

# Design of Pulsappen: A mobile healthcare application to make administrative work more efficient for caregivers

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DEPARTMENT OF DESIGN SCIENCES | FACULTY OF ENGINEERING LTH |  
LUND UNIVERSITY | 2020

MASTER'S THESIS



Design of Pulsappen:  
A mobile healthcare application to make  
administrative work more efficient for  
caregivers

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**LUND**  
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# Design of Pulsappen: A mobile healthcare application to make administrative work more efficient for caregivers

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Department of Design Sciences  
Faculty of Engineering LTH, Lund University  
P.O. Box 118, SE-221 00 Lund, Sweden

Publicerad av

Institutionen för designvetenskaper  
Lunds Tekniska Högskola, Lunds universitet  
Box 118, 221 00 Lund

Subject: Interaction Design (MAMM01)

Division: Department of Design Sciences

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## Abstract

Staff in hospital wards experience a number of issues related to administrative tasks. These problems include needing to document the same information in multiple systems, and difficulties in shift handovers between staff members. The existing product Pulstavlan, developed by Stretch Care AB, aims to solve these issues. However, as the product is stationary, it does not enable staff to bring the information it contains with them when providing bedside care to patients. This master's thesis describes a user-centered design process, in which a digital and interactive prototype of a mobile product compatible with Pulstavlan was designed. The aim of the product is to ease the administrative work load on caregivers, and to lay the ground for future design solutions within the same area.

The design was based on a user study of hospital staff, including 15 interviews with a total of 18 users, and six observations of Pulstavlan in use. The user study resulted in a number of expressed needs of the hospital staff, and goals that the mobile product design needed to fulfill to meet the needs. These needs and goals were used to formulate twelve necessary functions of the application design.

Four iterations of prototyping were done; two iterations of an analogue prototype and two iterations of a digital prototype. All iterations were evaluated by letting users complete test scenarios similar to tasks performed on hospital wards, while applying a think-aloud protocol. The final prototype was considered to have good usability by all test persons, who worked in healthcare and had experience of using Pulstavlan. This was indicated by their ability to successfully complete a majority of test scenarios and by the positive feedback given. It was also indicated by the System Usability Scale assessment 'good usability'.

To achieve a design fully optimised for caregivers, additional iterations can be made to test the design. A greater number of the desirable functions expressed in the user interviews can also be implemented to improve the final prototype further. Finally, the number of people testing the prototypes could be increased.

**Keywords:** Usability, mobile application, healthcare, eHealth, UX

## Sammanfattning

Personal på sjukhusavdelningar upplever ett antal problem kopplade till administrativa uppgifter. Bland dessa problem ingår att behöva dokumentera samma information i flera system, samt svårigheter vid överlämningar mellan skift. Den nuvarande produkten Pulstavlan, utvecklad av Stretch Care AB, har som mål att lösa dessa problem. Pulstavlan är dock stationär och möjliggör därför inte för vårdpersonal att ta med informationen tavlan innehåller in till patienter. Detta examensarbete beskriver en användarcentrerad designprocess, där en digital prototyp av en mobil produkt som är kompatibel med Pulstavlan designas. Målet med den mobila produkten är att underlätta det administrativa arbetet för vårdpersonal, samt att lägga grunden för framtida designlösningar inom detta område.

Designen baserades på en användarstudie av sjukhuspersonal, innehållande 15 intervjuer med totalt 18 användare, samt sex observationer av Pulstavlan vid användning. Användarstudien resulterade i ett antal uttryckta behov, samt mål som den mobila designen behövde uppnå för att tillgodose de uttryckta behoven. Dessa behov och mål användes för att formulera tolv nödvändiga funktioner i applikationens design.

Fyra iterationer av prototypdesign gjordes; två iterationer av en analog prototyp och två iterationer av en digital prototyp. Alla iterationer utvärderas genom att låta användare utföra testscenarios lika uppgifter som görs på sjukhusavdelningar. Under tiden fick användarna berätta hur de tänkte. Den slutgiltiga prototypen ansågs ha bra användbarhet av alla testpersoner som arbetade i sjukvården samt hade erfarenhet av att använda Pulstavlan. Detta indikerades av att de lyckades utföra de givna scenarion samt av den positiva feedbacken som gavs. Det indikerades också av betyget på skalan System Usability Scale 'bra användbarhet'.

För att få en design som är helt optimerad för vårdgivare kan fler iterationer utföras för att testa designen. Ett större antal önskvärda funktioner som uttrycktes under användarintervjuerna kan också implementeras för att förbättra designen. Slutligen kan antalet testpersoner ökas i kommande iterationer.

**Nyckelord:** Användbarhet, mobil applikation, sjukvård, eHälsa, UX

## Acknowledgements

In this section, we would like express our gratitude toward a number of people who have provided us with support and who have enabled this master's thesis. To our supervisor from the department of Design Sciences at LTH, Christofer Rydenfält, we would like to say thank you for the guidance given, which we have needed to complete our work and to write this report. We would also like to thank the people working at Stretch Care AB, especially our supervisors Daniel Terborn and Charlotta Tydén, for the opportunity to design a mobile product inspired by one of the products in their portfolio. We would also like to thank them for the valuable feedback we have received along the way.

To the hospital staff who took the time to help us establish the current needs for a mobile device on hospital wards, and to the people who helped us test our design and came with important inputs, we would also like to say a big thank you.

Last but not least, we would like to thank our friends and family who volunteered to take part in the testing of some of our prototypes, when the ability to test the prototypes on target users was limited, due to the prevailing circumstances with Covid-19.

## List of acronyms and abbreviations

App = Application

Hi-fi = High fidelity

Lo-fi = Low fidelity

PDL = Patientdatalagen (Swedish patient data law)

SUS = System Usability Scale

UCD = User-Centered Design

UX = User experience

# Contents

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Introduction</b>                                   | <b>9</b>  |
| 1.1      | Stretch Care AB . . . . .                             | 10        |
| 1.2      | Delimitations . . . . .                               | 10        |
| <b>2</b> | <b>Background</b>                                     | <b>11</b> |
| 2.1      | The strain on the Swedish healthcare system . . . . . | 11        |
| 2.2      | Pulstavlan . . . . .                                  | 12        |
| 2.2.1    | Methodology on which Pulstavlan is based . . . . .    | 12        |
| 2.3      | SBAR . . . . .  | 14        |
| 2.4      | Libra/Care strain . . . . .                           | 15        |
| 2.5      | Design theory . . . . .                               | 15        |
| 2.5.1    | Interaction design . . . . .                          | 15        |
| 2.5.2    | User experience . . . . .                             | 16        |
| 2.5.3    | User-centered design . . . . .                        | 17        |
| 2.5.4    | Design principles . . . . .                           | 17        |
| 2.5.5    | Fitt’s law . . . . .                                  | 19        |
| 2.5.6    | Hick’s law . . . . .                                  | 19        |
| 2.5.7    | Gestalt principles of design . . . . .                | 19        |
| <b>3</b> | <b>Design process overview</b>                        | <b>21</b> |
| <b>4</b> | <b>Establishing the needs</b>                         | <b>24</b> |
| 4.1      | Target group . . . . .                                | 24        |
| 4.1.1    | Choosing hospital wards . . . . .                     | 25        |
| 4.2      | Getting familiarised with Pulstavlan . . . . .        | 25        |
| 4.3      | Qualitative data collection . . . . .                 | 25        |
| 4.3.1    | Conducting interviews . . . . .                       | 26        |



|          |   |           |
|----------|---|-----------|
| 4.3.2    | Interview with an initiator of Pulstavlan from a hospital in Region Skåne . . . . . | 26        |
| 4.3.3    | Pilot study . . . . .   | 26        |
| 4.3.4    | User interviews . . . . .   | 27        |
| 4.3.5    | Observations . . . . .  | 27        |
| 4.4      | Qualitative data analysis . . . . .   | 28        |
| 4.4.1    | Thematic analysis . . . . .   | 28        |
| 4.4.2    | Goals . . . . .   | 28        |
| 4.5      | Function categorisation . . . . .   | 30        |
| 4.6      | Developing personas . . . . .   | 30        |
| 4.7      | Results of qualitative data analysis . . . . .                                      | 30        |
| 4.7.1    | Identified themes . . . . .   | 30        |
| 4.7.2    | Main issues . . . . .   | 31        |
| 4.7.3    | Formulated goals . . . . .  | 32        |
| 4.7.4    | Formulated functions and function categorisation . . . . .                          | 33        |
| 4.8      | Personas . . . . .  | 36        |
| <b>5</b> | <b>Concept Generation</b>   | <b>38</b> |
| 5.1      | Generating concepts . . . . .   | 39        |
| 5.1.1    | Method for concept generation . . . . .   | 39        |
| 5.1.2    | Results . . . . .   | 40        |
| 5.2      | Concept evaluation . . . . .  | 49        |
| 5.2.1    | Results of concept evaluation . . . . .   | 49        |
| 5.3      | Final concept . . . . .   | 50        |
| 5.3.1    | Final concept result . . . . .  | 50        |
| <b>6</b> | <b>Prototyping</b>  | <b>52</b> |
| 6.1      | Approach . . . . .  | 53        |
| 6.2      | The lo-fi prototype . . . . .   | 55        |
| 6.2.1    | Iteration 1 . . . . .   | 55        |
| 6.2.2    | Iteration 2 . . . . .   | 63        |
| 6.2.3    | Feedback on lo-fi design from Stretch Care AB . . . . .                             | 67        |
| 6.3      | The hi-fi prototype . . . . .   | 68        |
| 6.3.1    | Feedback from lo-fi tests to include into the hi-fi prototype . . . . .             | 68        |
| 6.3.2    | General design decisions before the iterations . . . . .                            | 70        |
| 6.3.3    | Iteration 1 . . . . .   | 71        |
| 6.3.4    | Feedback on hi-fi design from Stretch Care AB . . . . .                             | 79        |
| 6.3.5    | Expert interviews . . . . .   | 80        |

|          |  |            |
|----------|--|------------|
| 6.3.6    | Iteration 2 and final prototype . . . . .              | 80         |
| <b>7</b> | <b>Evaluating the design</b>                           | <b>87</b>  |
| 7.1      | User testing . . . . .                                 | 87         |
| 7.1.1    | Results of testing the final hi-fi prototype . . . . . | 89         |
| 7.1.2    | System Usability Scale . . . . .                       | 92         |
| 7.2      | Proposed improvements . . . . .                        | 95         |
| <b>8</b> | <b>Discussion</b>                                      | <b>96</b>  |
| 8.1      | Discussion of results . . . . .                        | 96         |
| 8.1.1    | Implemented functions . . . . .                        | 98         |
| 8.2      | The design process . . . . .                           | 99         |
| 8.2.1    | Establishing the needs . . . . .                       | 99         |
| 8.2.2    | Concept generation . . . . .                           | 100        |
| 8.2.3    | Prototyping . . . . .                                  | 101        |
| 8.2.4    | Evaluation . . . . .                                   | 101        |
| 8.2.5    | Next steps . . . . .                                   | 103        |
| <b>9</b> | <b>Conclusions</b>                                     | <b>105</b> |
|          | <b>Appendices</b>                                      | <b>111</b> |
| <b>A</b> | <b>Interview questions</b>                             | <b>112</b> |
| <b>B</b> | <b>Identified themes</b>                               | <b>114</b> |

# Chapter 1

## Introduction

Nurses in hospital wards face several problems in handling administrative tasks related to admitted patients [1][2]. These problems include difficulties in shift handovers between staff, and the ability to access patient information without having to return to a specific location. Additional problems involve getting an overview of all patients currently admitted, as well as saving time to write patient notes on a whiteboard. To solve some of these problems, a digital product called Pulstavlan (translation The Pulse Board) was developed by the company Stretch Care AB [3]. Pulstavlan gives an overview of the admitted patients and their treatment plans during their hospitalisation.

Although there are current products that facilitate patient administration, there is a lack of a good mobile version that utilises the opportunities of mobilisation and replaces outdated methods used within healthcare. Such outdated methods include e.g. printing of digital patient calendars to carry around on physical pieces of paper. Furthermore, a majority of the hospitals in Skåne currently use two or more systems to document patient information. Consequently, there is a widespread problem of double or triple documentation that needs to be solved. A mobile tool integrated with current systems not only solves the problem of double documentation, but also eases the work load of hospital staff. This could in turn increase the amount of time caregivers devote to bedside care.

This master's thesis intends to start the process of solving the mentioned issues, and to lay the ground work for future work within the area. This is done through a user-centered design process, where the interface of such a mobile tool is designed. An extensive user study was conducted, in which target users from hospi-

tals in Skåne were interviewed. The interviews were analysed to obtain the needs that the mobile version aimed at solving. The needs were then used to generate concepts, on which paper-based, analogue prototypes and digital, interactive prototypes were based. The prototypes were tested on users in several iterations until the final prototype was designed.

## 1.1 Stretch Care AB

Stretch Care AB is a Swedish company based in Malmö and a part of Stretch Group. The company was founded in 2018 and specialises in digital products, intended to be used within the healthcare system. Stretch Care AB collaborates closely with healthcare professionals during the development of their products and aims at creating products that facilitate everyday work tasks for caregivers. The importance of patient safety, cost efficiency and usability is what signifies their solutions. *Pulstavlan*, one of their most well known digital tools, is today installed on over 150 hospital wards in Region Skåne.

## 1.2 Delimitations

One delimitation was to only focus on the needs of caregivers in the form of hospital staff on two wards in Skåne. Furthermore, the application was designed based on an existing product, *Pulstavlan*. Since the app was meant to be integrated with *Pulstavlan*, the design choices were slightly limited to resemble the current product. Additionally, information included in the design was constrained by the Swedish patient data law (PDL), which regulates the use of patient data [4]. Therefore, only information not classified as patient record data was included in the prototypes.

Although this master's thesis has been written in collaboration with Stretch Care AB, the final prototype design does not consider all relevant factors needed, if it was to be included in their product portfolio. The final prototype has primarily been based on the user study, together with existing literature in the area of interaction design. Factors such as IT landscape, regulations in terms of information ownership, and what is feasible given the current hardware in hospitals have not fully been taken into account. Therefore, Stretch Care AB cannot stand by the final design fully, and it does not entirely reflect their company brand.

# Chapter 2

## Background

In this chapter, background to the current situation within Swedish healthcare will be given. Tools used to manage administrative work on hospital wards will be of particular focus. The chapter will also bring light on methodologies used in healthcare, as well as theoretical background about the areas of interaction design and user experience (UX).

### 2.1 The strain on the Swedish healthcare system

According to *Vision e-hälsa 2025*, Sweden aims at being a leading country in making use of the opportunities of digitisation and e-health [5].

Sweden has had greater resources in the past 20 years within healthcare than other OECD countries, in terms of physicians and nurses per capita [6]. However, the number of acute care hospital beds per capita has been lower than the average for countries within the EU. Furthermore, the Swedish care guarantee (vårdgaranti), which was first introduced in 2010, aims at improving patients' access to healthcare.

As of 2019, the care guarantee states that a patient in need of medical care should be able to get in contact with the healthcare system on the same day as seeking care. The patient should, furthermore, within three days have met with a caregiver within primary care. Within 90 days should the patient have gotten in contact with a medical professional within specialist care, and after 90 additional days have been treated according to a medical assessment by a physician [7][8]. Despite

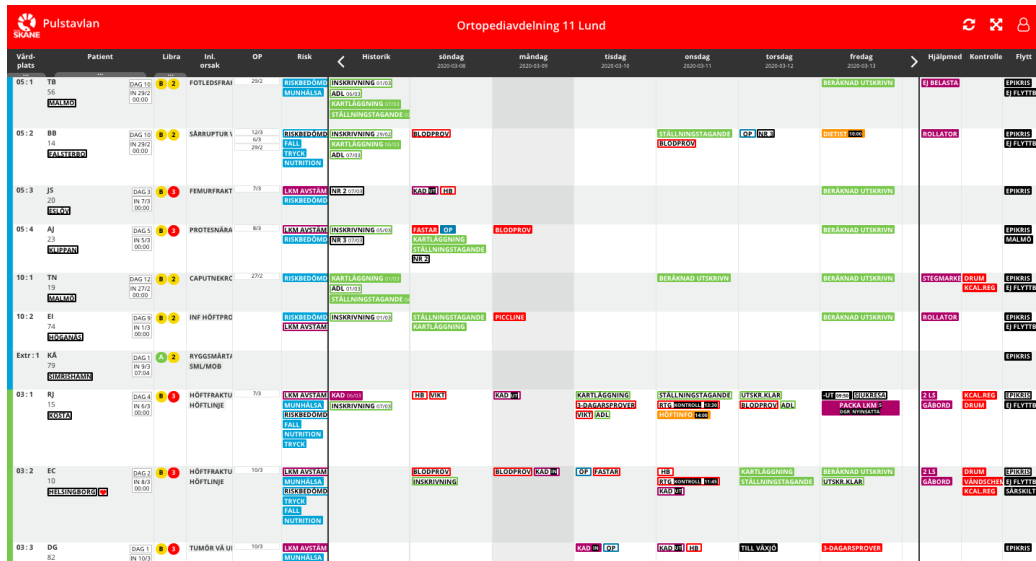
this, and improvements in care availability, only seven out of 21 regions reach the goal of patients meeting a caregiver within primary care within three days [9]. Furthermore, Swedish medical professionals spend on average less than 40% of their work time in direct contact with patients. The majority of the remaining time is spent on administrative tasks [10]. For this reason, there is a significant desire to decrease the amount of time spent on administration, and to increase the time spent with patients. One way to approach this issue could be to make administrative tasks and coordination of work less time demanding.

## **2.2 Pulstavlan**

Pulstavlan (see Figure 2.1) is a digital tool based on the pulse methodology mentioned below. It is used in healthcare to optimise caregivers' work flow and patient care. Pulstavlan was initially created during a collaboration between Stretch Öresund AB and Region Skåne. Hospital wards in Region Skåne had previously been using whiteboards/magnet boards to visualise work flow and patient treatment schedule. Pulstavlan is now owned by the company Stretch Care AB. The board enables detailed overview of admitted patients and their treatments. It is currently primarily used in Skåne, but intended to be used all over Sweden in the future. When patients are admitted to a ward, they automatically appear on the board. The board can be used in two modes, either logged in or anonymous. The information displayed the anonymous mode is not classified as patient data and therefore less sensitive. Pulstavlan is placed on the ward, not available to visitors or patients. This allows for the information on the board to only be viewed by members of staff.

### **2.2.1 Methodology on which Pulstavlan is based**

In 2012, Region Skåne decided that the pulse methodology should be used within healthcare in all hospitals. The pulse methodology was introduced to improve internal communication between caregivers and thereby improve the patient care, patient flow and care logistics [11]. When the decision was made, each ward was provided with a whiteboard/magnet board, also known as a 'pulse board'. The board displayed basic patient information, such as scheduled examinations. Daily pulse meetings have since then taken place around the pulse board [12]. The pulse meetings aim at providing an overview of the workload, resulting from the amount



**Figure 2.1:** View of Pulstavlan where each row contains information such as planned examinations and discharge dates.

of care the admitted patients require, as well as the duration of their stay.

Region Skåne’s traditional whiteboards display a patient schedule for upcoming days. The use of such boards, however, could induce several risks. These risks can partly be eliminated by transferring the analogue system to a digital one. This is what Pulstavlan, and other similar products, have accomplished. The benefit of using Pulstavlan is that caregivers’ time can be used more efficiently, since the interactive board is less time demanding to add tasks to. Furthermore, the digital pulse board, Pulstavlan, gives a better overview of the admitted patients, since it can include more information than a traditional whiteboard. The system can be accessed from several different units, including both the digital board and computers stationed on the wards. This enables changes to be made from different locations. The primary goal of Pulstavlan is to decrease the care time for admitted patients [3].

The pulse methodology, and thereby also Pulstavlan, is based on the lean methodology. This methodology optimises organisational resources to create value for customers [13]. The methodology has its roots in Toyota’s manufacturing indus-

try. It is an implementation-oriented approach where the lean terminology means 'eliminating waste' [14]. This concept has been applied to healthcare, with the patient as the customer and the hospital staff as the organisation, with successful results [15][16][17][18]. The implementation of lean methodology in hospitals has reduced patient waiting time, increased patient flow and reduced costs [19] [20]. The goal of using the lean methodology in healthcare is to create the best value possible for patients by cutting waiting time and side tasks and strive for continuous improvement [21].

## 2.3 SBAR

A contributing factor to a majority of care related injuries among patients within the Swedish healthcare system is inefficient communication between different clinicians. SBAR (**S**ituation, **B**ackground, **A**ssessment, **R**ecommendation) is a model created to improve communication, using structured forwarding of critical information [22]. It was first introduced by the US Marine Corps in order to communicate essential facts efficiently in critical situations. It has since then been further developed to act as a common structure of communication within healthcare. SBAR was launched in Sweden in 2010 [23]. It is a suitable model, for instance for reports after finished shifts, consultations between clinicians or in order to facilitate documentation and administrative work [22].

The SBAR system is used by healthcare workers in Region Skåne on so called patient bed lists. These patient bed lists contain patient information needed to quickly get an overview of the patient's status. Pulstavlan is similar to the SBAR system as it also contains necessary patient information, needed for coordination of work and communication.

- **Situation** - Presentation of situation/reason for contact.
- **Background** - Background information relevant to the situation. Declaration of circumstances leading to the current situation.
- **Assessment** - Summary of the most important facts related to the situation together with a reasonable interpretation of them.
- **Recommendation** - Recommendations to the recipient, possibly a plan of suggested future actions.



## 2.4 Libra/Care strain

On hospital wards, the principle of care strain ('vårdtyngd') (as of recently also called libra in healthcare) is used to keep the workload even between all staff teams [24]. The care strain is a graded measurement of a patient's medical needs, as well as their need of social care ('omsorg'). The medical need is graded from A-C, where A is a light medical need and C is a demanding need. Similarly, the social need is graded from one to three, where one is a light need of social care and 3 a demanding one. For example, one patient's care strain can be expressed as **C:1**, where the C indicates a demanding medical need, and the number one indicates a light social need. The grades assigned to patients are determined differently, depending on medical speciality. Using this system, the overall medical and social need of a ward can be expressed by summing up all medical and social needs respectively. The total sum of the care strain for all patients in a certain staff team can thereby be used to determine which team patients should be assigned, to balance the work load evenly. See Figure 2.2 for a visual representation of the care strain.

|        | Medical | Social | Sum |
|--------|---------|--------|-----|
| TOTAL  | 55      | 63     | 118 |
|        | Medical | Social | Sum |
| BLUE   | 18      | 19     | 37  |
| RED    | 15      | 17     | 32  |
| GREEN  | 12      | 16     | 28  |
| YELLOW | 10      | 11     | 21  |

**Figure 2.2:** Example of how the care strain might look on a ward with 25 admitted patients distributed among four staff teams. The numbers have been taken from a model version of Pulstavlan.

## 2.5 Design theory

### 2.5.1 Interaction design

Preece et al [25, p.23] defines interaction design as *'Designing interactive products to support the way people communicate and interact in their everyday and*

*working lives*'. One main focus of interaction design is to reduce features of the product that cause irritation or discontent on behalf of the user, and instead enhance features that make the product easy, effective and pleasant to use [25]. In order to ensure the appropriateness of an interactive product, a user-centered design approach is preferably carried out, where users are involved throughout the entire design process. This can be achieved in numerous ways; for instance through observations, interviews or questionnaires.

## 2.5.2 User experience

User experience (UX) is of fundamental importance to interaction design [25]. All products that are used, and/or interacted with by someone generate user experiences [26]. Of significance to the UX are aspects such as usability, functionality, aesthetics, content, evoked senses and emotions on the user's part. The UX includes the user's total impression of how good a product is to use [25].

