Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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Design Recommendations for Mobile Nursing Care Plans: A User-Centered Approach

Master's thesis in Computer Science
Supervisor: Yngve Dahl
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Abstract

This thesis describes a user-centered design process used to create a mobile app for nurses. The app aims to supplement the nurses' current workflows, as well as potentially move work currently done on desktops to being done on the mobile device. The app has a narrow focus on functionality compared to existing mobile solutions, focusing only on nursing care plans, which are a part of a patient's electronic health record. The main research question of the thesis is: **What key design considerations should be taken into account in the development of mobile nursing care plans?** This question is explored through a user-centered design process involving literature reviews, field studies, and testing with various prototypes. The findings indicate that such an app is an attractive and effective addition to an already existing computer-based system, but that it will not render any feature of such an existing system obsolete. The findings also reveals interesting aspects of nurse workflow in a computer-based working environment. The thesis concludes with list of key design recommendations for such apps.

Sammendrag

Denne oppgaven beskriver en brukersentrert designprosess brukt for å lage en mobil app for sykepleiere. Appens mål er å forbedre arbeidsflyten til sykepleiere, i tillegg til å potensielt flytte arbeid som i dag gjøres på PC over til mobilen. Appen fokuserer kun på behandlingsplaner for sykepleiere, som er en del av pasientjournalen. Den har dermed et smalt fokus på funksjonalitet sammenlignet med lignende mobile løsninger. Forskningsspørsmålet i oppgaven er: **Hvilke designvalg bør det tas hensyn til når en utvikler mobile behandlingsplaner?** Dette spørsmålet blir utforsket gjennom en brukersentrert designprosess som involverer litteraturstudier, feltstudier, og testing med diverse prototyper. Funnene indikerer at en slik app er et attraktivt og effektivt hjelpemiddel som kan brukes side-om-side med en allerede eksisterende PC-løsning, men at den ikke totalt overta funksjonalitet som i dag blir gjort på den eksisterende løsningen. Studiet finner også interessante sider ved arbeidsflyten til sykepleiere som jobber i et miljø hvor datamaskiner blir mye brukt. Oppgaven konkluderer med en liste med designretningslinjer for apper lik den presentert.

Acknowledgments

First and foremost, without the backing by DIPS ASA this would not have been possible. I am very appreciative of their help and enthusiasm surrounding this project - a special thanks to Runar O. Hjerpbakk for joining me in forming the research question and inital plans. Diakonhjemmet Hospital in Oslo have been equally enthusiastic and helpful when participating in field studies and evaluations. A special thanks to Tone Lande at the hospital, for making arrangements and fulfilling my every need promptly whenever I visited. Advice given by my supervisor, Associate Professor Yngve Dahl, has also been invaluable. Finally, a thanks to my dear dog Jimin, for providing much needed distractions from my writing and research.

Preface

Unfortunately, the final iteration in this project could not be completed due to the emergence of the COVID-19 pandemic that came to Norway in early March 2020. This means that the final and most conclusive evaluations of the final iteration could not be performed. The thesis still provides good information and design recommendations, and briefly outlines the plans for the final iteration for others to follow.

Contents

List of figures

Abbreviations

EHR	Electronic health record
NCP	Nursing care plan
ABC	Activity-based computing
UCD	User centered design
CIS	Clinical information system
GUI	Graphical user interface
TAM	Technology Acceptance Model

1 Introduction

Most modern hospitals use clinical information systems (CIS). The introduction of computers in hospitals during the past decades has altered the workflow of health care workers significantly [11]. Nurses nowadays do most of their documenting of patient care on computers rather than on paper, and access most patient information in the same way. Benefits of this new workflow include reduced costs, ease of information sharing between health care institutions, ease of access to data, and structured data resulting in fewer errors and therefore more accurate patient care.

Despite all the benefits of electronically stored information, today's situation is far from unproblematic. For nurses, there are issues regarding documenting patient treatment. This consumes significant portions of their time, is often erroneous, and does not fit well into an exceptionally mobile workflow. A recent article from 2019 [34] discusses some of the issues with computer based software for health workers and finds that cumbersome, outdated and error-prone software designed to be usable by a wide range of users end up not being specific enough for many of the targeted user groups. One recent study finds that 78% of physicians exhibit symptoms of burnout [20], which CIS play a major role in.

This thesis explores the question "**What key design considerations should be taken into account in the development of mobile nursing care plans?**". A mobile app could alleviate some of the cumbersome documenting nurses currently have to do on computers. The approach in this thesis is a rather novel one, as almost all existing mobile applications found have significantly broader functionality than only nurse-patient care. The app proposed in the thesis is made for use by nurses in hospital wards, in various situations including at the patient's bedside. A qualitative approach is chosen when designing the app, using a User-Centered Design (UCD) approach. The process involves three iterations, each including user evaluation and various prototypes. Methods employed include a literature review, field studies, and testing with prototypes both in focus groups and in a natural environment. Field studies and evaluations that inform the design of the prototypes are done at Diakonhjemmet Sykehus in Oslo, Norway, spread across four medical wards.

