however only cover the needs and designs for doctors and nurses. Suggestions on functions for nurse assistants will be made but designs and further investigations will unfortunately be excluded. The study will also unfortunately exclude investigatig the opportunities of eNursing improving interpersonal meetings with patients and involving them further in their treatment (mentioned in the background). Additional systems which provide data other than existing Mequal data will not be produced if any needs for other data is identified. Existing popular commercial solutions will instead be used without regards to their precision and performance. The mobile web application prototype will in this study be developed towards a tablet solution and large touch screen monitors. The study will not use quantitative data for answering the problem definition.

1.4 Problem definition

This study answers several questions along its progression but primarily focuses on answering the following questions:

- What are the benefits, if any, from introducing a eNursing concept through a mobile ICT solution?
- How can the concept improve rounding and handovers for the healthcare department HLAVA
- How should an eNursing concept, partly implemented on a mobile ICT platform, be designed to reach those potential benefits?

Chapter 2

Theory

The general characterisation of good design is when the user is able to easily, efficiently and safely conduct a task in short time. This can only happen when designers understand people as well as technology i.e. they can take as many different perspectives as possible into consideration (Hackos and Redish, 1998). According to Goodwin (2009), a good design will increase the efficiency and minimise the risk of errors being conducted. This study has used a mixture of user- and activity-centered design approaches during the design process. User-centered design involves end users throughout the design process, allowing them to influence the design decisions (Williams, 2009). The aim is to optimize a product around end users needs, wants and limitations. Activity-centered design, on the other hand, base design decisions by analysing the activity a user would perform with a technology and the tasks needed to be enabled by the technology to perform that activity (Williams, 2009; Kaptelinin et al., 1999). Data gathering methods and design approaches have been from both user-centered design respective activity-centered design. Gestalt psychology is an approach which has been used in addition for visual design in this study and is independent from both user- and activity-centered design.

2.1 Activity-centered design

2.1.1 Activity theory

Activity theory originates in early 1920's Soviet. It is built on Lev Vygotsky's basic principle insisting on human thinking being a result of cultural, social technical mediation and interactions (Bödker and Bertelsen, 2003). In activity theory, human consciousness is the product of an individual's interaction with other people and artifacts the environment and is related to cultural and social experiences but also properties. An artifact is in general a sign or a tool. In the case of product development may be a full commercial release or any end-result of a design activity such as a concept. Before proceeding, it is to be noted the whole product in this study, i.e. both the mobile platform and its

applicaiton, is viewed as the artifact. This interaction is part of the unit of analysis in activity theory which sums up in that activity theory tries to understand the unity of consciousness and activity (Kaptelinin et al., 1999).

Activities have a hierarchical structure consisting of an object, a subject, operations and actions (Kaptelinin and Nardi, 1997). An activity is performed, by a subject, on an object which motivates the activity and has a specific goal. This goal must not necessarily always be in the subjects consciousness. The subject is either a group or the individual performing the activity. Activities are built upon goal directed actions that must be undertaken to reach the goal of each activity. Goal directed actions are always conscious and different actions may be undertaken in order to reach the same goal. Actions are executed through the necessary series of automatic operations for each action. Operations do not have their own goals and should rather be viewed as necessary automatic adjustments needed for an action to be executed. Actions become operations during execution (Kaptelinin and Nardi, 1997) .

Activity Theory differentiates between internal and external activities, emphasizing that they cannot be analyzed separately due to that they interact with each other (Kaptelinin and Nardi, 1997). Activities which only use mental processes and do not have any manipulation with or on real objects are considered internal activities e.g. reading. Internal activities can be externalized and transformed into external activities and vice versa. In previous example, the activity becomes external when the read text is verbally articulated. Activities always involve artifacts which also are regarded as internal or external. An example of an external artifact is a chainsaw whilst an internal artifact could be the manual (Cluts, 2003).

Artifacts influence the way a human interacts with its environment by controlling how an activity should be performed. As a result artifacts also control how internal activities appear through how we choose to perform respective external activities. An artifact can thus different types of information regarding its user which can demonstrate how activities have evolved over time before being completely ready for execution (Kuutti, 1996). Using activity theory, one can accomplish a good understanding on the origin of how an activity is performed (Cluts, 2003).

2.1.1.1 Activity checklist

Activity theory has a tendency to become comprehensive in the analysis of an activity depending on how it's interpreted. The Activity Checklist is a conceptual tool which was developed from this issue in order to simplify its use in a human- computer interaction design and evaluation (Kaptelinin et al., 1999). It serves as a complement to other design and evaluation methods aiming to identify and analyse the most important contextual factors influencing the use and taken actions of a human- computer interaction system

(Kaptelinin et al., 1999;Kaptelinin and Nardi, 1997). In other terms, its purpose is to cover how the system supports, or is intended to support, actions taken by the user. The checklist contains four components:

1. **Means and ends** — To what extent the technology simplifies or complicates the attainment of a user's goal goal. It also analyses if the technology resolves or raises conflicts between goals.
2. **Social and physical aspects of the environment** — Answer how to integrate a target technology with requirements, tools, resources, and social rules of the environ- ment.
3. **Learning, cognition, and articulation** — Answer how the system shall support internal and external activities
4. **Development** — The wrap up of the foregoing components as a whole i.e. how to integrate them together into the system.

2.1.2 Observation

Observation is a data gathering technique based on watching and perceiving people or a situation (or both). The observer tries to learn about peoples' activities and how the situation develops by documenting and analysing what has been observed. It is important to view the observation as being about the subject or situation and to be open-minded regarding the specific events that one chooses to document (Button and Sharrock, 2009). It is however important to have predefined goals and in advance plan what to put focus and attention to whilst still being open-minded to changing these during the observation. It is not unusual for observers to use aids which throughout the observation guide the observer should primarily focus on. These aids often appear in the type of fill-in fields such as open areas for writing down for example time, place and actors and more detailed information about events, feelings and actions.

The researchers role as an observer is either as passive, participant or a mixture of the two (Sharp et al., 2007). An observation can in turn generally be executed either in a directly or indirectly matter. The role of a passive observer is to ideally observe the participants or a situation without interfering or making them feel monitored. On the contrary, a participant observer contributes and cooperates equally with participants in a situation and acts as being a member of the group (Sharp et al., 2007). An observation can take place in the field, i.e. the natural context where the action naturally happens, or in a controlled situation as a laboratory setting (Sharp et al., 2007). Direct observations are when the observer is present, whether it's in the field or a laboratory setting, explores and investigates the situation as it unfolds. Indirect observations on the contrary are investigations where the observer goes through recordings of a situation after it has occurred.

2.2 User-centered design

2.2.1 Questionnaire

A questionnaire can be viewed as an indirect structured interview where users' opinions are collected by giving a list of questions with possible answers and/or empty fields to fill in. It is a useful tool when wanting to collect a broad range of views. Questions can be open or closed ended questions and there are no restrictions in using a mixture of both. Closed ended questions have a list of possible answers for the users to choose from whilst open questions invite users to further motivate their answer. A questionnaires' shape is based on its purpose and type of questions are chosen accordingly. Open ended questions provide more in-depth answers whilst closed questions however is easier to answer. How many open or closed questions to include in a questionnaire depends on the respondents' motivation for filling it out (Sharp et al., 2007).

2.2.2 Interviews

An interview should be viewed as a conversation rather than a formal meeting. Interviews have a specific purpose or goal that is reached through questions. There are four different interview approaches: unstructured, semi-structured, structured and group interview. The purpose or goal of the interview determines which approach to implement. Resources such as access to users and available time are also factors influencing the choice of approach. The structured approach is in many ways similar to a questionnaire having precisely predefined questions and expectations on what the answers will contain or provide. Structured interviews are generally suitable when the goal is clearly defined. Unstructured interviews rejects this idea and has no predetermined questions. There is, however, certain topics in mind which are intended to get covered during the interview but the approach relies on having a flow like an everyday conversation by having open-ended questions. The purpose with unstructured interviews is to explore a topic, letting more or less the interviewee share answers and views regarding the problem. A plan is made before the interview defining which topics to elaborate on. Semi-structured interviews are a combination of an unstructured and a structured interview. A few questions are predefined however but the main purpose of the approach is to allow answers progressing naturally. Focus groups or group interviews are conversations often led by a trained facilitator. An interview is best executed face-to-face, but can also be conducted over the phone, mail, chat or by using a video-conference system (Sharp et al., 2007).

2.2.3 Focus groups

Focus groups are a form of group interview that capitalizes on communication between participants in order to get knowledge about how people form thoughts and emotions

in a social context (Kitzinger, 1995). People are gathered to discuss and share thoughts and experiences about a particular subject and group interaction is part of the method. It is an efficient and inexpensive method to gather a wide collection of data and opinions such as how people's knowledge and experiences are related to how they think and why they think in a specific way. Usually a focus group consist of circa 3-11 participants and enrolls in a semi-structured or unstructured way (Lazar et al., 2010). A focus group has a facilitator whose task is to guide the conversation normally following a predefined plan and goal but can also follow up on unexpected topics (Kitzinger, 1995;Sharp et al., 2007).

2.2.4 Normans design principles

Design principles are generalizable abstractions intended to guide, rather than specify, interaction designers on what aspects of their design to consider and provide guidelines on how they can be improved (Sharp et al., 2007). There are two information sources, namely previous knowledge and experiences or already existing and clear information from the environment, which humans use to identify how to use an object when it is being encountered for the first time according to Norman (2002) . The undertaken processes from both sources play a significant role in a human computer interaction designs usability and are best managed if the designer carefully applies the principles affordances, visibility, feedback, constraints and consistency onto the design (Norman, 2002;Sharp et al., 2007). These five best known and common design principles, out of several promoted ones, together emphasize what to view for users and how they have to carry out tasks to reach a certain goal (Sharp et al., 2007).

Affordances: is a term which refers to how an attribute of an object signals people on its possible actions, applications and functions. For example, a hammer invites lifting and hitting an object (preferably a nail). When thinking about affordances in interface design it is therefore of interest to look into the user perception of how to use it. At a very simple level, to afford means "to give a clue" (Norman, 2002). When affordances are perceptually obvious it is easy to at first glance know how to interact with it.

Visibility: Users are more likely to be able to know what to do next when functions are more visible functions. On the contrary, functions become more difficult to find and complex to use the more they are "out of sight".

Feedback: Feedback is about the information sent back regarding the taken action and what it accomplished. The purpose is to through an instant and clear effect allow the person to perceive that s/-he can continue with the next activity. Usual feedbacks for interaction design are sound, visual transitions and effects, text alerts and combinations of these.

Consistency: Emphasizes that interfaces should have similar operations and use similar elements for achieving similar tasks. In particular, a consistent interface

is one that follows rules, such as using the same operation to edit any object. Inconsistent interfaces, on the other hand, allow exceptions to a rule.

Constraints: Refers to how and what possible ways of user interaction that can take place should be restricted. There are four types of constraints according to Norman (2002):

- **Physical constraints:** Physical constraints rely upon properties of the physical world for example a square cannot fit into a small hole. In conclusion, physical constraints can be used to reduce the number of possible actions that can be taken. The more visually clear and easy to interpret the constraint, the higher the chance that the user will understand and avoid taking "wrong" actions that are restricted. On the contrary, if not visually clear and easy to interpret, the result will become that the physical constraint prevents the wrong action from succeeding only after it has been tried (Norman, 2002).
- **Semantic constraints:** Semantic constraints are based upon how the meaning of a situation controls the possible actions and our knowledge of it and the environment. It tries to answer questions regarding why the action is being undertaken for example the driver in a car must have a clear view and therefore the windshield cannot be toned. Such knowledge can be a powerful and important clue for the user.
- **Cultural constraints:** Each culture has a set of conventional rules and allowed actions for different social situations which are followed by its members. For example, red is a conventional standard for a stop light which is placed on the top of the three stacked lights in a traffic light or a police vehicle (in Sweden) often is in the color of white and blue and a tone of yellow. Cultural issues can become therefore become the root of many of the problems humans can have with new machine if it is unfamiliar and there are no familiar, known or accepted conventions or habits on how to deal with them (Norman, 2002).
- **Logical constraints:** Natural, or logic, descriptions on how an object how it works can be provided by using logic to constrain actions i.e. logical constraints. If two switches control two lights, the left switch would logically work the left light and the right switch the right light. In general, the most effective and robust way for location and operation when having indicators that reflect the state of different parts of a system is to have a natural relationship to the spatial or functional layout of the system according to Norman (2002).

2.2.5 Prototyping

Practitioners of human computer interaction design have throughout the years agreed upon that a typical case is that users can't tell you what they want without something to refer to. However, users will be able to find out what they don't want when introduced

to a limited representation of the product, better known as a prototype of the product, which they can interact with and explore (Sharp et al., 2007). According to Aneja et al. (2006), the primary objective of prototypes is for having a good communication about the design regarding exploration, refinement and evaluation of design ideas between users and the designer. In early years, Rudd et al. (1996) stated that prototyping was recognized as reliable method for refinement and optimisation of interfaces early in the product development cycle. The optimum methods had, however, not yet been agreed upon by that time and is still not agreed upon. Different types of prototyping methods exist and they are categorised either as high- or low-fidelity. The advantages and drawbacks differ between not only the two categories but also between the different methods in each category. Prototyping methods are divided into two general categories namely low- and high-fidelity prototypes (Sharp et al., 2007).

2.2.5.1 A model of the goal of prototypes

Hill and Houde (1997) have introduced a model which represents a three-dimensional space corresponding to important aspects of the design of an artifact, see figure 2.1. The edges of the model represent the dimensions of the model and are named role, implementation and look and feel. Each dimension corresponds to a class of questions which form the design of any interactive system and are important to answer. The model is shaped as a triangle to emphasize that all dimensions are equally important (Hill and Houde, 1997).

”Role” refers to questions about the function or utility that an artifact brings or has to bring to the user and in which way it is or can be useful. Prototypes having role as dimension are built in early stages to demonstrate and evaluate the functionality of an artifact with little attention on for example a first draft of its design (Hill and Houde, 1997).

”Look and feel” denotes questions about users perception and experience of using an artifact e.g. what the user looks at, feels and hears when using it. The intention is to simulate the foundation of an artifact and how it will feel looking at and interact with. Several look and feel prototypes can be built to visualize and demonstrate different look and feel possibilities (Hill and Houde, 1997). Users interact with them to see how the foundation of an artifacts look and feel could be improved.

”Implementation” refers to questions about the techniques and components through which an artifact performs its function and users impression. Implementation prototypes are used to discover methods by which adequate specifications for the final artifact can be achieved. Designers build implementation prototypes as experiments to demonstrate technical feasibility of the artifact and to get feedback from users on performance issues (Hill and Houde, 1997).

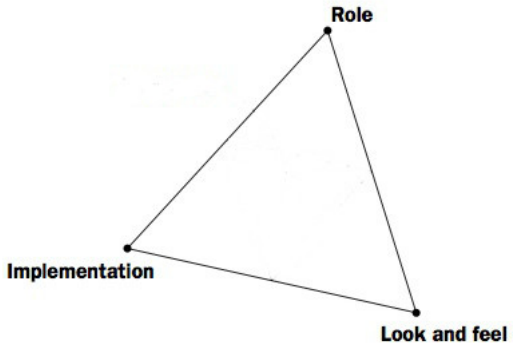


Figure 2.1: The model displaying the different types of prototypes a prototype can be categorized as

Hill emphasizes that the model in figure 2.1 displays that prototypes can be composed of different amounts of the three dimensions rather than distinctly by one dimension. However, the two general categories have their dimensions which their methods range between.

2.2.5.2 Low-fidelity prototyping

Low-fidelity prototypes are those that do not look very much like the final product and have limited or no functionality and limited interaction (Rudd et al., 1996). For example, they generally use other materials such as paper and cardboard instead of electronics and screens. The main purpose of them is to in the earliest stages of a product development cycle present and get feedback on functionality concepts, design alternatives and screen layouts (Sharp et al., 2007). There are several low-fidelity prototyping techniques where paper prototyping is represented as a commonly used technique for any type of human computer interaction product (Aneja et al., 2006). Low-fidelity prototypes typically range between the role and look and feel dimensions in different orders depending on the methods themselves (Hill and Houde, 1997).

2.2.5.3 High-fidelity prototyping

High-fidelity prototypes are built with the materials expected to be used in the final product and demonstrates the shape of the final product (Sharp et al., 2007). For example a prototype using actual code and functionality is higher fidelity than a paper prototype. High-fidelity prototypes are characterized by that they take longer time to create than low-fidelity prototypes and studies have shown that they often review

superficial aspects for example the functionality rather than content (Sharp et al., 2007). Designers use high-fidelity prototypes primarily for reviewing discover usability issues regarding interaction with the system and its functionality rather than the content. It has also been shown in studies that high-fidelity prototypes can achieve more detailed feedback on the interface (Rudd et al., 1996;Finlay et al., 2004).

2.2.6 Usability testing

Usability testing refers to the activity focusing on observing users interacting with the product performing tasks that are real and meaningful to the users. It is an approach used to analyse the property of how usable the product is meaning that the product is primarily being tested rather than the user (Sharp et al., 2007). The general goal is to through the test discover possible or needed improvements that makes the tasks the product was designed for being achieved in a usable way by the intended users (Dumas and Redish, 1999). Usability tests are mainly conducted through the key components the test itself and either an interview or questionnaire regarding satisfaction and review on the product (Sharp et al., 2007). The think aloud protocol is usually used when conducting the test where users speak out loud what the reasoning and mental process being taken when conducting a task (Finlay et al., 2004). Tasks are given in a test environment which can be either a laboratory setting or out in the real environment (the "field") that the product is intended for. The laboratory can be formed in different ways where the core is to have an environment which the designers are in control of all situations and actions. For example, the laboratory can be a quiet room or a well-equipped office containing sophisticated audio/visual recording devices, two-way mirrors etc. which cannot be replicated in the work environment (Finlay et al., 2004). The questionnaire/interview is used after the test to review users impressions of the product.