### Usability goals

The usability of an interactive product involves optimisation of the interactions people have with the product, to facilitate different activities carried out [25]. The following goals of usability can be used by the designer to assess different aspects of a product and its UX. By turning the goals into questions for the designer to answer, potential unfortunate design issues could at an early stage of the design process be detected, and thus avoided.

- **Effective to use** - The product is supposed to live up to the expectations of its intended use.
- **Efficient to use** - The product should support the user in carrying out regular tasks efficiently, using minimal number of steps.
- **Safe to use** - The user should be protected from e.g. carrying out unintentional actions on the product, resulting in dangerous and/or undesirable situations.
- **Having good utility** - The product should be equipped with the right functionality, allowing needed and wanted actions on behalf of the user.
- **Easy to learn** - The product should be easy to learn how to use. The period of time required for learning how to use the product should not be long, if it does not correlate to the complexity of the product.
- **Easy to remember how to use**

- The product should be easy to remember how to use. The user should not have to relearn how to do different tasks every time the product is used.

### 2.5.3 User-centered design

Garret [26, p. 17] defines user-centered design (UCD) as "*The practice of creating engaging, efficient user experiences*". This means that the perspective of the user is taken into account throughout every step of the entire product development process [26]. The following three principles of design were suggested in 1985 by Gould and Lewis in order to ensure that an interactive product is useful and easy to use [27].

**Early focus on users and tasks** - The designer needs to be aware of who the users of the product will be. This can be accomplished by studying different characteristics of the users, preferably in an environment where the product is supposed to be used.

**Empirical measurement** - At an early stage of the development process, possible users should be invited to try e.g. simulations or prototypes of the product. Their performance and reactions while trying to carry out real work-related tasks should be observed and analysed.

**Iterative design** - Problems found during the user testing must be adjusted. This results in an iterative cycle of design where the steps of testing, measuring and readjusting the design are repeated as many times as found necessary.

### 2.5.4 Design principles

Design principles act as guidelines for designers in order to help create positive user experiences [25]. The foundation of most principles of design lies in a mix of theory, experience and common sense. Design principles are not detailed descriptions of how to design certain features, rather suggestions of what should be provided and avoided in an interface.

Today, there are numerous well-known principles of design. In this master's thesis, the choices of design made have primarily been based on the principles expressed by Donald Norman and Preece et al [25] [28]. They are described briefly

below.

**Affordance** - Refers to the relationship between the properties of an object and the user's perception of what different possible actions the object invites to or supports ('affords'). *Afford* can at a simpler level be translated into 'to give a clue'. Furthermore, affordance can be enhanced or clarified using *signifiers*. In a user interface, this could for instance mean that there is text on a button to give a clue of what is going to happen if it is pressed, or that the colour of the button is changed when it is pressed.

**Consistency** - Refers to that the operations and used elements in an interface should be similar to perform and achieve similar tasks. A consistent interface follows rules and does not give room for exceptions. A great benefit of having an interface that behaves consistently is that it will be easier for the user to learn and use.

**Constraints** - Refers to different ways of restricting the possible user interactions in a system at given moments. There are many potential ways to add constraints to a system. A common example is to shadow or make certain menu options grey that are deactivated for given scenarios. An advantage of having these kinds of constraints is to prevent the user from selecting incorrect options, and thus reduce the risk for mistakes and confusion. Another example can be to constrain the user's interpretations of a certain issues by the choice of graphical representation portraying the relations between different objects.

**Feedback** - Refers to the sending back of information about performed actions and accomplishments. This way the user is allowed to continue with an activity while being aware of what the consequences are and have been. There are many types of feedback, for instance audial, visual or verbal. These may be used in combination with each other. However, it is of importance for the designer to decide which type of feedback that is appropriate for different activities.

**Visibility** - Refers to how visible the different functions of a system are to the user and how easy it is to overview the system. If the visibility and the intuitiveness of controlling devices increases, it is more likely that the user will figure out what to do next. In contrast, if functions are hard to see and locate, more frustration and uncertainty on behalf of the user can be caused.

**Mapping** - Refers to the relationship between elements in different sets or compositions. Mapping is of special importance when designing the layout of different controls or displays. If there is spatial correspondence between a controller and the device intended to be controlled, it facilitates the understanding of how they are supposed to be used.

### 2.5.5 Fitt's law

Fitt's law describes the relationship between the distance toward an object on a screen, such as a button, and the time it takes to click on it [25]. Equation (2.1) describes this relationship more closely.  $T$  is the time it takes to move the pointer to a target,  $D$  is the distance between the pointer and the target,  $S$  is the size of the target and  $k$  is a constant of approximately 200 ms/bit. Although this law is more applicable in computer based interface, as mobile devices lack pointers, this law can be applied in regard to how quickly the user will find the target, relative to where on the screen they were previously looking. Fitt's law states that a target is more easily detected and clicked if it is bigger and more closely located to the user's line of sight.

$$T = k \times \log_2\left(\frac{D}{S} + 1\right) \quad (2.1)$$

### 2.5.6 Hick's law

Hick's law states that there is a linear relationship between the reaction time of the user and the task complexity measured in bits of information [29]. In other words, having a fewer number of options available to the user in a user interface reduces the time it takes the user to make a decision.

### 2.5.7 Gestalt principles of design

The term 'gestalt psychology' describes how the appearance of individual objects can cause an observer of these objects to perceive a different image, namely the whole of the image as opposed to only its individual components [30]. Several Gestalt principles exist, where the most commonly mentioned principles in design theory are the following:

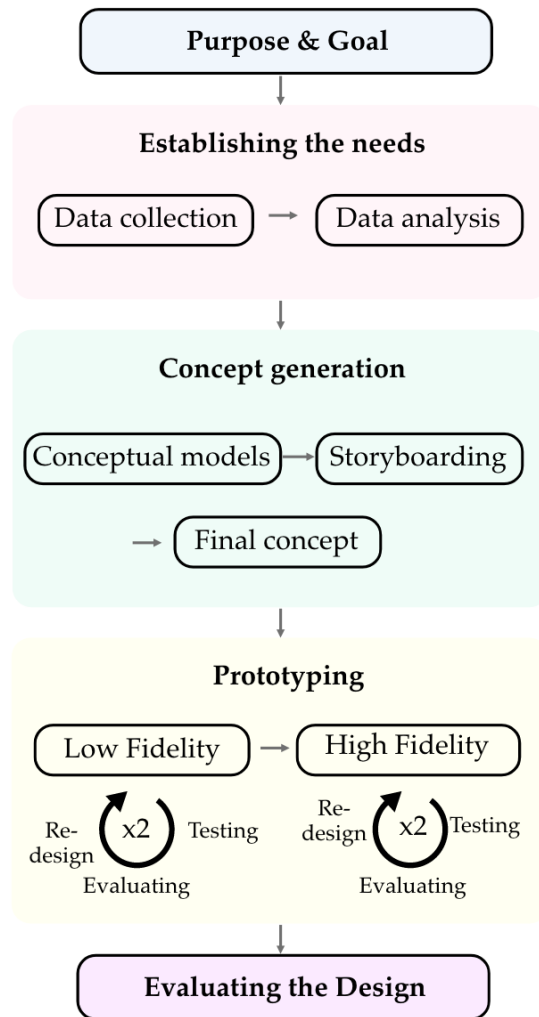
- **Proximity** - Objects that are located within the same proximity, i.e. that are close to each other, appear to belong to each other.

- **Similarity** - Visually similar objects are interpreted as belonging to each other
- **Closure/Continuity** - The users perceives separate object as part of a whole image by filling in the missing parts. This is the case in a shape whose contour is dotted, where the observer still interprets the contour as if the gaps were filled in.
- **Good continuation** - A user will follow a certain shape or object with their line of sight by following the most smooth path of vision.

# Chapter 3

## Design process overview

This chapter gives an outline of the user-centered design process and methods used in this thesis. Figure 3.1 shows a general view of the entire process. Design processes vary greatly depending on the context of the design project. In this chapter, the methods deemed most suitable for this project, are described. The choice of methods was based on the aim of the application design and the resources available within the given time frame. The 'Purpose Goal' of the design project was first formulated to make sure there was a need for a mobile caregiver application. The needs of the caregivers at hospital wards were established to get a more detailed and updated image of the current work environment with regard to administrative tasks and digital tools. 'Concept generation' was done to visualise the usage of the mobile application and to explore multiple design alternatives. Once a final concept was illustrated, the final application was designed gradually by first designing a simple prototype followed by a more complex and interactive prototype. Each of these prototypes were designed in two iterations each to enable continuous feedback from users and to allow for improvements to be made throughout the process. Finally, the final prototype was evaluated using well-known methods in the field of usability testing.



**Figure 3.1:** The process followed in this master's thesis

### Establishing the needs

To establish the needs and requirements of a mobile product, semi structured interviews with hospital staff were conducted. The interviews focused on needs related to administrative tasks and the functionality of Pulstavlan. Observations of the staff using Pulstavlan were also conducted to catch interactions with the board that were not mentioned during the interviews. Thematic analysis was used to analyse the data to formulate goals related to the desired functionality of the mobile product. A couple of main issues that the product aimed at solving were



also formulated. Personas were created based on the thematic analysis. These personas were kept in mind during the concept generation.

### **Concept generation**

The results of the user study were used to generate conceptual models of the mobile product. This was done through individual concept generation followed by storyboarding. Four individual concepts were then evaluated using a weighted matrix. The evaluation was based on how well each concept addressed certain necessary functions and main issues. A final concept was then generated based on the evaluation.

### **Prototyping**

The prototyping part of this master's thesis was done in two iterations per type of prototype (lo-fi and hi-fi). The lo-fi prototypes were tested on five people in total. The hi-fi prototypes were tested on five people per iteration. Feedback received during the tests was incorporated to improve the prototype between the iterations.

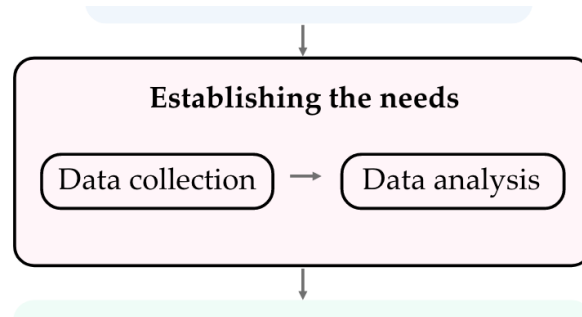
### **Evaluating the design**

The final design was evaluated by letting five target users test the prototype and afterwards ask them to fill out a questionnaire according to the System Usability Scale (SUS). The evaluation of the design also included verbal feedback given by users in association with completing seven different scenarios using the prototype.

# Chapter 4

## Establishing the needs

This chapter describes the steps of the user study to establish the needs that a mobile tool aimed at addressing. The target group of the user study is presented, followed by the collection and analysis of data. The methods for collecting and analysing the data are first described chronologically together with brief theory of the methods, followed by the results of the analysis.



### 4.1 Target group

The target group in this thesis was the primary user group of Pulstavlan. Nurses, assistant nurses, medical secretaries, heads of units and coordinators at hospitals in Skåne were interviewed since they use Pulstavlan on a daily basis as a tool to optimise their tasks.

### **4.1.1 Choosing hospital wards**

A list of all hospital wards in Skåne that used Pulstavlan was provided by Stretch Care AB. From that list, wards were chosen to get as wide of a perspective of Pulstavlan's use as possible. There was a variation in the type of clinical care provided by each ward and how long they had been using Pulstavlan. Furthermore, the wards chosen were located in two hospitals in Skåne to eliminate that all interviews were based on a single hospital, where systematic usage of Pulstavlan might occur.

## **4.2 Getting familiarised with Pulstavlan**

At the start of the thesis process, Pulstavlan was demonstrated by one of Stretch Care AB's employees. This was done to gain a basic understanding of how the tool is used, and of the functions integrated in the product. This knowledge was then used as background when observing staff use Pulstavlan, as well as when hearing about its use during interviews.

## **4.3 Qualitative data collection**

To be able to understand and establish the needs, wishes and requirements of the end users, data can be gathered using various techniques. A suggestion of good practice, however, is to employ what is known as *methodological triangulation*, meaning that the information obtained is gathered using (at least) two different techniques [25]. This way, if compatible, results seen from one perspective can be used to e.g. either validate or discredit results seen from another perspective.

For the user study of this thesis, it was decided to gather data primarily through semi structured interviews and observations of Pulstavlan in use. This was a result of the authors' lacking prior knowledge of administrative work tasks on hospital wards using Pulstavlan. Observations were made to catch any usage of Pulstavlan not mentioned in the interviews and to get a more detailed image of the context in which the board is most often used.

### 4.3.1 Conducting interviews

There are four main types of interviews; unstructured, structured, semi-structured and focus groups [25]. What signifies these types is the amount of control the interviewer has on the questions and responses, and how specific the responses are likely to be. In an *unstructured* interview, the responses can vary greatly between the different interview subjects. The interview can take any given direction within the field if allowed. A *structured* interview on the other hand, is where the formulation of the questions limits the response options. For instance by giving the interviewee different response alternatives. Semi-structured interviews combine structured and unstructured interview types to make sure there is a resemblance between each interviewee's response, whilst welcoming responses that the interviewer could not have foreseen. For example, a question with limited answers can first be asked followed by a more open-ended question such as "why?".

### 4.3.2 Interview with an initiator of Pulstavlan from a hospital in Region Skåne

Early on in the process, an unstructured interview was conducted with an initiator of Pulstavlan from the healthcare area. This was done to establish the underlying needs of the healthcare that resulted in Region Skåne using Pulstavlan. The knowledge gained from this interview was used as basis for the user interview questions.

### 4.3.3 Pilot study

Around 25 interview questions were formulated after having interviewed one of the initiators of Pulstavlan. The mentioned needs for the initiation of Pulstavlan were a lack of time in the daily routines for staff, as well as better integration with the pulse methodology and meetings. The interview questions were thus grouped into three relevant areas; *Daily routines*, *Pulse meetings* and *Pulstavlan*. The questions were reviewed by an employee at Stretch Care AB who had previously worked as a nurse, as well as the mentor at Lunds Tekniska Högskola, LTH. They were then used during two pilot interviews with nurses from two different hospital wards. After these interviews, interview questions were edited or added if necessary. This resulted in the 27 interview questions used during the user interviews. The interview questions can be found in Appendix A.

#### 4.3.4 User interviews

The original aim was to interview staff from 15 different hospital wards. However, since many wards were rather difficult to get in touch with, two interviews were held on the same ward, resulting in a total of 14 wards used for interviews. Two of these wards were part of the pilot project, in which Pulstavlan was introduced during the summer of 2018. All remaining wards chosen were given Pulstavlan at the latest in May 2019. A total of fifteen semi-structured interviews were held with primary users of Pulstavlan working on hospital wards in Lund and Malmö. In three of the fifteen interviews, two people participated. Therefore, a total of 18 people were interviewed.

The following professions were interviewed; *nine* nurses, six of which also had a coordinating role, *seven* assistant nurses, six of which also had a coordinating role, *one* head of unit and *one* medical secretary. They were interviewed with regard to their daily routines, administrative tasks and how Pulstavlan was integrated with these.

#### 4.3.5 Observations

Another method for collecting data is by performing observations [25]. Depending on what is being investigated, users can be observed when using a product or performing tasks. Alternatively, a product can be observed to find out how it is used and interacted with.

Five different pulse meetings held around Pulstavlan on five different hospital wards in Lund and Malmö were observed. Three of the observations took place in the morning and two in the afternoon. The pulse meetings lasted between three to 15 minutes in length. The number of admitted patients, the number of people present, and visible columns on Pulstavlan were noted for each meeting. Notes were taken of the different routines for the meetings, who the meeting was led by and if and how Pulstavlan was interacted with.

The main purpose of the observations was to deepen the understanding of how Pulstavlan is used, and to get a sense of the communication and interaction between different professions during pulse meetings.

Apart from observing pulse meetings, one three hour observation of Pulstavlan

was conducted. This was done to determine the average frequency at which the board was used. The number of interactions with the board during the observation was very few and the staff was seen using their physical papers to take notes on instead of on the board. This observation gave a very clear result that Pulstavlan is used very little, apart from during pulse meetings, and that there is a gap in the needs of staff and functions covered by the board.

## **4.4 Qualitative data analysis**

### **4.4.1 Thematic analysis**

The data were analysed using thematic analysis. There are two main ways of identifying patterns within data using thematic analysis [33]. These ways are referred to as either *inductive* or *theoretical*. The choice between inductive and theoretical thematic analysis can be based on whether the data is coded for a specific research question (suggesting theoretical approach), or if the research question is allowed to evolve during the coding process (suggesting inductive approach).

For this thesis, the inductive approach was found most suitable. In the inductive (also known as 'bottom-up') approach, patterns identified often have little relation to specific questions asked. This approach is primarily a process of organising data to avoid fitting it into a pre-set coding frame based on assumptions already made by the researcher [33].

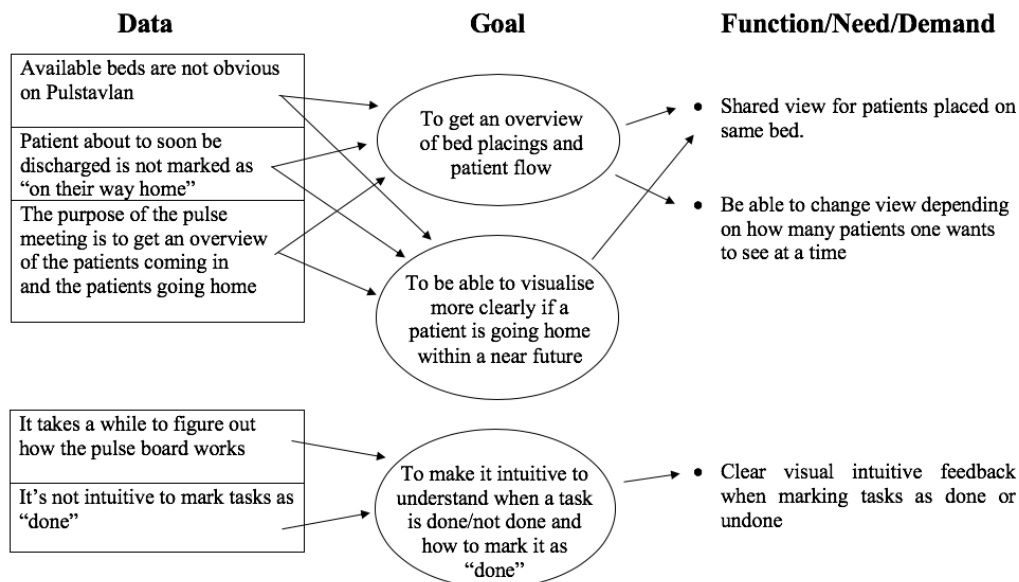
27 questions were answered by 18 users in 15 interviews, which led to around 400 answers being gathered. These answers along with notes of the observations made during pulse meetings were grouped together using the above mentioned inductive thematic analysis. One response could fall under one or more of the observed themes. The interview responses were compiled in an excel document where each response was in a different cell. Each cell was tagged with different themes. These cells were then copied and organised into one or several PowerPoint slides where each slide represented a theme.

### **4.4.2 Goals**

The identified themes, as well as individual interview responses relevant to the design of a mobile tool, were written in a table column. The data were chosen

so that each unique response was covered in the table. Since many responses had overlapping and almost identical content, many of these responses were hence eliminated in this step.

From these data, goals that would meet the expressed issues in the data were formulated and added into another column in the same table. All data points used as background for a formulated goal were connected through an arrow to that goal. Functions, demands and needs that would implement the goals were written in the third table column. This resulted in one function having several possible goals connected to it. Each goal, in turn, had several possible data points connected. In other words, the final structure resembled a map of functions and the reasons for their formulation, see example in Figure 4.1. In conclusion, the themes and data points worked in parallel to formulate goals of the mobile tool, which in turn was used as a base for a series of functions/needs. To enable backtracking of the functions to the relevant goals and data, a system of digits was used to group them together.



**Figure 4.1:** Example of how data extracted from the thematic analysis were used to formulate goals of the product which in turn resulted in desirable functions of the tool.

## 4.5 Function categorisation

The functions formulated were reevaluated depending on whether each function was deemed to be *necessary*, *not necessary*, or *desirable*. The necessary functions included functions without which the product would not help solve the main issues (see Section 4.7.2). Furthermore, the necessary functions were also considered essential in order for the product to add value to the current flow of work observed during the user study. Not necessary functions were functions that would not be relevant in a mobile version since the mobile version circumvents certain issues associated with the larger Pulstavlan screen. Desirable functions might be included later on, but are not necessary for the mobile version to work.

## 4.6 Developing personas

Personas are often used in UCD processes, in order for the designer to better understand users. Similarities and themes among several users in a user survey are, in terms of behavioral patterns and characteristics, grouped together to represent typical user profiles [34]. By creating personas, the designer gets a more concrete image of who the user might be, instead of attempting to design incoherent solutions that are supposed to suit everyone.

To capture the needs and goals formulated in the table exemplified in Figure 4.1, three different personas were developed. Each persona covered a particular portion of the needs and goals of the qualitative data analysis, and represented a certain professional role on a given hospital ward in Region Skåne. The personas were developed with the key roles interviewed during the data collection in mind. The resulting personas had different goals of using the mobile tool, as well as different work descriptions. They were used as base for the concept generation phase (see next chapter).

## 4.7 Results of qualitative data analysis

### 4.7.1 Identified themes

The themes identified when analysing the interview responses and observations can be found in Appendix B. The themes gave a good idea of the general patterns in the responses, and an indication of the direction the mobile product would take.



As one response could fall under more than one pattern, some themes were given less attention than others. For example the theme 'Arguments for a mobile tool' overlapped heavily with 'Notes and bed lists on physical papers'. Therefore, most responses in the first mentioned theme had already been covered during the evaluation of the latter theme.

Furthermore, some of the identified themes covered ground that laid outside the scope of creating a mobile product. They were therefore also given less attention. For example the theme 'Lack of information' referred to the lack of information during the introduction to Pulstavlan. This was not something a design solution would be able to solve, other than by making the product more intuitive. The theme was therefore disregarded from.

Some themes covered responses where the interviewees expressed whether they saw a need for a mobile product that gave the patients more detailed information about their stay. As the majority of the responses mentioned the lack of such a need, this theme was also deemed as being outside the scope, in which the primary focus was to design a product that would favour caregivers rather than patients.

#### **4.7.2 Main issues**

The data analysis resulted in a few main problems the mobile product aims at solving. These problems are a summary of the data and were mentioned by a majority of the interviewed target users. Furthermore, the problems were deemed big enough to limit the use of Pulstavlan, or the efficiency of the patient care.

- **Issue 1:** Distribution of staff resources according to the care strain.
- **Issue 2:** The need of a physical paper list of patients which is carried around by each member of staff.
- **Issue 3:** The handover with information transfer between staff at the end or beginning of a shift.
- **Issue 4:** To get a good overview with regard to the patient flow in and out of the ward.

### 4.7.3 Formulated goals

Based on in total 94 data points sorted into identified themes, the following 33 goals were formulated:

- To be able to choose how much information you wish to see, e.g. examinations.
- To get an overview of bed placings and patient flow.
- To be able to see which bed a new patient will be placed in.
- To be able to visualise more clearly if a patient is going home within a near future.
- To avoid using patient bed lists that require printing.
- To be able to update Pulstavlan without having to go to a computer or the physical board.
- All users should be able to add tags (examinations, procedures etc.), but not several of the same tag.
- To make it intuitive to understand when a task is done/not done and how to mark it as 'done'.
- To make the use of the mobile product intuitive.
- To make export of information or communication with e.g. the municipality easier to facilitate the discharging of patients.
- To avoid double or triple documentation.
- To avoid needing to use an external and local document which only can only be edited from one unit at a time.
- To avoid having to take notes by hand to an individual schedule.
- To be able to look back on the care strain within a given interval to ease the team distributions.
- To be able to see who is working the same shift on the same team.
- To make the patient information support SBAR for an increased overview.
- To be notified when a new patient is admitted so a team can be assigned to the patient.
- To be able to make personal notes.
- To avoid having to add several associated examinations separately, e.g. surgeries and their follow-up controls.
- To avoid having a separate physical paper for daily medical controls.