While the final and most conclusive tests could not be performed, the main contribution of this thesis is a set of design recommendations for an app with a target audience of only nurses. It is found that such an app is desired by its target audience and is likely to increase productivity and satisfaction as well as be accepted by users. This insight should be useful for CIS development companies or hospitals looking to increase the productivity and satisfaction of nurses where an existing desktop solution already exists, and may help decide between this narrow approach and the more common approach of aiding as many users as possible with a single app or service.

The thesis begins by introducing the necessary nursing and hospital terms and presenting relevant prior research. The research design is then outlined, before describing the existing desktop solution and the hospital visited. Following this, the methods and findings of each iteration in the UCD process are presented. Finally, the impact of the findings is discussed before the thesis concludes with a list of design recommendations.

2 Background and Related Work

2.1 Nursing and Documentation

A nurse's primary job is to care for patients while they are in the hospital's care. Nurses do not partake in medical procedures, nor are they responsible for patient admittance or departures. A nurse's most important tasks are giving patients meals and medicine, performing light treatments, helping patients be comfortable in general, and documenting the state of patients as well as any notable actions taken when caring for them. While the documentation is is the main focus of this study, all of these tasks are highly relevant. Documentation used to be done on paper until most hospitals changed to computer-based documentation systems during the past few decades. Documentation is done in order to ensure proper care, enable cooperation between nurses, and to fulfill legal requirements. The system studied in this project is called DIPS Arena and will be further detailed in a following chapter.

A medical ward in a hospital is a section of the hospital dedicated to housing patients, usually in need of similar types of medical care. The wards discussed in this thesis mainly have rooms with beds for patients to stay in - surgeries and most treatments are performed elsewhere. A ward usually has its own set of nurses, a few physicians, secretaries and other staff more or less permanently stationed at that ward.

All digital data on a patient in a hospital comprises the patient's *electronic health record* (EHR). A patient's EHR includes a variety of things such as medical history, allergies, laboratory test results, radiology images, personal statistics like height and weight, and billing information [19]. The EHR is used by a wide range of health care professionals for a wide variety of tasks. A subset of the EHR is what this thesis refers to as a *nursing care plan* (NCP). The NCP only contains information about past, present and possibly future care for the patient while they are in a hospital or are being cared for by health care professionals in other ways. In this thesis, the other aspects of EHRs will not be discussed. A more detailed description of an NCP is provided in chapter 4.

2.2 Previous Research

A recent study published in 2018 from the University Hospitals of Geneva [14] discusses usability studies of a mobile application with a similar, but broader function than the app presented in this thesis. This existing paper presents usability tests used to evaluate the app in terms of navigation and interaction design, and the results of these. While the direct results in terms of navigation and graphical user interface (GUI) from the usability studies are not relevant to this thesis, the study concludes (with limitations) that there is high acceptance and satisfaction for the app in question. This is the only study found which discusses an app similar to the one presented in this thesis, and the findings indicate that such an app can be received well by nurses.

While the existing paper discusses a similar application, it only investigates the GUI and navigation, and relates this to the flow of a nurse when completing a task within the app. My thesis, however, is more concerned with exploring the context of use and identifying use cases, and less concerned with performing the standard usability evaluations found in the paper. Thorough usability testing is advised, of course, but is left to future work. Key elements that this thesis discusses which are not mentioned in the existing paper are:

- Discovering in which situations the nurses are likely to use the app. This will enable developers to make informed decisions about whether to include or exclude features of the desktop solution, and these findings will be reflected in the design recommendations.

- How satisfied a nurse is with using a mobile solution in specific contexts - not mainly concerning what's on the screen, but how this impacts their work, to what degree they will actually use the mobile alternative, and benefits or drawbacks of doing so compared to using the desktop solution.

- The contribution of this thesis - a set of design recommendations - is also something not found in the paper.

A case study performed by the University Hospitals of Geneva in 2013 [15] discusses some challenges that arise when implementing a mobile application in clinical practice. Many of these are outside the scope of this thesis, but provide good insight for parties managing the entire decision process of doing so. Following are some discussed points worth mentioning:
Dealing with limited financial resources;
Choosing appropriate hardware: A very relevant topic for the adoption and possibly development of such a mobile service. For this project it is assumed that a mobile phone will be the target hardware. A benefit of this is that designing a responsive GUI with a phone in mind makes it much easier or in the best case entirely effortless to use the service on a tablet, something which is not true the other way around;
Sustainability of the app: many apps have short "life cycles";
Data protection and authentication: As this project is more concerned with supporting nurses in regards to workflow and usability, the consideration of data protection and authentication is left to the stakeholders of the finished result, and assumed to be of little impact on the user experience of the nurses. For instance, with the advent of authorization by both fingerprints and facial scanning, logging in should not be a hassle;
Linking the mobile device with the existing clinical information system.
Combining the research from the paper with that of this thesis should provide a thorough understanding of both the practical challenges and design aspects of implementing such a mobile solutions for nurses in hospitals where existing desktop solutions exist.