2.3 Gestalt psychology

Gestalt psychology theory has its roots in psychology and attempts to make a concrete description of how humans make sense of their perceptions (Fraher and Boyd-Brent, 2010). One of the fundamental principles in gestaltpsychology is the Law of Prägnanz emphasizing that people tend to interpret and group elements into a stabile and cohesive shape when presented with a set of ambiguous elements (elements that can be interpreted in different ways) (Fraher and Boyd-Brent, 2010). Applying gestalt psychology principles has improved screen layout and other problem areas in many projects and researches within the field of human computer interaction according to Fraher and Boyd-Brent (2010).

There are six principles in gestalt psychology which humans use when interpreting shapes:

Similarity: Objects looking similar to one another tend to be perceived as a group or pattern by humans. Dissimilar object can be easily be identified when similarity occurs.

Continuity: Humans tend to be more welcome to perceive even and continuous shapes rather than the contrary. Continuation occurs when the attention evenly, easily and subconsciously move through one object and continue to another object.

Closure: Incomplete objects are fully perceived through the human filling in the missing information when enough of the shape is indicated in order to see the complete object.

Proximity: Elements that are placed close together tend to be perceived as a group if there is a mixture of different elements.

Figure and ground: The eye differentiates an object (figure) from its surrounding area (ground) making it more clear when there is a balance between the two. Using unusual figure/ground relationships can capture attention to the desired subject.

Symmetry: Humans tend to perceive objects as symmetrical and formed around a center point meaning that they form mirrored images of themselves.

Chapter 3

Design process

The project in whole was divided into the following four phases:

- **Data gathering**
- **Low-fidelity prototyping**
  - Design
  - Evaluation
- **High-fidelity prototyping**
  - Design
  - Evaluation
- **Usability testing**

Figure 3.1 displays the work flow process followed through this study. This chapter dedicates a section for each phase where applied methods are described. Each methods planning and execution are presented. The sections are wrapped up with a summary on essential findings of the phase which are considered into subsequent phase. In this study, findings from the data gathering phase formed a foundation to follow as much as possible throughout the design process.

Figure 3.1: A demonstration of the workprocess this study has followed

3.1 Data gathering phase

3.1.1 Observation

Observation was used early in the design process to gain an understanding of a healthcare professionals work, context and information exchange between healthcare professionals during rounding and handover sessions. An observation form a good base for gaining design inspirations by relating interactions between healthcare professionals with possible mental processes that form the base for taken actions (Lazar et al., 2010;Sharp et al., 2007). Observing the context and environment can also be used for designing and preparing interviews and focus groups methods (Sharp et al., 2007). It was decided to implement a semi-structured type of approach for observations in this study. This means that it is allowed to during the observation change factors to focus on and diverge from the predetermined plan and goal. Factors and variables to put attention to were thus of ambiguous character such that the observation had to be executed with an open minded attitude and without any preconceived or predetermined beliefs.

3.1.1.1 Preparations for observation sessions

It was pre decided during planning that attention should be on the informations being processed and how it flows for all different healthcare professionals with main attention put on the nurse. Other professionals were not excluded. It was also of interest to identify existing information and information that was needed which didn't exist. The intention was however to try to put attention to this during activities beyond rounding and handover procedures as well. A checklist form (Appendix A) was made which was used during the observations to check that needed information was covered. It was made sure prior to both the observations that it was allowed to perform an observation. The

purpose of the observation and how it was to be conducted was also clearly addressed to all involved in the observation in order to ensure a natural behavior from all individuals. What can be said about the observation in general, in addition to what the list (Appendix A) displays, is that the following additional questions needed to be answered in order to know how to proceed:

- What are the different titles in a ward and what are their respective role?
- How is work executed at HLAVA?
- Where do they typically work and what are their typical routes?
- What is the information needed and how does it flow?
- When do they need the information?

The observation did also try to, as an extra, observe the amount of times that they passed different areas and if there were any typical areas which were used as ”checkpoints”.

3.1.1.2 Performing observations

Two observation sessions were conducted, with the same predefined plan, during one day- and one evening shift respectively. The purpose was to cover more cases but also to see how the handover and roundings differed from each other depending on the shift. Both observations took place at the HLAVA department at SÄS where one team was chosen to conduct the observation on. One of the employees at Domitor was present during the first observation and helped out with paying attention and making notes on part of the focus list (Appendix A). The second observation became more specific in what to observe which made it unnecessary for the Domitor employee to be present. However, the execution was the same and time spent on both sessions was equal which was the whole respectively shifts. It was emphasized to the team-members the purpose of the observation to avoid affecting and changing their work behavior and how they answer questions.

The passive observer role was taken during both sessions to focus on data collection. Personal note taking was the only way to record the observation. Notes were taken during the observation on the most relevant activities and events as much as possible. Video and audio recording were left out due to confidential issues. Questions were asked directly to the observed healthcare professionals if confusing activities or information occurred. The amount of questions were kept to a minimum in order to, again, avoid disturbing healthcare professionals from conducting their work naturally. Regulations and other obstacles regarding the work environment and patients made it not possible for observers to accompany to all locations and routes. Roundings and handovers were the activities where observers could participate directly. Important to mention here is that each observation was executed on different healthcare professionals. Elapsed time for handover and roundings was documented during observations by roughly following

timestamps on a watch. Measurements are thus not of high validity in this study. The number of observations and the approach indicate that measurements should be viewed as a rough estimation rather than an ensured measure.

3.1.1.3 Findings from the observations

The different titles and their role

Before proceeding it is important to describe each title and their role in a hospital setting. The different titles and their roles are summarized in figure 3.2. Below, their respective responsibilities are further described.

The doctor
Doctors at a department can have three different positions which is either physician, specialist or assistant physician. All three have a comprehensive contact with other parts of a hospital outside of the department such as consultations with other doctors and different labs. The physician is the one making decisions for a treatment. It is worth mentioning that a department can have several physicians. Specialists act as advisors and are titled consultants if they are not part of the hospital or department. The assistant physician are interns with a general background from their medicine studies, usually newly graduates. Assistant physicians are undergoing an education under supervision of a specialist in order to become specialists themselves. Physicians are specialists as well but differ in their employment in comparison to the specialist title. The assistant physician is usually the one most present at the department and are distributed on a limited amount of patients. Each team have an assistant physician when a department undertakes team-organization management. Their work consists of reading and writing reports and thus they spend a lot of their work in an office-like room at the department. They are, however, available as much as possible for other errands or questions. In whole, all three doctor titles mainly come in close contact with nurses and assistant nurses during the rounding where they inform about the treatment decisions.

The nurse
The nurse is responsible for the overall nursing of a patient and following up treatment decisions delegated by the physician such as medication dosage at different situations. In addition, a nurse measures the vitals of a patient such as blood pressure etcetera. Issues regarding treatment is thus a communication between the nurse and the physician where the physician delegates and informs what to do in consideration of what they have deliberated from other sources and informations on incidents, occurrences etcetera. This communication is mainly done through the rounding with the exception that they personally look up and inform each other during changes which causes urgent needs for communication. A major part of a nurses work is to manage and

report medical records aside from following up treatment decisions. Also they are the ones preparing a transfer of a patient or discharges. Nurses conduct a handover procedure between the shifts, for instance day shift nurses make a handover to the evening shift nurses etcetera when each shift is about to start. Nursing care issues are handled and communicated with the nurse assistant.

The nurse assistant
The nurse assistant practically conducts the nursing of a patient. They are also responsible for a patient's basic needs such as getting correct food and liquids and assisting patients when dressing or going to the bathroom etcetera. The nurse assistant is thus the one healthcare professional who spend most time with the patient. They have therefore, depending on how the work is done, the opportunity to build a relation with the patient which can contribute to a patients health and view of the medical care team. Nurse assistants are often the ones who discover if additional actions are needed. A nurse or doctor is needed in most of these cases which means that even nurse assistants are in need to contact either of the professionals. Also for nurse assistants it is vital to read and report to medical records.

The co-ordinator
The co-ordinators role is to support nurses with administrative work in order to release more time for direct patient care. The co-ordinator is also responsible for organizing the team if the department follows a team organisation.

The work environment

HLAVA share a whole floor with another care unit where they both are dedicated a long hallway each. This hallway consists of several partitions called modules. Each module contain a total of three patient rooms, a computer bench with one desktop computer, one laptop computer and a rack for referrals and other medical stuff. Also, each module has a so called module board, shown in figure 3.3. This board contains information regarding a patients upcoming activities, specific statuses such as if they are waiting for a curator, and diet. The icons represent if a patient follows a schema for avoiding decubitus, needs assistant for bathroom visits etc. The purpose of the module board is for the team members to write information regarding a patient which can provide them a general view when using the board. The ward has a so called overview board, placed by the co-ordinators desk which is shown in figure 3.4. The overview board covers information about all modules and their corresponding patients. The board shows information which the module board does not contain such as each modules responsible team members, each patients burden of care, gender and their preliminary discharge date. The post-it notes represent the burden of care on the patient. To note is that none of these boards contain patient names or patient id's, meaning that the healthcare professionals through these boards only know the upcoming activities for a certain patient bed without any regards to who this patient is if they don't remember this individual by memory. The restriction of information on these boards are due to legal regulations on what you are

	Core responsibility	Tasks related to core responsibilities	Other tasks
Physician	Medically responsible for the patients treatment and diagnosis	Holds the rounds and ensures they cover everything important about the patient, determine diagnosis and treatments	None identified
Nurse	Follow up on physicians treatment decisions and ensure that patients get accurate care	Monitor patient's vitals and overall health, distribute medicine and carry out rounds with physicians	Communicate with relatives, report to the medical record etcetera
Nurse assistant	Assist patients with basal daily life activities	Assist patients with food and keep track of their diet, take blood tests etcetera	Look after supplies
Co-ordinator	Administrate the work at the ward	Administrate registration and discharge of patients, status regarding rounding order, how many doctors needed for patient etcetera	None identified

Figure 3.2: Summary of different titles of a healthcare professional, their role and responsibilities

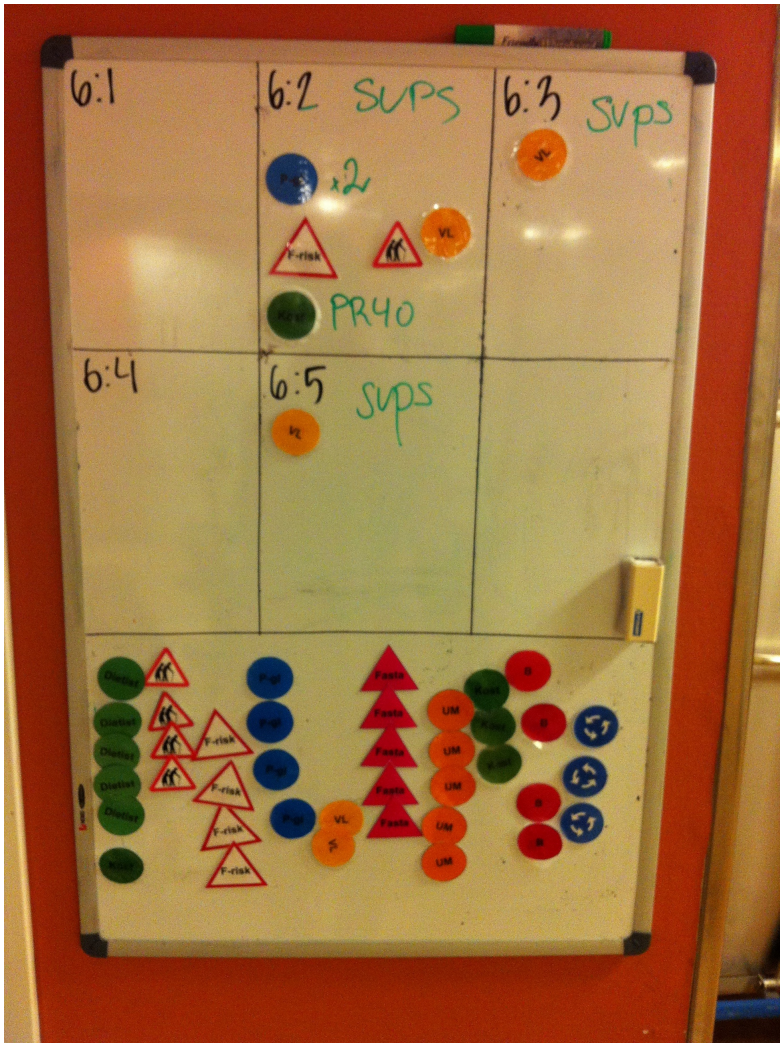


Figure 3.3: Moduleboard at module 6

allowed to show in a "public manner" according to the healthcare professionals.

The desktop computer at a module is used for Mequal and a surveillance software. The surveillance software tracks patients ECG and their approximate position in that room. The Mequal computer can only provide a read-only list on medications whilst the medication computer can be, and is, used for other actions regarding medication. Two of the patient rooms hold two patients each and the third room holds one patient. A module can thus contain a maximum of five patients. Figure 3.5 shows a sketch over how one module looks from a birds view. Note that each room is marked with two numbers where the first number and second number represent concerned module and patient bed respectively. A patient is thus assigned and related to a patient bed in a module which also is shown in figure 3.5.

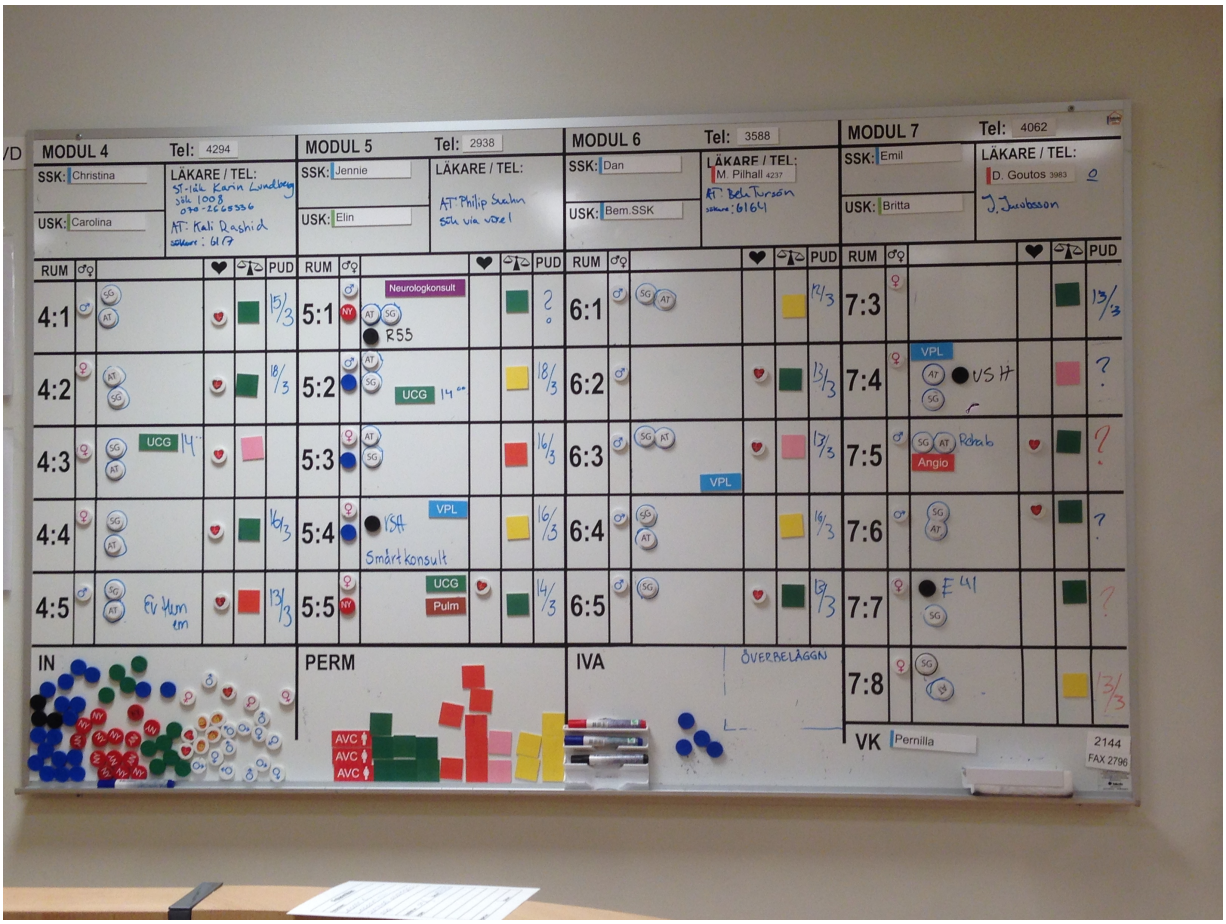


Figure 3.4: Co-ordinators overview board

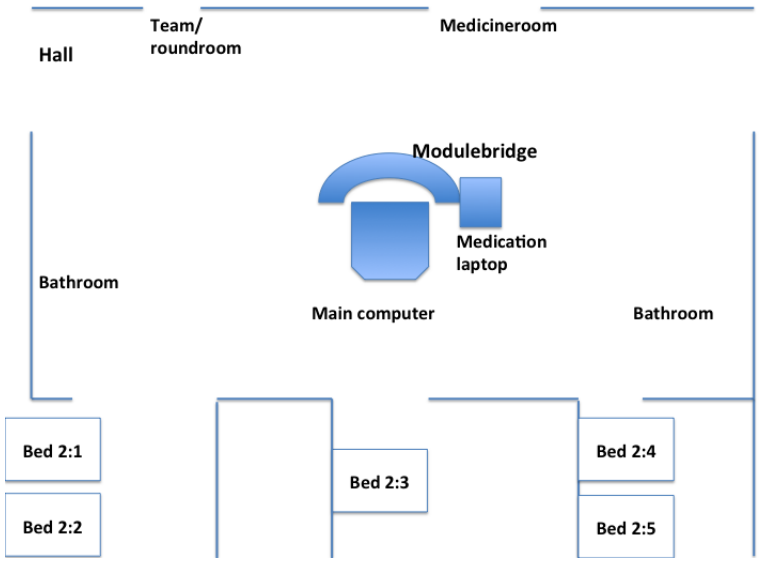


Figure 3.5: One module from a birds eye view

HLAVA uses nurse call systems which provide a patient the possibility to call for the nurses attention from the nurse specifically by pressing a nurse call button. The call causes a signal either as an audible signal over the whole ward or as a personal signal to the, corresponding modules, nurses pager. The nurses pager can also be connected to for example monitors which read patients ECG to give an alarm if it is dropping. The nurse can locate the room from which the alarm was sent either by reading room number being shown at a display in the corridors roof or by reading their pager. Figure 3.6(a) and 3.6(b) show how the roof display and pager. To note is that figure 3.6(b) shows the one display at the co-ordinators area. Each module at HLAVA have their own roof display hanging by their module bridge. The nurse call signal can mean anything from the patient wondering when the doctor will come to that they feel a stomach ache.