- To be able to choose which patients you wish to display (either all patients, or those assigned to a team).
- To avoid having to log out from the system/computer every time Pulstavlan is used.
- To make the log-in process easier.
- To get a better overview of when partial tasks have been completed, e.g. when one out of three NEWS controls are completed.
- To facilitate communication between different professions.
- To not oversee a prescribed order by a doctor.
- To increase the staff's desire to use Pulstavlan/additional tools associated with Pulstavlan.
- To ease administrative tasks and decrease the time spent on completing the tasks.
- Staff should be able to have the mobile unit on them so they do not accidentally put it aside and leave it.
- To be able to find out how patients are doing (patient wellness) without having to ask colleagues.
- To not miss when new patients are added into the system.
- To not have to manually click your way to a date far ahead.
- To avoid having to use several separate tools, e.g. a calculator to calculate calorie intake and BMI for a patient.

#### **4.7.4 Formulated functions and function categorisation**

The 33 goals previously described resulted in the 26 functions/needs/demands below. The functions in italics were deemed as partially outside the scope, as they would not be enabled through solely a design. They deal with complex matters, such as patient confidentiality and integration of systems. However, they were included in the design under the assumptions that these functions would be possible to integrate.

| <b>Not necessary</b>  | <b>Necessary</b>   | <b>Desirable</b>  |
|---|--|---|
| A function for patient wellness                                 | <b>Function 1:</b> Easy access to more detailed patient information in a different view from the one with all patients                 | Combined view of patients being admitted to, and discharged from the same bed   |
| <i>Easier way of logging in to the app on the mobile device</i> | <b>Function 2:</b> Being able to change view/layout based on which kind of information and how many patients the user wishes to see    | A function to choose the amount of text or information the user wishes to see   |
| <i>Allowing any user to add new tags</i>                        | <b>Function 3:</b> A handy mobile version with the same information as on the patient bed lists  | <i>Integrating patient records with the mobile version to be able to access e.g. new lab results and medication during patient visits</i> |
|   | <b>Function 4:</b> Intuitive visual feedback when marking an examination as done   | Adding optional examination/tag packages when certain examinations always have other examinations/tags associated with them               |
|   | <b>Function 5:</b> The mobile tool should be able to be used to update Pulstavlan on other units                                       | Staffing information being visible for the same shift and sorted team-wise  |
|   | <b>Function 6:</b> Display of the current care strain for the different teams with a function of being able to view the strain history | The information content of the mobile version should be based on the SBAR model   |

|  |  |  |
|--|--|--|
|  | <b>Function 7:</b> A notification should be received when a new patient is admitted to the ward that signifies that the patient must be assigned a staffing team and a bed | <i>Having a free text field in the mobile tool where e.g. examination preparations can be added</i>  |
|  | <b>Function 8:</b> Possible changed view of how to place the discharge date and exams (as opposed to the current pop-up window)  | Built in function for calculating calorie intake and BMI in the mobile version   |
|  | <b>Function 9:</b> The mobile version's patient view should be able to be filtered and sorted by team  | <i>The mobile version should be individual and not require the user to log out each time the use of the mobile version is discontinued</i> |
|  | <b>Function 10:</b> A function where you can check off parts of a task such as controls taken several times a day  | <i>Messaging function between colleagues to alert them to tasks that need to be done</i>   |
|  | <b>Function 11:</b> The mobile unit fits in the scrubs / work outfits  | Adding tasks to a specific date using a calendar function  |
|  | <b>Function 12:</b> Adding a bedding view as a complement to make the patient overview more intuitive to look at   |  |


**Table 4.1:** Function evaluation

The first of the not necessary functions in Table 4.1, 'A function for patient well-

ness', was deemed not necessary as the condition of admitted patients tends to vary more frequently than caregivers can take notes of their current wellness. Furthermore, the caregivers part of any given patient's team would be familiar with their wellness from caring for them anyway. The second of the not necessary functions, 'Easier way of logging in to the app on the mobile device', was deemed both not necessary and outside the scope, since this function was not relevant for the design of the mobile product. The third not necessary function, 'Allowing any user to add new tags', was also deemed as outside the scope. This function would be more relevant in the product Pulstavlan than in a mobile version as the the administrative settings options are regulated on the bigger screen.

## 4.8 Personas

The three developed personas developed are given below:

|  |   |
|--|---|
| <p><b>Name:</b> Maria Sand<br/> <b>Age:</b> 26<br/> <b>Role:</b> Nurse</p> <p><b>Personal values and interests:</b><br/> Patient care is highly prioritised and the patient is always in focus. Administrative tasks come second.</p> <p><b>Needs:</b><br/> To get an overview of what needs to be done during her shift from the information given in Pulstavlan. To easily see if a task is completed and easily mark it as done. To be able to bring medication/prescription information from the patient records to the patient. To always have patient information available. To easily find out which colleagues she can ask for help if it is needed.</p> <p><b>Limitations:</b><br/> Doesn't want to spend more time than necessary on administrative work, and rather wants to work with patient care. She is relatively new on the ward and hasn't learned all there is to know about routines and how to use the technological tools on the ward yet.</p> <p><b>Goal with product use:</b><br/> To quickly be able to update Pulstavlan without having to leave the patient. Wants to quickly get access to new lab results, medication lists as well as information regarding the patient's planned care. Wants to avoid double documentation and to quickly use the mobile tool without always having to ask for help.</p> <p><b>Scenario for product use:</b><br/> She is with a patient to take a blood sample and to hand out the correct medication, after which the patient asks for their planned care and lab results.</p> |  |
|--|---|

**Name:** Lena Hansson  
**Age:** 54  
**Role:** Head of care unit



**Personal values and interests:**  
Efficient, doesn't care about details.

**Needs:**  
To get a quick overview of the ward situation; who is working during the current shift, find out possible deviations as well as any overworked personnel. Wants the text on the screen to be big enough to read and not appear cluttered.

**Limitations:**  
Prefers efficiency over accuracy. Low patience in regard to new types of technology. Reduced vision over long distances.

**Goal with product use:**  
Wants to quickly see and access information about staff as well as deviations on the ward. Wants to get a good overview of the number of admitted patients.

**Scenario for product use:**  
Going into a meeting with other heads of care units and wants to know the care strain as well as the current over-intake of patients on the ward. Wants to see how the care strain has been over the past week as well as the deviations.

**Name:** Pia Andersson  
**Age:** 43  
**Role:** Ward coordinator/assistant nurse



**Personal values and interests:**  
In need of control; needs to know the general situation for all admitted patients and ward staff. Cares about the wellbeing of staff and wants to make sure no-one is overworked. She is used to working with digital tools in her work.

**Needs:**  
To get a structured overview of the different beds on the ward in regard to who is being discharged and admitted. She needs to quickly find who to contact regarding patient transportation, examination scheduling etc. She wants Pulstavian to be updated more often and to see who is working on the different staff teams. Also want to streamline the ward's administrative tasks to avoid double and triple documentation. To have smooth and continuous contact with the municipality and external resources is important.

**Limitations:**  
Works part-time with patient care and cannot use 100% of her working hours on administrative tasks.

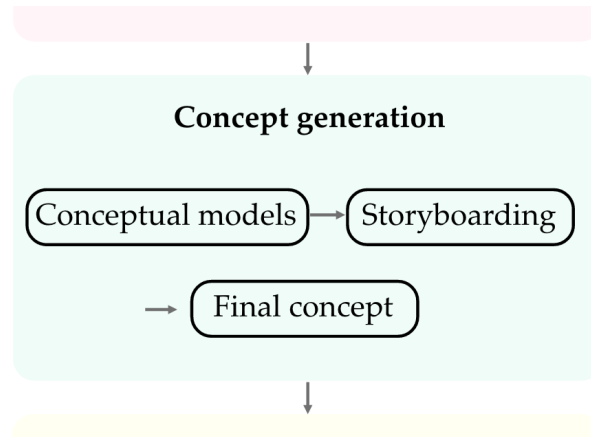
**Goal with product use:**  
Wants to find out if the information on Pulstavian is updated, to see when a patient is going to be discharged and to see who the next patient in the same bed will be. Wants to easily see who is coming to pick the patient up as well as how they can be contacted.

**Scenario for product use:**  
Leads the pulse meetings in the morning and needs to both be able to have access to updated information and to add information that is discussed during the meetings. After the meetings, she makes transportation arrangements for patients and coordinated the admittance and placement of elective patients.

# Chapter 5

## Concept Generation

This chapter covers how four different conceptual models were generated from the needs established in the user study. Each concept is described by a short summary, a mind-map and a storyboard. The chapter also covers the evaluation of these concepts and the development of a final concept, later used for prototyping. In each section, the methods used are described, followed by the results.





## 5.1 Generating concepts

### 5.1.1 Method for concept generation

#### Conceptual models

Before creating prototypes of a product, a conceptual model can be designed to indicate what the function of the system is to users, as opposed to how it appears [35]. This is done to avoid limiting the product design to one of few ideas that might have come up in connection with the data analysis. It is important that the user's idea of the product matches the idea the designer had in mind when designing the system. A conceptual model can be described as the high-level structure of a system, as well as how it works. By designing a conceptual model, the designer has established possible metaphors used in the design to make the system more intuitive to the users. Designing the conceptual model also establishes which functions are included in the product and the relationship between these functions.

Two conceptual models were designed by each author with focus on the relationships between the functions in the system. Each author used a different tool to visualise the concepts, since the authors had different prior experiences of digital tools. The aim was that all functions and needs considered *necessary* were to be covered by each individual concept. The personas were kept in mind to make sure that their needs and goals of the product use also were covered by the conceptual model.

#### Storyboards

Storyboards can be employed in order to help visually communicate a context in which a technology or concept will be used [34]. By illustrating different stories or narratives in form of e.g. scenarios, empathy for the end users can possibly be built. Storyboards may also be used to consider different options of design at early stages of the design process.

For each of the conceptual models, a storyboard was drawn to depict the flow of each concept with regard to a specific task or scenario. The scenario selected covered both how a coordinator would deal with admittance of a new patient and discharge of another. This scenario was chosen since it would be able to include illustrations of a majority of the functions and services considered *necessary* (see

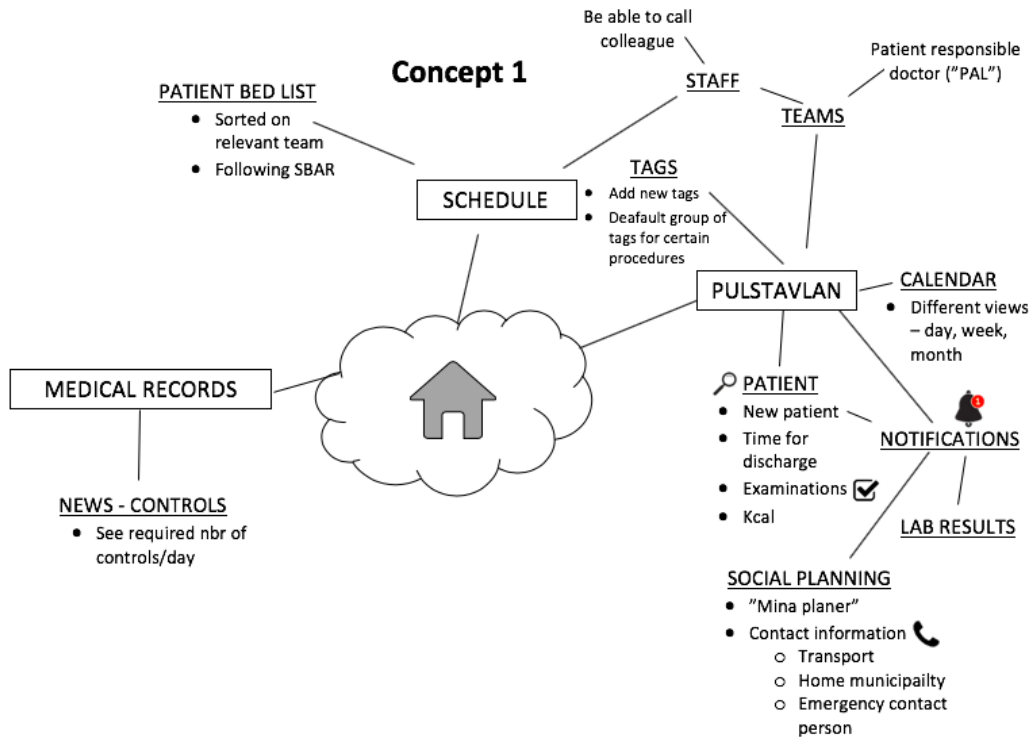
4.1). It was, furthermore, also a frequently reoccurring scenario mentioned as time demanding during the user study.

## **5.1.2 Results**

### **Concepts**

#### *Concept 1*

The first concept has some kind of homepage as base for all other functions and services. There are three main other areas of focus (seen in squared text fields), which in some senses are connected to each other. The lines of the mind map show the relations between the different areas. Pulstavlan should be reachable from the mobile device. However, the view may be altered to improve overview and to fit a smaller screen. In order for the system to feel more familiar for the user, well-known symbols and formats have been included as metaphors. Examples of symbols are shown in the mind map. The majority of the headlines in the mind map can be found in Pulstavlan, or other used systems. The different subconcepts should thus be easily recognised by the user.



**Figure 5.1:** The first concept generated

*Concept 2*

The second concept consists of three views/tabs from which information can be accessed. The main view resembles the current main view of Pulstavlan to allude to a familiar view and ease the use of the mobile version. The focus in the main view is information about patients. It includes functions, such as being able to check off completed tasks and access patient information. The staff view aims at providing information about staff working different shifts and at displaying history of care strain. The third view, the contact view, includes contact information to other wards, examinations, patient relatives and transportation. The main view contains a schedule, which in turn contains the patient beds with patients in them. In other words, each row in the schedule view corresponds to a physical bed on the hospital ward with a patient.

## Concept 2

### Main view

Visible parts:

- Table like structure with admitted patients
- The general care strain (vårdtyngd)
- See the number of currently admitted patients on the ward

Patient information visible in main view:

- Name, personal number, home city, bed number, planned examinations, cause for admittance, planned discharge date

Functions:

- Be able to change to "bed view"
- Check off completed tasks and edit existing ones
- Click a patient to enter the patient view:
  - Add examinations
  - See lab results, medication lists and 'Mina planer'
  - Expand the calendar view to see more days
  - Calculate calories and BMI
  - Find contact information to relatives and for social planning

### Staff view

Visible parts:

- See who is working the same shift

Functions:

- Click to see who will be working during upcoming shifts
- Click to see the care strain over time

### Contact view

Functions:

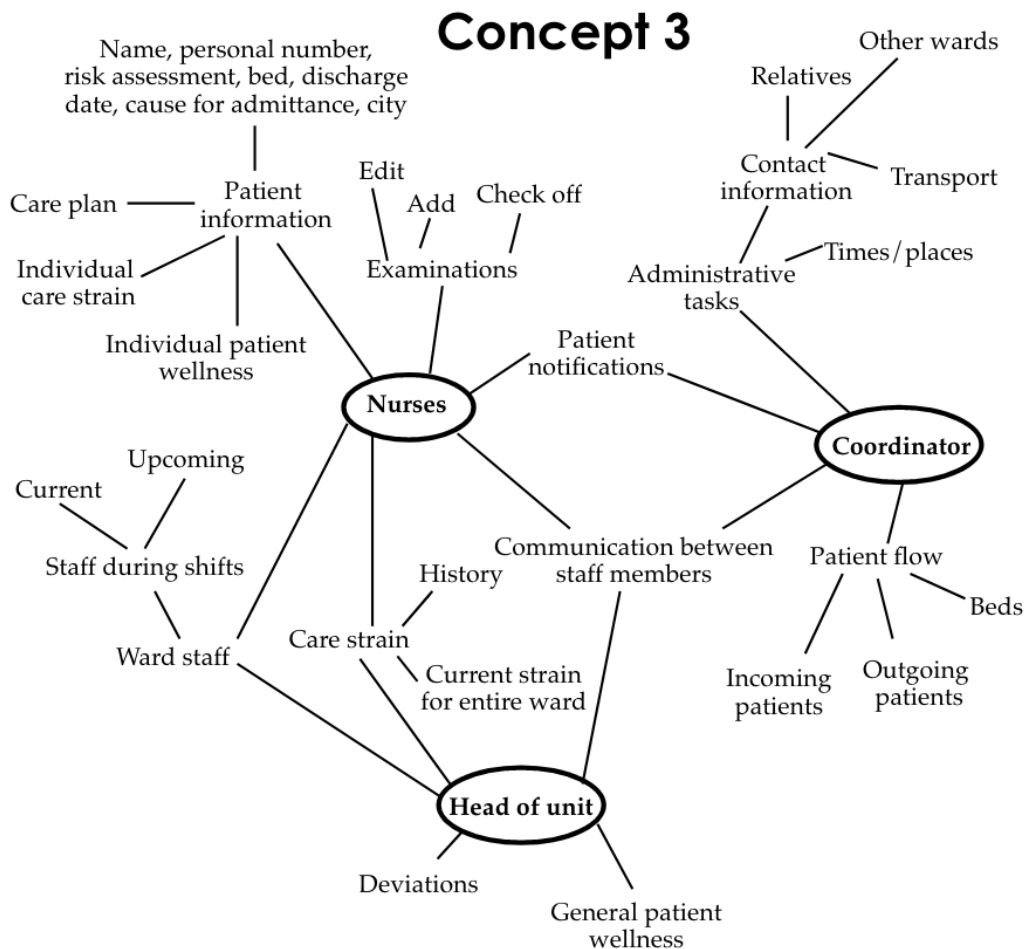
- Be able to contact colleagues
- Be able to call social planners
- Be able to call other wards within the same hospital
- Be able to call and arrange transportation

**Figure 5.2:** The second concept generated

### *Concept 3*

The third concept differs from the previous concepts in the sense that the views are centered around the type of user. Any of the three user views can be used regardless of the user's role to make the varying tasks less time demanding to perform. For example, in the coordinator view, the layout of the patients differs from the nurse view. The purpose of the coordinator role is to have an overview of the patients, with focus on the admittance and discharge time. The metaphor that this

concept builds on is the difference in tasks included in the users' work. This concept reflects the difference through a customisation of the options available from the different user views. The focus here is the patient, but the subinformation varies depending on the user view. For a nurse, the subconcepts include e.g. examinations, whilst the subconcepts for a coordinator might include transportation arrangements.

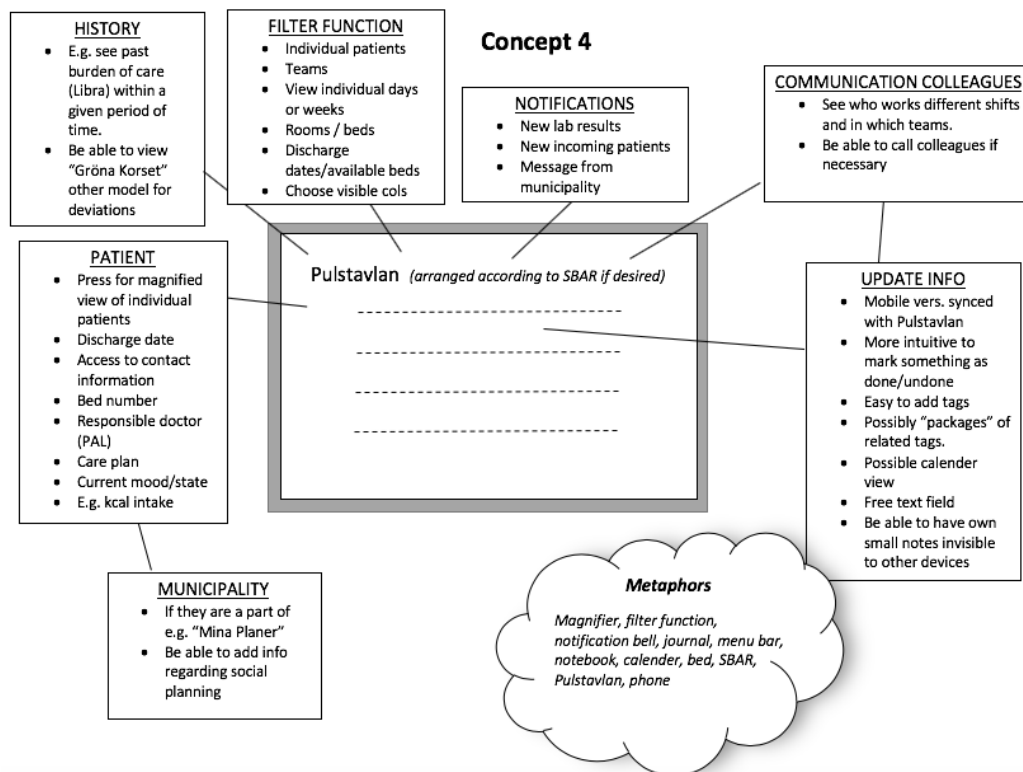


**Figure 5.3:** The third concept generated

#### *Concept 4*

The fourth concept is almost entirely based on the already known structure of Pulstavlan with additional functions and possibilities. The lines coming out of the board in Figure 5.4 all represent functions or information reachable from the

board, which work as the main page. The view of Pulstavlan, however, can be adjusted to fit the preferences of the user. The use of Pulstavlan as base is a metaphor supposed to increase the comfort of users previously familiar with Pulstavlan. It will hopefully also encourage a more frequent use and updating of the information in Pulstavlan. This way, internal communication should be facilitated and multiple executions of the same task avoided. The external communication with municipalities or other units should be more efficient through the use of a notification system.



**Figure 5.4:** The fourth concept generated

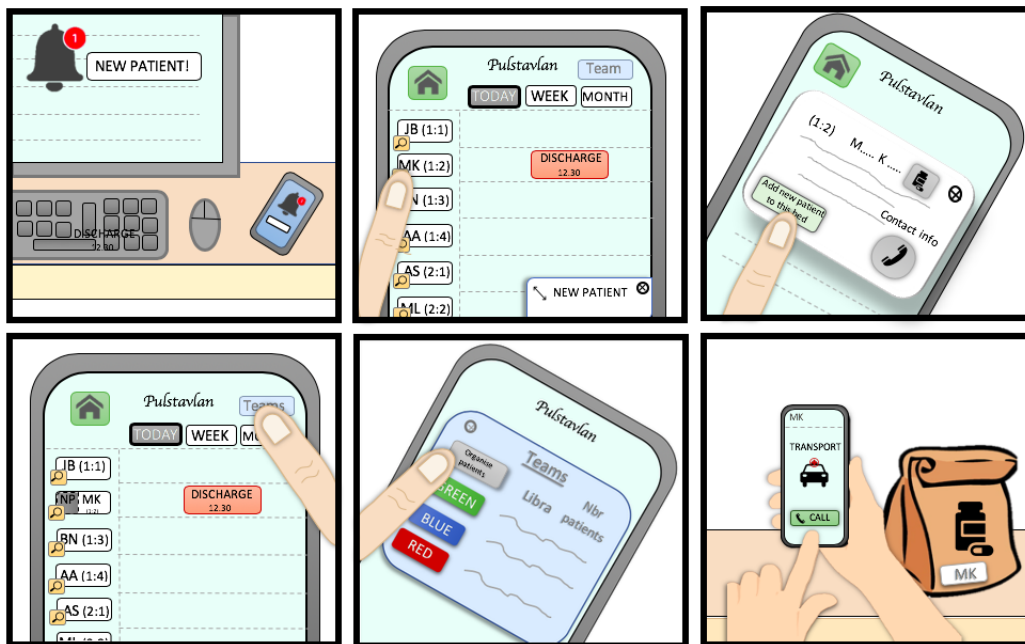
### Storyboards results

The following scenario was basis for the storyboards representing each individual concept:

A coordinator is sitting at her desk when a new patient shows up on both her screen (Pulstavlan) and on the mobile product. The new patient needs to be assigned a team and placed in an available bed. She also needs to know if there are any other patients about to be discharged. If so, who and when. Finally, she needs to see if the patients going home need any transportation, or medication to take with them upon discharge.