Studies have been performed in order to understand the workflow of nurses [10, 35]. One study from 2010 with an objective to quantitatively measure workflow and computer use among nurses [10] concludes that nurses were found constantly switching activities and locations in a seemingly random pattern, and that there is little "flow" in nurse workflow. In a time of rapidly evolving medical software, these studies can be considered somewhat outdated. In addition, the existence of an even somewhat universal nurse workflow can be questioned. Indeed, as witnessed, even between somatic and psychiatric wards in the same hospital in this study the differences are vast. Therefore, a field study is deemed necessary in order to attempt to determine a workflow for the nurses of this hospital. Thus, one more insight into the pool of nurse workflow insights will be provided.

A Korean study [9] describes the decision driver, development, and implementation of an integrated mobile EHR application. The scope of the study - recreating the entire EHR - is much broader than this thesis' focus on NCPs. The usability tests performed in the study also indicate user acceptance.

In 2010, Bardram presented an *Activity-Based Computing* (ABC) system for hospital work [7], mostly for physicians and nurses. The need for such a framework arose from the health workers using many different systems without intercommunication. The paper provides some helpful insights, but the main contribution is not immediately relevant to this thesis - as Bardram himself writes: "Although the ABC framework does not preclude users from running the Activity Bar and applications on such portable devices, the support for mobility in the ABC framework is more specifically designed to help users to exploit devices in their vicinity". In other words, the ABC framework is not made for being used on mobile phones. Additionally, the system presented in the paper is a brand new one, acting as a middleware tying together outputs from many other systems. DIPS Arena, used at Diakonhjemmet Hospital, already includes many of the separated systems mentioned in the paper (and, naturally, enables communication between them), and the mobile application presented in this thesis is not so much a brand new solution, but rather a complementing one with a subset of features of an existing system. Otherwise, the paper confirms that support for mobility is *essential* to hospital work. While not the approach in the ABC-system, the author believes that "roaming a subpart of an activity to a small device, instead of roaming the whole activity" can be useful. This, essentially, is the entire idea of this thesis and its proposed app - to have subparts of activities supported on a mobile device. Examples of these activities are visiting the patient's bedside, consulting with a physician, or the activity of documenting patient care itself. Other relevant insights from the paper will be inserted in respective chapters in this thesis.

3 Research Design

3.1 User-Centered Design

The user-centered design process [4] is a framework for developing interactive digital products with an end goal of maximizing usability. By properly integrating user-centered design into the development of a product, it can turn out better, as well as reduce total risk and amount of work [30]. The formal definition of usability is "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use"[4]. In the hospital setting, effectiveness and efficiency are particularly important, as nurses are often understaffed and working with patients in critical conditions. Assuming the app will indeed increase the efficiency and effectiveness of the nurses, satisfaction also plays an important role in helping them do their job better, as low satisfaction will cause fewer nurses to incorporate the app into their workflow. This will be explored more in-depth in chapter 3.3.

The UCD standard defines the following elements as part of a UCD process. All except for the last one have been incorporated into my process - the exception being because this project does not grant me access to more personnel than myself.

- The design is based upon an explicit understanding of users, tasks and environments
- Users are involved throughout design and development
- The design is driven and refined by user-centered evaluation
- The process is iterative
- The design addresses the whole user experience
- The design team includes multidisciplinary skills and perspectives

The main, iterative parts of the user-centered design process include [3]:

1. Understand and specify the context of use. This involves identifying users of the product, what they're using the product for, and in what environments.
2. Specify the user requirements: identifying the business requirements and user goals of the product.
3. Produce design solutions to meet user requirements. This step can involve translating requirements into design solutions, prototypes of varying complexity, and user testing.

4. Evaluate the designs against requirements, ideally through usability testing with actual end users. If the evaluation results do not satisfy requirements, one should revisit either of the previous steps and follow the flow from there.

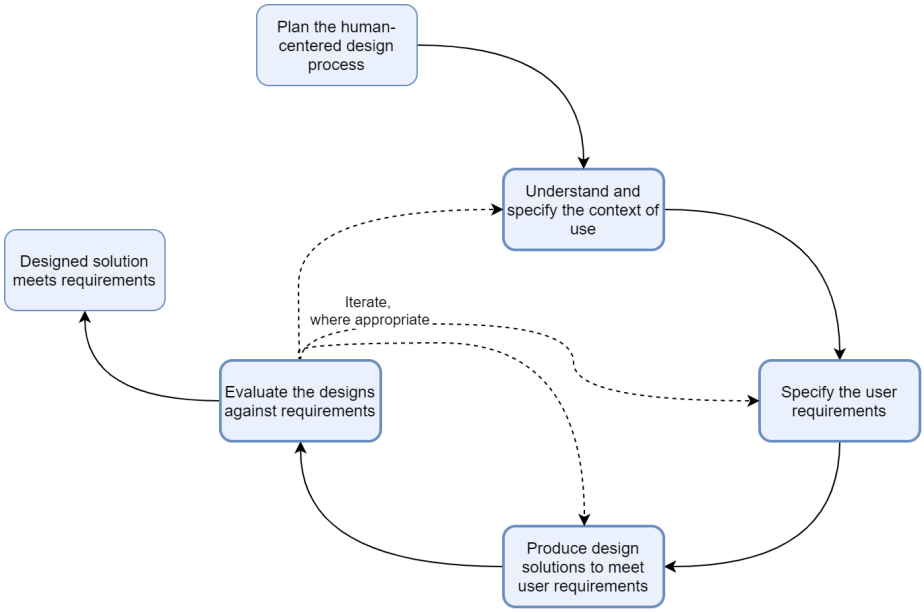

Figure 1: The user-centered design process, as described in ISO 9241-210[4]