(a) The pager delivered by Ascom

(b) The roof display which displays where alerts sent from a patient comes

Figure 3.6: The pager and roof display

Healthcare professionals work mode

HLAVA tries to work toward implementing patient-centered care as much as possible. Patient-centered care means providing an efficient patient flow whilst having each individual patient experience high-quality care. HLAVA uses a team organization where all healthcare professionals at the ward is divided into so called teams. Each team consists of one person of each title i.e. physicians, nurses and nurse assistants. Nurses and nurse assistants are strictly paired to one team whilst a doctor can be part of several teams. Some teams can from time to time consist of two doctors, usually a specialist, or a physician, and an assistant physician. HLAVA has one co-ordinator that is shared among all teams. The role of co-ordinator is taken by either a nurse which means that nurses can from day to day, depending on their schedule, be working as co-ordinator. Each team and its team-members are assigned to one module each and are responsible for that

modules patients. One of the modules is shared between two teams during evening- and night shifts where the sharing team takes two beds each. Healthcare professionals can thus during evening and night shifts be assigned to two modules. The fifth bed, i.e. bed number x:3 in the shared module is never occupied by a patient during these shifts. However, the shared module is staffed and can have all beds occupied during daytime shifts.

The teams work in three-shift; morning shift, afternoon shift and night shift. The night shift was not studied during the observational research of this project. A workday and its activities for each team is unpredictable since it is highly dependent on the state of the day. However, a list of standard work activities is always followed by the nurse and nurse assistant which in summary is the following:

- **Handover:** The nurse and the nurse assistant boarding an upcoming shift and the nurse finishing a shift exchange most important informations about patients. The boarding nurse gets a verbal report from the previous shifts nurse.
- **Preparations:** The nurse writes down other needed information about patients which they usually find by reading the medical records. A to-do-list on things that shall be done during the shift is also written based on the handover and the other informations.
- **Introduce to patients:** The nurse and nurse assistant boarding the shift introduce themselves to each patient.
- **Rounding:** The nurse conduct a rounding session together with one or more doctors.
- **Follow up and medicine distribution:** The nurse distributes medicine to patients in the module according to what the doctor has prescribed. The nurse and nurse assistant also follow up with delegated activities according to the doctors order. Medicine is normally given to the patients at certain hours.
- **Updating medical records:** The nurse maintains the medical records of the modules patients with reporting conducted activities according to patients care plan, results of tests and treatments of each patient.
- **Handover:** When the next shift starts the nurse conducts a handover similar to when boarding a shift.

Boarding nurse and nurse assistant start their shift approximately two hours before the respective titles finish their shift. This makes the boarding nurse able to conduct rounding without having to care if something happens to a patient during rounding. It is to be noted, before proceeding, that the term team members will be termed for issues which concern both nurses and nurse assistants.

Handovers The handovers served as a review of a modules patients. The handover covered essential information about each patient in relation to what has happened or been done during the shift. As earlier mentioned, the nurse from the previous shift exchange information, as an informant, with the nurse and nurse assistant who are boarding the upcoming shift verbally from personally taken notes. The nurse who exchanges the information follows the same structure and categories on each patient:

General facts: Age, language skills, diet, adverse events, patients feelings etcetera.

Reason for intake: The date the patient arrived and why

Previous events: Performed treatments, transfers from different wards, conducted planned activities during the last shift etcetera

Status: Planned upcoming activities or extra needed activities

The articulated information was perceived by the boarding nurse and nurse assistant who write it down in the form of own personal notes. The boarding nurse and nurse assistant of the upcoming shift used these notes to plan how to proceed with a patient or as a reminder. Questions related to conveyed information were the only ones asked by the boarding nurse and nurse assistant. From this it was observed that questions regarding subjects other than the information distributed were never asked. Each individual would during the handover notify the informant if help was needed for any of the articulated nursing actions or upcoming care plans.

Handovers varied in amount of exchanged information and detail of the informational content for each information category both when observing different informants and shifts. Handovers between night and morning shifts mainly focused on previous treatments, upcoming treatments and upcoming care plan activities for each patient. The handover between morning and evening shifts covered treatments and care plan activities instead on a basic level and contained more general information about patients such as the patients feelings and future nursing needs. There was no significant difference in elapsed time between the morning and evening shifts. Average elapsed time for this handovers was approximately 25-35 minutes. The boarding nurse would after the handover go to the co-ordinators' overview-board where they would make updates.

In the subsequent preparations phase, the boarding nurse studied each patient's medical records to choose and print data which was important to discuss at the upcoming round which was done at the module link. The order and level of focus on a patient was based on the patient's rounding priority which is displayed by the colored dots on the overview-board, see figure 3.4. The nurse assistant ran errands on other locations in the department and the other nurse continued with the work as planned. Errands were run by the boarding nurse as well from time to time during preparations. She/he would be absent from the module link for a certain period and return to the module link to work again. Whether it was the to-do-list, preparations or other things they worked with differed between observations. The module link was the place where all team members would visit most frequently and used it as a starting point all routes they took.

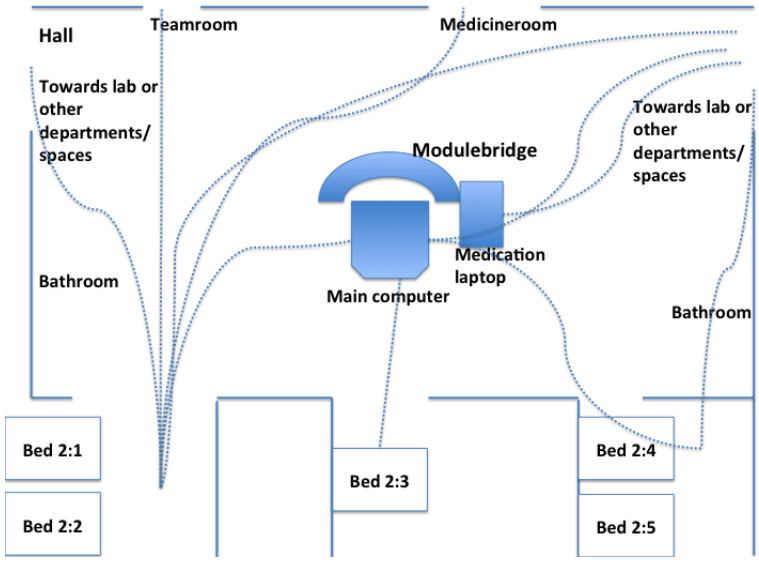


Figure 3.7: Example on routes taken by team members during one observation (not all taken routes) from a birds eye view

Figure 3.7 shows an example of the routes that could be taken by the team members. All team members did usually come back to the module link before running to other locals or running an errand. The activity they did when returning to the module link differed from time to time where continuing with preparations, to-do-lists and checking medications were usual.

Rounding Roundings at HLAVA are conducted every day between only doctors and nurses for gaining a view on each patient's condition and needs for deliberating how to proceed with their treatment. Each module's corresponding nurse have their own rounding with their corresponding doctor where they together sit in the module's team room. The team rooms at HLAVA have several screens, both larger displays and desktop displays, and one desktop computer which the doctor uses to read and look at patients medical records in Mequal. Roundings are conducted between 8 am - 11.30 am during morning shifts and between 4 pm - 6pm on evening shifts.

All roundings follow the same structure where they start with discussing the patients' with highest rounding priority which is symbolised with the red dots in figure 3.4. Patient's who are to be discharged (green dots) are discussed next followed up with patient's not finished with their treatment (blue dots). Each patient is discussed with different structure and topics of interest depending on their current state and how long time they have been at HLAVA. Roundings usually start with the doctor asking the nurse about the the patients current state where typical topics of special interest is how the patient feels, recent measurements, medications and occurrences such as if the patient has become violent etcetera. The nurse responds with data they have been able to collect, set up and interpret from the handover and their own preparations. Depending on patient,

the doctor would discuss with the nurse about their information and the doctors own thoughts to deliberate how to proceed with a patient. Delegations which were ordered, or reached agreement, on how to proceed were written down on personal notes in the same way as during the handover. The doctor mainly used Mequal during the rounding but had before the rounding gathered information and suggestions from other sources such as notes from the emergency unit that received the patient. The following were the usual topics brought up for discussed during roundings:

- **How the patient is feeling, acting etcetera in general**
- **Changes in medication**
- **Ordination of assignments (measurement, treatments etcetera)**
- **Deliberations regarding if a patient can be discharged or not**
- **Informing and discussing changes on care plans**

The nurses answer was usually quite hesitant, imposing a feeling on that they were not fully sure, on all questions or discussions regarding how a patient actually was feeling, acting etcetera.

Rounding during morning shifts differ significantly from the evening shifts rounding. The evening shifts serve more as a follow up on what was stated during the morning shift rounding. The doctor delegated tasks to the nurse and inform changes in medication if any and further discussions were not held between them during evening rounding. Some data was brought and discussed by the nurse for the evening rounding but not as much in comparison to the morning rounding. Average elapsed time for morning and evening rounding was approximately 1 - 1,5 hours and 30 - 40 minutes respectively.

Everyday activity outside of handovers and rounding The team members have standard work activities, beyond the handover and rounding, which they follow as mentioned in the list above. All team members ran errands which were related to the activity they were currently conducting. Following is an example on errands that were done for conducting a measurement on a patient:

> **9:15 am** The nurse walks away to get syringes. The nurse assistant is not present by the module.
>
> **9:24 am** The nurse bumps into the nurse assistant at the module bridge and asks the nurse assistant to conduct the measurement on patient 6:3. The nurse assistant informs that help is needed for that. *Note:* The nurse assistant was present in the module the whole time, taking care of patient 6:5 but was not spotted by neither the nurse or the observers.
>
> **9:34 am** The nurse walks away from the module. The nurse assistant walks away with notes.

9:45 am The nurse assistant returns, performs urine test on a patient and walks away from the module again.

10:00 am The nurse returns with notes which were taken when answering a call from the lab department and printed results on a patient that was picked from another department. Starts distributing medication and works with the medication laptop.

The team members, in whole, were rarely present in one area for longer than fifteen minutes if they were not treating patients or working with Mequal. Figure 3.7 shows the nurses routes they took in conjunction with their errands. To mention here is that other than using Mequal, nurses did frequently visit the medication laptop to check for updates in medication lists and other activities for distributing medications.
Notes from both the handover and rounding were either used often or rarely during their whole shifts depending on different factors such as who the team members were, the errands need for information, details etcetera. Mequal was often used as a complement during cases where the personal notes were not enough.
The example above shows that the nurse is responsible for handling correspondence with patients family or relatives but also correspondence with other departments or units. The following is another example on correspondence in which Mequal was necessary as a complement. Note that in this example the nurse boarding their shift is named Helen and the nurse finishing their shift is named Peter:

2:55 pm Nurse Helen receives a call telling her to transfer patient 4:5 from HLAVA to the HIA ward. She tells nurse Peter to call HIA and inform about the transfer. Peter informs to HIA his notes written for the handover. Nurse Helen goes through patient 4:5 in Mequal and writes in notes about recent hospital visits, background, diagnoses etcetera.

3:05 pm Nurse Helen makes a call to another department and goes away on an unknown errand. Returns 20 minutes later

3:25 pm Patient is transferred to HIA by nurse Helen. Returns 3 minutes later.

The nurses pager signaled several nurse call alarms during their whole shifts. In addition, some alarms came from the roof displays which then, as previously mentioned, sounded over the whole ward. Attention was always given to all alarms i.e. both from the roof display and the pager. However, not all pager alarms resulted in a patient visit which the roof display alarms did. Some pager alarms became ignored by the nurse.
It was unclear whether the module board and the overview board were used by the team members since this would involve eye tracking. However, when asked they would say that the module board is rarely used for other than critical patients, reading if a patient had a any of the icons mentioned above or checking patients diet. Updates on notes or new notes were made on the module board, whether this was dependent on the individuals themselves or if it was a prioritisation issue remained unclear.
The overview board was used often by the team members when they wanted a general view on their modules present state. Updates were made either by the co-ordinator or

nurses. The co-ordinator would do these updates through periodically collecting status information by asking each modules team members, make notes and then return for updating the board.

3.1.2 Semi-structured interviews

Learning about the target groups background and expectations on what purpose the mobile platform should serve has been central in the design and study in all. However, it has also been central to get an understanding on how different staff members view their work. Three semi-structured interviews with people of different roles were performed in order to achieve this. The purpose for this interview was to get a view on how different healthcare professionals viewed their work and what they would expect from the system.

3.1.2.1 Preparations for interviews

Approximately 10 questions were prepared before the interviews which covered topics regarding the systems that are used today, expectations on the product, the view of their work role and its relation to the information that is handled and processed. Interviews were then scheduled with three carefully chosen individuals which were chosen as interviewees. Chosen interviewees were based on indications on their engagement in reviewing both the work and presently used computer aids. Interviews were performed separately on different occasions and answers were compared afterwards to put together a general result summarizing all interviews. The interview followed a semi-structured approach with the goal to use an interview script whilst allowing to let the interview develop into an open conversation and change focus if more interesting topics appeared. The interview script was designed accordingly towards containing questions covering four phases according to following sequence (Adams and Cox, 2008):

- Let the interviewee share their background and experience with different equipments that have been used throughout their time. The background should rather be about their technical background during this phase. Personal background, if needed, is more suitable to talk about when the interviewee feels more comfortable and starts trusting the interviewer.
- Open ended questions are suitable to warm up the interview itself, letting participants to, without being forced, talk about a set of key points that they want to tell you about.
- Issues that have not naturally been dealt with through the second phase go into this phase and become initiated.
- Wrap up the interview by rounding off with a summing up of all that has been discussed to let the interviewee feel that they have presented all the information.

A time limit on the interviews were set to maximum 75 minutes in order to not exhaust interviewees (Lazar et al., 2010). Appendix C demonstrates the predefined questions of the interview.

3.1.2.2 Performing interviews

The interviews took place at HLAVA and were conducted with the interviewees after their shifts, usually after the daytime shift. According to Adams and Cox (2008) the more natural setting the interview takes place in, the more likely they are to give naturalistic responses. Choosing the staffroom where other people were present felt thus most convenient. Adams and Cox (2008) also mentions that " ... asking them about technologies they would use at home makes it easier for them to respond in their home environment" which argues for that an interview taking place after a shift will have interviewees having fresh opinions and examples. Notes were the only documentation that was taken during the interviews since there could be interruptions during the interview resulting in pauses for the interviewer. Audio recordings were intended to be used when planning the interviews but were instead excluded due to background noise and would thus be both exhausting and time consuming when analysing. The length of the interviews varied but did never exceed the maximum length criteria. It was out of interest to get a broad view of the work at HLAVA as possible which motivates that two nurses and one doctor were interviewed.

3.1.2.3 Findings from interviews

The interviewed healthcare professionals had in general the same attitude towards technology but differed, as in the society as a whole, how technically experienced they were. All interviewees were in general technically experienced and use mobile technology frequently in their spare time. Compiling the interviews resulted in a collection on how these interviewees view their work, issues both mutual and unique but worth noting and their exepectations on what eNursing should do.

The first sight in a system was one mutual issue which all interviewees pointed out as a big issue. Unclear buttons and navigation were examples on common problems in previous systems they had been involved with. This did at those times result in long learning curves and general frustration from their coworkers which in turn cause a bad attitude towards the technology. According to the interviews, this attitude is unfortunately inevitable in healthcare today since there will always be individuals who either experience the same issues no matter how well designed a system is or just have this attitude in general even in their everyday life. A typical problem which healthcare professionals experience today is so called double documentation. For example, during a measurement they would by the patient bed write down results as notes and afterwards report the values written in the notes in Mequal. Nurses would also mention that their work in general was exposed to interruptions. Depending on the case it would sometimes

be difficult to after a resolved interruption continue the previous work. As a simple example, reporting values into Mequal would not always necessarily be done directly after a measurement when interruptions occur. One interviewee mentioned that a usual case was that many of their handwritten notes unfortunately disappear.