### Concept 1

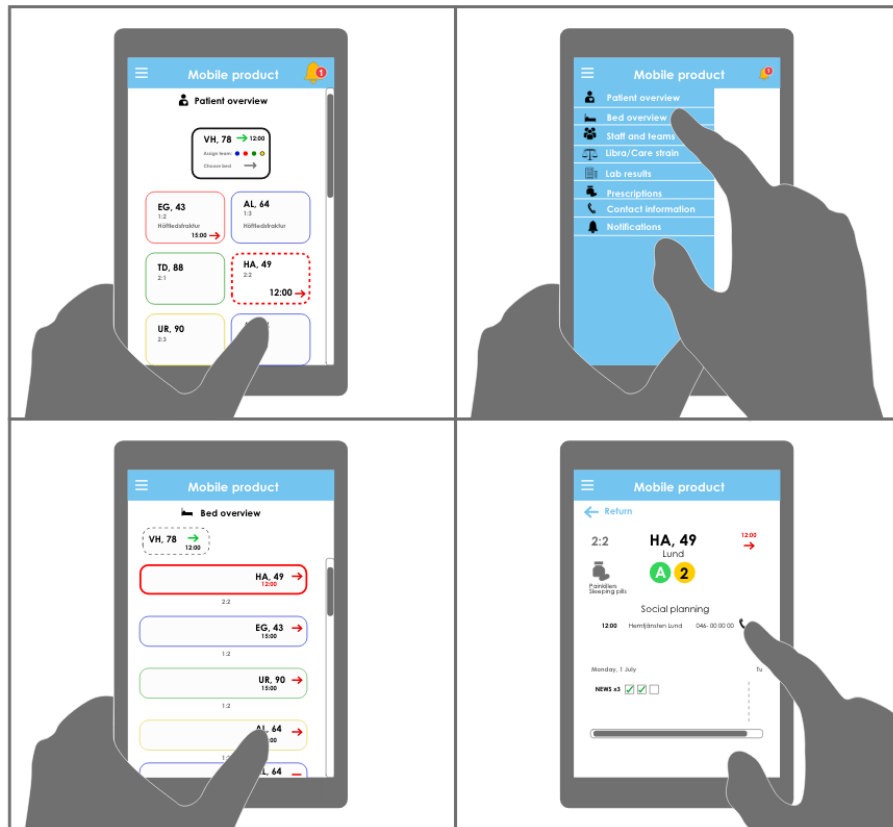
The second picture in Figure 5.5 shows an overview of the admitted patients, similar to Pulstavlan. The new patient remains on the screen until it has been assigned a bed. The coordinator sees that a patient named 'MK' will be discharged that same day and assigns that bed to the new patient. The view of that bed is now shared view between the incoming patient and the one about to be discharged. She checks the current libra and assigns the new patient to an appropriate team. To facilitate the discharge process, it is possible to zoom in on individual patients and to reach contact information to family or municipality, and also information regarding prescriptions etc.



**Figure 5.5:** The storyboard of the first concept.

### Concept 2

The storyboard of the second concept shows a coordinator first entering the main view where all the patients are listed. The new patient is shown at the top of the screen in a field where both team and bed can be assigned. To assign a bed, the coordinator can either go to the main menu and choose the 'Bed overview' option or simply press 'Choose bed' in the field in the first window. When the coordinator has been redirected to the bed view, the best suited options for the new patient are presented at the top. The patient can then be dragged into the correct bed. The coordinator can also click on any patient to get information about the process of their discharge including information about transportation, medications to bring home and what time the patient will leave.



**Figure 5.6:** The storyboard of the second concept.



### Concept 3

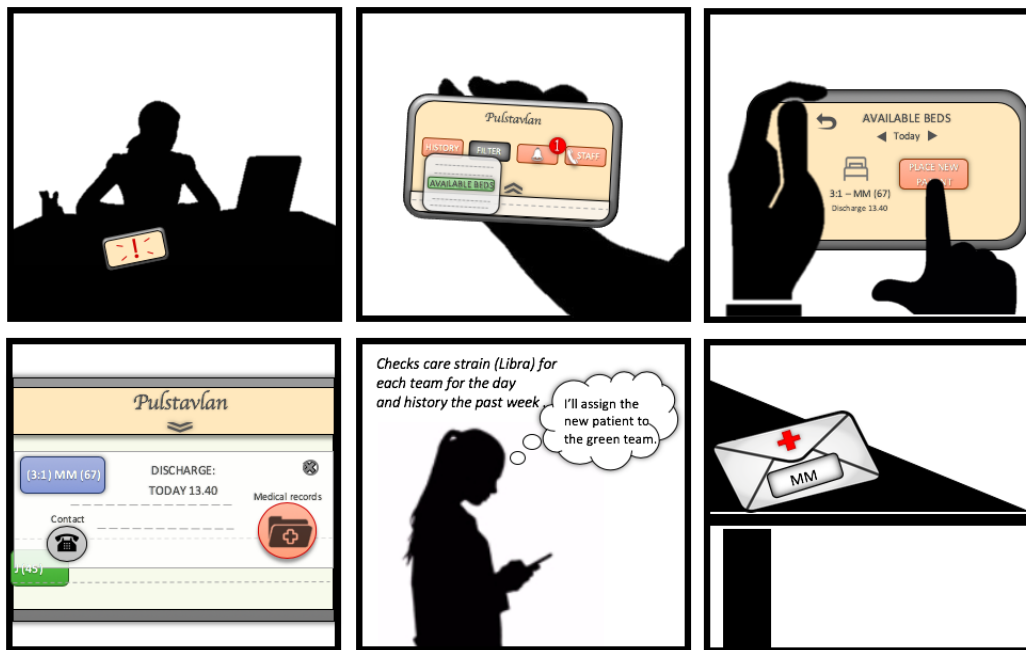
The coordinator receives a notification of a new patient on the ward on both the Pulstavlan screen and on the mobile unit. The patient can from the pop-up window that appears be assigned a team, via the bed view, where all patients are shown according to when they will be discharged. This view is also shown in the right edge of the mobile tool as the 'coordinator view', where the focus is patient overview rather than examinations. The new patient can be dragged to the correct bed. The coordinator can also see more specific information about when the patient will go home, who will pick them up and which medications they need to take with them.



**Figure 5.7:** The storyboard of the third concept.

#### Concept 4

The interface of the fourth concept is preferably seen by holding the device side-ways, as shown by the storyboard. The basis for the concept is, as mentioned, Pulstavlan. There are, however, numerous filtering options to easily be able to e.g. find available beds, as seen in the third picture. The coordinator efficiently assigns the new patient to the soon available bed. This concept also includes a feature for magnifying individual patient info, which preferably is used to facilitate the discharge of 'MM'. In order to assign the new patient to the right team, the coordinator is able to both check the libra of the day, but also statistics during a certain past period of time, making sure that no team is repeatedly carrying a too heavy load of work.



**Figure 5.8:** The storyboard of the fourth concept.

## 5.2 Concept evaluation

The functions categorised as necessary in Table 4.1, and the main issues in Section 4.7.2 were used as a base when evaluating the four concepts and their storyboards with the help of a weighted matrix [34]. Each concept was graded on a scale from 1-3, where 1 indicated that the function was not included the concept, and 3 where it was very well included. This resulted in one of the concepts gaining a higher total score/grade than the other concepts.

### 5.2.1 Results of concept evaluation

| Functions                    | Concept 1 | Concept 2 | Concept 3 | Concept 4 |
|------------------------------|-----------|-----------|-----------|-----------|
| 1. Information access        | 3         | 3         | 3         | 3         |
| 2. Changing layout           | 2         | 2         | 1         | 3         |
| 3. Bed list similarity       | 3         | 3         | 3         | 3         |
| 4. Intuitive feedback        | 1         | 3         | 2         | 1         |
| 5. Pulstavlan compatibility  | 3         | 3         | 3         | 3         |
| 6. Care strain display       | 2         | 1         | 2         | 3         |
| 7. Notifications             | 2         | 3         | 3         | 3         |
| 8. Tag view improvement      | -         | -         | -         | -         |
| 9. Team filtering            | 3         | 3         | 3         | 3         |
| 10. Checking off task parts  | 1         | 2         | 2         | 1         |
| 11. Size of mobile unit      | 3         | 3         | 3         | 3         |
| 12. Bedding view             | 1         | 3         | 3         | 3         |
| <b>Sum/final evaluation:</b> | 24        | 29        | 28        | 31        |

**Table 5.1:** Weighted matrix: Evaluation of concepts based on the necessary functions. The dashes on the row for Function 8 signify that this function was not covered by the depicted scenario and is therefore not relevant to compare (although it is still relevant for the product).

| <b>Main issues</b>           | <b>Concept 1</b> | <b>Concept 2</b> | <b>Concept 3</b> | <b>Concept 4</b> |
|------------------------------|------------------|------------------|------------------|------------------|
| Staffing by care strain      | 3                | 2                | 2                | 3                |
| Physical bed list            | 3                | 3                | 3                | 3                |
| Shift handover               | 3                | 3                | 3                | 3                |
| Ward overview                | 2                | 3                | 3                | 1                |
| <b>Sum/final evaluation:</b> | 11               | 11               | 11               | 10               |

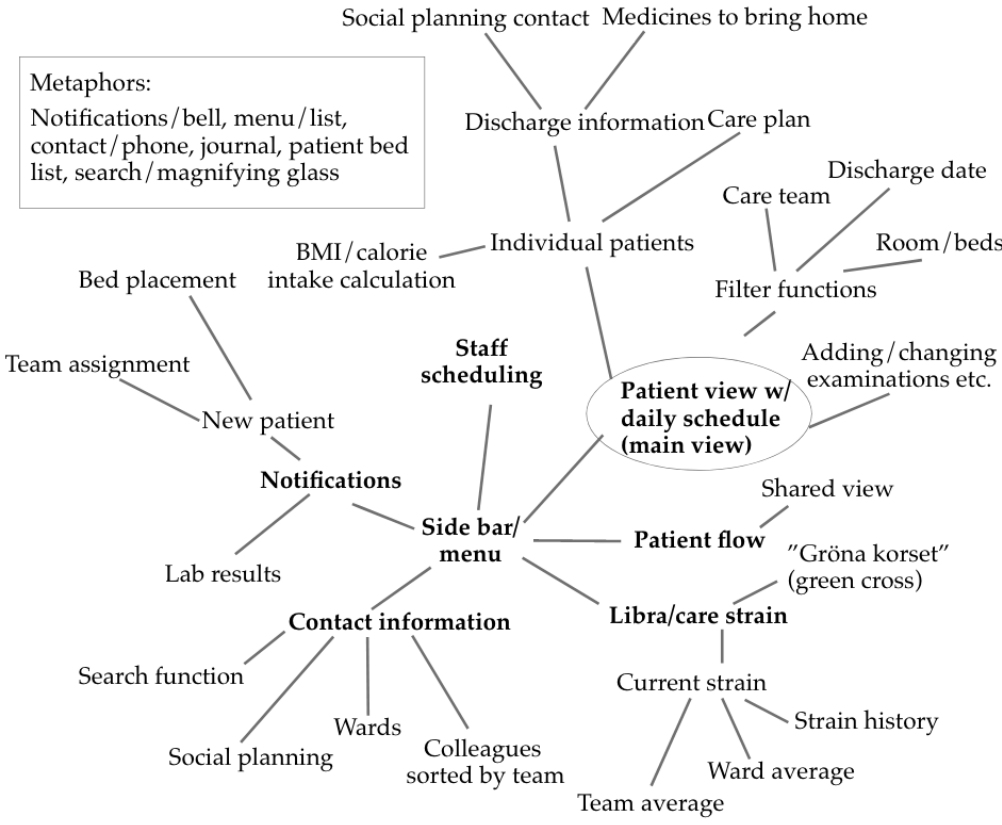
**Table 5.2:** Weighted matrix: Evaluation of concepts based on the four main issues (Section 4.7.2). Main issues 2 and 3 are covered by all concepts equally since they are all mobile versions and thereby ease the handover between shifts and eliminate the need for a physical paper.

## 5.3 Final concept

Since the scores in the weighted matrix of all concepts were quite close to each other, the final concept that was generated by combining the best features from all four concepts, where the fourth (and highest scoring) concept was used as a base. For each of the necessary and desirable functions previously categorised, each concept was gone through. For each function, the feature best corresponding to the function out of all the concepts was chosen to be included in the final version.

### 5.3.1 Final concept result

The main view of the final concept consists of the patient view with daily schedule, i.e. a list view of all admitted patients with examinations during the current day visible. More detailed patient information, such as discharge information and care plan can be seen by clicking the patient and being redirected to a view of only one patient. Through a menu, options such as staff scheduling, notifications, contact information, libra as well as patient flow can be accessed. Patient flow gives an overview of the admitted patients with special regard to the discharge and admittance dates. The concept aims at being intuitive to use and with the possibility of adding/editing examinations to a patient's care plan. The concept also intends to include intuitive ways of checking off completed tasks and in some instances choose the amount of information displayed.

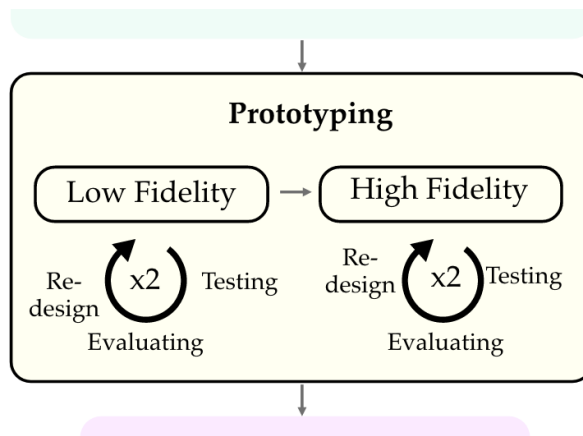


**Figure 5.9:** The final concept generated from the previous four concepts.

# Chapter 6

## Prototyping

This chapter begins with an introduction of the general approach and underlying ideas to both lo-fi and hi-fi prototypes. It is then described how a lo-fi prototype was designed and tested on users to establish the intuitiveness and flow of the mobile product. A hi-fi prototype was later also designed and tested, resulting in the final prototype. Both hi-fi and lo-fi prototypes were developed and tested in two iterations each.



### The effects of Covid-19

In the spring of 2020 when this master's thesis was written, the spread of Covid-19 had affected the ability to visit hospital wards. Overall, the ability to meet with people to test the prototypes was limited due to the virus outbreak and the social

distancing that followed. It was considered a priority to include feedback from target users in the final iteration of the hi-fi prototype as opposed to in an earlier iteration. For this reason, the people that tested the other prototypes were not part of the target group to the same extent as one might have hoped. Furthermore, the number of people who tested the prototypes were not as many as first intended.

## 6.1 Approach

One of the key principles of user-centered design described by Gould and Lewis [27] is the importance of iterative design. This enables the possibility to repeatedly make small adjustments and improvements to the product. To redesign a user interface based on results of user tests could improve the usability of an interface essentially [36]. Nielsen [36] suggests that two iterations should be the minimum of an iterative design process, and that the results of each iteration of tests should determine how to proceed next.

With respect to the limited time frame of this thesis and the prevailing circumstances with Covid-19, it was determined to do two iterations of both lo-fi and hi-fi prototypes and use the below given number of tests per iteration and prototype. Moreover, the number of test persons chosen were also based on research indicating that a majority (about 80 %) of all usability problems can be exposed by four to five test persons [37].

### **Lo-fi prototype**

Iteration 1: 2 test persons

Iteration 2: 3 test persons

### **Hi-fi prototype**

Iteration 1: 5 test persons

Iteration 2: 5 test persons

The main issues (see Section 4.7.2) were used to lay the foundation of how the application was thought to be organised, in terms of different views and menu choices etc. They were the inspiration in the development of all prototypes. As one of the main problems concerned the need for a physical paper list of patients, one of the main goals of the product was to be able to replace this list. When developing the prototypes, the aim was thus to include metaphors and analogies related to the list, in order to allude to the mental models of the target users [38].

The necessary functions listed in Table 4.1 were also used as basis for the functions chosen to be implemented in the prototypes. It was for example, as stated in

the fifth function, considered essential for the information in the mobile product to be fully synced with the information in Pulstavlan, in order to not create an additional and time-demanding moment of documentation.

Norman's principles of design [28] together with the usability goals formulated by Preece et al [25] were kept in mind during the development of all prototypes, along with Fitt's law [25], Hick's law [29] and the Gestalt principles of design [30]. Particular choices of design are described in each lo-fi/hi-fi subsection.

All medical information included in the prototypes was selected randomly from an orthopedics section demo version of Pulstavlan. Other medical specialties may use different choices of displayed columns etc in their Pulstavlan. The terms and abbreviations used for the different 'tags' are written according to how they are generally expressed within the Swedish healthcare system. All patient initials are fictional and there are no real medical accuracy between each cause of admittance and the displayed procedures.

Integration with the patient record system is presumed in the design of the prototypes below. Although no specific information regarding lab results have been included in the application, the integration is presumed to enable notifications of when new lab results are available in the patient record. In other words, a reference to where the lab results can be picked up is included, but not specific information about what the lab result says.

Since it was considered to be outside the scope of this master's thesis to handle user log in and authentication with regard to the Swedish patient data law (PDL [4]), it was in all prototypes decided to use the same system for handling patient data as is Pulstavlan, when it is set in anonymous mode. This means that each patient is represented by their initials and year of birth.

Likewise, one of the desirable functions was that the mobile product should use the SBAR model as a base. However, as the use of SBAR entails using patient data, which the mobile product cannot display with regard to PDL, SBAR could not be incorporated fully. Instead, those parts of the SBAR principle that did not include sensitive patient information were used in the design of the prototypes.



## 6.2 The lo-fi prototype

A lo-fi prototype intends to represent the final product in a simplified version with limited functionality [25]. It is often less time-demanding or expensive than hi-fi prototypes. The lo-fi prototype can be created with simple materials such as pens, paper and cardboard. The benefit of using a lo-fi prototype as part of a design process, is that it can easily be modified, and the general flow can be tested early on in the prototyping process. It is primarily used for exploration of flow and functions rather than specific design features.

### 6.2.1 Iteration 1

#### Creating the lo-fi prototype

The prototype was constructed by designing/drawing different buttons and views in Google Presentations. This was done to enable co-editing by both authors when working from different locations. The different parts drawn were printed and cut out. A piece of cardboard was then cut in the shape of the edge of a smartphone. The cut out parts were assembled in a fashion resembling a smartphone screen and placed inside the cardboard frame. The parts could be moved around depending on how the user would like to scroll.

#### Resulting design of the first iteration of the lo-fi prototype

Figures 6.2 - 6.4 show sample images of the lo-fi prototype used during the first iteration of tests. At this stage of the process, the application had not been given a name. It was therefore simply referred to as 'Mobil produkt' (mobile product). Below are brief descriptions of the intended use of each option in the side menu (see top left in Figure 6.4) followed by motivations to some choices of design. The menu choices for care strain ('*Libra*'), staff schedule ('*Personal/team*'), contact ('*Kontakt*') and settings were not implemented in the lo-fi version, since they were not covered by the testing.

- '*Patienter*' - The main view of the application. All admitted patients are listed in the left column. Their initials, year of birth, home municipality, bed number and cause of admittance are shown. Their planned examinations and procedures etc. are presented in a calendar view in the right column. Beside each planned activity is a check-box to be clicked by the user whenever a task is completed. The planned discharge dates are shown to

the far right of each row. It is possible to scroll in the calendar view to view both future and past dates. In the bottom of the window, there is a button with the option of adding new activities to the calendar. If the field containing a patient's name is pressed, the user is navigated to an individual view, shown to the lower left in Figure 6.3. The square at the top left shows a new planned incoming patient.

- *Individual patient view* - Shows more detailed data, specific to a particular patient.
- *'Avdelningsflöde'* - Shows the currently admitted patients sorted by their upcoming discharge dates (see lower right in Figure 6.4). It also shows a new planned incoming patient in the dashed square. The purpose of this view is for the coordinator in charge of patient flow to have a better overview of where a new patient can be placed depending on the discharge times of other patients.
- *'Libra'* - Supposed to show an overview of how the care strain is divided between different teams, for wards interested in libra.
- *'Personal/team'* - Supposed to show the staff schedule and distribution of staff between the teams.
- *'Kontakt'* - Supposed to show contact information to e.g. other units, municipalities and transports etc.
- *Settings* - Represented by the cogwheel at the bottom left of the menu. The settings are supposed to enable each ward to customize the different views in the application depending on the kind of information relevant for their medical specialty and patient care.
- *Notification centre* - Accessed by pressing on the notification bell to the right on the top bar in each view. Notifications of e.g. new incoming patients and lab results are shown.

### **Design choices in the lo-fi prototype**

During the user survey, it was revealed that the current system used in Pulstavlan to handle tags was not completely understood by all users. The misconceptions were primarily regarding how to mark a task as done (see example in Figure 6.1).

During the observations of users interacting with the board, some did not realise that the tags either needed to be double clicked, or be pressed and then clicked a second time in a 'Mark as done' square, in order to change status. Furthermore, the patient history column, i.e. gathered tags that had not been marked as done from previous days, on some wards took up significant parts of the entire board, since older tags, not marked as done, were too many. This may have been due to insufficient information about the use of Pulstavlan from superiors. However, it was seen as a risk, where some users' lack of knowledge of the system may result in poor communication between colleagues. In the mobile version, it was therefore decided to introduce a new system to mark something as done, related to the way things are marked as done on the lists. Traditional check-boxes were introduced. The intention was to partly allude to the system with physical paper patient lists, but also to make it more intuitive for users not previously familiar with Pulstavlan to mark something as done.



**Figure 6.1:** Appearance of a typical tag seen on Pulstavlan. The filled task to the left is not done and the empty task to the right is done.

The majority of the people participating in the testing had, as mentioned, unfortunately no prior medical experience, or experience of using Pulstavlan. Extra thought was thus put in to the design theory described in Section 2.5 in order to create an as intuitive interface as possible. Below are examples of thoughts behind different principles of design applied to the lo-fi prototype.

The affordance of the buttons in the top menu bar was signified by the use of common symbols, like the hamburger menu and notification bell, familiar to users from other applications, such as social media. In order to give the user a hint of what to expect when pressing the different options in the side menu, additional symbols were used to enhance the meaning of the associated text [28]. The ability to work with shadowing of buttons in order to signify that they could be pressed is somewhat limited when creating lo-fi prototypes. However, the shapes of the buttons with rounded corners were intended to add to that perception. To signify the purpose of the check-boxes, a check mark was added from the beginning to some of the squares to suggest their intended purpose.