Perhaps the most integral part of user centered-design is *testing*. Usability tests aim to find the most design flaws at the lowest cost (cost of participants, cost of observers, and cost of equipment, in addition to time limitations) [8]. Other tests can also be performed early in the process to inform design in other ways. Early studies found that at least 80% of usability problems are found in tests with four or five participants [38, 29]. Later studies, however, found that more participants are required, but this was also mostly for more complex systems. Lewis [22] concludes that the ideal number of test subjects varies with many factors, such as surroundings and the technology in question. Aside from the focus group testing, this project follows Jakob Nielsen's claim of "Five users is enough", advising that running more frequent, smaller tests with fewer subjects yields better results [26]. Nielsen emphasizes that this is especially true when the usability issues uncovered are big, which they are likely to be in the early stages of product development. For future work, I recommend following the five-person usability testing regime, splitting the project up into smaller design iterations with smaller tests to achieve the best end result.

A common approach in projects employing a UCD process is the concept of

participatory design: "A method where participants are given design elements or creative materials in order to construct their ideal experience in a concrete way that expresses what matters to them most and why" [33]. Participatory design has not been employed in this design process, because of the existence of a desktop solution. The mobile solution should not be very different, and should allow the users to use their mental models from one solution in the other. Therefore, *generating* design ideas is not as important - adapting existing ones to this new medium is the challenge.

3.2 Implementation of the User-Centered Design Process

How a project moves through the steps and iterations of the user-centered design process is determined not only by results of evaluations, but also by resources available. In this case, both time, distance, and money were limiting factors; the time from the first field study to the soft deadline for collecting results was only a few months. The designer team consists of only one person. The hospital where observations and testing could be carried out lies far away from the designer's city of residence, so flights and other traveling costs were funded by DIPS, but there was a limit of three trips total, which is less than ideal.

The final implementation of the process can be viewed in Figure 2. The results from the iterations are described in detail in the chapters following this. Below is a brief summary of the contents of each iteration.

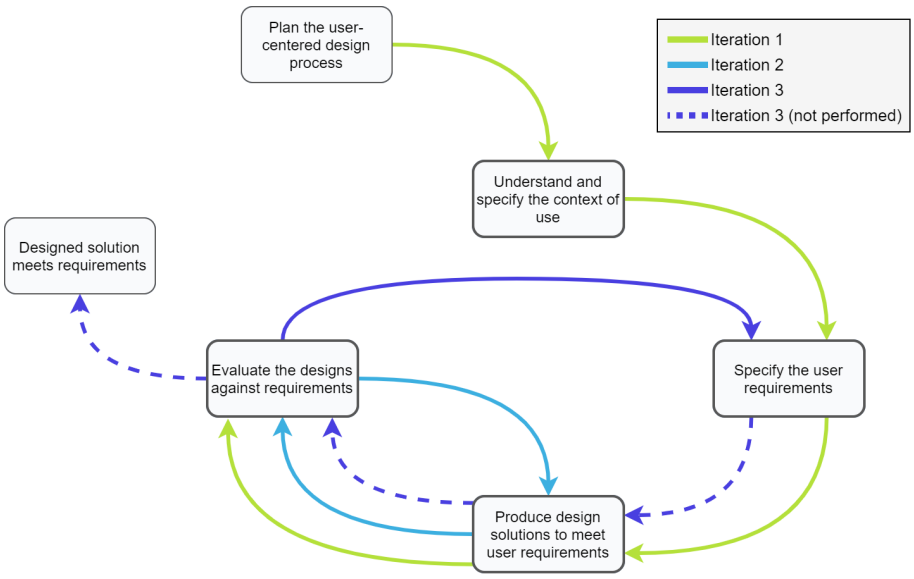

Figure 2: Implementation of the user-centered design process

Iteration 1 was planned to be the most time-consuming iteration. It started off with reading existing literature on the subject of software for nurses, mobile solutions for hospitals, as well as general HCI-related texts to help plan this process. Following that, a visit to the hospital to conduct field studies in the form of shadowing, observation, and interviews, in order to understand the context of use as well as specifying the user requirements. Thereafter a rough paper prototype was created and evaluated by a nurse employed by DIPS and therefore available to meet me without the need to travel far. Feedback from this evaluation was used to create a second paper prototype and perform the same evaluation again.

The second iteration revolved around a prototype made using the Figma. Figma is a tool for creating visual, interactive prototypes which can be viewed on any kind of device - in this case, mobile phones. This prototype was then evaluated in focus groups at the hospital, with nurses using their own phones.