The doctor would mention, as their own corresponding example on double documentation, checklists which they use when planning future proceedings with a patient. These checklists could sometimes be of several pages, which they would print out and bring with them to mark some of the checkboxes in the checklist when meeting the patient. The result would then be brought to a computer and reported into the patients medical record.

Keeping track of the agenda of the shift for the nurse, i.e. the upcoming plans on each patient which was covered during the handover, was another problem similar to the memory issue in the previously mentioned interruptions problem. This scenario was described by one of the nurses: "A typical problem which pretty much all of us at this ward feel is the following scenario: You run errands connected to for example preparations for an angiography at 11 am. All of a sudden during those preparations you start thinking 'Hmm, there was an activity with a patient which is due soon but I can't remember what I am supposed to do, on who and when!'" This interviewee added that Mequal aids in one way with this, however it was emphasized by both the nurse interviewees and the doctor that their work consists to great extent of fetching or leave different types of documentations such as information, referrals etcetera. With these documents being handled as physical paper sheets, this means that they are exposed to walking to the corresponding area for the document type more often than they walk to meet and care a patient. One of the interviewees said as a summary on this issue "It is as if an e-mail is being impersonated. You want to send information, request information etcetera but none of it is done electronically, it is done manually by humans". The interviewees fully agreed when asked if a good description is that they themselves are the communication technology.

When talking about interruptions, a question arised regarding the pager alarms. The nurses responded with that it is usual that those alarms are checked if it is about a monitor that sends the alarm whilst some alarms which are sent from the patients are ignored depending on what they are currently doing. It is thus a prioritisation issue. What they did emphasize was that the alarms from the monitors are often not correct and the reasons could be in the device or other factors. All those alarms are still taken seriously by for safety. Thus a problem which they felt they suffered from was that they become so used to the constant alarm sounds that alarms alarms are ignored instead of being silenced, leading to even more extensive alarming which often affects their patients.

Lastly all interviewees were to give their views on important factors for eNursing and what they hope it will function as. According to the interviewees, eNursing should:

- Easily provide an overview over the current state at a module in real time. It should be the same for the whole ward or details about a patient.
- Allow one to make inputs for changes or reports irrespectively of position and you should not have to worry if this reaches everyone.
- Should as a mobile solution have minimized amount of needed clicks for all operations, navigation etcetera.
- It would be perfect to be able to report values, conduct checklists etcetera. into Mequal right at the bedside
- It would be appreciated if eNursing can assist nurses with reminders on planned activities for all patients.
- eNursing should make it possible for me to spend more time meeting a patient

3.1.3 Questionnaires

A questionnaire was designed to complement the interviews and include those that were not chosen for the semi-structured interview, see Appendix H-I. The purpose of following up with a questionnaire was to gain a more solid foundation for the upcoming design phase. The questionnaire asks the users to share about their technical experience such as what mobile applications and websites they frequently use.
The design of the questionnaire aimed to follow the interview script as much as possible with some adjustments which made it more general than the interviews. This was due to that a questionnaire should avoid containing too many questions which need well thought and long answers if you want a high response rate (Adams and Cox, 2008;Sharp et al., 2007). Also, the users who received the questionnaire had a profile which wasn't suitable for the same questions as the interview such as their engagement and attitude to the interviews topics. Adams and Cox (2008) emphasizes that a common accepted rule for questionnaires is to not make it over long. People tend to complete long questionnaires less accurately according to Adams and Cox (2008) due to that humans in average have short attention spans meaning that they will want to finish them as fast as possible. Focus was therefore put on being concise and minimize the number of questions whilst still being able to achieve valuable data. There is however no standard rule for the number of questions a questionnaire should contain. The questions were designed in such way that they aim on making the participant feel that filling them out and contributing to the study would benefit them. 8 questionnaires were handed over personally to the chief of the department who in turn personally distributed them out to random people in her staff and all 8 questionnaires were replied.

3.1.3.1 Findings from questionnaires

Findings from the questionnaires did in general repeat what the interviews provided above. The majority of the questionnaires pointed out easy access to an overview, intuitive navigation structures and being assisted with reminders on upcoming activities as the most important utilities to be provided with by eNursing. When compiling the results it turned out that most of the healthcare professionals at HLAVA in general are technically experienced. Even if not experienced the average learning ability of healthcare professionals is considered somewhere between quite good and good. The most usual application which the healthcare professionals use in the spare time was any of the google services gmail, google drive etcetera. Additionally, the most used applications were spotify, facebook, västtrafik (a public transportation travel planner application) and any of the weather forecast applications SMHI or YR. All these applications were considered as having intuitive design and satisfying needs. One of the questionnaires described a scenario which the interviews did not cover. This person, obviously a nurse, wished for the possibility to notify the nurse assistant when a rounding was being conducted. It was desirable to as an example during the round notify the nurse assistant to conduct for example a sample taking on a patient if the doctor during the round had ordinated one as urgent.

3.1.4 To consider on to the next phase

The data gathering phase provided an understanding on the problems for a healthcare professional today. Their work consists of visiting many different areas, running errands and handling correspondence whilst devoting as much time as possible to treat a patient. Adding up consumed time from each mentioned activity together with more time consuming activities such as handovers and roundings results in little time left for what all healthcare professionals seem to wish for, namely actual treatment of and meetings with their patients. What eNursing is to solve is thus to reduce as many unnecessary time consuming activities or at least reduce their time consumption.
To consider from this is that there are obvious needs for healthcare professionals to be able to at any time and place retrieve and report information. This information should then be stored and accessed through a central source to avoid for each team member to reach in order to avoid information being lost or becoming incorrect in the same way as today. In addition, there is a need for mobile communication between healthcare professionals. Being able to not having to physically locate each other for communicating information or ordinations etcetera were striking findings from the data gathering phase. Observations and interviews indicated that healthcare professionals burden their memory to great extent in their work, specially when it comes to the agenda for a patient. A solution to solve this will also be considered as an important factor to include into the low-fidelity design phase. The questionnaires provided suggestions on applications which served as design inspiration together with theories in chapter 2 to solve the above problems. Note that the following design process are towards tablet and large touch

screens as mentioned in section 1.3. However, one finding important to take into consideration during the design of the prototypes was that of the legal restrictions against the module and overview boards.

The following are the most crucial findings form the foundation for eNursing:

- Functions are needed which reduce, or eliminate, the need of extensive walkings and conducting the mentioned non-value adding activities which results in minimal time for actual caring of patients when activities such as rounding and handovers become time consuming.
- Regulations can limit the design and allowed content.
- Healthcare professionals need support for being freed from burdening their mind with memorizing everything so that focus can be put on their actual works.

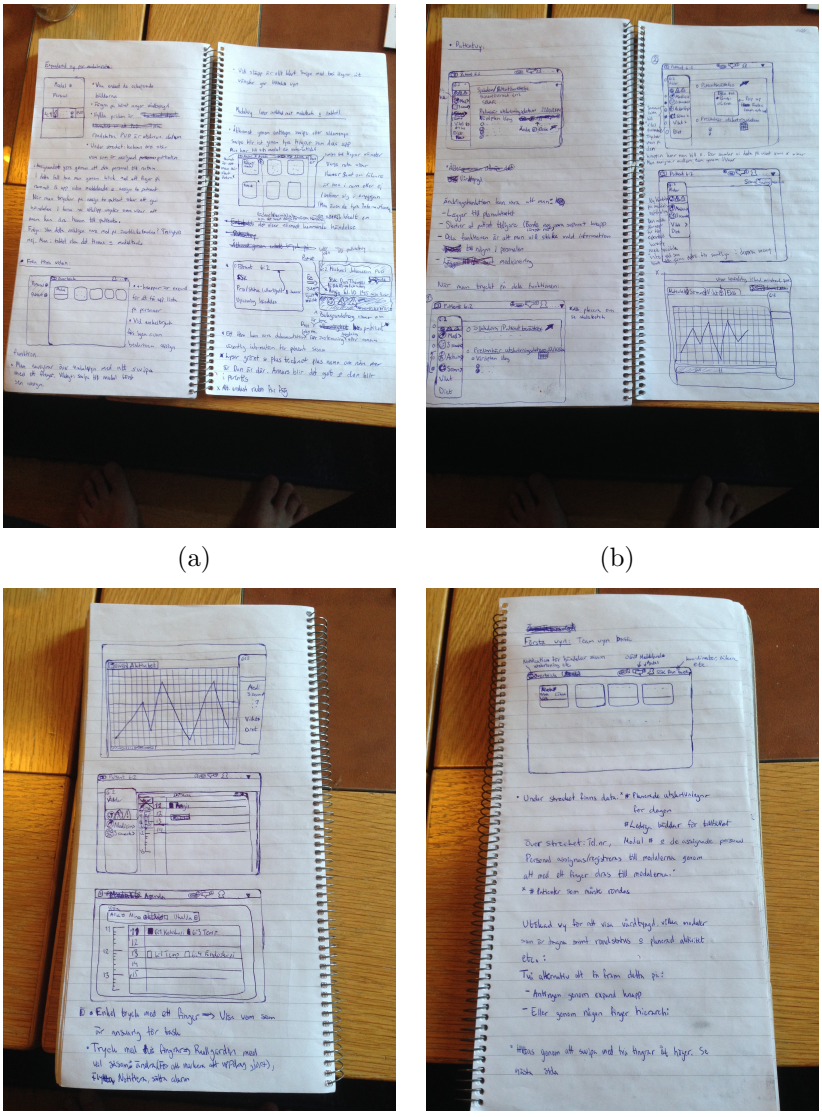
3.2 Low-fidelity prototyping phase

A general sketch displaying structure and functions based on findings from the data gathering phase was presented, discussed and evaluated together with the CEO of Domitor who has been involved in the project from start. Figure 3.8 shows this general sketch with notes explaining the idea. A low-fidelity prototype with refinements that were suggested together with Domitor's CEO was then produced. Detailed design was also then based on theories from activity theory, Normans design principles and gestalt psychology in Chapter 2 to produce a final low-fidelity prototype. It was decided to go with a paper prototype category with more detailed sketches on each view and functions than the first sketch.

3.2.1 Low-fidelity prototyping: Paper prototype - construction and evaluation

A paper prototype is a type of a low-fidelity prototype visualising the layout and interface of the design or system. Paper prototypes serve as a quick and easy method for communicating the whole concept and discover strengths and weaknesses in a design. Using pen, paper and markers, a paper prototype having close to all the pages was produced after several hours. Each page of the application is sketched and represented by a separate paper. There are no requirements on what level the visual design should have. It is however recommended to have such level that users clearly can perceive the structure and building blocks such as buttons etc. (Hill and Houde, 1997).

Evaluation of a paper prototype was performed by letting users, one at a time, interact with the prototype as they would with an actual finished physical product. The users are instructed with tasks by the designer which and the prototype is designed thus in



(a) (b)

(c) (d)

Figure 3.8: The general sketches (with notes) showing the basic idea on structure and design

order to test and evaluate specific things. One individual is present during the evaluation acting as a "human computer" physically manipulate the content in relation to taken action by the user. For example, a press on the logout button would result in the "human computer" changing to the login page. Also, a second individual is present during the evaluation, having the role of paying attention and documenting the users interaction and other variables such as time, number of clicks etc. In this study, each paper was inserted into a prototyping application designed for mobile platforms named POP - Prototyping on paper. Areas are marked on each page and configured as clickable making them buttons or actions such as swipe or pinch. Each of these areas are linked to a certain page thus making the interaction being an initial level of the application but

on the actual physical device it will be used on. Thus, the role of "human computer" was not needed and the evaluation was instead performed with two people where the second individual (the designer) acts like observer. The observer was also the one instructing the tasks users were to do.

There are no restrictions on the amount of users an evaluation should be carried out on. The evaluation of the paper prototype in this study was carried out on a total of four users. Each evaluation was followed up with a semi-structured interview to review the prototype and its design (Appendix D). This interview was planned with the same considerations as the semi-structured interview from the data gathering phase with the exception of trying to avoid the interview to ask leading questions about the design.

3.2.2 The design

A walkthrough on the design and a motivation behind the design is needed to be done before proceeding to the findings. Functionalities are based on what was found in the data gathering phase.

3.2.2.1 Needed information and functionality

Several types of information and information sources were, as previously mentioned, detected in the data gathering phase. The next step was to deliberate which of the information eNursing needs to provide in relation to the role it should play. Results from the observation was analyzed by using the activity checklist in chapter 2. Implementing the activity checklist meant identifying the most usual activities and their corresponding means and ends. The remaining three categories in the activity checklist were found through data from the interviews, which results is presented above.

It was concluded that the healthcare professionals often were interested in each patients status, i.e. how they felt, if something had happened etcetera out of all information covered in handovers. This was also what they would ask most questions about if they felt that provided information was fallible. We have already mentioned that the plan on how to proceed with a patient also was out of great interest, which also was indicated from interviews and questionnaires.

One activity and artifact which was frequently revisited by nurses was the medication laptop. Medication as a category was beyond that, a usual discussion subject during roundings. It was thus concluded that healthcare professionals are in need of being provided with medication lists containing information regarding what medication and the dosage. From the observations, it was found that vital parameters and lab-results are

two information categories which healthcare professionals use for deciding medication and dosages for a patient. Therefore, in order to provide one more dimension where healthcare professionals can both retrieve different types of data at any time.

A patients recent visits to the ward and who the responsible doctor was for those visits was out of special interest for doctors and some nurses both during work and roundings. It was unclear what this would provide in terms of the activity checklist theory. This information was added out of interest for review under the category recent contacts.
Lastly, information about a patients gender, planned discharge date, weight, burden of care, rounding priority and additional icons used on the module board would be added which was articulated to the users who would evaluate the low-fidelity prototype.

Lastly, the findings showed that double documentation is something which needs to be eliminated and that information often gets lost in conjunction with the handwritten notes being dropped, forgotten etcetera. eNursing should thus allow reporting and updating patient information and measurements directly from the bedside.

3.2.2.2 Design

As mentioned, the questionnaires from the data gathering phase provided a hint on design structures and building blocks that would give the best outcome. Google services were the most commonly used applications which serve as so called single page applications (SPA). The foundation of a SPA is to segment the screen into parts which consist of static elements mainly used for navigation whilst letting the remaining surface contain the content. This surface content change depending on what you choose from your navigation menu. There are several ways to design a SPA. Facebook, which was one of the top three applications which the HLAVA staff were familiar with, is also an example on a SPA. Figure 3.9 demonstrates the google drive web application, facebook mobile application and facebook web application. The observant reader will notice a difference between the mobile and web version of the facebook SPA. The web version uses a structure similar to the google drive, using a vertical tab bar at the leftside known as sidebar menu, whilst the mobile version instead choses to use a horizontal tab menu placed in the bottom of the surface. These horizontal tab menus are more popular on smartphones due to both the device size but also the usage context of a smartphone. A usual problem with horizontal tab menus is that they easily get covered by the hand which holds the device which can cause functions not being discovered or "hidden". It was therefore decided to in this low fidelity phase tryout a vertical sidebar in the same fashion as the google services and facebooks web application.
Single page applications cover a lot of the principles from both Normans design principles and gestalt psychology presented in chapter 2. Using a structure that is previously known to a user could give a hint, i.e. provide with affordances, on how the system functions. It was therefore out of interest to try using as many familiarities in the design and see if the findings from the data gathering provided true data. When it comes

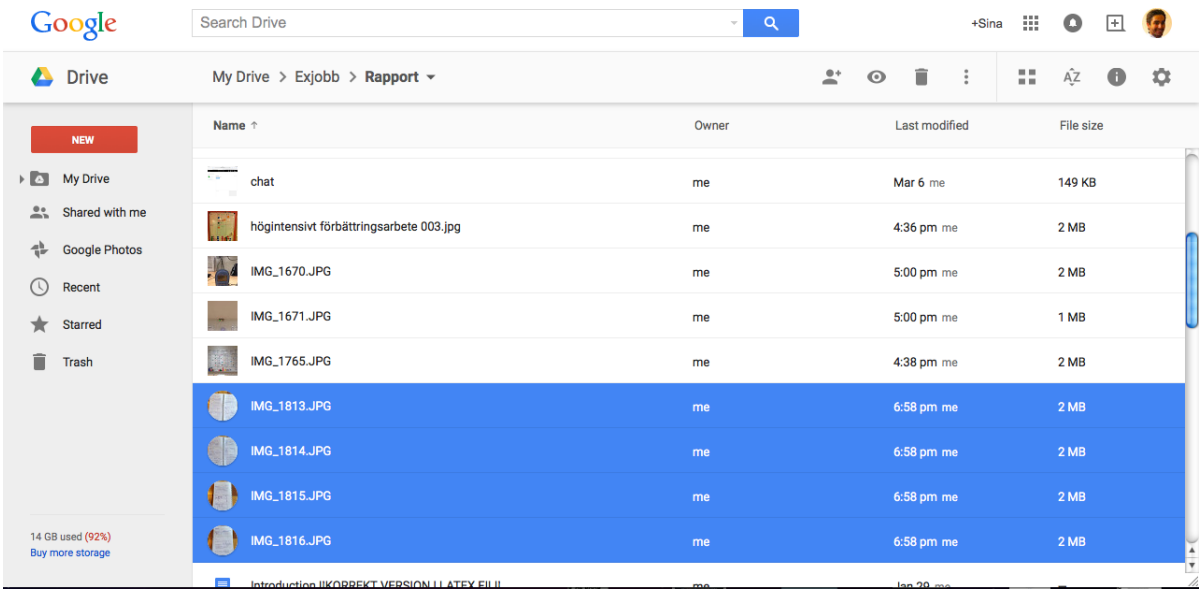


Figure 3.9: An example of a single page application - the google drive

to the visibility it is clear that the idea of a single page application is to make all the available functions visible. Single page applications should not be perceived as having any other functions as the ones being present in the static areas. As a result, users are constrained through physical and logical constraints in how to use the system. Meaning, they will not think of the single page application to be used in any other way than it is intended which leads them into using it the way the designer wants them to. They also cover consistency using the idea of static areas and areas which will change content depending on manipulation. Single page applications seemed thus as a decent design choice not only because of the questionnaires result.