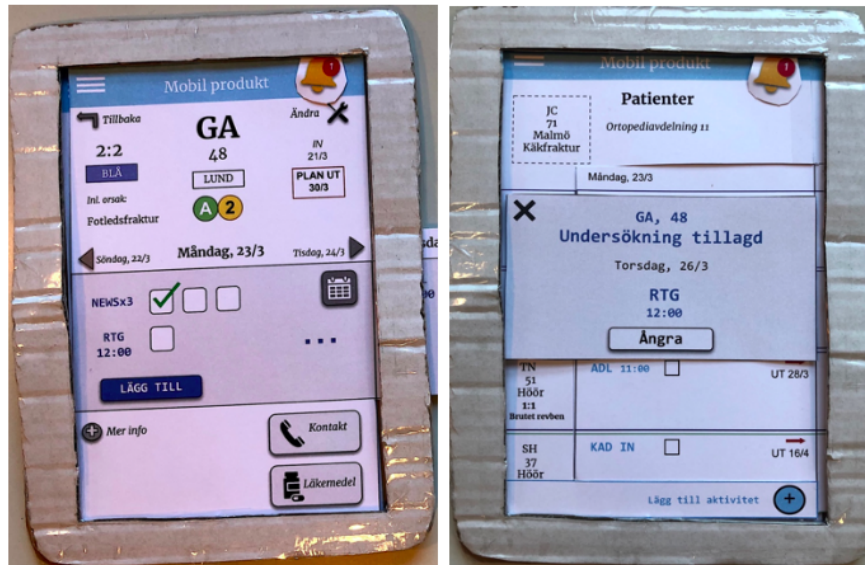
In order to create an interface considered safe to use, thought was put into the

visibility and constraints of the system [25][28]. A major aspect of the safety of a system is the prevention of the user carrying out unwanted actions unintentionally [25]. The amount of information shown in e.g. the general patient view needed to be limited. The user needs to maintain an overview of the most important information regarding all patients, but also not to mix different patients up and possibly expose them to risks. The majority of the possible actions related to more specific individual patient information were therefore placed in the individual patient view. The elements needed to be interacted with to achieve desired tasks were placed visibly, in order for the user to easily figure out where to press next [28]. The check-boxes were aligned and grouped together according to the Gestalt principles of proximity and similarity [30].

Another important aspect in order to avoid mistakes on behalf of users, was the introduction of feedback in the system. Feedback needs to be immediate and informative, to avoid causing frustration on behalf of the user [28]. Immediate feedback was given, for instance by a check mark in the check-boxes when something was marked as done. To add to the sense of safety, all actions related to patient data were provided with a feedback pop-up window and the option to undo the operation [25]. Example can be seen in Figure 6.3.



**Figure 6.2:** First version of the lo-fi prototype. Main view of the patients on the ward ('Patienter').

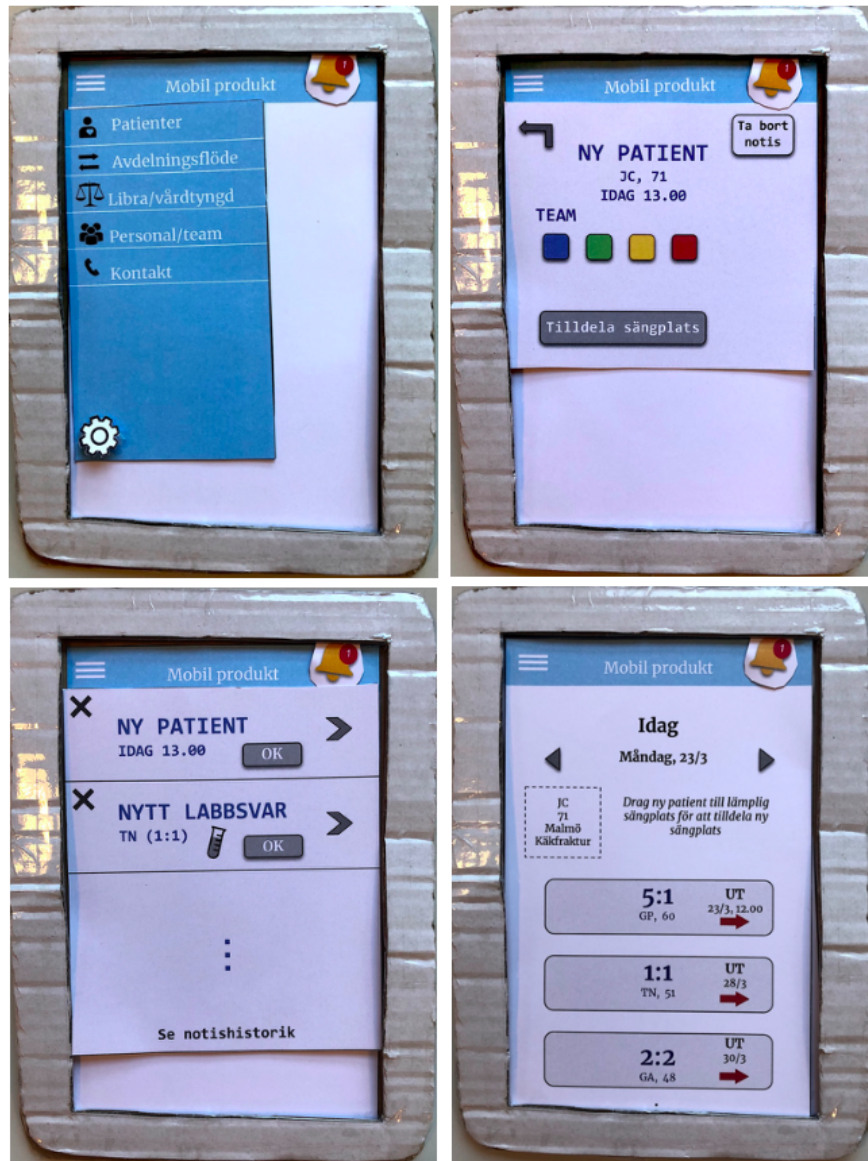


**Figure 6.3:** First version of the lo-fi prototype. *Left:* Individual patient view. *Right:* Pop-up window giving feedback that an examination has been added.

### Testing the first iteration of the lo-fi prototype

The prototype was during the first iteration tested on two students, not part of the target group of the mobile product. It was assumed that the testing of the intuitiveness and flow did not require end users from the target group to give valuable results. The participants were asked to tell their thought process while performing the different scenario-related tasks ('think-aloud protocol' [34]). After the test was done, they were asked to describe their general experience of using the product. Notes were taken throughout the testing process.

Three scenarios were constructed for the testing. They were deliberately chosen to focus on other parts of the interaction than the previously presented storyboards (see Section 5.1.2). The inspiration and background to the chosen scenarios were derived from typical scenarios described in the interviews during the user survey. The main aspects intended to be covered were how the prototype addresses the need of overview of patient flow and the need of a physical paper list of patients. These were two of the main identified issues previously described in Section 4.7.2. The three scenarios were the following:



**Figure 6.4:** First version of the lo-fi prototype. *Top left:* Side menu bar. *Top right:* New patient notification. *Lower left:* Notification centre. *Lower right:* Overview of the bed placings on the ward sorted on discharge dates.

- A patient, (named PR), asks you as a nurse what their schedule looks like two days from now (Wednesday). The patient in questions is planning on

*having a relative visit them and wants to know which time they can come.*

- *You as a nurse want to know if all daily controls (so called NEWS controls) have been done for a certain patient, (named GA), for today. If not, you would like to do the next control that is scheduled to be done and mark it as completed. You would also like to add an X-ray examination at 12 p.m. on Thursday.*
- *As a coordinator, you have been notified that a new patient has been admitted to the ward, but has not yet been assigned to a bed. Assign the patient to an appropriate bed.*

Table 6.1 shows which of the necessary functions in Table 4.1 that are covered by each scenario.

| Scenario | Necessary functions   |
|----------|---|
| 1        | 1. Information access, 3. Bed list similarity   |
| 2        | 1. Information access, 3. Bed list similarity, 4. Intuitive feedback, 8. Tag view improvement, 10. Checking off tasks |
| 3        | 7. Notifications, 12. Bedding view  |

**Table 6.1:** Relationships between scenarios and necessary functions.

### Results of testing the first iteration of the lo-fi prototype

*Scenario 1:* Both found the first scenario easy to complete. Feedback included confusion as to what the red arrows indicating discharge times for the patients really meant.

*Scenario 2:* The ability to click in to the individual patient view from the patient list was not intuitive. The first person searched for the option to choose specific dates and times for the added activities, to avoid first having to click or swipe to the correct date first. The second person expressed that the name 'Avdelningsflöde' (ward flow) in the menu was misleading. This person had no prior experience of using the term flow in terms of patients coming in and out of the ward. They therefore made the mistake of clicking on 'Avdelningsflöde' to find the controls and examinations. Both test persons found the marking of completed tasks intuitive and natural. The second person also minimised the window with activities

that popped up before swiping to the correct day and then expanding the window again. The large size of the window gave rise to a feeling of being in the way when scrolling between the dates.

*Scenario 3:* Both test persons understood the notification symbol, but expressed that the 'OK' button in the notification centre and the 'x' were interpreted as meaning the same thing and thereby finding one of the buttons unnecessary. The box containing the new patient in the bed overview was missed, as they did not understand the function of the box and, therefore, did not interact with it.

*Summary of findings:*

- Consistency in the interface was not achieved with regard to the elements used to change days and add activities to the calendar [28]. There were inconsistencies comparing the individual patient view to the overview of all patients. This resulted in confusion with respect to the meaning of the arrows indicating discharge dates.
- The option to press the patient column in order to reach the individual patient view was not signified enough [28].
- There was no possibility to add new activities to the calendar without first having to scroll to the correct date. This contradicted the usability goal of the product being efficient to use [25].
- The 'check-box system' seemed intuitive.
- In order to help the user understand the interface, the designer needs to provide clues that signify meaningful information [28]. The name 'Avdelningsflöde' was misleading and the intended system to place a new patient on an available bed was not communicated clearly enough.
- The use of a notification bell was considered intuitive. However, to use both an 'OK' button and an 'x' on the notifications was unnecessary and somewhat confusing.



## 6.2.2 Iteration 2

### Changes from previous iteration

The following changes were made to the lo-fi prototype before the second iteration of tests. The lo-fi prototype was re-designed into a second version, which was printed and cut out. The changes are sorted by to which view they were made:

#### *'Patienter'*

- The red arrow indicating discharge date was changed to a symbol of a hospital with an exit arrow. This was done to clarify the meaning of the date, and to remove the perception that the red arrows afforded scrolling in the calendar [28].
- Arrows to signify the option to scroll in the calendar, like in the individual patient view, were added to this view as well. This was done to improve the consistency of the interface [28].
- The left column was shadowed and given a V arrow to signify that it could be pressed, and increase the affordance to push [28]. The patient squares were also given colours to show which team they were assigned.
- Small plus signs were added to each patient row to signify to which patient a new activity was added [28]. The 'Lägg till aktivitet' button at the bottom of the screen was removed.
- The possibility to filter patients by team was added. This was done to include Function 2 in Table 4.1, which was forgotten during the first iteration.

#### *'Avdelningsflöde'*

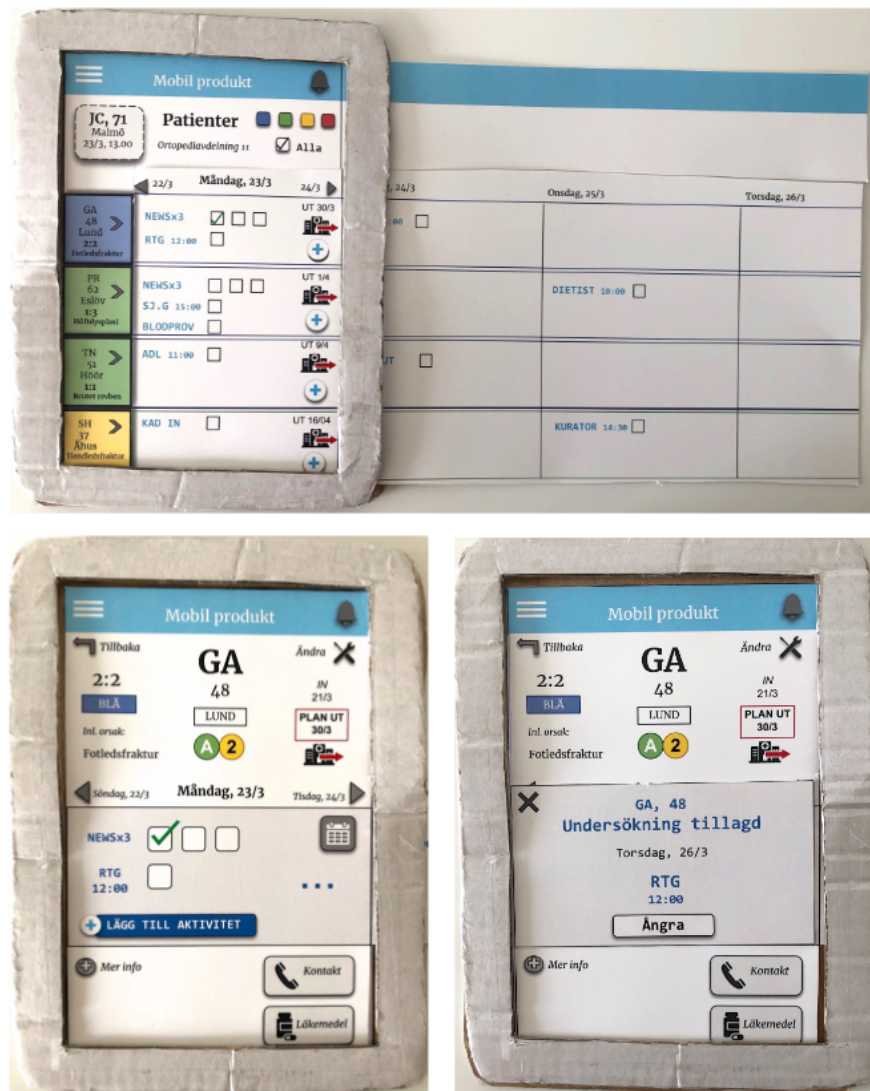
- The name of the patient going home the current day was placed to the right. Patients being discharged later were kept in the middle, with regard to the Gestalt principle of similarity [30]. There was also an empty dashed square created, signifying that a new patient could be placed on that bed [28]. See lower right in Figure 6.6.
- The name of the view was replaced with 'Sängöversikt'.

#### *Notification centre*

- A 'Remind me later' button was added to the notifications. The 'OK' button was removed, in accordance with Hick's law [29].

## Resulting design of the second iteration of the lo-fi prototype

Figures 6.5 and 6.6 show the results of the design of the revised lo-fi prototype, used during the second iteration of tests.



**Figure 6.5:** Second version of the lo-fi prototype. The pictures are displaying the same views and functions as in Figure 6.2 and 6.3.



**Figure 6.6:** Second version of the lo-fi prototype. The pictures are displaying the same views and functions as in Figure 6.4.

### **Testing the second iteration of the lo-fi prototype**

During the second test iteration of the lo-fi prototype, three people tested the prototype. These people were students and not part of the target group. The testing was conducted in the same manner as the first iteration. The test results were noted with the intention of being used in the hi-fi design.

The previously mentioned scenarios were kept the same with the exception of the third scenario, where the task of assigning the patient to a staff team (the yellow team) was added. This was done to involve and assess the intuitiveness of the color bar of teams. It would also include an assessment of the second function among the necessary functions in Table 4.1.

### **Results of testing the second iteration of the lo-fi prototype**

*Scenario 1:* One person chose to click the patient box and enter the individual view to go to the correct day. The other two clicked their way to the correct day in the 'Patienter' view using the arrows next to today's date.

*Scenario 2:* The first person quickly understood how to mark the tasks as completed in the patient overview. The second and third test person performed the task in a very similar manner. However, the second test person thought that clicking an already added task in the schedule would give more detailed information about the activity, such as at what time it is scheduled to take place. One person hesitated when clicking down the feedback pop-up window afraid that the 'x' would cancel the action.

*Scenario 3:* The notification symbol was intuitive and clicked by all to get more information about the notification. All test persons checked the appropriate box to assign team. The bed placement was also done successfully by all. The colour system of the teams was not clear to a layman and was instead interpreted as different wards. It was, furthermore, not completely clear that the 'View all teams' button in the 'Patienter' view belonged to the other coloured buttons, since it was not mapped to them in the same manner [28]. The way the buttons appeared in the notifications centre was preferable. A suggestion was to also make the 'View all teams' button checkered with all the team colours instead of white.

*Summary of findings:*

- The arrows above the calendar views seemed to be interpreted correctly in comparison to previous iteration. It was considered a matter of personal preference to use the calendar in the individual patient view over the one with all patients to look something up.
- The system to add new activities to the calendar was still not totally clear to all test persons. The plus signs on each patient row did not afford to be pushed in order to add something [28]. They were also inconsistencies in the intended ways of adding new activities in the 'Patienter' view, relative to the individual patient view.
- The format of the text next to the tags signified, wrongfully, that it could be pressed [28].
- The new way to place a new patient in an available bed seemed more intuitive. The dashed rectangles signified that the new patient is supposed to be dragged into the empty square (bed). It also constrained the number of other possible actions related to the specific task [28].
- Having two buttons visible to perform the same action, primarily caused distraction [28]. One option should preferably be removed with respect to Hick's law [29].
- The filtering function by team in the 'Patienter' view should be revised. The mapping of the buttons raised concerns about their true meaning in relation to each other [28]. Furthermore, with respect to the Gestalt principles of proximity and similarity, they should be aligned [30]. The consistency, would also increase if the filtering bar had the same appearance in all views [28].

### **6.2.3 Feedback on lo-fi design from Stretch Care AB**

An online meeting was held with the supervisors from Stretch Care AB. The focus was to discuss how the healthcare profession differs from other professions, as consequences of errors may affect patients' safety and health. In previous prototypes, the user could assign a bed to a patient directly in the application. However, as the supervisors pointed out during this meeting, the bed assignment is currently done directly in the medical records system and not in Pulstavlan. Therefore, the

actions of placing a patient in a bed in the application would not be synced with other digital tools in the hospital. It should preferably be removed in the application to not mislead caregivers into thinking it has been changed elsewhere. Instead, this function was limited to a decision support function, which simply displayed the most appropriate options of beds, but without the function of placing a patient.

Another viewpoint that Stretch Care AB provided was that the reason why the daily controls (such as NEWS-controls, not e.g. surgeries or X-ray) in Pulstavlan could not be marked as completed. This would mean double documentation for the staff, since they need to take notes of the results of the controls into the patient chart. There is thus no need for the marking of individual parts of NEWS-controls in the application as well. Consequently, the necessary Function 10 in Table 4.1 - 'A function where you can check off parts of a task such as controls taken several times a day', was in fact not necessary. For this reason this function was not taken into account into the hi-fi design.

## **6.3 The hi-fi prototype**

A hi-fi prototype can be designed to resemble the final product. It often has more functionality than the lo-fi prototype [25]. Furthermore, the hi-fi prototype enables users to interact with the prototype in a similar manner to how they would interact with the final product and can be used to explore and test how the final product will work.

### **6.3.1 Feedback from lo-fi tests to include into the hi-fi prototype**

The following list contains a summary of both issues and positive aspects discovered during testing of the lo-fi prototypes that were considered most important to include in the hi-fi prototypes.

#### *Issues*

##### *– Colours*

Highly saturated colours can strain the eyes and affect the ability to perceive details [39]. To colour the entire patient column in different team colours

made the overview a bit cluttered to some. The red arrows indicating a discharge also stood out, and were misinterpreted as scrolling arrows. A suggestion was to instead introduce the same system for showing team colours as in Pulstavlan, a coloured bar to the left in each patient square (see to the right in Figure 6.7). The symbols for discharge dates were removed and the date instead placed in the left patient column to group similar information together [30]. By introducing these changes, the 'Patienter' view would be more similar Pulstavlan. The aim was that the mental models of users previously familiar with Pulstavlan would help them predict how they should operate the system [38].

– *Adding new activities to the calendar*

The function for adding new activities to the calendar was never fully grasped during the tests. The plus signs on each row may have been too small, and the lack of associated text instead afforded magnification [28]. Harley [40] implies that all icons need text labels to clarify their meaning. Furthermore, the pop-up window showing the different possible activities to add, and selection of date and time (unfortunately not seen in any images of the lo-fi prototypes) was not completely understood either. In the first hi-fi prototype, it was instead proposed to use a familiar way of setting time and dates from other mobile applications. A vertical scroll calendar (seen to the right in Figure 6.8) was introduced. Finally, the moving of the discharge dates was supposed to increase the visibility of the plus signs, and thereby hopefully signify their intended purpose [28].

– *Misinterpretations of medical information, e.g. patient related data*

A reoccurring thought during both test iterations was whether the cause of some misinterpretations made, was due to inappropriate choices of design, or the fact that the test persons had no previous medical experience. For instance, the bed placement scenario was something completely new to the test persons, relative to e.g. a coordinator. To delimit the possibility of poorly displayed medical information in the hi-fi version, it was decided to consult medical professionals regarding how it is preferably presented.

– *Displaying new patients*

It was not clear to all, that JC, 71 in the top left corner was a new incoming patient. The reason may yet again be due to lack of medical practice. However, possible scenarios of having multiple new incoming patients also

ended in the realisation, that the current way of displaying new patients would not be manageable further on, with respect to visibility [28]. Instead, it was decided to proceed with a similar system like Pulstavlan had to display new patients, at the bottom of the patient list. The worry that these patients might be missed by users, was still considered to be addressed by the use of notifications.

#### *Positive aspects*

##### + *Check-boxes*

The affordance of the check-box system seemed intuitive to all test persons [28].

##### + *Individual patient view and overview of all patients*

The division into one general view showing essential patient information for all patients, together with the possibility to click in to a particular patient to show more specific information, seemed to be an arrangement clear to everyone.

##### + *Notification centre*

The concept of having a centre for notifications seemed to be clear to all test persons. The layout was familiar to them, as it was related to the notifications of e.g. social media.

### **6.3.2 General design decisions before the iterations**

Before the first iteration of the hi-fi design, it was decided to use the screen size of an Android smartphone (360x640 px). It was considered to be the most likely phone hospital wards would use, according to a contact via Stretch Care AB. Furthermore, it covered the necessary function of the mobile unit fitting into the scrubs (Function 11, Table 4.1). After having researched different appropriate design tools, the program Adobe XD was chosen. It was considered easily accessible, free and also enabled simultaneous co-editing. The authors had prior experience of using the program, which made this design tool the more appealing choice. Additionally, screen dimensions could be chosen to match existing products, such as Android smartphones. Design limitations that using Adobe XD entailed were e.g. inabilities to zoom in on different areas of the screen and to drag objects across the screen. There were also limitations in terms of the ability provide feedback in form of for instance sounds or vibrations.



### 6.3.3 Iteration 1

Based on the feedback received during the second lo-fi iteration as well as from Stretch Care AB, the first hi-fi prototype was designed in Adobe XD.