The third and final iteration of this project was, as mentioned, not performed. The plans for this iteration is to create a partially functional prototype. This prototype will be used for usability testing at the hospital in simulated settings and in focus groups.

3.3 Technology Acceptance Model (TAM)

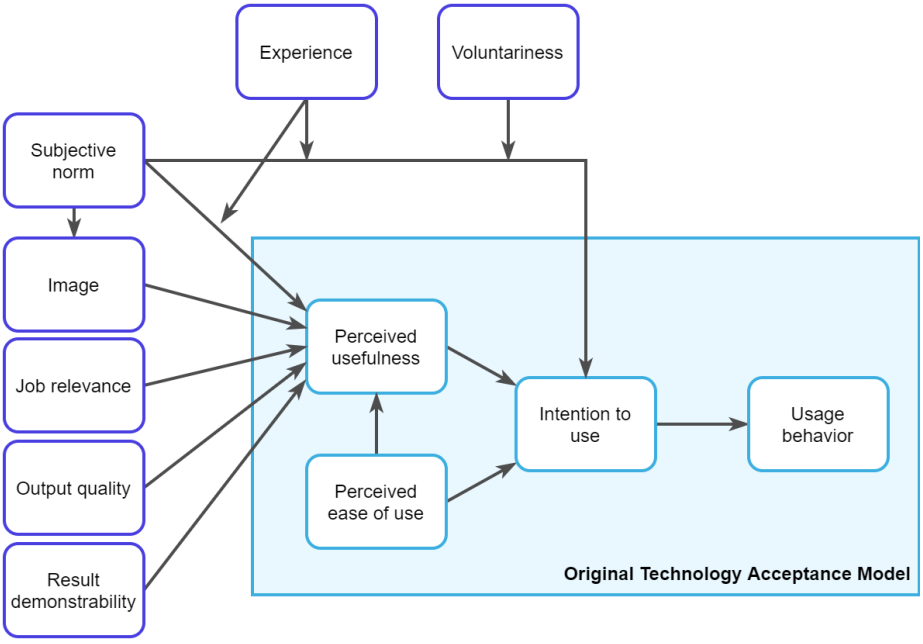

Figure 3: TAM 2, with the original TAM highlighted

TAM is a system specifically tailored for modeling user acceptance of information systems. TAM can be used both to predict adoption, and to explain why something isn't being used as hoped [13]. Since this project has a limited scope and the technology will not be fully functional by the time of its completion, only the predictive way of the model will be used in this thesis. Findings from this study will be discussed in light of TAM in later chapters. In 2000, a revision of the original TAM was made, commonly called TAM 2 [37]. Previous work [31] finds that this version of TAM works well for mobile applications in health care, so it will be used in this project to evaluate the final proposed app. Going forward, any mention of TAM refers to TAM 2. The model is illustrated in Figure 3.

A description of the elements in the model follow in Table 1. Table contents sourced from [37] and [36]

Process	Variable	Explanation of variable
Social Influence	Voluntariness	The extent to which potential adopters perceive the adoption decision to be non-mandatory
	Experience	The direct effect of subjective norm on intentions may subside over time with increased system experience
	Subjective norm	A person's perception that most people who are important to them think they should or should not perform the behavior in question
	Image	The degree to which use of an innovation is perceived to enhance one's status in one's social system
Cognitive instrumental	Job relevance	Perception regarding how relevant target system is to the individual's job
	Output quality	Perception of how well the system performs tasks that match the user's job relevance
	Result demonstrability	Tangibility of the results of using the innovation will directly influence perceived usefulness
Original TAM factors	Perceived ease of use	How effortless usage of the system is perceived to be. Involves factors such as system self-efficacy ("one's confidence in his or her abilities to perform a task successfully", or "an individual's ability to apply his or her computer skills to a wider range of computer related tasks" [21]), perceived risk, training, and prior use [37]
	Perceived usefulness	The user's subjective probability that using the system will increase their job performance

Table 1: Description of TAM2 elements

4 The Existing Desktop Solution

The software that the mobile solution aims to partially duplicate onto a mobile device already exists in a desktop version. It is a module in DIPS Arena, called Care Plan (referred to as DIPS Care Plan). This module fully represents the patient's NCP and is a part of a patient's EHR.

The containing program, DIPS Arena, has some key features relevant to explaining its NCP module. Most important is the patient selector (Figure 5). When using DIPS Care Plan, there is always exactly one active patient. The patient selector saves patients marked as favorites by the users (by pressing the star icon) and makes a switch from one patient to another available in only two clicks. There is a separate feature for searching for patients by name. When a list of patient search results is available after entering text into the search field, the only possible option is to select and thereby activate a patient.