This sidebar would be used for navigation to the information categories mentioned above meaning that each category gets its own view and button. Information categories about the patients status and the patients careplan was decided to be collected into one single view which would be the initial view when viewing a patient, called the patient view. This view contains two informations namely the patient status and a list of upcoming activities in the care plan the patient is under. The patient intends contain the general information about the patient which always was present in a handover. Navigating back to the patient view from all other views was suggested in the low-fidelity phase to be done by a swipe from the top of the view to the bottom. The top of the view was marked with a down arrow.

General information such as age, gender etcetera was decided to be summarized in a so called profile card which would be placed on top of the sidebar menu. The patient card was also to show discharge date and care plan for the patient but was not designed for the low-fidelity phase due to, again, that it was out of more interest to test the structure rather than the content. It was however clearly articulated to the users what that profile card would contain in the future in order to avoid confusion.

The top segment of the application uses a header similar to the one from facebooks web application. Starting from the right we have the user button which on a tap will show a dropdown menu with user related categories such as logging out, messages etcetera. Next is the message and the attachment buttons respectiveley, demonstrating that eNursing should provide healthcare professionals the ability to communicate with each other through sending chat messages. They should also be able to share information about a patient which is done through the share button symbolized by an arrow. Next is a text which shows which patient is being viewed that is their name and corresponding bed number and lastly is a notification button which shows the number of new events that has entered the eNursing system. Events could be changes in medication, new lab-results, messages etcetera. This notification button will also show a dropdown menu which displays a list with the events. Other than that, each category and header buttons have indicators displaying number of new events that has occurred in respective function or view. The notification buttons number indicated sum of all events.

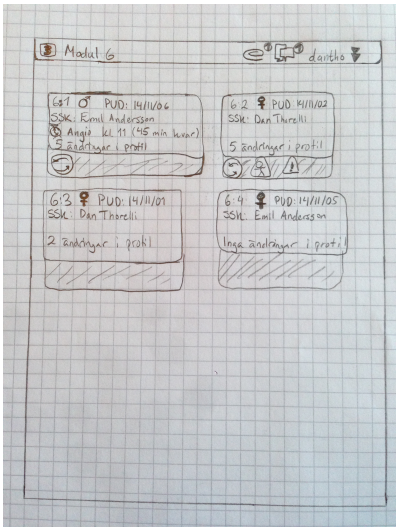
The agenda, which was under the category called "Mina aktiviteter" in the sidebar menu, places out the planned activities as displayed in figure 3.11(d). Filled boxes symbolized if any team member had assigned themselves to take on the activity and blank boxes the contrary. To the left was a so called time regulator to navigate the agenda through different time intervals. Also, a demonstration on adding the ability to filter out the agenda. The choices you could make was to view all activities on all patients, the current patients activities which in this would be only activities related to patient 6:2 or activities which you as a healthcare professional have assigned yourself to. A double tap with two fingers on an activity would show a dropdown menu in with you could make edits to the activity such as changing the time for it or assign yourself to the activity.

As a final, a view which provides summarized information on all patients at the module a healthcare professional is assigned on was designed called the module view. This view applied the profile card to all patients and placed them as figure 3.10(a) shows. To note is that this view was to be used both on the large touch screens, which were to replace the todays moduleboards, and the tablets. The large touch screen monitor would thus not have any unique functions or views and would only display limited information in the same manner as todays moduleboards due to the previously mentioned legal restrictions. Updates made on the tablets, related to this view, would however result in an update on the module board as well. It can thus be viewed that the moduleboard ended up in being a limited projection of the tablets moduleview, enabling healthcare professionals to be viewed a summary on all patients in a module without having to look at the tablet everytime.

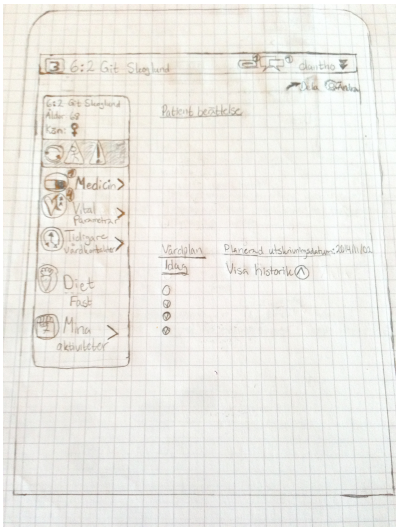
Visual design choices were based on the two principles similarity and continuity from gestalt psychology in chapter 2 but also with some ideas from Normans principles. The idea was to take something familiar, use similarities and dissimilarities in order to catch attention from the user on specific events and finally have a continuity in order to make

users trust the system and feel that it is easy to perceive. This has served as one of the main arguments for choosing to go with the google drive and facebook web application as inspirations for choice of application type and navigation structure. These inspiration sources have also been used in the agenda and recent contacts.
On the other hand there was one view which actually was based on how it looks in Mequal today, which was the vital parameters view. Deliberations and discussions were made with the CEO of Domitor regarding how the outcomes from the observations showed that a usual topic for healthcare professionals is how the patient is feeling and physical progression other than typical medical variables such as glucose, bloodpresure, ECG etcetera. It was thus decided to, out of interest, test the type of impact data on taken steps and amount of sleep can provide to eNursing when introducing this in vital parameters. Activity bracelets from Fitbit were used to retrieve measurement data on steps and sleep. It is to be noted that numerical values of this parameter type do not have a medical ground on what they indicate. However, presenting these numerical values in the form of a chart could at least show the trend and how the variables have behaved over time. The investigation would thus be in what eNursing through this approach can provide. As an extra, it was decided to use the chart idea in whole for the vital parameters view as well as the lab-results view with the previously mentioned as an argument. Navigation to the different variables in this chart would be done by using tabs which will be further shown in the high-fidelity phase.

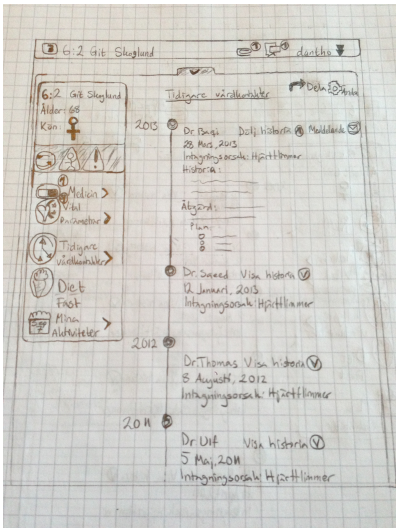
Figures 3.10 and 3.11 demonstrate the paper prototype and each designed view. Figure 3.12 demonstrates the paper prototype inserted to the POP app. It is to be said that in lab-results and medication views were left out in this low-fidelity phase due to that the purpose of the low-fidelity phase was to test the structure and navigation rather than the content. However, it was articulated during the interview that there is an idea to in the high-fidelity phase test if it is beneficial to implement a chart view identical to the one used in vital parameters.



(a) Moduleview

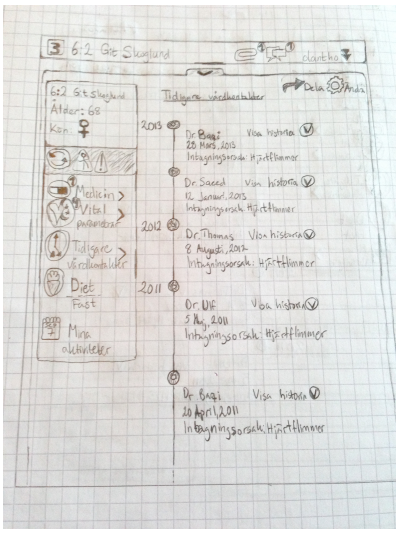


(b) Patienstatus

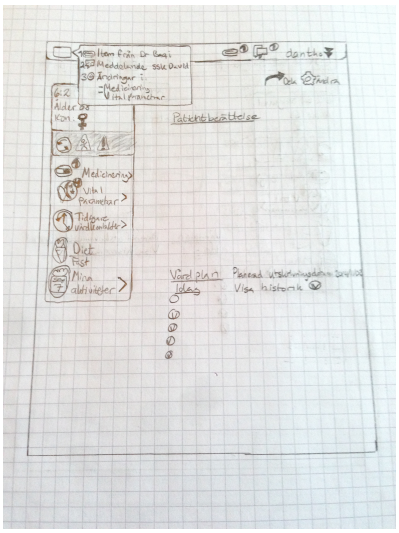


(c) Patients recent care contacts

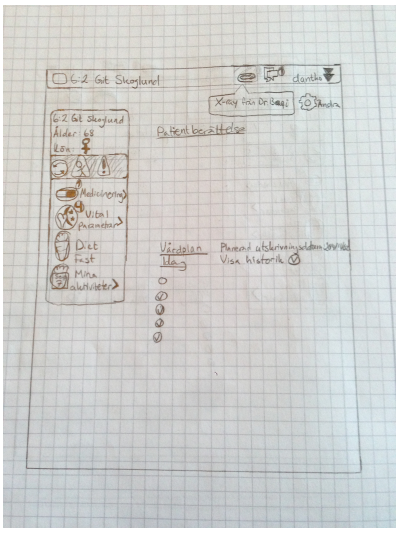
Figure 3.10: The paperprototype and three of the views made at the corresponding stage



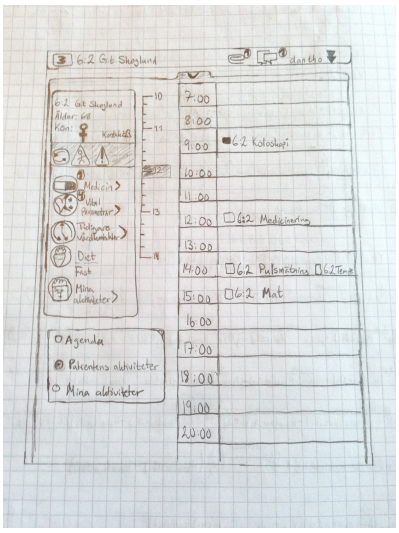
(a) Extended view of recent care contacts



(b) Notifications

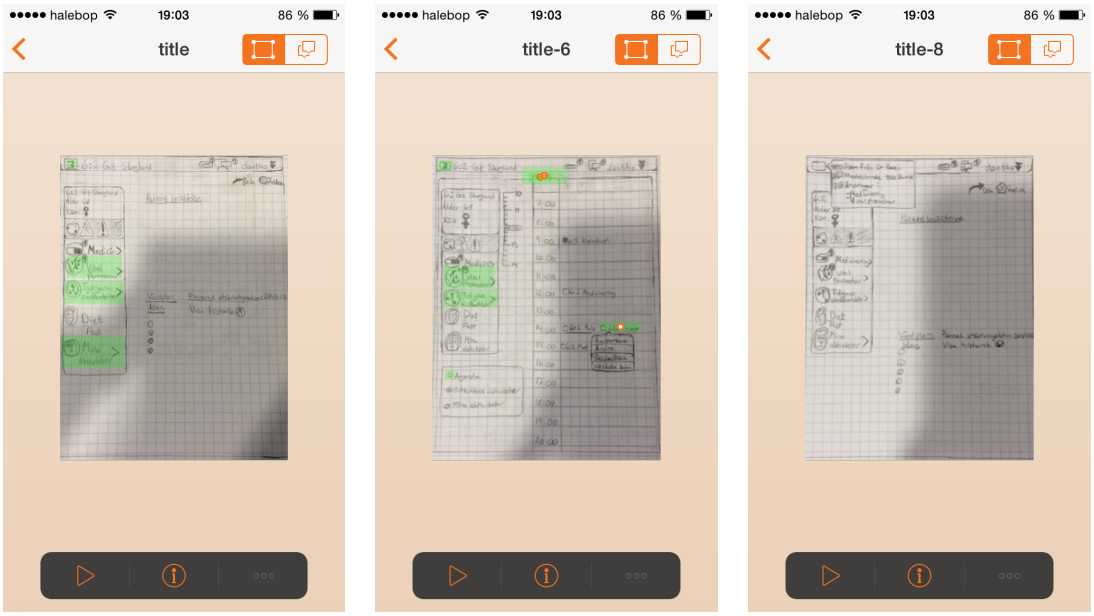


(c) Attachments



(d) Agenda

Figure 3.11: Continue of paperprototype and its views made at the corresponding stage



(a) (b) (c)

Figure 3.12: The paperprototype and how its transitions and views are set up in the POP app

3.2.3 Findings from the low-fidelity phase

Outcomes from the evaluations in this phase implicated in general a good impression of the design and that it was easy to use. Time estimations on how long time it took for users to navigate to different functions were seldom longer than one minute. Need for refinements did however turn up from observing the users but also from the subsequent interview. One commonly taken action by all users was that navigation back to the initial patient view was not attempted through the intended swipe from top to bottom idea. They would instead try to navigate back to the initial patient view by clicking the profile card. The users did during the subsequent interviews explain this behavior, without getting a question regarding the subject, by saying that they would have assumed the swipe action if the prototype was of higher fidelity. Other than that the usage of sidebar navigation and the button for the module view being placed in the upper-left corner was intuitively used. Most icons and functionalities such as the time regulator were intuitive as well with the notification button as an exception. When asking people to check if there had been any recent notifications they did use the notification button. A usual comment on the notification button was “I thought it was the notification button since there were not many other buttons to choose between”.

There were however some functions where the behavior differed between the users. Firstly, three of the users did struggle with finding the agenda whilst one did find it and use it easily. These three users did, unsurprisingly, not find the agenda function as intuitive mainly due to that the agenda only could be accessed by entering a patients pa-

tient view and that you couldn't reach it from the module view. During the subsequent interview, these users additionally commented that it was confusing that you could get an agenda view on all patients when you actually had were in a specific patients patient view. All users also had problems when asking them to try to change the time of an activity in the agenda. No one tried to see if they could find the option by double tapping with two fingers. Thus, without further discussions, it was considered into the high-fidelity phase that this needs a button instead of the double tap idea.

All users understood the idea with separating attachments from messages but mentioned that it probably would not be of big difference if they were separated or not. They also emphasized that decision support would be of great value if eNursing is supposed to allow work to be carried out in a mobile fashion. Healthcare professionals make comparisons between different types of data in order to make decisions. These comparisons could be simplified by introducing decision support into lab-results and vital parameters to avoid having to constantly go through all tabs to make the decision themselves. The chart would otherwise just be a more fancy version of using the tables. One of the users did however suggest merging messages with attachments and as an extension add a functionality. This user discussed about the risk for messages to be ignored if they do not contain an attachment and related it with todays' situation with the pager. The user suggested implementing a way to set some urgency level on messages and that notifications for messages would then differ depending on this urgency level. Lastly, the last user also suggested that a diet function should be added for the nurse assistants to both add and edit diet on a patient.

3.2.4 To consider into the high-fidelity phase

Most of the findings were important feedback to consider into the next phase. It was on the other hand important also to consider that some of the feedback, whether it was verbally expressed or identified from observing users, needs to be reviewed if it is vital to consider as a change. In some cases it can also be an implementation issue which was considered during the construction of the high-fidelity phase. Also, the high-fidelity prototype needed ideas on how to present important details such as burden of care and rounding priority on the profile card.

The above has in summary shown that:

- The, in general, successful evaluation of the low-fidelity prototypes design shows that the first phase was successful
- A thoroughly implemented and designed decision support forms a basis for eNursing and its goals.
- Legal regulations limited and affected the design of the moduleboard and can become an for eNursing in future designs. At this stage it was only the moduleboard that got affected and not the tablet version.

3.3 High-fidelity prototyping phase

The high-fidelity prototyping phase consisted for the most of constructing a more detailed and physical prototype through software programming with findings from previous phases taken into consideration. Additional changes and refinements were however made during the construction with respect to feedback from the group demonstration meeting if any. Ideas on how to present burden of care, rounding priorities and patient informations on . It is to be noted that some refinements were made due to implementation issues. Some of those refinements were about creating simple versions of a design or function just to demonstrate the functions purpose and that it would be further developed in the future whilst some refinements were technically restricted to be implemented as intended. High-fidelity prototypes look more like the final product, or system, and gives a concise and concrete demonstration on the final products functioning and aesthetics. They serve thus as good means for evoking responses regarding these subjects.

3.3.1 Group demonstration of the high-fidelity prototype

A demonstration of the software prototype was performed for a group of ten healthcare professionals of the HLAVA ward. The participants were invited to openly discuss the interface and make recommendations on changes and improvements to make for the upcoming usability testing. All ten members were of different titles.