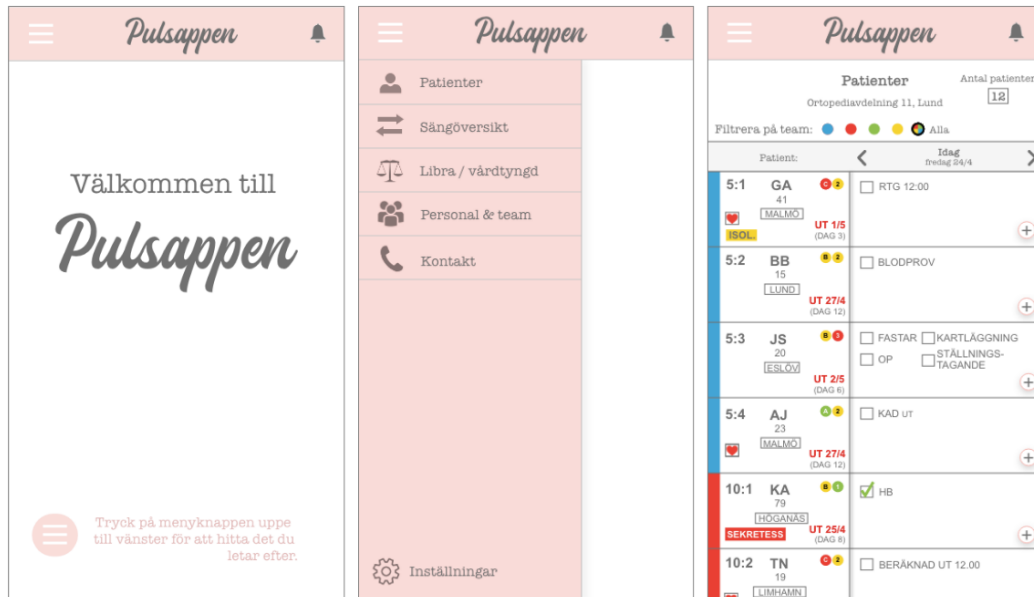
#### Resulting design of the first hi-fi prototype

Figures 6.7 - 6.10 show sample images of the first hi-fi prototype. The purpose of each view was very similar to the descriptions in Section 6.2.1. It is therefore below only expressed if there was a significant change to a view previously described, or if something new was added.

- *Welcome page* - A welcome page was added to introduce the user to the app and the menu button. It is shown when logging in to the app. See left in Figure 6.7.
- *'Patienter'* - The information in the patients column is now inspired by the same information shown on Pulstavlan. It is now also possible to see the individual patient libra, and the current time period of admittance. To add new activities to the calendar, there are small plus signs on each patient row.
- *Individual patient view* - The headlines 'Risk', 'Historik' and 'Social planering' are retrieved from Pulstavlan and may be changed depending on preference. When clicking on them, information is shown. When adding a new activity to the calendar, a traditional vertical scroll calendar is used to easily set a time and date for a planned activity. The phones next to each checkbox item indicate that it is possible to call the relevant unit, simply by pressing the phones.
- *'Sängöversikt'* - It is no longer possible to assign a new patient to a bed. The purpose of the view is primarily to act as a support for the decision.
- *'Libra'* - It is now also possible to view history of how the care strain has been distributed between the teams over a certain period of time.

#### Design choices in the hi-fi prototype

The application name was decided. The resemblance between the existing product Pulstavlan and the mobile tool was signified by the word 'pulse' in the name

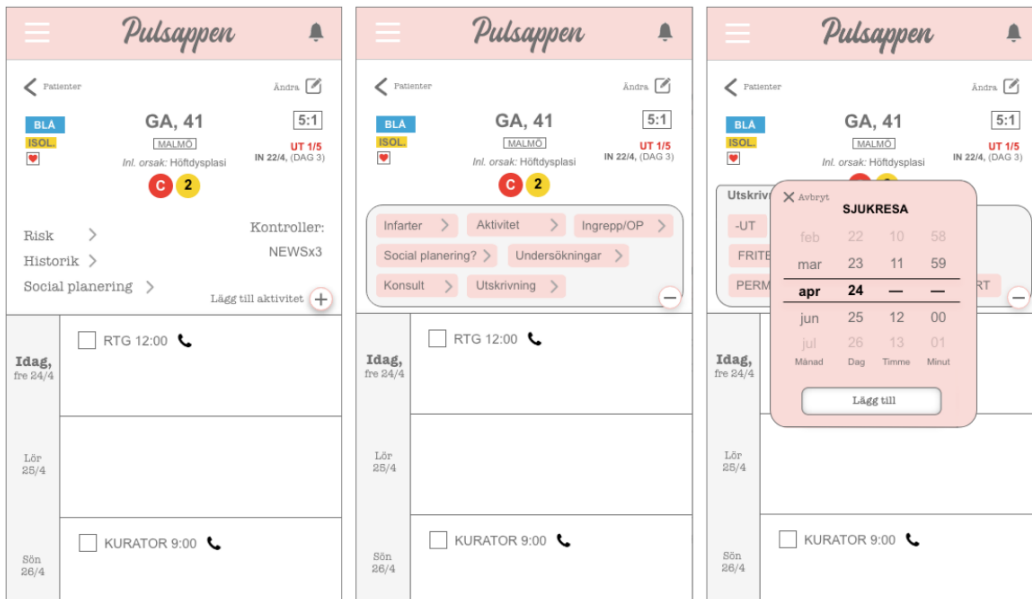


**Figure 6.7:** Left: Welcome page. Centre: Menu bar. Right: 'Patienter' - patients overview.

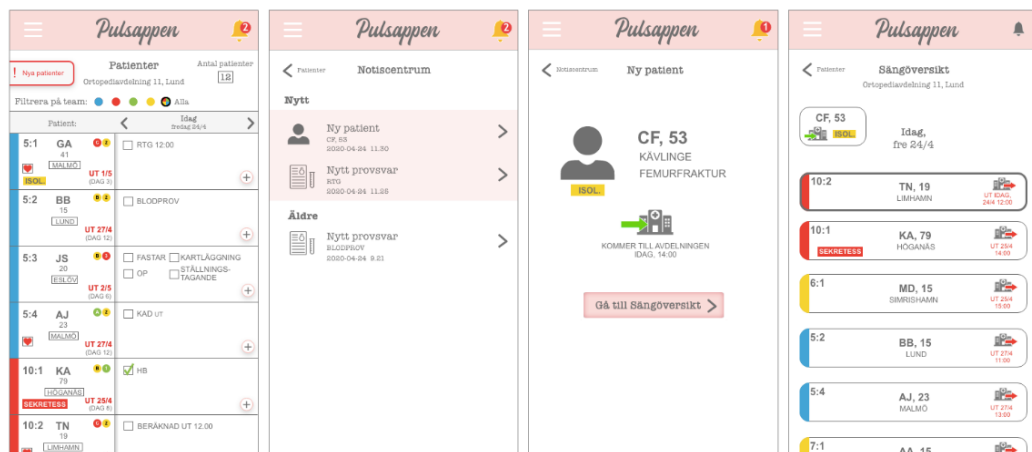
'Pulsappen' (eng. translation 'The Pulse App').

The mix of multiple colours with high saturation in Pulstavlan had been expressed as appearing cluttered by some interviewees in the initial data collection. When having *visual balance* in an interface, all elements appear as strong (or weak) to the user [39]. In the hope to increase the feeling of visual balance, the colours used in the mobile application were chosen to be more pleasant and soft to look at. The colour scheme included pastel colours such as pale pink and a light nuance of grey as the base colour of the application.

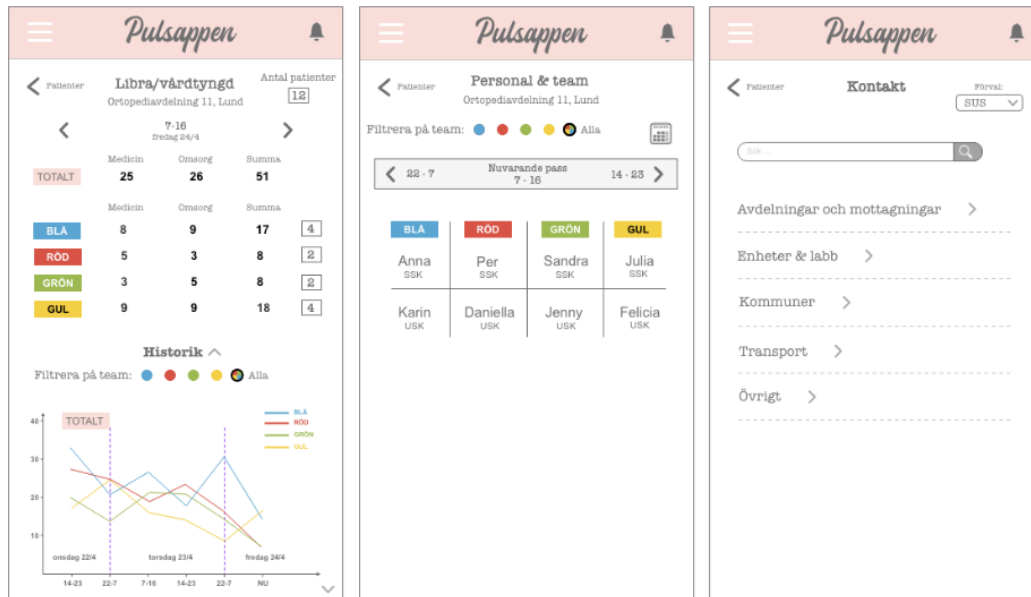
Three different text fonts were included in the design. The intention with the use of different fonts for different information was to improve the visibility and consistency of the interface [28]. The first font was only applied to the application name 'Pulsappen', in order to separate it from the rest of the text, and to add a personal touch to the design. The second font was used on all text, not related to the information found in Pulstavlan, such as menu options. The last font was used for e.g. all tags and patient related information. This font was considered to be extra plain, simple and easy to read.



**Figure 6.8:** *Left:* Individual patient view. *Centre:* Appearance of the bar when pressing the plus sign to add new activity. *Right:* How to select time and date for an activity.



**Figure 6.9:** *Left:* How the 'Patienter' view looks when there is a notification of new patients. *Centre images:* The notification centre (left) and view when pressing the new patient (right). *Right:* 'Sängöversikt'



**Figure 6.10:** *Left:* 'Libra' with possibility to view history. *Centre:* 'Personal & team' - staff schedule. *Right:* 'Kontakt' - external contact information of interest.

The overview of all patients ('Patienter') was, as mentioned, thought to be the main view of the application. To signify the option to easily navigate back to this view, a V arrow turned left and an additional text was added to the top left corner of all other views. The view could also be accessed by pressing the top headline 'Pulsappen'. Generally, to apply consistency to the system, right V arrows were used to signify the view of more information, and left V arrows were used to signify going backward to the previous view. Having two aligned V arrows pointing in each direction signified the affordance to scroll in the different calendar views [28].

The care strain view ('Libra') was designed to include analogies to how care strain was presented in Pulstavlan. This was once again thought to allude to the mental model most users already have from using Pulstavlan [38]. In order to increase the visibility, and constrain the amount of information shown at the same time, a V arrow was added next to the history headline. This signified that it could be pressed in order to view the history graphs [28]. The x-axes of the history graphs displayed time, divided into working shifts.

Since the current version of Pulstavlan did not include the function of staff scheduling, there was no model in particular to allude to. However, the view for the staff schedule was inspired by the appearance of a physical paper schedule for nurses, seen when visiting a ward during the user study. Staff working the current shift were displayed in a one-row table with one column for each of the teams. To view different shifts, side arrows were to be pushed to move forward or backward.

The contact view included frequently needed phone numbers, such as numbers to other units, labs or municipalities. Since knowledge of the correct terms and categorisation of information was lacking on behalf of the authors, example names of categories were used. The categories were arranged alphabetically and separated by thin dashed lines to increase the overview and visibility [28]. To the right of each category, a right V arrow was placed to signify that the arrow could be pressed to view all contacts related to that category. A search text field was included at the top to increase the efficiency when searching for a particular contact. Both text and a magnifying glass icon were added to signify the purpose of the text field [28].

As mentioned in the description of the lo-fi prototype, shadowed buttons with rounded edges signified the affordance to push. This was applied in the hi-fi prototype as well. Furthermore, the buttons in the filtering by teams panel were aligned and mapped to the filtering function. The filtering buttons were circle shaped, like radio buttons, to constrain the option to select multiple teams at the time [41]. Additionally, feedback, in form of a bold circle around the selected button, was given to make the user was aware of the option chosen [28].

A pop-up panel was used to add new activities to the calendar [42]. This enabled the ability to still maintain overview of the calendar, while adding new activities. In order to signify the option to minimise the window again, the plus sign was changed in to a minus sign once pressed [28]. The vertical scroll calendar was considered an efficient way of setting time and date for an activity.

### **Testing the first iteration of the hi-fi prototype**

The first iteration of the hi-fi prototype was tested on five people between the ages of 20-55, not part of the target group. They were asked to complete a series of tasks/scenarios using the prototype, which was opened in a web reader. Think-aloud protocols were once again applied, and notes were taken [34]. At the end

of each test session, the test person was asked about their general thoughts and impressions of the design.

The test scenarios were similar to the scenarios from the lo-fi prototype. However, as the hi-fi prototype was more detailed and included more implemented functions than the lo-fi prototype, the scenarios were formulated to reflect this. The purpose of testing the prototype was not only to get valuable feedback regarding the design and functions of the prototype, but also to test the prototype to a greater extent in order to discover more possible errors.

The scenarios for the first iteration of the hi-fi prototype were the following

- *Check how many patients a blood sample will be taken from today (Friday the 24th of April).*
- *You would like to double check that the patient GA, 41 is booked for an X-ray examination at noon today. Look up the phone number to the X-ray lab and call.*
- *Click on the patient with initials GA and check if they are risk assessed. Add 'sjukresa', i.e. transportation to or from the hospital on the 24th of April without a specified time for the same patient. Mark the X-ray examination as completed.*
- *You have received a notification about a new patient coming to the ward and would like to check which bed that is the most suitable to place the patient in.*
- *Check how the care strain (the libra) has looked for the red team over the past few shifts.*
- *Check who is working the current shift from the blue team.*

Table 6.2 shows which of the necessary functions that were considered to be covered by each scenario.

### **Results of testing the first of the hi-fi prototype**

*Scenario 1:* One person found the welcome page (left image in Figure 6.7) confusing as they pressed the image of the menu button at the bottom of the page

| Scenario | Necessary functions  |
|----------|--|
| 1        | 1. Information access, 2. Changing layout, 3. Bed list similarity                                  |
| 2        | 1. Information access, 2. Changing layout, 3. Bed list similarity                                  |
| 3        | 1. Information access, 4. Intuitive feedback, 5. Pulstavlan compatibility, 8. Tag view improvement |
| 4        | 7. Notifications, 12. Bedding view   |
| 5        | 6. Care strain display   |
| 6        | 3. Bed list similarity   |

**Table 6.2:** Relationships between scenarios in hi-fi iteration 1 and necessary functions. Function 11 has not been written in the table, but applies to all scenarios as the mobile device is design to fit in the work outfits of hospital staff.

instead of the real menu button in the top left corner. Three out of five test persons quickly found the tag for blood sample in the view and read the relevant patients aloud. The remaining two test persons instead thought they could use a search function to filter out the patients with blood samples in their calendar.

*Scenario 2:* No one had difficulties in finding the X-ray examination in the calendar. However, when trying to find the number to the X-ray lab from the main view of all patients (seen in the right image in Figure 6.7), there was no clear pattern in the task performance. One person tried to click on the '+' symbol in the calendar column, believing that this would lead to more information about the activity being provided. Two people wanted to click on the activity directly, also thinking this would lead to more information, such as phone numbers. One person tried entering the 'Personal & team' view from the menu to get the number. The final person found the number by entering the 'Kontakt' view in the menu. The four previously mentioned, who at first failed to do this, eventually succeeded in finding the number. None of the test persons entered the individual patient view to press the phone symbol (seen in Figure 6.8 next to the scheduled activities).

*Scenario 3:* One test person did not understand that they had to enter the individual patient view to see the risks. Instead, they looked around in the patient overview view. However, the majority of the others quickly found the risk assessment tag under risks in the individual view without any trouble. Adding 'Sjukresa' to the patient's calendar was quickly done by all without any problems. Marking the X-ray examination as completed was also easily done by all test persons. A

few commented that adding a check mark in a box was very intuitive and found the task simple.

*Scenario 4:* Four out of five people pressed the '! Nya patienter' tab at the top left corner in the home view instead of the bell symbol. From this step, they could not enter the bed view. It showed that there was an issue when some wanted to enter the notification view in other ways than intended. Eventually all test persons found their way to 'Sängöversikt', either by entering the menu option or by pressing the notification/bell symbol. Once there, they understood that the patient beds were sorted by the discharge dates of the patients in the beds.

*Scenario 5:* One person tried to access the care strain directly from the patient overview or by entering the 'Personal team' option in the menu. It is likely that the lack of understanding of the term 'care strain' led the some to try to click the red team in the hope of eventually finding something called care strain there. The remaining test persons found the care strain option in the menu and tried to interpret the number in the red team. No one clicked the side arrows indicating the ability to switch shifts to view at the top of the page.

*Scenario 6:* The final task was successfully done by four of the test persons without any difficulties. The fifth person first tried to click the label 'BLÅ' in the libra view in belief that this would lead them to a view of the blue team with information such as staff schedule in the blue team. Once realising this did not work, the task was completed successfully by entering the staff option ('Personal & team') in the menu.

*Summary of findings:*

- The welcome page filled no significant purpose. The original purpose of introducing the users to the menu bar was not even fulfilled. Although it was visually appealing to some test persons, it only added an extra click to the operations and thereby caused inefficiency.
- Lack of experience in healthcare affected the testing negatively, as prior knowledge was required to fully understand the tasks. For instance, a nurse used to work with Pulstavlan would not try to filter the tags in order to find patients supposed to take a blood sample. The scenarios involving the mentioning of a team color also mislead some of the test persons not familiar with the concept of dividing patient and staff into teams.



- The phone icons next to each tag in the individual view were unnecessary, as no one interacted with them. With further regard to a hypothetical scenario of having to specify to which unit one is supposed to call, every time a new tag is added to the calendar, the icons would probably cause inefficiency and frustration.
- The '+' symbols in the right column in the patient overview were once again misinterpreted as providing an expansion of information about the calendar activities, as opposed to adding a new task. The affordance of the buttons was still not clear [28].
- The text related to the tags were by some still thought to afford clicking to lead to an pop-up window with more information about the calendar activity [28].
- Once familiarising oneself with the menu options, the tasks were easier to perform than if being given a task without first having a look around in the application.
- The check-box was an intuitive signifier of marking an activity as completed. It also provided the user with immediate feedback on the action performed [28].
- The formulation of the notification-related scenario could have been a bit misleading. However, entering the notification centre should be enabled by clicking the new patient at the bottom of the patient list in addition to by clicking the notification symbol.

#### **6.3.4 Feedback on hi-fi design from Stretch Care AB**

A second online meeting was held with the supervisors from Stretch Care AB. Feedback was given with primary focus on the safety of the system. Concerns regarding the ability to add an activity/tag from the 'Patienter' view were raised. It was thought to possibly lead the user to accidentally add an activity to the wrong patient's schedule, without it being noticed. Furthermore, it was also considered a risk, that users would enter the calendar view of coming or previous days in the 'Patienter' view and mistake it for today. Potential consequences of these risks could result in patients receiving the wrong treatments, or scheduled treatments being missed. A third risk expressed, was that the display of new patients in

'Sängöversikt' may be misinterpreted as a bed assignment function, even though it is not. It was thus proposed to remove the example box with the new patient from that view. A final viewpoint provided by the company was that the word 'schema' (schedule) in healthcare often refers to the staff schedule as opposed to patient schedule. The term more frequently used to refer to patient schedules is 'kalender' (calendar). Therefore, the schedule title in both the individual and overview view of patients could favourably be changed to avoid confusion.

### **6.3.5 Expert interviews**

As stated in Section 6.3.1, there were uncertainties regarding which patient related information a caregiver wishes to see in the different views of the application. This knowledge had not been covered during the user study. To avoid having to redo this part of the design at a later stage, two contacts within healthcare were contacted and asked for advice. The first person was a head of unit who was part of the development of Pulstavlan. The second person was one of the interviewees from the data collection who had the role as both a nurse and a coordinator.

The questions were asked with respect to which information considered relevant to see in the general patient overview, relative to the individual patient view. Furthermore, it was also asked regarding information generally included in the physical patient bed lists.

The most important information to see in the patient overview included scheduled activities such as examinations as well as controls. The patient bed lists were described as containing the same information as Pulstavlan. Risks, social planning and patient history were by the nurse/coordinator considered not as important as the schedule activities or controls. They did therefore not need to be presented in the 'Patienter' view. The view displaying care strain history was found unnecessary. Instead, the opinion was that this might confuse users, as opposed to ease the overview.

### **6.3.6 Iteration 2 and final prototype**

#### **Changes from previous iteration**

After including feedback from both testing the previous prototype, expert interviews and supervisors, the following changes were decided to be made to the final

prototype. The changes are sorted by which view they were made to. If a change was made to multiple views, it is sorted under 'General changes'.

### *General changes*

- The welcome page was removed. It was considered to only add to the product being inefficient to use.
- The 'filter by team' buttons were enlarged. The previous size of the buttons was considered to be more proportional to a computer screen, rather than an android screen. To increase the visibility of the filtering function and to reduce the time it would take users to click the filter buttons, according to Fitt's law, they were made bigger [25][28].
- The option to remove a tag was a realistic need, not thought of to include during previous iterations of the prototype. In order to still maintain efficiency, the user could now choose to either mark the check-box immediately, or to press the associated text next to the box. When pressing the text, a pop-up window was received with the option to either remove the tag, update tag information, or mark the tag as done. The design of the pop-up window was influenced from the design of the same operation in Pulstavlan.
- The term 'Schema' was changed to 'Kalender'.
- The scrolling in the calendars was changed from horizontal to vertical. The tall and narrow shape of most handheld devices make applications, such as mobile apps, rely on the presentation of information in a vertical 'stack-like' pattern [42]. This was unfortunately not thought of during the development of the first prototypes, since Pulstavlan, which is a web application, was used as primary source of inspiration. However, in order to increase the usability and consistency of the system, vertical scrolling was introduced for all scrolling operations [28].
- The background was blurred when pop-up feedback windows were given, in order to constrain other possible actions [28]. See example in Figure 6.12.

### *'Patienter'*

- The ability to change dates in the right column was removed. After input from Stretch Care AB, this constraint was introduced with regard to the safety issues expressed in Section 6.3.4.

- The amount of information shown in the patient column was reduced. This was primarily done to increase the visibility of the view [28]. Having less information visible for the user to process, would hopefully also increase their reaction time [29].
- The ability to add new activities to the calendar was removed from this view. This constraint was introduced with respect to both safety and visibility [25][28]. Having plus signs on all patient rows was not a preferable way to signify the function to add new activities. The more text and icons removed from this view, the more visible became the essential information and functions [28]. If the user now wants to add activities to the calendar, they simply press the patient column and adds activities from the individual patient view. This was also considered to reduce the risk of adding something to the wrong patient's calendar.
- The option to view controls, such as NEWS, for all patients was added. This was a request expressed during the expert interviews. However, since displaying the controls for all patients in the list could clutter the view and compromise the visibility, it was introduced as a check-box option (with grey colours, to not be mistaken for a check-box tag) [28]. A stand-alone check-box can be used to signify a single option that can be turned on or off [28][41].

#### *'Sängöversikt'*

- The name 'Sängöversikt' (bed overview) was changed to 'Planerade utskrivningar' (planned discharges). The hope was to enhance the purpose of the view.

#### *Individual patient view*

- The calendar was reorganised into one tab with the calendar and one with 'Aktiviteter' (activities), including the headlines 'Risk' (risk), 'Historik' (history) etc. This was done to allude to the mental models, where the use of tabs should resemble folder tabs in file drawers [38]. Furthermore, it was thought to be an appropriate way to fit a lot of information into limited space.
- The small phone icons next to each calendar tag were removed, along with the option of calling by clicking the phone icon.

- The text 'Lägg till aktivitet' next to the plus sign was reduced to 'Lägg till', with respect to the meaning of the term 'aktivitet'. In Pulstavlan, 'aktivitet' only refers to a certain category of tags. Consequently, 'aktivitet' was removed to be able to cover all possible tags without having to change the name.

#### *Libra*

- The option to view libra history was removed.