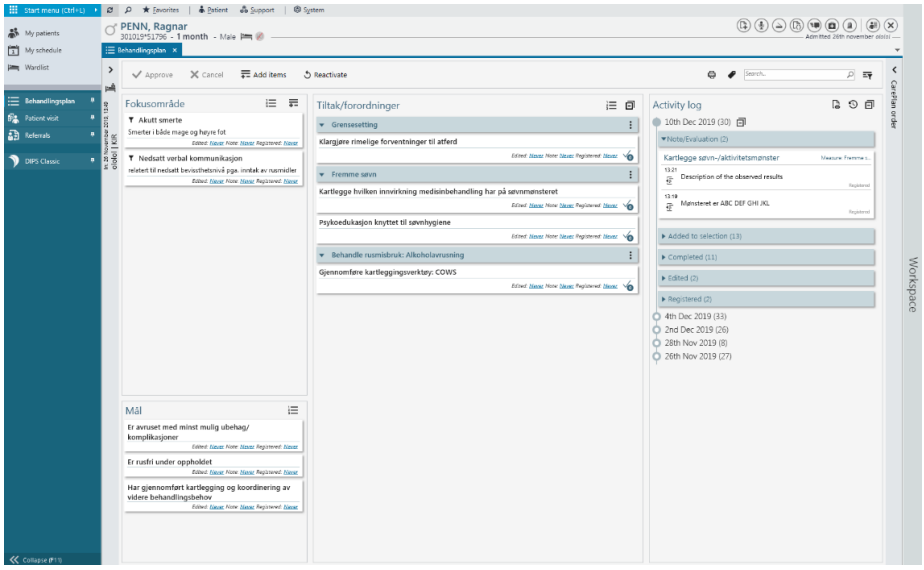

Figure 4: View of the entire DIPS Arena software, with Care Plan opened showing its default view with all active NCP elements. NCP history is to the right.

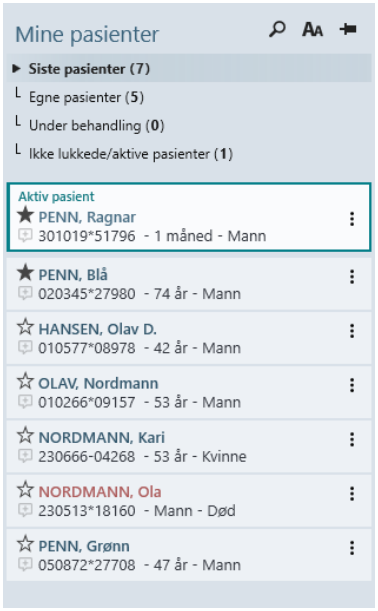

Figure 5: Patient selector showing recent and favorited patients. This can be opened with a single click, and when selecting a patient, that patient's NCP is loaded and shown.

The main viewable components of DIPS Care Plan are the NCP elements themselves and their history. These elements consist of:

- *Problems*: Defining some medical problem that the patient has. Examples of this is "Severe pain", or "Reduced verbal communication capacity". One NCP for a patient can have many problems.

- *Goals*: A goal is closely related to a problem, defining some goal for the patient during this hospital stay. This does not have to be the full elimination of the related problem, but could be an improvement of some issue.

- *Ordinations*: Ordinations represent actions needed to be taken with the patient. An ordination is also usually related to a problem. There are often multiple ordinations involved in treating one problem. These contextually similar ordinations are usually grouped together under meaningful headings - the blue elements in Figure 4. The grouping of ordinations is determined by the hospital, and can not be changed by a nurse using DIPS Care Plan. An example of one group of ordinations is "Determine experience and the best form of medicine administration", "Teach how to inject medicine", and "Observe for 20 minutes after injection". These ordinations exist in a department in the hospital, and are grouped under

the heading "Medicine injection guidance".

The available actions a nurse can make in DIPS Care Plan that do *not* affect the NCP's state:

1. Viewing all NCP elements and the patient's NCP history (Figure 4)
2. Viewing a specific element's history (Figure 6)
3. Filtering the elements shown based on tags, or by the element's state (active, planned, terminated, ++) (Figure 7)
4. Print the NCP in paper format

Available actions in DIPS Care Plan that *do* affect the NCP's state:

1. Registering that an ordination has or has not been performed (Figure 8)
2. Evaluating a focus area (Figure 8)
3. Editing either a focus area, goal, or an ordination (Figure 8)
4. Marking either a focus area, goal, or an ordination as terminated, removing it from the default view (Figure 8)
5. Adding new elements to the NCP (Figure 9)
6. Reusing elements previously marked as terminated. This is an alternative to adding new elements via the method above. It is a slightly complex process and will not be relevant for the mobile app because of this, so it is not illustrated or mentioned further.

Of the state-affecting actions, number one to four can be considered *core* actions - that is, actions that only interact with the current NCP of the patient without adding new elements. Whether the mobile application should only include core actions or all actions is further evaluated later in the thesis.

In DIPS Care Plan, elements' histories can be viewed by clicking the colored text at the bottom of each element. An example of a pop-up showing a group of ordinations' history is shown in Figure 6. The NCP's elements can also be filtered as seen in Figure 7.