Findings from the demonstration

The group demonstration resulted in most positive reactions on the prototype in whole and didn't provide much feedback. Several nurses gave, nevertheless, remarks on the introduction take steps and amount of sleep in the vital parameters view. There was an agreement from several nurses that the data could serve as a good mean for asking a patient how they feel when noticing that, for instance, sleep has deviated. A discussion was also brought up regarding the chat function when presenting it as a tool for communication and reaching each other. The discussion was about whether the function can become overwhelming when used for communication and reaching each other, especially when the underlying reason is as simple as knowing the location of your team members. Participants did emphasize lack of knowledge of a team members location as a usual problem. According to them, a lot of unnecessary time during a shift is spent on looking up each other, which already was indicated in the observations. A suggestion was made on implementing a separate chat function which is only intended for simple topics such as asking for location, approval for taking a break etcetera. The subject was considered as a further last refinement before the usability testing and discussed together with the CEO of Domitor. It was brought up as a suggestion to test using a real time location system (RTLS) with which healthcare professionals become located by wearing tags which are scanned by access points. The idea was to provide the eNursing system with this data and present this location.

3.4 Usability testing

The final stage of the study was to test the product and evaluate if the product had reached its purpose and if it is possible to reach it. A laboratory environment was set up at the Domitor Consulting office simulating the real environment the medical staff work in at the HLAVA unit. Each office room corresponded to a patient bed and the meeting room became the team-room where handovers and rounding were conducted. The module board which is placed outside of the team-room and serves as the so called bridge area which each module has at HLAVA. The usability testing was set up as a role playing session, where the main objective was to test if eNursing can affect handovers and roundings in a positive manner. Employees of Domitor Consulting participated in the roleplay and undertook roles with predefined actions and events that were written down in the manuscript (Appendix E-G). One acted as doctor and one as a nurse assistant, there were no individuals acting as patients. Patient data was created and implemented into all views mimicking real world examples except for the patient status. The patient status in the patient view was still unknown in what information it was supposed to contain. The patient status data for the usability test was therefore hard coded after retrieved examples from the observations and was therefore reserved for demonstrating what it will contain. It was in the manuscript tested to see if the todays verbal reporting in handovers could be removed against letting the nurses use eNursing to all on their own build a view on all patients state. Roundings were formed in the same way as today. However, the manuscript had predefined lines on what the doctor would say and expectations on how users would react in order to identify how they will use eNursing. For example, the doctor would during the rounding ordinate a measurement from the nurse in which the expectation was that the nurse would pay this ordination forward to the nurse assistant through the chat function. The manuscript was based on findings from the observation in the data gathering phase to make the role playing as substantial as possible. A specialist named Dr. Hans Tygesen helped out with values in vital parameters and lab-results to also make the patient cases substantial. The manuscript contained events in which there were expectations on how the nurses were going to react on them. The events were the following:

- Ordinations and briefings through messaging
- Ordinations on tasks during roundings
- Trigger an alarm to call for help with a patient

The nurses interaction with the product was observed by one person and recorded on video. The observer would only focus on taking notes on the nurses facial and body expressions. A subsequent unstructured interview was used as a wrap up of the testing scenario where the nurses were free to discuss or express their thoughts about anything. The interview did however ask questions related to observed actions to some extent whilst keeping an open ended conversation to let the nurses review how they felt about the product and the test itself. The performed one time on five nurses in total making it a total of five nurses. Testing one version with five nurses will provide with finding

approximately 85% of the usability problems on that version according to Nielsen and Landauer (1993). This study has been made towards healthcare professionals at one specific ward at one hospital. The usability testing was therefore limited in the number of available professionals of each title when trying to put together a schedule together with the director of HLAVA. In addition, the study lacked resources used by nurse assistants and doctors respectively. The usability testing was thus constrained such that it point black only could be conducted on nurses. To note also is that an incomplete version of the reporting function was constructed only as a demonstration that it will be possible to report from bedside in the future.

Findings from the usability testing

The usability testing was only conducted on three out of five of the booked nurses due to two nurses unfortunately suffering the flu. Nevertheless, the usability testing did provide with useful data and results. The video recordings and feedback indicated in whole that the applications design was easy, intuitive and that the application was pleasing to use. Suggestions were made on refinements which however were of detailed level. All of the nurses who conducted the test did mutually express the advantage of having data about the patient available at any time and place. The case of the event where an alarm was triggered by the nurse assistant to call for help with a patient which had fallen out of his bed. All nurses emphasized the advantage of eNursing providing access to vitals and lab results at the bedside in these cases. One of them explained that they today rely alot on their memory if they want to avoid spending time on looking up data through Mequal. According to this nurse, eNursing would instead provide definite data, at bedside, on how the fall can affect the patient and if further measurements are necessary after this accident. All nurses, however, suggested an extended medication view. The medication view today only provides them with the list of medications a patient is under and lacks details such as dosages, time for dosage etcetera. The same nurse further expressed that the present prototype would only give them real time updates on changes in the medication list and not changes in dosages. This would thus mean that the present prototype would not eliminate the extensive walkings done for checking updates on the medication laptop at the module bridge would.

There were mixed opinions regarding the handover being removed against completely using the eNursing. One of the nurses expressed that the patient status in the patient view flawed in the information that was available for the test. The hard coded examples in the patient status did not provide a good view on the patients general state according to this nurse. Another nurse did mention that the patient status was lacking but did believe that it was possible to get a good view on all patients state during the roleplay through looking into the lab-results and vital parameters. Interesting to note is that both nurses did however have the same opinions on what information to complement the patient status with. The third nurse did not give any feedback regarding this at all. However, all nurses did see the same potential with using eNursing in a read report

manner instead of todays verbal approach namely that each individual healthcare professional can choose to look into what they personally consider important to know. It is also beneficial in terms of efficiency according to the nurses to go with this approach. As mentioned in section 3.1.1.2, team members of the upcoming shift board approximately two hours before the team of the previous shift finish. Using eNursing for read report can then improve the efficiency in a handover according to one of the nurses since it allows the leaving team members to keep working without interrupting for preparing and conducting a handover. The team members of the previous shift could then, as a suggestion, could then instead be available for questions from the boarding team.

As mentioned, the objective of this test was mainly about the handover and rounding in which the nurses expressed again the advantage of not having to make preparations before the rounding as an effect of the eNursing concept. The most appreciated effect was the ability for nurses to, in real time, during the rounding could ordinate a task to a nurse assistant and follow the result from the measurement. One of the nurses mentioned that roundings today are interrupted if the doctor ordinates a measurement that is urgent. The nurse goes then to look up the nurse assistant, ordinate this measurement and then return to the rounding and follow up with reporting the result. To note is that this case was never identified during the observations phase. They also referred back to the medication view that the extended medication view would be especially pleasing for when a doctor during a rounding informs a change in medication. During observations it was rather noted that nurses would take notes on ordinations and follow this after the round. The nurses pointed then out that this ensures the quality in the care since there will be no risk for important activities or information to be lost. Further discussions touched the subject about how eNursing can improve roundings and handovers in terms of time consumption. All nurses mutually expressed it as a difficult question to answer. The quality and amount of consumed time in these activities depends on a combination of the individual holding them and the situation, or case in general, at a module according to the interviewed nurses which supports the identified in section 3.1.1.2.
Lastly, the reporting function was found by two of the nurses and was tried by one of them. No further discussions were held about the function other than that one nurse asked if the function was complete or not.

Chapter 4

Final result

This chapter summarizes the findings regarding eNursing and its potentials into one final result which will be further discussed in chapter 5. The final design of the high-fidelity prototype, for this study, is also presented.

4.1 What eNursing should be about

Findings from the usability testing showed that using eNursing as a read report instead of the verbal approach used in handovers today has a potential in eliminating time consumed by preparations and conducting handovers found from section 3.1 provided that the patient status becomes more detailed and extensive. Each healthcare professional is also allowed to, under better circumstances than todays approach, retrieve what they view as important information for them or their shift. Team members of the finishing shift can thus continue with patient treatment or other related work activities. In addition, using eNursing as a read report in a reasonable time instance before the finishing shift is finished gives the boarding team members the opportunity to use finishing shifts team members for complementary questions to gain a further clear view on the modules present state. eNursing can, hence, improve and further ensure the transferral and processing quality of information between healthcare professionals of different shifts through providing easy access to all necessary information and providing a low risk of information getting lost, irrespectively of location and situation.

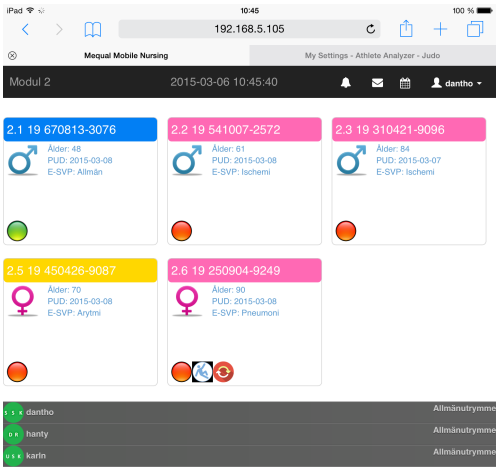
As previously mentioned, eNursing can improve the efficiency on a rounding through the ability to instantly during roundings ordinate tasks or measurement to the nurse assistant and in real time receive feedback on the tasks. Reducing consumed time for conducting a rounding is a difficult question to answer from retrieved results in this study. The final results indicate that there is a need to look into if consumed time for a rounding is dependent on the doctor, the patient cases in total or if it is the way that it is conducted in general. The findings on consumed time for the rounding in the

usability test are rather biased and based on a case similar to the one written in the manuscript. However, providing easy access to all patients data and the state of the module ensured, according to one nurse opinions regarding the using eNursing in the test, that all important subjects about a patient was covered during a rounding. eNursing aids the nurse to easily be able to follow what is being discussed during the rounding and thus provides them a better understanding the doctors reasoning. Providing mobile communication opportunities, easy access and real time updates on data into a mobile platform in the same way as eNursing, has a potential in eliminating extensive walkings for revisiting for instance the module bridge and looking up team members. As a consequence, eNursing frees time which healthcare professionals can use to conduct actual treatment of a patient or other more important activities.

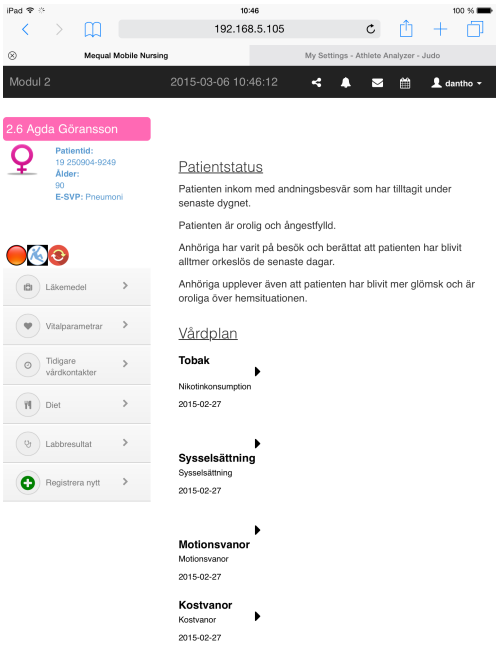
4.2 The final design

Figures 4.1 and 4.2 show the final high-fidelity prototype which was used during the usability test. Also, figure 4.3 demonstrates the differences between the low-fidelity and high-fidelity prototype

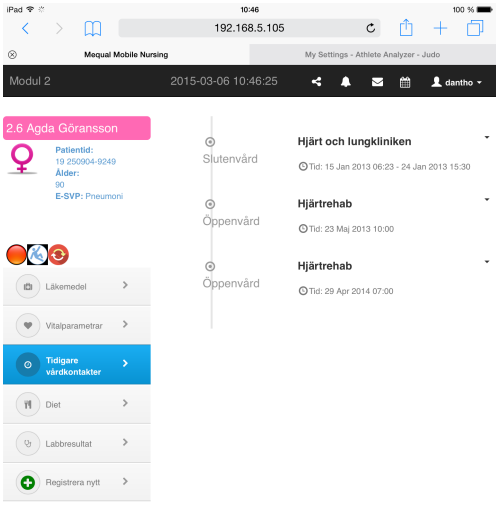
The final eNursing prototype had an incomplete function which was implemented only to demonstrate that eNursing is to allow reporting measurements and results from bedside.



(a) Moduleview

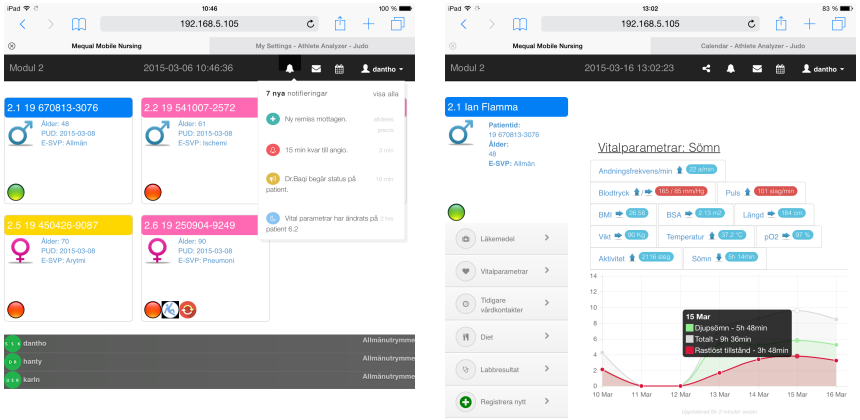


(b) Patienstatus



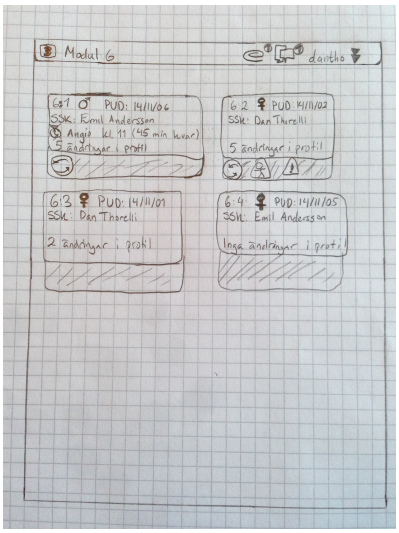
(c) Patients recent care contacts

Figure 4.1: The final design

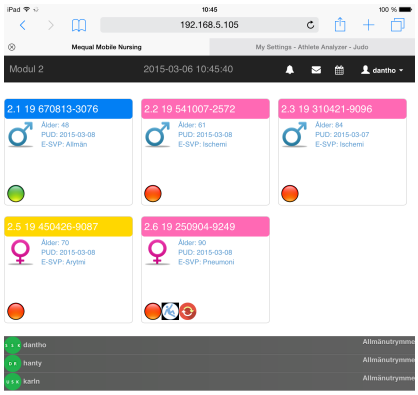


(a) Notifications (b) Vital parameters

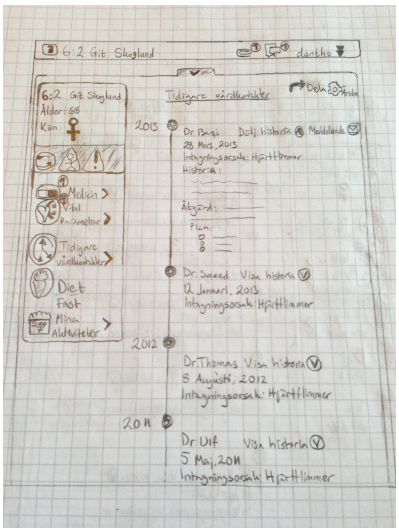
Figure 4.2: The final design continued



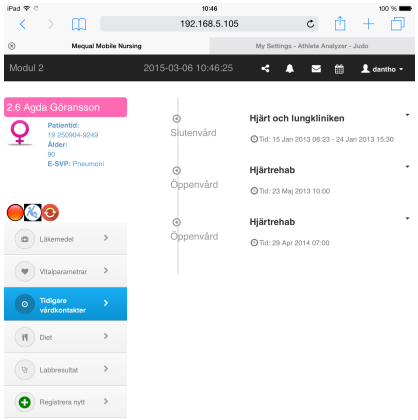
(a) Low-fidelity moduleview



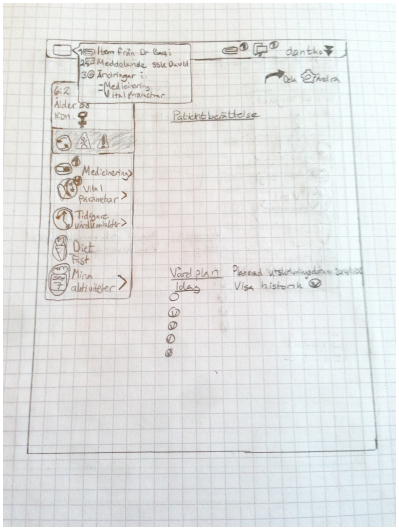
(b) High-fidelity moduleview



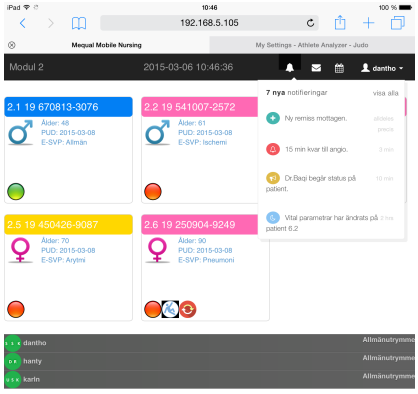
(c) Patients recent care contacts (Low-fidelity)



(d) Patients recent care contacts (high-fidelity)



(e) Low-fidelity notifications



(f) High-fidelity notifications

Figure 4.3: Comparision between the final design and the low-fidelity prototype

Chapter 5

Discussion

This chapter is initiated with a discussion and review regarding some of the chosen methods and their execution throughout the project. A discussion and a review of the final results will also be made and related to the discussions regarding the methods as a wrap up.