#### *'Personal & team'*

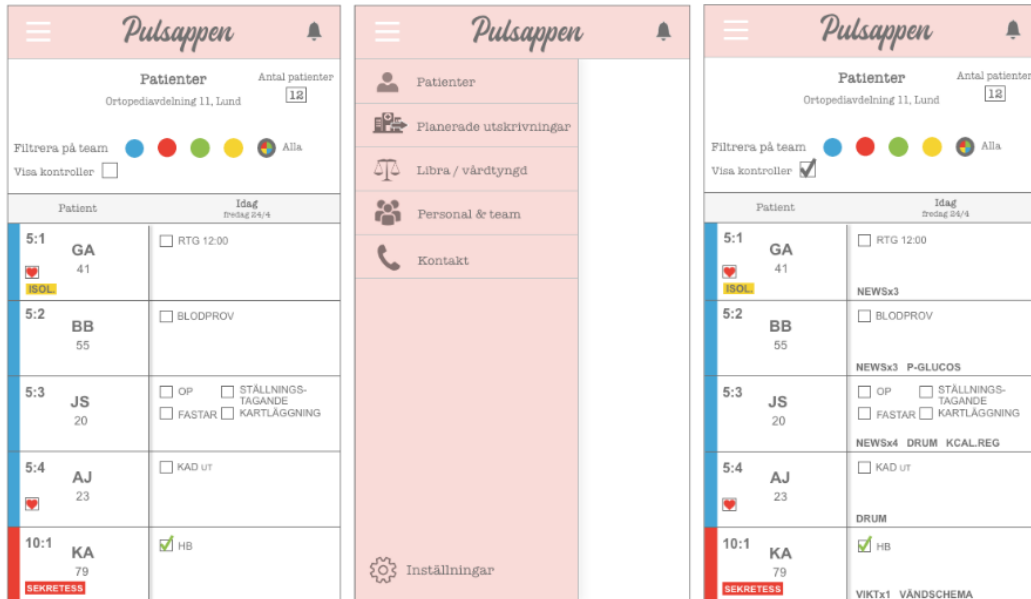
- Multiple tabs were added to view schedule of e.g. doctors and physiotherapists as well. Once again, the metaphor of a file drawer was used.

#### *Notifications*

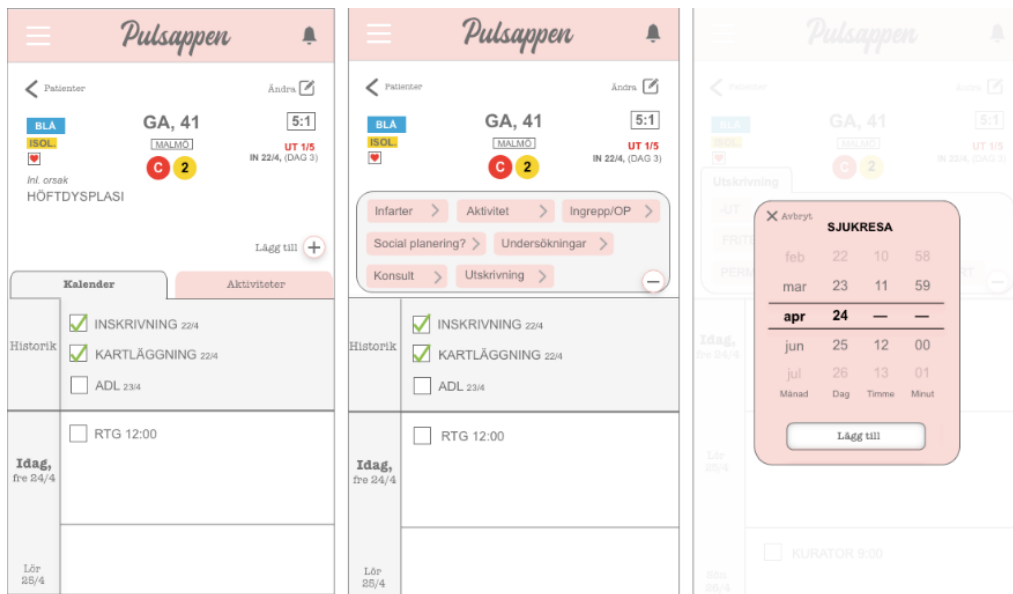
- The option to click on the new patients to enter the same view as when pressing on the notification bell was added.
- The possibility to reach 'Sängöversikt'/'Planerade utskrivningar' directly from the notification centre was removed. This was done to clarify that the 'Planerade utskrivningar' view was not intended to be used for actual patient placement.

### **Resulting design of the second (and final) hi-fi prototype**

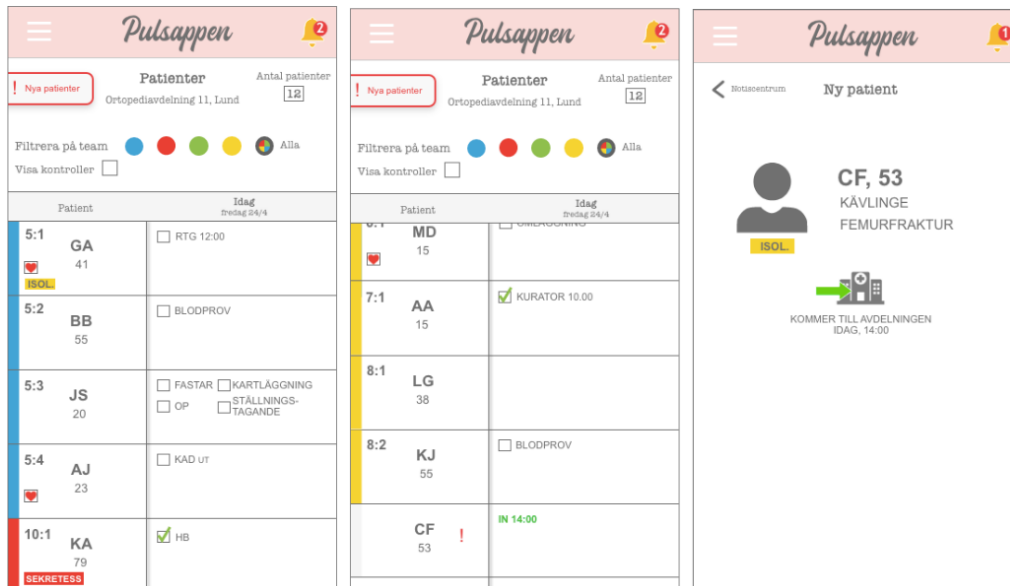
Figures 6.11 - 6.15 show sample images of the final hi-fi prototype.



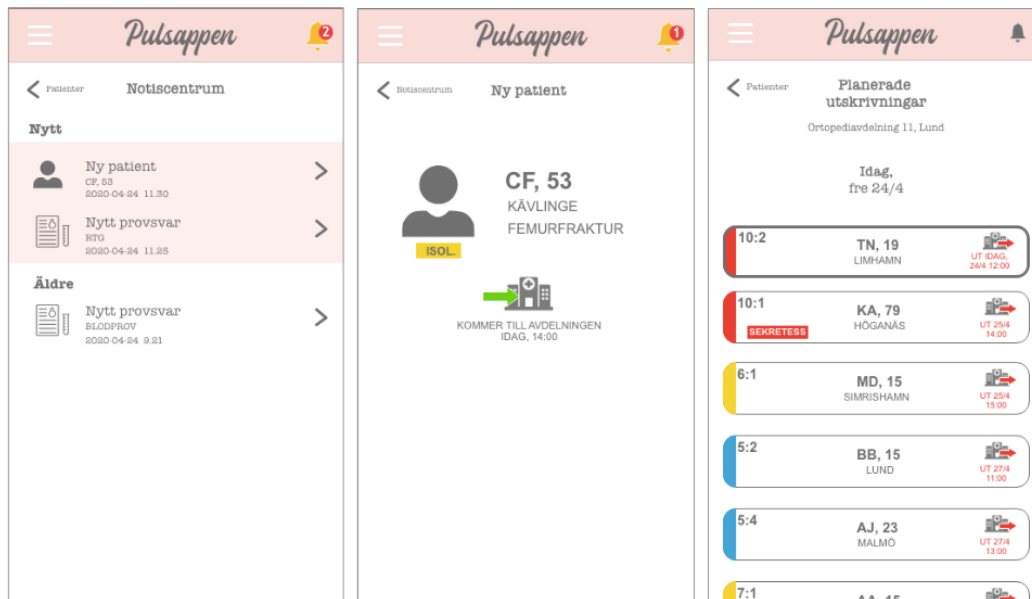
**Figure 6.11:** *Left:* 'Patienter' - patients overview. *Centre:* Menu bar. *Right:* Patient overview with controls in bold at the bottom of each patient activity field.



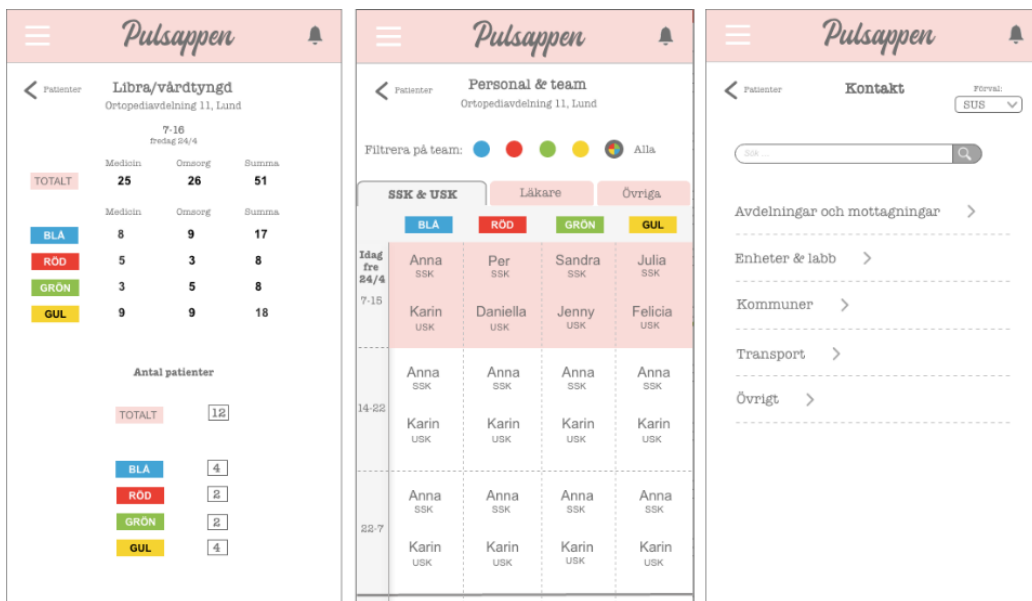
**Figure 6.12:** *Left:* Individual patient view. *Center:* Individual patient view with magnified 'Lägg till' window. *Right:* Vertical scroll calendar.



**Figure 6.13:** *Left:* 'Patienter' view with new notifications. *Centre:* 'Patienter' view when pressing the button '! Nya patienter'; an automatic scroll to the bottom of the patients list. *Right:* Notification of new patient.



**Figure 6.14:** *Left:* Notification centre. *Centre:* Notification of new patient. *Right:* 'Planerade utskrivningar' view.



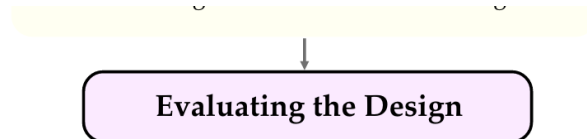
**Figure 6.15:** *Left:* 'Libra' view. *Centre:* 'Personal & team' - staff schedule. *Right:* 'Kontakt' - contact view.



# Chapter 7

## Evaluating the design

This chapter describes both the method and the results of the evaluation of the final hi-fi design. The evaluation was done by user testing, including observations of test persons completing scenarios using the prototype, as well as verbal feedback given after the testing. The user testing also included a numerical evaluation tool, the System Usability Scale (SUS).



### 7.1 User testing

The second (and final) hi-fi prototype was tested on five people who all had experience of working in healthcare, and of using Pulstavlan. As a result of hospital wards being closed for visitors due to Covid-19, the tests were held using a digital meeting tool, *Zoom*. The test participants were sent a link to the prototype, which they opened in their own web browser. They were then asked to share their screen content with the authors. After they had given their consent, their screen was recorded.

The test persons were asked to first freely use the prototype to click around and get to know the tool. They were once again asked to apply a think-aloud protocol

during the entire test [34]. After having had an initial look, they were given a series of scenarios, which were performed in the same manner as when testing the first hi-fi iteration. After having finished the scenarios, each person was asked three questions:

- How was your experience completing the scenarios? Was there any scenarios that were particularly difficult or easy to complete?
- Was anything missing?
- Would you have preferred to complete any of the scenarios in a different way?

At the end of the test sessions, each participant was given a link to a SUS-form which they filled out. At the bottom of the form, there was a voluntary option to add extra thoughts and/or opinions of the experience/product.

The scenarios used to test the second iteration of the hi-fi prototype were determined based on the scenarios used both during the lo-fi testing as well as the first hi-fi iteration with some alterations. For example, the scenario related to how the libra had looked over the past few shifts was now changed to the current shift. The scenario with the notification about a new patient was rephrased, as the earlier test results indicated that the previous formulation led to some misinterpretations of the task.

The scenarios for testing the final iteration of the hi-fi prototype were the following:

- *Check which controls (e.g. NEWSx3) that are in the calendar today (Friday the 24th of April) for your patients (in the yellow team).*
- *Check what the patient GA has scheduled two days from now.*
- *You want to double check that the patient GA is booked for an X-ray examination at 12 p.m. today. Look up the number to the X-ray lab and call.*
- *Click in on patient GA, 41 and check if they have been risk assessed. Add 'sjukresa', i.e. transportation to or from the hospital, on the 24th of April without a specified time for the same patient. Mark the X-ray examination as completed.*

- *A new patient will soon be admitted. You have received a notification in the application about this and would like to see in which bed the patient preferably could be placed.*
- *Check how the care strain (libra) currently looks for the red team.*
- *Check who are working during the current shift in the green team.*

Table 7.1 below shows which necessary functions in Table 4.1 that are covered by the scenarios mentioned above.

| Scenario | Necessary functions   |
|----------|---|
| 1        | 1. Information access, 2. Changing layout, 3. Bed list similarity<br>9. Team filtering                                    |
| 2        | 1. Information access, 3. Bed list similarity   |
| 3        | 1. Information access   |
| 4        | 1. Information access, 2. Changing layout, 4. Intuitive feedback,<br>5. Pulstavlan compatibility, 8. Tag view improvement |
| 5        | 7. Notifications, 12. Bedding view  |
| 6        | 6. Care strain display  |
| 7        | 3. Bed list similarity  |

**Table 7.1:** Relationships between scenarios in the second hi-fi iteration and necessary functions.

### 7.1.1 Results of testing the final hi-fi prototype

The collective test results for the final iteration of the hi-fi prototype are presented below. All of the test participants were between the ages of 25-60. They worked either as nurses or heads of units. Answers to the questions asked at the end of the scenario completion have been included in the presentation of the test results.

During the first general exploration of the design, two out of five test persons limited their exploration to the page with the patient overview. The way they navigated back to the main view varied, as some chose to use the back arrows with the text 'Patienter', and others clicked the application title at the top of each view. The relationship between the existing Pulstavlan and the mobile application was clear to all participants during this exploration. This was expressed in comments

made on the structure and layout of the 'Patienter' view, as well as colour choices for the teams and symbols used to indicate patient isolation.

*Scenario 1:* The task seemed intuitive, as all completed it quickly and without having to ask any questions. There were minor alterations in the task completion. Three out of five people used the filter function to see the relevant team patients before clicking on 'Visa kontroll' (show controls), while two scrolled down to see the relevant team patients.

*Scenario 2:* The scenario was somewhat confusing to a majority of the test persons. Three out of five tried to change the date by scrolling horizontally in the main view of all patients. Two people realised, without being given a hint, that they needed to enter the individual patient view to find more information. Furthermore, it was not obvious to all that only the left column, containing the patients' names, was clickable. Some first tried to click in the right column containing all tags to enter the individual patient view. Once in the individual view, all test subjects scrolled down to the correct day and read the scheduled activity.

*Scenario 3:* To confirm that the patient had a scheduled X-ray examination was quickly done by all test persons, as they saw the activity in the patient overview. Finding the phone number to the X-ray lab did, however, prove to be more difficult. Two tried to access the number by clicking on the activity tag. They expected this action to give a pop-up window with more information about the activity. The persons that tried this and failed eventually found the 'Kontakt' view in the menu bar and later also the phone number. The others went straight to the 'Kontakt' view and found the phone number.

*Scenario 4:* All test persons entered the individual patient view from the 'Patienter' view by clicking the relevant patient GA. After having a quick glance at the individual patient view, they easily found the checked tag for risk assessment under the activities tab ('Aktiviteter'). They then clicked on 'Lägg till' to add the tag ('Sjukresa'). Two people first clicked the 'Kalender' tab before clicking on the 'Lägg till' button. The others clicked it without exiting the 'Aktiviteter' tab first. Both options resulted in the same action. Finally, all test persons intuitively marked the X-ray tag as completed by checking the box.

*Scenario 5:* Two clicked the '! Nya patienter' banner at the top left to access the notification. One person immediately pressed the 'Planerade utskrivningar' view,

without looking at the notification first. The remaining two clicked the notification symbol in the top right corner to view the new patient. From there however, all test persons but the one mentioned, had difficulties finding the next step. Three had to ask for help after they had tried to enter other different menu options available. Eventually they found 'Planerade utskrivningar'. Once finding this option, they all understood the purpose of the view.

*Scenario 6:* Four out of five quickly pressed the correct menu option, 'Libra/ vårdtyngd', and found the care strain for the relevant team. One person first pressed to filter on the relevant team before entering the menu option and interpreted the total care strain for the ward as the care strain for the relevant team. This person was under the impression that the filter function in the 'Patienter' view worked as a filter function applicable to all places in the application.

*Scenario 7:* All managed to quickly find the 'Personal & team' menu option the correct staff names without having to ask for help or looking in other places of the app.

*Feedback given during the testing:*

Below are the summarised comments about the test participants preferences and suggestions of improvement in the design:

- The information found in the 'Kontakt' option in the side menu was expressed as currently desired among hospital staff.
- The option to only see the current day in the 'Patienter' view was appropriate, as it is rarely necessary to see future activities for several patients simultaneously. Furthermore, this is compatible with the patient bed lists, which are meant to be a simple information representation.
- The check-box system was easy to understand, as this system is used on patient bed lists to mark tasks as completed.
- The check mark in the check-box for 'Visa kontroll' (show controls) can preferably have a unique colour to colour code it with corresponding control tags to more clearly understand that these functions are related to each other. The way of viewing controls, however, was expressed as wanted on their ward by one test person.

- Adding a visible scroll bar to areas that are scrollable was mentioned would make it easier to understand that the field is scrollable in the individual patient view.
- The name 'Planerade utskrivningar' was considered misleading, and not logical, if the purpose of the view was to find a bed for a new incoming patient. Quote: '*Admittance and discharges are two completely different things, and it is not logical to look for empty beds in a 'planned discharges' view*'. It was suggested that the view also should include empty beds if it was supposed to fulfill its intended purpose.
- The system with notifications was considered useful, in order not to miss certain events.

### 7.1.2 System Usability Scale

A System Usability Scale (SUS) is a simple and fast tool used to assess the usability of a wide variety of products and systems [31]. It is composed of 10 statements (seen below). Each statement has a five-point scale that ranges from *Strongly disagree* to *Strongly agree*. There are five positive and five negative statements that alternate every other statement.

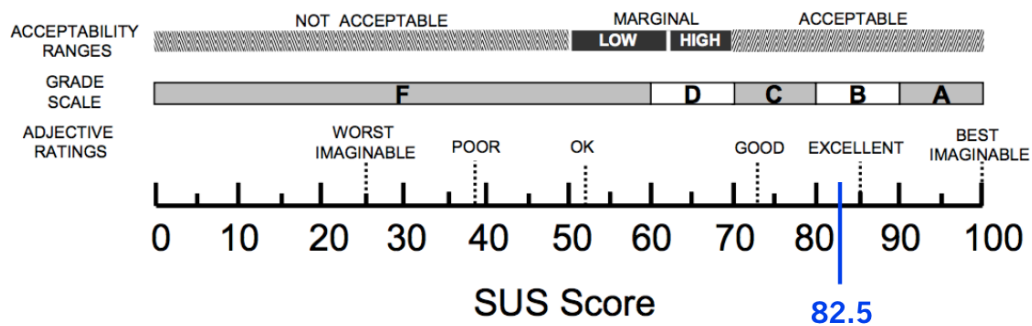
1. I think that I would like to use this product frequently.
2. I found the product unnecessarily complex.
3. I thought the product was easy to use.
4. I think that I would need the support of a technical person to be able to use this product.
5. I found the various functions in the product were well integrated.
6. I thought there was too much inconsistency in this product.
7. I imagine that most people would learn to use this product very quickly.
8. I found the product very awkward to use.
9. I felt very confident using the product.
10. I needed to learn a lot of things before I could get going with this product.

The SUS is generally used immediately after the user has tested the product to be evaluated. SUS scores range from 0 to 100 and are calculated by summing the points obtained for each statement. For the positive statements, the score is calculated by subtracting 1 from the entered number on the scale. For the negative statements, the score is calculated by 5 minus the entered number on the scale.

The sum of all statements is then multiplied by 2.5 to obtain the final SUS score [32]. Below are the results of the SUS score of the final hi-fi prototype. Table 7.2 shows the individual scores of each test person who filled out the SUS form. Figure 7.1 shows the placement of the final result of the mobile tool relative to an adjective grading scale [31]. The product is considered 'good' in regard to usability.

| Test person | SUS score   |
|-------------|-------------|
| 1           | 85          |
| 2           | 90          |
| 3           | 75          |
| 4           | 75          |
| 5           | 87.5        |
| <b>Mean</b> | <b>82.5</b> |

**Table 7.2:** The result of the System Usability Score according to five test persons along with the mean score.



**Figure 7.1:** The result of the mean SUS score for the five test persons who filled out the form, placed on the SUS Score scale. The final prototype falls in the field labelled 'GOOD'.

### Summary of test results

In general, the testing of the final prototype showed that the design was intuitive to use. This was shown by the lack of significant difficulties in completing the scenarios, by the positive comments given during the testing and by the SUS score.

The majority of the scenarios were completed in a smooth manner, with the exception of scenarios three and five.

To increase affordance, the menu and notification symbol were designed to resemble symbols in other common mobile applications [28]. Despite this, some of the test persons had trouble interpreting the meaning of these symbols. This is likely not a result of bad affordance, but rather of the test persons lack of prior experience using mobile applications where these symbols are common. Widening the test group would possibly confirm if this is the case and provide further insight regarding alternatives.

The test persons encountered in general little trouble in regard to the design of the final prototype, with exception to the navigation/flow and labeling of the options. The flaws in the application are likely a result of improper implementation of the design principles on which the design was based. For example, test persons expected the function to call the X-ray lab to be close to the calendar tag. If the Gestalt principle of proximity had been more thoroughly implemented, this could be solved. The different ways to access the contact info were constrained to the menu bar exclusively, in order to simplify the use of the application [28][25]. In spite of this, there was an expressed desire by users to see more information about the examination in the pop-up window. This may be due the test persons' expectations of a certain flow in the task completion, as a result of the scenario formulation and due to the Gestalt principle of proximity. If the option to find more information about the activity, including phone numbers, was to be added as a shortcut option, users would probably find the number more efficiently.