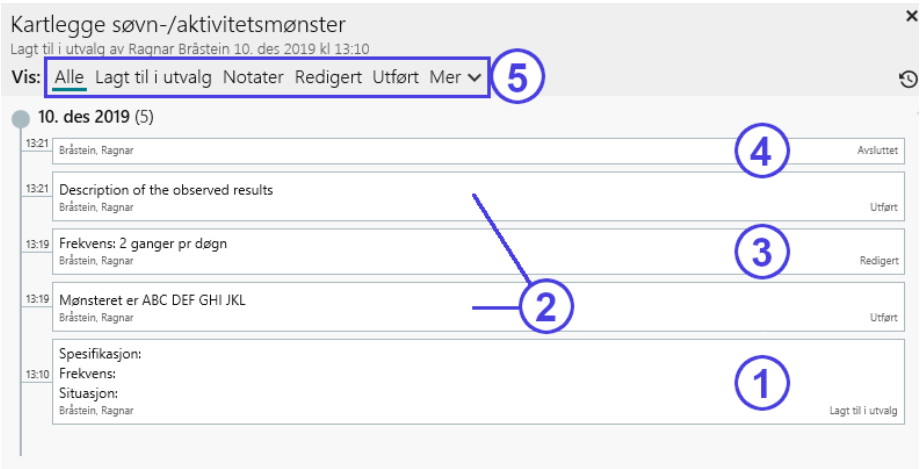

Figure 6: History of one selected ordination. This is a pop-up shown by clicking a button on the ordination in the NCP. Any changes to the ordination is displayed in chronological order, including when it was initially added (1), whenever it has been performed (2) - which can be many times, edits to its *specification* or *frequency* (3), and when it was marked as *terminated* (4), removing it from the default view of the NCP. The tabs above (5) can be used to only view one specific type of the previous changes - for instance, if one is only interested in seeing how the specification, which is often used to give further instructions on how to perform the ordination, has changed throughout a hospital stay. Similar historical views can be seen for *problems* and *goals* as well.

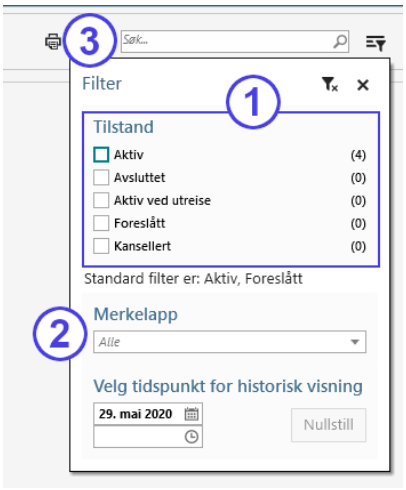

Figure 7: Pop-up for filtering elements. By default, only *active* and *planned* elements are visible, to make sure that information that is irrelevant most of the time is not cluttering the screen. One can view other elements, such as those previously active, by applying other filters (1). Additionally, elements have tags grouping them together in meaningful ways - here, a nurse can apply the tag filters they desire (2) and thus work with an NCP which is only showing the elements they need. There is also a search field just above the pop-up (3), for filtering elements by matching their names to the input text.

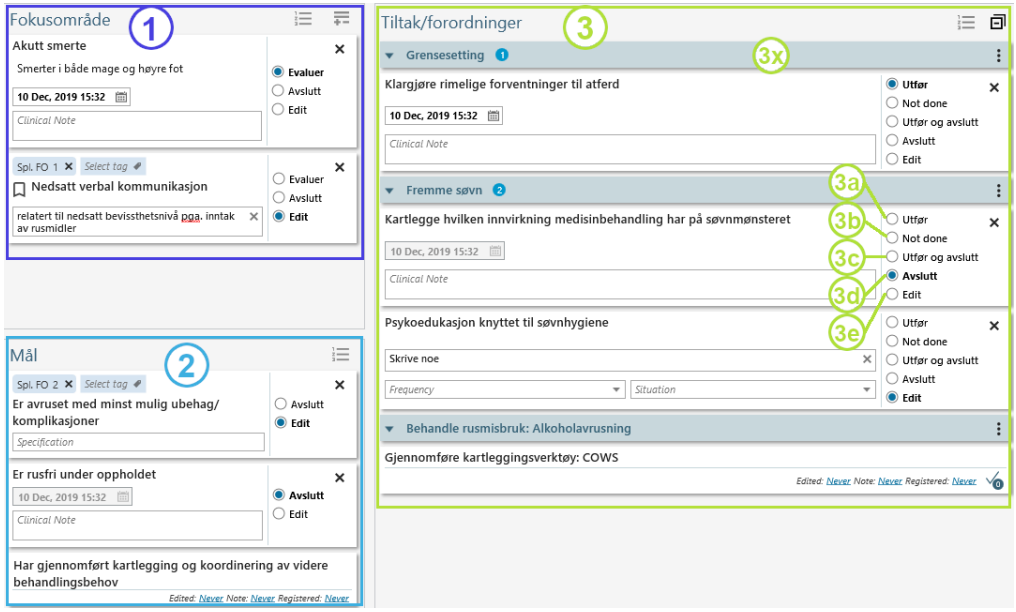

Figure 8: In this picture, most of the *documentation* possible in DIPS Care Plan is shown. To go from read-mode to documentation mode on an NCP element, the user need only click it.