5.1 Methods

Observations

A usual question at issue in this topic is whether an object, or subject, behaves in their natural way when being observed. Healthcare professionals work is a nonlinear kind of work meaning that highly unlikely that you can predict how any taken actions will be even if the situation is similar. For example, a drop in blood pressure level will not always result in increasing a medication dosage. The question above regarding how observations will affect the outcome becomes therefore complex to answer. This does not mean that there a healthcare professional work does not contain tasks that can executed differently under an observation. One example is the identified issue that healthcare professionals rely a lot of their work on their memory and their notes. It was however noted during observations that different healthcare professionals did have different approaches in their work. For instance, there was one nurse who brought notes on alot of data on patients to the rounding whilst the other did the contrary. The outcome was however not different with some reservations in details which will not be further discussed. It is nevertheless worth mentioning that the study can have been exposed to false data if the observation did affect the observed healthcare professionals.

Interviews

An interview can be implemented in many styles. This study used the student-tutor approach as mentioned in 3.1.2.2 which according to Adams and Cox (2008) is the easiest and quickest to pick up and implement. Understanding the context which eNursing is to be used in i.e. when should it be used and in what way. In the student-tutor approach, the interviewer takes on the role of a student who is asking questions from an expert. Adams and Cox (2008) emphasizes that this approach articulates to the end user that their opinions are highly valued. However, the initial state of this study was like a blank page since healthcare professionals at HLAVA been in contact with a technical solution like the one this study aims to introduce. Using the student-tutor approach has thus also been a useful approach to make the interview gain a clear understanding of the problem to solve.

There has been discussions regarding the importance in how an interview is planned and performed. A weakly planned and performed interview can according to Adams and Cox (2008) result in a lot of time spent on trying to gather meaningful data since you will otherwise have to conduct interviews again. Choice of interview structure to follow, the setting and how to record data are affect the outcome of the interview according to Adams and Cox (2008). Previous section indicated clearly that the semi-structured style was chosen. Adams and Cox (2008) argues that an interview, no matter what structure, needs to allow change of focus where necessary in order to maximise the information obtained. Rigidly following predefined questions and the original focus can result in that the interview imposes a feeling on the interviewee that questions and topics are forced on them rather than the interview having a natural flow (Adams and Cox, 2008). The interviewee can then become annoyed, leading to them wanting to finish the interview quickly. Using a semi-structured interview gave the opportunity to avoid this. It is still important to make sure that the interview covers what it was intended to cover. Sharp et al. (2007) suggests using a list of issues and to throughout the interview check them if they get covered. Also, Adams and Cox (2008) mentions that it is beneficial to link things already being discussed to new issues on the list, so the conversation feels natural and not forced. This was the approach for all interviews in this study, but without a list. The outcome of the interviews whole did cover all that was intended. However, all interviews were not equally pleasing individually. It is therefore interesting to discuss if checklists would have further improved the interviews.

One must also be aware that interviews ask the interviewee to use their memory which, by human nature, can cause the interviewee to ignore or miss details a designer is likely to be interested in (Nielsen, 2010;Adams and Cox, 2008). To predict this during an interview and ask follow up questions which provide these details is something that takes practice and experience. It is therefore recommended by many authors to pilot test the interview to ensure that the questions are well planned and to gain feedback on how to conduct the interview. The observant reader will note that this study did not do

this. Piloting an interview puts the interviewer at risk with having expectations on the interviews outcome and mentally hinder the interview from being able to change focus if other interesting topics turn up. This study chose therefore to avoid doing pilot tests on the interviews. Another consequence which can emerge from this is, again, the interviewees feeling that questions and topics are forced on them (Adams and Cox, 2008). This studys' interviews would however have, to some extent, benefited from piloting the interviews with an experienced interviewer since not all interviews were equally pleasing. Whether it would have provided better results or data for the study in whole is nevertheless difficult to answer. It is to be noted though that interviews are partially dependent on the interviewees answers. Unpleasing interviews are thus inevitable no matter what the planning (Adams and Cox, 2008;Sharp et al., 2007).

In addition to the above, analysis of qualitative data involves human interpretation and there is no statistical significance to back up the interpretation with. Data is thus at risk of biased interpretation by the interpreter causing information becoming false or lost even if present (Sharp et al., 2007). Nielsen (2010) states furthermore that there is a distinct difference between what users say and what they do. There is thus a risk to become exposed to false data also during interviews and not only during observations. The opinions differ therefore between researchers and practitioners whether the interview method is valid or not. Conducting and analysing interview data require large amount of time in general. Amount of time needed for analysing data is based on how structured an interview is and how easy it is to identify the false data if any. Rule of thum states that the less structured, the harder it is to analyse afterwards (Adams and Cox, 2008). The semi-structured interview was however in this study a good balance between having an open ended discussion retrieving data that is not too hard to analyse. Judging from the findings in this study, a good amount of useful data was retrieved by having a semi-structured interview which allowed questions and answers emerge instead of being forced. It can thus be stated that a naturally flowing semi-structured interview can avoid false data quite extensively.

Group meeting paper prototype evaluation

(n.d.) states that the Census Bureau's Usability Lab found that conducting quick and easy, iterative, low-fidelity to increasingly more high-fidelity prototypes is one of the most effective ways to work under during design and development. The results from the evaluation of the paper prototype in this study didn't end up in any major changes to the first design. Several authors recommend that that it is beneficial to make and evaluate at least two paper prototypes during the low-fidelity phase. Nielsen (2001) mentions that users have a hard time to tell what they actually want, like or dislike without being viewed something concrete. Furthermore, he emphasizes that findings on issues in a design only will tell what users dislike or didn't understand and not the underlying reason or what they want instead. These statements are often used as an argument for making at least two paper prototypes. The observant reader will note that

this has not been followed in this study. The underlying reasons can be summed up in both resources and no ability to conduct brainstorming session with a group of people. This became thus an obstacle for producing more than one idea and an alternative solution was not found. The design process relied instead on finding inspirations through the interviews and questionnaires to produce an initial design. Both methods gave a good understanding on how technically experienced the average healthcare professional at HLAVA was. The questionnaires however, as mentioned in 3.1.3, provided ideas and inspiration on building blocks to use in the design meaning that the design relied on making a design which the end users would be familiar with rather than being innovative through picking the best out of several prototypes. The fundamental idea of iterative design is to make changes and refinements based on the results from evaluation of the most recent design iteration. The main idea in this study was to iteratively evaluate and improve the initial design. A designer has however the freedom to choose the changes and refinements which should be done. It is thus the designer who decides when to stop the iteration of a phase. The chosen approach to gather data which inspired to go for a design which the users were familiar with resulted in that the iteration stopped early during the low-fidelity phase. The observant reader will however notice that refinements were suggested on both the low-fidelity prototype and high-fidelity prototype. However, these refinements were not comprehensive. The outcome of the evaluations were convincing enough to stop at the first iteration from the designers point of view. This indicates thus that an iterative approach should always be taken to some extent but that the choice of design approach necessarily can result in low amounts of iterations which became the case in in this study. One can thus further discuss if this is the usual case for when using a design which is end users are familiar with from apps they use frequently in their everyday life. It can nevertheless be stated that this chosen approach together with the mixture of activity-centered design and user-centered design theories was successful.

It can still be further discussed whether chosen approaches in this study were decent substitutes against applying the iterative approach on several designs. Sharp et al. (2007) argues that the this studys' approach is beneficial in such way that there is no need to reinvent the wheel. Nevertheless, Sharp et al. (2007) also emphasizes that there is a risk for the mindset during the design to become limited to the inspiration sources meaning that one should aim at using an existing solution but be innovative. In the case of this study, this was followed through letting the participants in the interviews and the group meeting describe their feelings and thoughts which to some extent provided inputs on where to be innovative. Nielsen (2001) makes an interesting discussion regarding reliability in users answers during interviews and focus groups. He emphasizes the importance to take human nature into account accordingly:

- Humans tend to answer questions with what they think you want to hear (particularly in a focus group) or what's socially acceptable.
- Humans tell you what they **remember** doing and human memory is fallible, especially when it comes to details. Humans cannot remember some details at all,

in design this could be interface elements that "they didn't see".

- When talking about their actions they remember, humans **rationalize** their behavior. A typical example is for example "If the button was bigger I would have seen it." This might be the case. However, all we know is that the user didn't see the button.

It can thus be argued whether the approach in this study at all compensated for the iteration issue or not. Deciding to stop an iteration will however, again, always be based on human interpretation which makes it hard to identify if the number of iterations actually was a weakness in this study or not.
Tying this together with iterative design, it can be argued that this study would have probably resulted in producing a more unique and different solution if focus instead would have been on producing and evaluating at least two low-fidelity design suggestions. How this approach would have affected the outcome on eNursings' design and functioning in whole is however hard to predict since the final tests produced positive feedback.

Laboratory usability testing

Nielsen and Landauer (1993) argues that five users will yield 85% of the issues in a design. The formula which he uses for this argue was presented in the early 90's where testing with many users was expensive due to limitations in technology and test equipment. Page (n.d.) mentions that Nielsen's formula use a constant which assumes that the smallest issue will affect at least 31% of the total users you test on i.e. the issue has 31% visibility. According to Page (n.d.) this constant is not valid today due to that the smallest issue will not affect as many today compared to what Nielsen presented during the time of his report. He bases this with arguing that todays average user is technically more experienced and competent which leads to that todays equivalent to the "smallest issue" during Nielsen's time is visible and obvious. What he means is that five users mainly will identify visible issues and smaller issues, which still can be important, will be overlooked since they are not as obvious today. In other words, the constant is lower according to Page (n.d.). He suggests therefore that testing with more users is more necessary and that it is not as expensive to conduct a test today compared to during Nielsens time. However, it can be argued that using an iterative process will solve this issue. The first five testers will discover the obvious issues and the next five testers who will test on the new, edited, version will discover the issues which were not discovered during the previous session etcetera. The observant reader recalls that this was the intention of this study but was not followed due to the limitations mentioned in 2.2.6. Also, doctors and nurse assistants were excluded in these tests which in turn could have affected the outcome of the usability testing. Observations and interviews did identify functionalities that both nurses and doctors mutually benefit from. However, referring back to Nielsen (2001) indicates that additional issues would probably have been discovered if the test would have been conducted on doctors as well. Including doctors would have been beneficial and strengthened the test.

Using a laboratory setting for the usability testing together with role playing is beneficial in that it provided control over the testing equipment, the environment and the situation. Also, it ensured that each participant's experience was the same i.e. they could relate to how it would have been in their natural setting. This has been important for this study in order to collect views on both the design but also how eNursing can support healthcare professionals work. Additionally, it is important to impose a natural feeling for the test subjects when collecting quantitative data for reviewing the usability in order to make them act as they normally would have (Sharp et al., 2007). Using a real doctor or nurse assistant would have further increased this natural feel. More importantly, allowance of mobile work, how this affects interaction between healthcare professionals and their work could then have been reviewed in a broader sense. Current execution served more as a demonstration where users were to give their impressions on the design and feelings on what ways eNursing will aid them in their work. Also, the fact that events and patient cases were predetermined made that the findings only could indicate possibilities to improve handovers and roundings rather than actually ensuring it. Using the patient data and cases the same way as in this test but instead with a doctor included could have been a way to test how roundings would have been. Furthermore, observing how the doctor and the nurse would have interacted between each other with the eNursing prototype would have provided more solid findings on the design and if the concept reaches out i.e. if for instance the doctor would have used the chat the same way as the "acting doctor" in the manuscript. Looking into results on the rounding with both a real doctor and a real nurse conducting it would have additionally provided more interesting data. Again, this was not possible due to resources and that mimicking a real life situation at HLAVA remains nearly impossible. Tests at the actual environment at HLAVA are needed for that.

5.1.1 Results and findings

As previously mentioned, most of the methods provided useful findings and received feedbacks were in general positive. Interesting to note however is the feedbacks on contents in the patient status and the medication list. It was mentioned in the introduction that eNursing would look into importing information from other systems if needed which was done when introducing the Fitbit wristbands. The received feedback on the patient status and medications list pointed out a need to extend the content in both views which to some extent was an expected feedback to receive. Used content in the patient status during the usability test were only a collection on what had been recorded from the observations and the medication list was simply a copy of the data Mequal displays. Nurses informed that the information which they wanted corresponding views to be extended with are present in another patient record system, used at HLAVA called Melior. However, attempts were made to collect feedback on what to include in the patient status from the group meeting where no one actually came with any feedback even when asked for help in this area. Also, the medication list was viewed during this group meeting and still there were no suggestions or opinions regarding the two views. Feedback on these views was not thus received until the actual tests. This confirms the

statement by Nielsen (2001) regarding that users don't know what they want until they actually have something concrete in their hand. One could then ask why this happened since the individual interviews provided answers which led to a good low-fidelity prototype. However, this is a complex question to answer since there can be several additiona factors which caused this effect. For example, the participants were never actually interested in engaging in the group meeting and felt forced to take part. From this it can be said that the study missed out on these details due to that the observations lacked focus on those subjects. An extra observation, or interview, should have thus been conducted as a complement to investigate these subjects. Nevertheless, the importance in planning an observation becomes clear from this finding and that it can become hard to catch everything during a data gathering phase if not being prepared. Summing up findings from the data gathering phase together with the received feedback on the final prototype implicates that the data gathering phase can in whole be viewed as successful.

Interesting to note is the difference in answers and behaviors between each individual which was observed, interviewed and evaluated the prototypes throughout the study. As discussed earlier, Nielsen and Landauer (1993) provides a rule of thumb on the amount of needed users to conduct a test which can be questioned if it still applies today. Throughout this study it has been noted that discovered issues and unique feedback starts to level out as soon as the fourth individual has conducted the instance in the same way as Nielsens' theory. One can speculate whether if the additional received feedback and issues would have been equally rewarding as the first ones to the study. However, as earlier mentioned, there were some differences in outcomes from the different instance and additional differences would have probably been identified if more observations were done, more people were interviewed etcetera. This shows that each healthcare professional have their own way of viewing and conducting their work. It is therefore reasonable to assume that they would behave and act differently with the eNursing concept. However all test-users, in average, interacted and used the concept similarly with respect to some minor differences in interaction and usage but minor feedbacks on the design were articulated. Meaning that in this study, the differences in individuals has mainly affected in their opinions on the design but not on how they will interact with the product. Also, the concepts design and its content was satisfying according to all except the content in the patient status.

It can thus be questioned if they in relation to this would have had a different view or expectations on what eNursing should do. Even if true, one must take into consideration that all healthcare professional have strict policies on how work should be conducted and they also have a great responsibility over a patients life. It would thus be a rather noticeable finding if their wants, needs and expectations on eNursing would have been deviant.

Results and findings can all be summarized in one problem, which has already been mentioned. Namely that, the work of a healthcare professional is mobile whilst there is an absence of retrieving and reporting information in a mobile fashion. This has in turn resulted in the earlier mentioned extensive walkings which consumes time from treating

a patient.

Chapter 6

Conclusion

The questions in the problem definition from section 1.4 was:

- What are the benefits, if beneficial, from introducing a eNursing through a mobile handheld computer solution and will it improve rounding and handover procedures for the healthcare department HLAVA?
- How should eNursing, implemented as an app, be designed to reach those potential benefits?

The first question needs for starters a summary on the current situation. Field studies showed that it can in general be concluded that there is a great absence of using technology as a supporting tool in healthcare today. This has resulted in the following when it comes to the absence of mobile information and communication technology:

- Healthcare professionals frequently spend time on transporting themselves to locations or individuals to retrieve and communicate information. These extensive walkings are not time consuming individually but do become so when summarized.
- Double documentation is a crucial problem in information handling since it leads to patient information being at risk of not being documented if forgotten to report it in to the system and thus not reaching everyone directly. The information is also at risk of being lost when handwritten notes are lost, which happens occasionally according to the findings.
- Healthcare professionals are not used efficiently due to todays approach in activities such as handovers.
- Patients receive less nursing treatments than they can due to the lack of time which occurs from all the above mentioned in combination with the time consuming rounds.

A test was conducted, mimicking a real life practice at HLAVA, with the designed and tailored eNursing mobile web application to see the results in order to answer the first question. Results showed that eNursing provides the following improvements:

- The opportunity to through mobile communication and mobile access of information, eliminate a majority of unnecessary extensive walkings and non-value adding activities especially those related to ordinations during rounding.
- Possibilities for handovers and roundings to become more efficient and don't have to be conducted verbally.
- Each healthcare professional means for building their own perception based on their own information need at any time and place. They can also, irrespective of location, follow a patientss treatment progression and care plan progression.
- Quality assurance on correct information i.e. correct corresponding patients data will always be shown, reported and communicated.

A better explanation is needed on the second item in the bullet list above. When it comes to handovers, they can instead be conducted individually by each healthcare professional during a time instance prior to the previous shift finishing their shift. The finishing shifts team members can thus answer on questions if the boarding team members have questions and this can be done whilst they carry on with their work. Time for treatment of a patient is thus not wasted on both the finishing and boarding team members conducting a verbal handover based on handwritten notes from finishing teams nurse. This in turn implicates again the last bullet in the list above. As for the roundings, it is now easier for nurses to keep track with the doctors discussions. It is also easier for nurses to come to the roundings with a clearer view on a patients current state. Additionally, bullet number two indicates that eNursing will through its mobile communication eliminate time in the nurses everyday work as well.

Answering the second question becomes less extensive where two facts can be stated:

- Using a familiar design from frequently used apps will provide a short learning for users to get acquainted with the app.
- A thoroughly conducted data gathering will help you identify most of the needed content early in the design phase.