The fifth scenario was also somewhat challenging for the test participants. Once they had entered the new patient's view, they got stuck in the sense that they expected the next step to be accessible from that view, but could not find it. The button 'Gå till Sängöversikt' (Go to Bed overview) was removed after a discussion with Stretch Care AB, due to the risk of misinterpretation of the purpose of the function. Furthermore, the lack of consistency between the individual patient view accessed from the view of all patients ('Patienter'), and the view for the notification of a new patient, may have caused the users to expect different behaviours in the two views, despite them providing the same information [28]. If they would have had a clear consistency, the user might more quickly have understood that the next step must be found elsewhere in the application. Another solution could be to put the button 'Gå till Planerade utskrivningar' back in the new patient view



to guide the user to the next step. Possibly with a warning that this would not be synced with the patient records.

## 7.2 Proposed improvements

Based on the feedback received from the evaluation of the final prototype, there are some improvements that could be made in order to further increase the usability of the application. However, as the time frame of the project limited the ability to do yet another design iteration of the prototype, these changes are left as a list of suggestions below.

- Add a shortcut reference button to the 'Kontakt' view in the pop-up window displayed when pressing a tag to improve the efficiency [25].
- Change the name 'Planerade utskrivningar' to something signifying that the view deals with empty beds as well, rather than only discharge dates [28].
- Re-add a shortcut reference button to the view of discharge dates on the notification of a new patient (similar to first iteration of the hi-fi design).
- Re-design the 'New patient' view so that it looks like the usual individual patient view, but with less information (to improve consistency) [28].

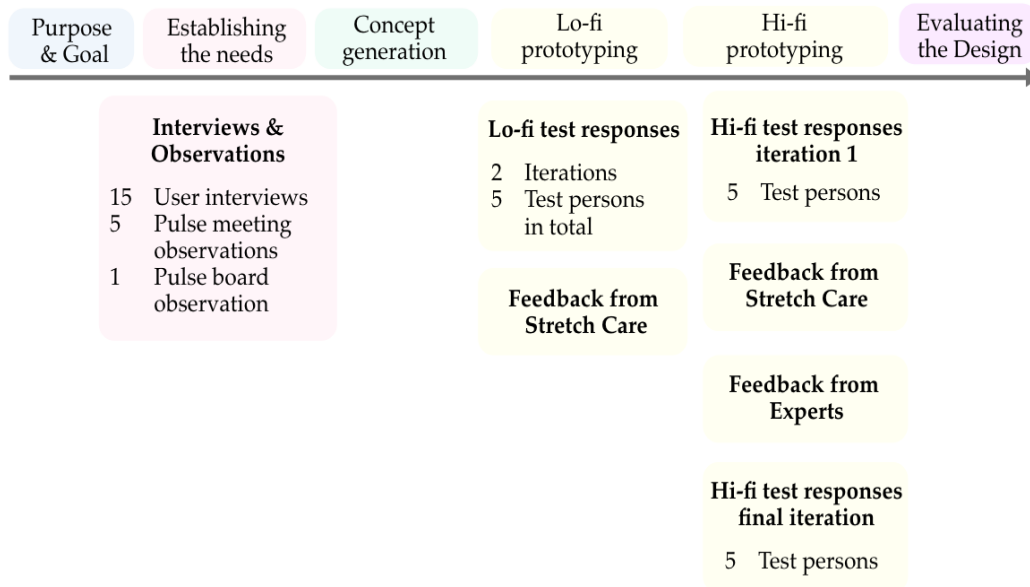
# Chapter 8

## Discussion

In this chapter, the results of the master's thesis will be discussed, followed by a discussion regarding the methods used in the design process. Figure 8.1 shows the collected data next to a time line of the design process. The data collected were interviews, observations, and test responses, along with feedback from both experts and Stretch Care AB. Since the prototyping was done in several iterations, users and experts have been consulted throughout the entire process to provide additional input on how to improve the prototype.

### 8.1 Discussion of results

The intention of this master's thesis was to ease the administrative burden on hospital staff. An attempt to achieve this was by eliminating four main issues experienced by the staff. These issues included '*Distribution of staff resources according to the care strain*', '*To get a good overview with regard to the patient flow in and out of the ward*', as well as '*The handover with information transfer between staff at the end or beginning of a shift*'. The last issue was '*The need of a physical paper list of patients which is carried around by each member of staff*'. The notes taken on this list were copied into Pulstavlan, as well as into the medical records system. In other words, there was a clear need for a mobile tool which would eliminate the need for a physical patient bed list. As seen in Table 7.2 and Figure 7.1, the final hi-fi prototype of Pulsappen was considered being a good product with regard to usability. The relationship between the existing Pulstavlan and the mobile application was also clear to all participants. This indicates that the thorough process of establishing the needs of target users was successful



**Figure 8.1:** The data collected at the different stages in this master's thesis.

in creating a useful product.

The first main issue was addressed, as the prototype includes views for care strain, as well as for staff. Furthermore, the issue *'The need of a physical paper list of patients which is carried around by each member of staff'* is also considered to be solved, as the app is supposed to replace the patient bed lists. Since the app can be used to update, and view the information in Pulstavlan, the need of printing out the information on the board is no longer relevant. Another consequence of the application being synced with Pulstavlan is that the issue *'The handover with information transfer between staff at the end or beginning of a shift'* has been solved. This was otherwise done by updating a local document on a computer. Finally, the menu option *'Planerade utskrivningar'* (planned discharges) solves the issue *'To get a good overview with regard to the patient flow in and out of the ward'*. This function, coupled with the notifications, solved the issue of lacking overview of patient flow. In other words, the functionality of the final prototype is considered to cover the main issues found to limit the use of Pulstavlan, or the efficiency of the administrative tasks.

Certain functions, such as the incorporation of patient records in the mobile appli-

cation, could have been included, if the application did not intend to follow PDL. However, to make the prototype more realistic and intended for future use by hospital staff, this regulation had to be followed. Another limitation in the design was that the app should be compatible with Pulstavlan. If the app did not have to be compatible with Pulstavlan, more attention could have been paid to desirable functions expressed during the user study that were deemed outside the scope of this master's thesis. Despite the final hi-fi prototype being a result of frames provided by Stretch Care, the needs expressed by the users have been the main base for the prototype design.

As mentioned previously in this thesis, there is a lack of a good mobile version that utilises the opportunities of mobilisation and replaces outdated methods used within healthcare. Furthermore, eliminating the need to document the same information in multiple places likely increases the amount of time caregivers devote to bedside care. The user experience, i.e. the total impression of how good a product is to use, was deemed good when testing the design. This was indicated by the feedback given by the final test persons which not only focused on the usability of the design, but also on the need for the specific functions provided by the prototype. The prototype presented in this master's thesis is in other words a promising candidate of such a mobile product that has previously been missing.

### **8.1.1 Implemented functions**

The third scenario only aimed at testing Function 1 in Table 4.1, i.e. 'Easy access to more detailed patient information in a different view (individual view)'. Although some struggled with completing this scenario, Function 1 was also covered by the first, second and fourth scenarios. As these scenarios were completed without any significant difficulties, the challenges in the third scenario should not affect the overall realisation of Function 1. Despite this, improvements should ideally be made, as mentioned. Conversely, the second half of the fifth scenario being difficult for users to complete entails Function 12, i.e. 'Adding a bedding view as a complement', was not fully solved by the design, as it was difficult to navigate to. However, as this can be solved with the proposed options mentioned, it does not constitute a major problem for the design as a whole.

In Table 4.1, eleven desirable functions are listed. Seven of the desirable functions fell within the scope of this master's thesis. The first desirable function, 'Combined view of patients being admitted to, and discharged from the same bed' was

in early prototypes included, but not in the final prototype, as it was believed to be misconstrued for assigning patients to a certain bed. The desirable function of choosing the amount of text or information the user wishes to see has been solved with the tab in the individual patient view called 'Aktiviteter'. Under this tab, the number of activities such as risks, social planning etc. that are viewed here can be determined in the settings of the application. The function of adding tag packages with associated tags was not included in any of the prototypes. This was due to the limited time frame of this master's thesis, and the lack of knowledge of the mentioned examinations. The desirable function 'Staffing information being visible for the same shift and sorted team-wise', is included under the menu option 'Personal team'. The information content of the mobile version is based on SBAR as per this desirable function, with the limitation of the information presented being anonymised to be compliant with PDL. The function of calculating the BMI and calorie intake was also excluded due to the limited time frame given. Finally, the function of adding tasks to a specific date using a calendar function was covered in the prototype through the scrolling function seen in the far right image in Figure 6.8.

## **8.2 The design process**

The design process was iterative. Users and experts have been contacted on different occasions throughout the entire process to obtain valuable comments on how the product could be improved.

### **8.2.1 Establishing the needs**

In the user study, all interviews and observations were conducted at two hospitals in Skåne. A benefit of including more than one hospital, is that systematic issues that might occur at individual hospitals are avoided. For this reason, if the scope and time frame of this master's were greater, the number of hospitals, as well as the number of regions these hospitals were located in could ideally be increased. Moreover, in accordance with having early focus on users and tasks, users should preferably be studied in an environment where the product is supposed to be used [27]. For this reason, proximity to the hospitals was required for the data collection to successfully be done. An increase in the number of interviews conducted may also have lead to a wider conception of general needs of target users, relative to their administrative work load. However, given the depth of the interviews and

that the data collection and analysis were qualitative, using 15 interviews with 18 users likely eliminates the risk of missing needs. Furthermore, it increases the chance of distinguishing outliers, i.e. exceptions to the general needs of the target users [43].

Thematic inductive analysis was used as a tool to analyse the interview responses to identify themes in the data which could be translated into general needs of the target group [44]. The reason why this method was used, as opposed to content analysis, which is another method for analysing qualitative data, was that content analysis is more often used where circumstances such as who says what and to whom are unknown [45]. As the interview was held under controlled conditions with these circumstances known, thematic analysis was considered the better choice. Using the themes from the thematic analysis, goals were formulated was to summarise the results from the data analysis and to lay the ground for the concepts that were to be generated. This step was taken to allow for functions to be formulated around which the product would be based.

Personas were developed to capture the needs of specific roles often encountered during the user interviews that would enable the design to be more targeted to specific user profiles [34]. The reason this was done was to make the data more relatable. If the profiles of the users had not been as clear as they were, more personas might have needed to be designed. However, as the data collected during the user interviews pointed to one of three clear profiles and intentions with their use of Pulsappen, three personas was considered sufficient.

### **8.2.2 Concept generation**

The concepts were illustrated using mind maps and storyboarding [34]. One might argue that the use of different digital tools and incoherent ways of drawing the storyboards and mind maps between the authors could complicate the concept evaluation and the arrival at a final concept. A thought could have been to determine a more consistent format to stick to beforehand. However, this could have limited the depiction of the individual ideas, and affected the ability of the final concept to address the main issues and necessary functions poorly. Furthermore, the combination of multiple concepts into a final may include a risk of missing out on particular functions or demands that a certain individual concept could have best fulfilled. This could be solved by starting over and designing new individual concepts as opposed to combining the existing ones. As this was not allowed within

the time frame of this master's thesis, this option was not resorted to.

### **8.2.3 Prototyping**

In the design of the mobile application, PDL and the need for the application to be somewhat integratable with the existing product Pulstavlan, limited the design choices slightly. Had the application been done independently from Pulstavlan, other design decisions could have been made. However, this would probably not solve the problem of decreasing the workload for caregivers, and therefore these limitations were necessary.

The purpose of designing a lo-fi prototype before a hi-fi prototype was to test the flow and navigation of the application design before moving on to more detailed parts of the prototype. This was successfully accomplished, as the majority of the comments on navigation in the application were brought up during this part of the prototyping. This allowed the testing of the hi-fi prototype to focus on more complex tasks.

The choice of design tool to use when creating the prototype enabled more time to be spent on design, as opposed to getting to know the design tool. Furthermore, it allowed for remote testing of the prototype which was needed due to the outbreak of Covid-19. Limitations of Adobe XD were e.g. that the functions of dragging objects across the screen, as well as zooming in and out, could not be implemented. This was, however, considered small limitations, given the benefits the design tool provided. The limitations were thus not considered to have worsened the quality of the final prototype.

### **8.2.4 Evaluation**

Due to Covid-19, only the final testing of the hi-fi prototype included people who worked in healthcare who had experience of using Pulstavlan. Errors found in previous test iterations concerned the general usability of the product. For this reason, it was assumed that these errors could be found by testing the design on people outside the target user group. When testing of the final prototype, however, the most valuable feedback was believed to be provided by target users. They could assess what the product needed in order for them to want to use it in their daily work routines.

It would arguably have been better if the end users were included earlier in the prototyping process. Nevertheless, the mix of users with and without experience of using Pulstavlan could affect the final result of the prototype in a positive way. Users without experience of a similar product are less likely to interpret changes in the tested product in comparison with the previous product as flaws. Saving the experienced users for the final round of testing may therefore have been positive.

The testing of the hi-fi prototypes was done using a web browser since social distancing prevented physical meetings with the test persons. The different size of the app in a browser might have affected the testing. Additionally, the intuitiveness of the application might also have been affected. For example, scrolling is done by swiping a finger across the screen on a smartphone, whereas on a computer, it is often done in a different manner, using a computer mouse. Furthermore, users might expect a hover effect on a computer, in which the visibility of the system is provided by hovering with the cursor above a certain function. As they were in fact testing a mobile application, this expectation would be false and might mislead the users. If done again under different circumstances, the testing would ideally be done on a smartphone application platform instead of on a computer-based browser.

The test sessions in the final iteration were held over the video conference program *Zoom*. This tool allowed for multiple participants to be part of the same video call. Furthermore, this tool could be used to share participants' screens with other participants and to record both audio and video. This allowed for the authors to be present during the meeting and guide the user without dividing their attention to taking notes. Although this tool did not fully correspond to a live meeting, it gave a sufficient representation of a live scenario and enabled the testing to occur despite limitations due to Covid-19.

The think-aloud protocol is a popular and efficient method for usability testing [46]. There are, however, some risks with the method that may affect the test results. Not all people are comfortable with expressing their thoughts verbally, which may affect how they choose to express themselves during the tests. Some of the test participants had some kind of prior relationship to the authors, which also could bias the way they communicated their thoughts. Another common complaint in relation to the think-aloud protocol is that the user often stops talking when encountering an extra challenging task [46]. This complicates the analysis for the designer, since what could be the most important feedback of the UX is



probably excluded. An alternative could be to employ what is known as *Retro-spective Think-aloud*, where the user completes the tasks in silence while being recorded, and are then invited to comment on their thought process afterwards while reviewing the recording [34][46].

The think-aloud protocol was, however, not used as a single method to evaluate the usability of the design. The use of the SUS score provided the ability to quantify the results of the design, and give insight to the evaluation of the final prototype as the SUS responses were given anonymously by the test persons. Using only this system brings with it the risk of missing important information about the users' perception of the design, as it is a simplified version of a complex image. However, as the evaluation of the design consisted not only of the SUS score, the use of this method was not regarded as a flaw in the evaluation, but rather a valuable addition.

#### **Other evaluation methods that could have been used**

During the testing, the number of clicks it took for each test person to complete each of the given scenarios was noted. However, as the number of steps taken to complete a task doesn't say as much about the usability, this was excluded from the evaluation [26][47]. The remaining part of the testing phase of the second hi-fi prototype included completing tasks, using the SUS, as well as asking the test persons follow-up questions about their experience. Therefore the testing was deemed to cover the necessary ground of thoroughly evaluating the prototype without counting clicks.

#### **8.2.5 Next steps**

If the chance were given to once again do the study, some things could be done differently. The observation of Pulstavlan being used in the everyday work routines provided very little valuable information about the use of Pulstavlan outside of pulse meetings. This may be due to the low frequency of its usage. It is possible that all interactions with Pulstavlan during an entire day's shift should be observed. This could be done through a greater number of observations at different times during the day.

Alternate methods to thematic analysis could be explored. It is possible that there are other methods that would have provided other insights about the data that was

not found during this user study. In a similar manner, other methods for formulating the functions of the mobile application could be explored. Few of the desirable functions were included in the final prototype in this master's thesis as a result of the time frame provided. The number of functions that were then used in the prototype design could be increased to include all of the listed functions in Table 4.1.

The concept of lo-fi and hi-fi prototyping would probably not be used differently. However, more people could be included in the testing of the prototypes. Finally, a wider user group could have been used during the user study as well as in the testing of the prototypes, with special regard to a mix of ages, medical specialties and experience of using Pulstavlan.

# Chapter 9

## Conclusions

Staff in hospital wards often experience an unnecessarily heavy administrative workload since a minority of tasks make up a majority of the workload. The same patient information needs to be documented in several systems since these systems are not integrated with each other. Furthermore, the current digital systems used are limited by a stationary product.

By using an application that enables simultaneous documentation of patient information to several different places, and by allowing for the information to be mobile, this workload will likely decrease. *Pulsappen*, the prototype designed in this master's thesis is an example of such a product. Given the positive results obtained when the design was tested by caregivers, it seems to provide a promising ground for further development in the area. Benefits of this prototype include the ability to bring updated patient information around the ward using a mobile device, eliminating the need to document certain information in multiple places, easing the handover between shifts and distributing staff resources according to the current care strain.

To achieve a design fully optimised for caregivers on hospital wards, additional steps can be taken. These steps include implementing more of the desirable functions listed in this thesis and testing the final prototype on a wider user group. Furthermore, the proposed improvements mentioned in this thesis can be implemented and tested on target users in an additional iteration as a next step. In addition to increasing the number of iterations in the testing of prototypes, the number of people testing each iteration could also be increased.

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# Appendices

# Appendix A

## Interview questions

Intervjufrågor till primära användare av Pulstavlan

### Dagliga arbetsrutiner

- Vad har du för roll på din avdelning?
- Hur ser din rutin ut när du går en rond?
- Hur många vårdgivare ingår i varje team? Vilka roller har dessa?
- Ungefär hur många patienter är ditt team ansvarigt för och när träffar du dina patienter fysiskt?
- Ungefär stor andel av din arbetstid lägger du på administrativa sysslor? Vad är det för sysslor?
- Brukar du konsultera kollegor när du arbetar med patienter? Vad brukar detta isåfall oftast gälla?
- Vilka av dina dagliga arbetsuppgifter är generellt mest tidskrävande? Är något moment mer omständligt än vad det hade kunnat vara?
- Vad ingår i dagliga undersökningar för inneliggande patienter (utöver de specialbehov som kommer av deras inläggningsorsak)?
- Hur dokumenteras det som görs för varje patient under dagen?
- Hur uppdaterar du dig på ditt schema och dina patienters vårdplan under dagen?

- Hur vet du vem som jobbar samma pass som du? I samma team?
- Vilka är de vanligast förekommande avvikelserna? Hur rapporteras dessa?
- Finns det någon information som ni som vårdgivare har som patienten hade gynnats av att ha konstant tillgänglighet till?
- Finns det något du tänkt på som saknas för att underlätta för dig under din arbetsdag (kanske främst administrativt)?

### **Pulsmöte**

- Hur ofta har ni pulsmöten och hur går ett pulsmöte till? (Längd, vem som närvarar, m.m.)
- Vad är syftet med pulsmötena och anser du att det syftet uppfylls?
- Har ni några andra möten inom teamet utöver pulsmötet?

### **Pulstavlan**

- Hur länge har ni haft Pulstavlan på avdelningen?
- Använde ni en icke-digital representation av Pulstavlan tidigare, ex. magnetavla eller whiteboard?
- Hur använder du Pulstavlan i ditt arbete?
- Är det lätt att använda Pulstavlan? Varför?
- Finns det några svårigheter med att använda Pulstavlan? Vilka?
- Finns det något behov som du upplever inte tillgodoses av Pulstavlan som den ser ut idag?
- Hur långa avstånd är det mellan patienter och Pulstavlan?
- Hur många gånger måste man gå fram till Pulstavlan per dag (eller timme)?
- Fördelar/nackdelar med att ha Pulstavlan i anonymt läge?
- Använder ni pulstavlan främst via den stora skärmen eller via datorer?

# Appendix B

## Identified themes

- **Current alternatives to Pulstavlan:** If a method or tool other than Pulstavlan was currently primarily used on the ward to get overview of the admitted patients and patient flow.
- **Previous alternatives to Pulstavlan:** Previous methods or tools used by the ward to get overview of admitted patients and patientflow before Pulstavlan was introduced.
- **Notes and bed lists on physical papers:** Indications of patient information and/or personal notes beeing carried around by staff on physical paper.
- **Arguments for a mobile tool:** Expressed needs and information suggesting that a mobile tool related to Pulstavlan would facilitate certain routines and/or tasks.
- **Patient round routines:** Information regarding different daily routines for patient rounds.
- **Overview:** Mentioning of features that affect the overview of the patient flow.
- **Technical habits:** Previous personal technical habits affecting the ability to perform certain tasks. The majority were answers suggesting that lack of technical practice on behalf of the user was main reason for something not working as expected.
- **Functions not covered by the current Pulstavlan:** Needed functions that Pulstavlan currently did not cover.
- **Accessibility:** Information concerning accessibility to Pulstavlan based on e.g. location of

computers and distances to patients.

- **Lack of information:** How lack of information from superiors had affected the use of Pulstavlan.
- **Updating Pulstavlan:** How Pulstavlan was updated, by whom and type of information added.
- **Use of Pulstavlan:** How Pulstavlan was used as part of the daily routines and work performed by staff on the ward. This differed from *Updating Pulstavlan* since the updating refers to in which scenarios Pulstavlan was approached and updated, whereas this refers to the function Pulstavlan contributed to the overall work on the ward.
- **User frequency of Pulstavlan:** How often Pulstavlan was approached, either to find information that is displayed on it or to add information.
- **Computer vs. screen:** If Pulstavlan was accessed primarily by the use of computers or by interaction with the physical screen.
- **Usability:** Specific comments about the general usability of Pulstavlan, i.e. if it was easy to use and understand, as well as specific remarks about difficulties

or improvements that might improve its usability.

- **Documentation:** How patient data and administrative information was documented. For instance, that the patient information was documented in the patient record system Melior.
- **Sensitive information:** Any mention of occurrences where sensitive patient information needed to be taken into consideration when using Pulstavlan or when communicating with other staff members.
- **Pulse meetings:** The circumstances around which the pulse meetings took place. Length, the number of staff members present, the time and frequency were some of the information mentioned.
- **Purpose of pulse meetings:** The experienced purpose of the pulse meetings on the different wards.
- **Other meetings:** Meetings apart from the pulse meeting where staff met to discuss either patients or administrative tasks.
- **Team and patient distribution:** How many staff members and patients included in each team.

- **Necessary/beneficial patient information:** Information that patients might have benefited from having access to anytime they wanted.
- **Not necessary patient information:** Occurrences of expressed opinions that there was no information that the patient would benefit from taking part of that they did not already know.
- **Consultation/communication within staffing groups on the ward:** What information the staff communicated with each other and when the consultation occurred.
- **Lack of time:** Any mention of lack of time being the reason for certain work routines or (lack of) use of Pulstavlan.
- **Staffing schedules:** Where/how the staff could find out who else was working the same shift.
- **Updating individual staffing schedule:** How the staff knew what tasks they should carry out as well as when it should be done during the shift.
- **Daily patient examinations:** Examinations routinely performed on all admitted patients irrelevant of their reason for being admitted.
- **Double and triple documentation:** Any mentioned occurrence of having to document the same information in more than one place.
- **Administrative shift proportions:** The proportion of the working shift used to perform administrative tasks.
- **External contact:** Any communication with people outside the ward, e.g. to book patient transportation, booking X-ray examinations, calling the municipality etc.
- **Time demanding administrative tasks:** Tasks that came across as more time demanding than remaining administrative tasks.
- **Problems with the current product Pulstavlan:** Specific problems with Pulstavlan mentioned by the interviewees during the interviews.
- **Improvements and suggestions:** Suggestions of improvement mentioned during the interviews.