Discussions regarding the methods, obtained results and the usability test do indicate that eNursing is just at its first phase and future work is needed for further ensurance on how eNursing can both improve and support healthcare:

- A full complete functionality of reporting measurements at bedside needs to be implemented i.e. insertion of measurement results should go to the database and update it in real time. It is furthermore needed to evaluate the effects from this function being introduced.
- The patient status view and the medication view need to be further developed in order to evaluate if conducting handovers in such way as suggested in the test and mentioned above needs is beneficial and makes the procedure more efficient or not. So far, opinions and thoughts are the only supporting facts for this.
- The next usability test should be conducted with both actual doctors and nurses

to get a more truthful picture on the interaction between the different healthcare professionals. A main objective should as a follow up be on answering whether doctors can benefit from the use of eNursing and if there are needed changes to make eNursing beneficial for them as well.

- The diet view should also be implemented to include the nurse assistants into the test.

Bibliography

(n.d.).

Adams, A. and Cox, A. (2008), Questionnaires, in-depth interviews and focus groups., *in* 'Research Methods for Human Computer Interaction.', eds. P. Cairns and A. Cox, Cambridge, pp. 17–34, Cambridge, UK: Cambridge University Press.

Aneja, S., Periyasami, S., Pangam, A. and Lim, Y. (2006), Comparative analysis of high- and low-fidelity prototypes for more valid usability evaluations of mobile devices., *in* 'NordiCHI '06 Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles', 14:th October , 2006 , Oslo, pp. 291–300.

Button, G. and Sharrock, W. (2009), *Studies of Work and the Workplace in HCI: Concepts and Techniques.*, 2nd edn, San Rafael: Morgan Claypool Publishers.

Bödker, S. and Bertelsen, O. (2003), Activity theory., *in* 'HCI Models, Theories, and Frameworks: Toward a Multidisciplinary Science', ed. J.M. Carroll, pp. 291-324. New York: Morgan Kaufmann Pub.

Cluts, M. (2003), The evolution of artifacts in cooperative work: Constructing meaning through activity., *in* 'GROUP '03 Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work', 9:th November, 2003, Sanibel Island.

Dumas, J. and Redish, J. (1999), *A Practical Guide to Usability Testing.*, UK: Intellect Books Exeter.

Eriksson, H., Ferreira, M., Tygesen, H. and Herlitz, J. (2014), 'Tablet computers with mobile electronic medical records enhance clinical routine and promote bedside time: a controlled prospective crossover study', *Journal of Neurology* . November 7:th, http://link.springer.com/article/10.1007

Finlay, J., Dix, A., Abowd, G. and Russell, B. (2004), *Human-computer interaction.*, 3rd edn, Upper Saddle River, NJ: Prentice-Hall, Inc.

Fraher, R. and Boyd-Brent, J. (2010), Gestalt theory, engagement and interaction., *in* 'CHI EA '10 CHI '10 Extended Abstracts on Human Factors in Computing Systems', 9:th April, 2010, Atlanta., pp. 3211–3216.

Hackos, J. and Redish, J. (1998), *User and task analysis for interface design.*, New York: John Wiley Sons Inc.

Hill, C. and Houde, S. (1997), What do prototypes prototype?, *in* 'Handbook of Human-Computer Interaction', eds. M. Helander and T.K. Landauer and P. Prabhu, pp. 367-380, New York: Elsevier Science Inc.

Kaptelinin, V. and Nardi, B. (1997), Activity theory: Basic concepts and applications., *in* 'CHI EA '97 CHI '97 Extended Abstracts on Human Factors in Computing Systems', 22:nd March, 1997, New York, pp. 158–159.

Kaptelinin, V., Nardi, B. and Macaulay, C. (1999), 'The activity checklist: A tool for representing the "space" of context.', *Interactions* **vol. 6**, issue 4, pp. 27–39.

Kitzinger, J. (1995), 'Qualitative research: Introducing focus groups.', *BMJ (Clinical research ed.)* **Vol. 311**, issue 7000, pp. 299–302.

Kohn, L., Corrigan, J. and Donaldson, M. (2000), *To err is human*, Washington D.C: National Academy Press.

Kuutti, K. (1996), Context and consciousness: Activity theory and human–computer interaction, *in* 'Activity theory as a potential framework for human – computer interaction research.', ed. B. Nardi, pp. 17-44. Cambridge, MA: The MIT Press.

Lazar, J., Feng, J. H. and Hochheiser, H. (2010), *Research methods in human-computer interaction.*, West Sussex: Wiley Sons Ltd.

Nielsen, J. (2001), 'First rule of usability? don't listen to users', *Nielsen Norman Group: Evidence-Based User Experience Research, Training, and Consulting* . August 5:th, http://www.nngroup.com/articles/first-rule-of-usability-dont-listen-to-users/, (2015-01-30).

Nielsen, J. (2010), 'Interviewing users.', *Nielsen Norman Group: Evidence-Based User Experience Research, Training, and Consulting.* . March 26:th, http://www.nngroup.com/articles/interviewing-users/, (2015-01-30).

Nielsen, J. and Landauer, T. (1993), A mathematical model of the finding of usability problems., *in* 'Proceedings of ACM INTERCHI'93 Conference', 24-29 April, 1993, Amsterdam., pp. 206–213.

Norman, D. (2002), *The design of everyday things.*, 2nd edn, New York: Basic Books.

on Quality of Health Care in America, C. and of Medicine, I. (2001), *Crossing the Quality Chasm: A New Health System for the 21st Century*, Washington D.C: NATIONAL ACADEMY PRESS.

Page, J. (n.d.), '"why you only need to test with 5 users" is no longer relevant', `http://blog.webnographer.com/2014/04/why-you-only-need-to-test-with-5-users-is-no-longer-relevant/`. Accessed: 2015-02-05.

Rudd, J., Stern, K. and Isensee, S. (1996), 'Low vs. high-fidelity prototyping debate.', *Interactions* **Vol. 3**, issue 1, pp. 76–85.

Sharp, H., Rogers, Y. and Preece, J. (2007), *Interaction design: beyond human-computer interaction.*, 2nd edn, New York: John Wiley Sons Inc.

SKL (2014), 'Myter och fakta om vården i sverige'. June 30:th, http://webbutik.skl.se/sv/artiklar/myter-och-fakta-om-varden-i-sverige.html, (2015-01-18).

Ulander, K. and Grill, M. (2014), '93-åring väntade på akuten i 14 timmar – fick trycksår', `http://www.svt.se/nyheter/sverige/93-aring-fick-trycksar-vantade-pa-akuten-i-14-timmar`. Accessed: 2015-02-16.

Williams, A. (2009), User-centered design, activity-centered design, and goal-directed design: A review of three methods for designing web applications., *in* 'SIGDOC '09 Proceedings of the 27th ACM international conference on Design of communication', 5:th October, 2009, Bloomington.

Appendix A

Observation checklist: factors of interest to focus on

- **Handover and rounding**
  - Time elapse
  - What type of information is exchanged
  - How is it communicated and routing of it
  - Cognitive and physical tasks needed
  - Existing and missing information

- **Typical "urgent" actions needed in nursing (both after planned activities and not planned)**
  - Average time they consume
  - Consequences on team-members
  - What information is exchanged at these situations? (Try exclude those identified as unique and focus on typical ones)
  - Cognitive and physical tasks needed

- **When staff follows plan accordingly/normal work**
  - How (well) team-members keep track of each other (where they are, what they have done that is)
  - Typical places they visit
    - Average time spent at each place
    - How often?
    - Consequences on team-members
  - Information exchanged
    - Management
    - What information

Appendix B

Frågor för krav & önskemål/förväntningar på system och identifiering av vad systemet ska spela för roll

- Berätta lite kort om din bakgrund innan du blev sjuksköterska
- Hur skulle du beskriva ditt arbete utefter hur en vanlig arbetsdag ser ut?
    - Arbetsmiljön
    - Uppgifter
    - Roll

- I din yrkesroll, vad är viktigt att ha koll på för att utföra arbetet som önskat?
    - Bygg vidare härifrån och försök komma åt svar angående om vad för information man kan behöva när man rör sig runt
      Exempel: När du springer ärenden, vad brukar en vanlig grej vara som du vill kunna kolla när du är on-the-go? (Förklara tydligare om mening med on-the go inte förstås)

- Berätta vad/vilka appar/tekniker du är eller vart i kontakt med mycket i din vardag
    - Vad har du använt det för?
    - Hur tycker du din användningsnivå är från novis eller erfaren?
    - Vad är det du uppskattar mest ifrån den stora favoriten? (om flera)
    - (Om möjligt att relatera, kom tillbaka till denna fråga senare isådanafall):
      Tror du det finns någon funktion/struktur/design i denna teknik/app som du tror skulle kunna komma till nytta i ditt arbete?
    - Av den informationen du nämnde precis, finns det någon du känner att du kan klara dig att inte kolla upp när du är on-the-go?

- Om du fick en produkt idag i handen som hade allt det vi gått igenom, finns det något krav du hade haft på den utöver att den är “enkel att använda”
    - Vad tycker du att dagens system misslyckas med?

Appendix C

Frågor att ställa efter evaluering av paperprototype

- Evaluera design
    - Vad var din känsla överlag?
    - Om du hade friheten att ändra/lägga till något, vad hade du ändrat/lagt till?
    - På en skala 1-10, hur var navigeringen?
    - Vad tyckte du var bra?
    - Som avslutning, hur var strukturen att ta till sig på en skala 1-10? (1 = dåligt, 10 = perfekt)
- Utöver dessa frågor, ställ frågor gällande hur de tänkte och kände kring uppgifterna som de fick av mig
- Kolla var användaren klickar, hur lång tid det tar och vad för misstag som sker
    - Ställ frågor relaterade till dessa, få det att handla om designen och inte personens misstag

Appendix D

Manus för usability test

Roll-lista:
Nicklas: Dr Hanty
Karl: USK Karln
Sina: Observerare/SSK sinsyr som ska gå av sitt skift/SSK student sinsyr som medverkar på rondning. Följer med SSK annars som hjälp och stöd gällande programmet.

1. SSK kommer in och vi möts allihopa vid modulbryggan.
2. Det klassiska överlämningsmomentet är borttaget.
3. Dr Hanty är ej närvarande vid bryggan. Sitter i läkarexpedition och överlägger behandlingar, åtgärder etc.
4. Vi skickar iväg SSK som får tid att gå igenom applikationen i cirkus 10-15 minuter och bekanta sig med det.
    - Hypotes: Under den tiden som SSK bekantar sig med programmet hoppas vi att SSK får en bild av läget på modulen som ersättning på överlämningen.
5. USK karln rapporterar in mätvärde 135/85 på patient **2:3**'s blodtryck som gör att det blir ok värden och skickar meddelande till SSK om att patient **2:3**'s blodtryck har lugnat sig då den var urspårad från senaste mätningen.
    - "Blodtrycket på **2:3** har sjunkit och är ok nu. Den var utanför referens tidigare"
6. Hanty skickar meddelande till SSK om att han önskar skriva ut patient **2:1** tidigare och undrar hur denne således mår.
    - "God morgon. Jag funderar på att skriva ut **2:1** lite tidigare än planerat. Tänkte be dig kolla med honom hur han mår så kan vi fortsätta vid rondningen"
7. USK karln skickar meddelande om patient **2:6** som var ångestfylld. Denne har nu lugnat ner sig. Meddelar också om att anhöriga vill prata med SSK över telefon.
    - Hypotes: Förhoppningsvis kmr SSK att be om tempmätning på **2:6** av USK.
    - "**2:6** var ångestfylld tidigare men har lugnat ner sig nu. Anhöriga till **2:6** önskar att du ringer dem idag, nummret är 0738518818"
8. Meddelande från Dr Hanty till en gruppchat, som består av dantho, hanty och karln, att utföra mätning på patient **2:1** inför rondningen, kolla upp om patients P-glukos, Hb värde samt hur aktiviteten stämmer överrens med patientens uppfattning.
    - "Se gärna till att få gjort en mätning på **2:1** innan rondningen. Gäller hans P-glukos, Hb värde och kolla gärna upp om aktiviteten stämmer överrens med patientens egna uppfattning"
        - Hypotes: Dantho följer bara konversationen och har koll på vad som sker. Förhoppningen är att denne inte springer iväg för att kolla om karln gör mätningarna eller ej.
    - Karln rapporterar in mätvärden 7,6 P-glukos och 170 Hb.

Appendix E

9. Larmet dras i **2:2**, patienten har ramlat av bädden. Behöver hjälp att bära upp patienten. Hanty kmr o kollar läget. SSK sinsyr dyker också upp, avslutar med att fråga:
    - "Jag avslutar mitt pass nu, är det något du undrar över? Ok då kan du introducera dig för patienterna o kolla din att göra lista i några minuter nu då som du brukar. Det kommer förresten en SSK student sen som ska medverka i rondningen. Du får ha hand om honom"
    - Vi låter sedan SSK att introducera sig till patienter/jobba med vad som.
10. Ge SSK 5 minuter att interagera med produkten, kolla sina att göra punkter etc. Därefter kan du säga att du går hem.

Rondning

11. SSK blir upphämtad av hanty för rondning!
    Rondningsrepliker:

12. <u>Hanty</u>:
    - "Hur är läget just nu med **2:6**? Är hon fortfarande ångestfylld eller har du hört något från någon?"
    - "Jag vill också att tempen tas på henne. Eller vet du vad, jag behöver faktiskt veta hur hennes temp, kapulärt b-glukos o hb ser ut just nu. Ta en mätning på andningsfrekvensen med." (**2:6** har pneumoni.)
        - Hypotes: SSK ska skicka meddelande till USK att utföra mätningar samt kollar upp så att mätningarna kommer in.
        - Karln rapporterar in mätvärden temp = 38,8, B-glukos = 6,9, andningsfrekvens = 26 och Hb = 108.
    - "Aktiviteten vill jag gärna att du kollar med patienten och utvärderar hur det stämmer överrens med patientens egna uppfattning.
    - **2:5** arytmi, troponinen är hög.
        - "**2:5** har hög troponin som du kanske sett. Vi får helt enkelt fortsätta med övervakningen enligt plan på henne. Annars har jag inget mer att tillägga där."
    - "**2:2** följer vi helt enligt plan men det får förberedas angio med pci redskap. Jag har inget att tillägga där annars utöver det. Om du inte har något att tillägga där så kör vi vidare med **2:3**"
    - "**2:2** , även där föjer vi helt enligt plan och behöver det förberedas angio med pci redskap. Jag har inget att tillägga utöver på honom heller.
    - "Hur var det nu med **2:1**'s aktivitet? Vad sa han själv?"
    - *SSK babblar*
    - "B-glukoset är högt på **2:1**. Meddela USK karln att ta kapulärt b-glukos. Jag vill gärna få klart detta direkt innan vi skriver ut honom för jag kan inte skriva ut honom annars om allt inte är ok."

Appendix F

        - Om inte detta sker så kommer USK karln att röra sig i närheten och student sinsyr att lägga märke till detta på modultavla o därifrån leta upp karln och hugga tag i honom
            - Sinsyr: “Karln är ju där enligt modultavlan. Jag säger till honom"
            - Karln rapporterar in mätvärden B-glukos = 7,5
            - När karln rapporterat in så meddelar sinsyr att resultatet ska vara inne o då bestämmer hanty om patient ska skrivas ut eller ej.
            -
    - “Ok det ser ut såpass. Vi skriver ut honom/skriver inte ut honom”
    - “Har mätvärdena kommit på **2:6** där än?” (Mest för att notifieringsfunktion inte finns just nu)

13. Slut

Appendix G

Kort enkät för undersökning i projekt Mequal teamtavla och platta

		Låg nivå			Medioker		Hyfsad		Bra		Perfekt
	Fråga	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Genom angiven skala, hur skulle du bedöma din användningsvana av mobila appar?										
2	Om du själv fick bedöma, hur snabblärd skulle du anse att du är när det kommer till mobila appar?										

3. Ange vilka av följande appar du använder om du har en smartphone eller surfplatta

- ☐ Facebook
- ☐ Valfri nyhetsapp (Aftonbladet, GP, DN, SvD etc.)
- ☐ Instagram
- ☐ Twitter
- ☐ Google tjänster (Gmail, Google Drive, Google Calendar, etc.)
- ☐ Skype
- ☐ SMHI eller YR
- ☐ Västtrafik
- ☐ Dropbox
- ☐ Valfritt mobilspel (Ange gärna vilken)

_____
_____

- ☐ Spotify
- ☐ Ange övriga som saknas på listan

_____
_____
_____
_____
_____
_____

Appendix H

4. Ange en app, hemsida eller annan tekniskt program/mjukvara/tjänst som du använt/använder där du vart väldigt nöjd över hur den är designad, hur den funkar samt hur lätt den är att ta till sig.
Max tre stycken om fler än en.

_____
_____
_____
_____

5. Beskriv kortfattat ett typiskt scenario där du upplever ett återkommande problem som du önskar att applikationen löser
- Exempel: "Jag upplever att jag ofta har ett scenario där jag springer på ett ärende, säg angio klockan 11, kommer sedan tillbaka till "bryggan" och kommer på "det var något jag skulle göra snart men minns ej vad."
Om nedan stämmer för dig som mest typiska scenario att lösa, svara då med ett kryss.

_____
_____
_____
_____

6. Markera de tre punkter du anser vara viktigast att vår web-applikation uppfyller

- **Enkelt och intuitiv navigering**
- **Överskådlighet över patienter och personal i alla lägen**
- **Snygg design och snabb i att få fram senaste information om patient**
- **Direktrapportering av mätresultat**
- **Få hjälp med att påminnelser om kommande aktiviteter samt kunna se planerade aktiviteter**

Om ingen ovan, ange övriga som ej finns med:

_____
_____
_____
_____