For *problems* (1), the available actions are to *evaluate* one - giving an update on whatever is wrong with the patient; to mark one as *terminated*, which is done if the patient no longer has the problem; and to *edit* one, which is done if the specification needs to be updated to reflect changes in necessary details (for instance, specifying where on the body a problem called "Severe pain" is located).

For *goals* (2), available actions are the same as for *problems*, minus evaluating.

For *ordinations* (3), which are grouped together with other ordinations relating to the same issues in *ordination groups* (3x), there are more actions. Marking one as terminated (3d) or editing (3e) work the same way as for problems and goals. One can also register that an ordination has been performed (3a). This can for instance be that blood pressure has been measured, or that a wound has been checked. Here, one *can* write additional information regarding the activity, but one does not have to. Documenting that ordinations are performed turns out to be the main focus of the mobile app presented in this thesis. Finally, if an ordination should have been performed but has not been, this can be noted (3b), and (3c) is shortcut for combining 3a and 3d.

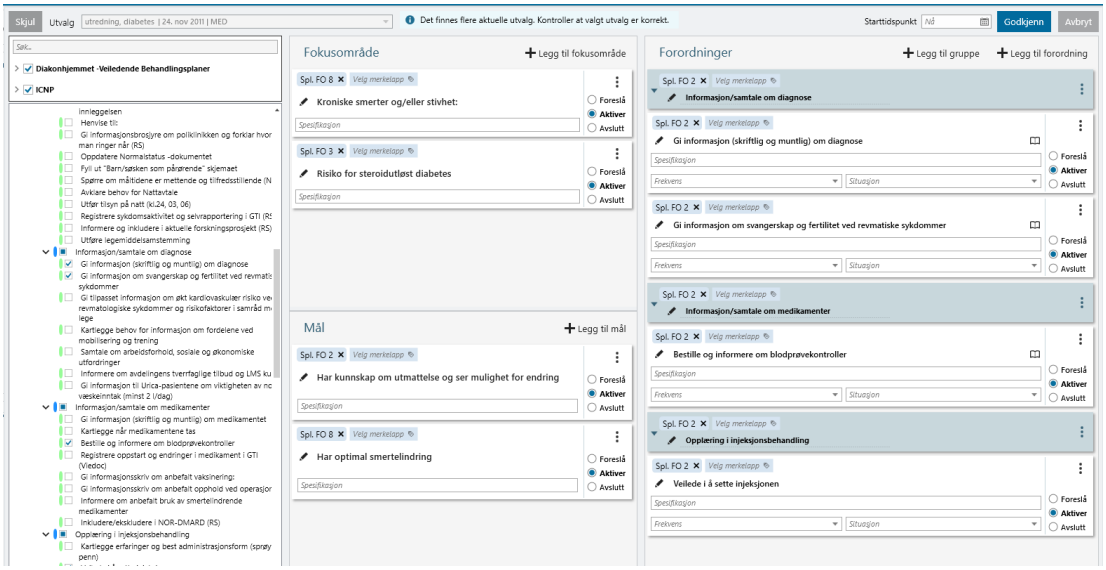

Figure 9: Adding new elements of all types to the NCP. Elements are found in the nested tree to the left. In this tree, there are hundreds or thousands of items. Each hospital has its own list of elements, their names, and how they are grouped together. Once elements have been selected from this tree, they can be specified more closely in the main view to the right.

A feature that is *not* a part of DIPS Care Plan, and thereby not included in this desktop solution's NCP, is a patient's *Vital Signs*. Vital signs are measurements vital to the patient's status, such as blood pressure, pulse, oxygen levels, etc., and the historical values of these. Vital signs are a part of the patient's EHR, but the numbers themselves are not necessarily a part of the NCP. At Diakonhjemmet Hospital, nurses still use a pen-and-paper system for registering and viewing vital signs, but this will be added as its own module, which can be reached from the NCP, in the future. As this is not in use, no screenshot is provided. This functionality is deemed potentially desired by nurses, and is therefore included in the prototypes. Later, it is discovered that this feature should indeed be included in the mobile solution.

5 Case: Diakonhjemmet Hospital

Diakonhjemmet Hospital [1] in Oslo agreed to participate in this study. Diakonhjemmet is the local hospital for about 150 000 inhabitants in the region, in addition to being the main hospital in Norway for treating problems related to the back and muscles. It is roughly the tenth largest hospital in Norway in terms of employees [39]. The hospital has about 1 700 employees, spread across three campuses. The main, somatic departments are located in the area visited. At this hospital, four wards were visited:

- *Medical Ward A*: A ward housing patients with heart and lung conditions
- *Medical Ward B*: A ward housing patients needing internal medicine care (the prevention, diagnosis and treatment of internal diseases - mostly related to internal organs)
- *Medical Ward C*: A ward housing patients with gastrointestinal as well as hematology-related problems
- *Orthopedic Ward B*: A ward housing patients post- and pre-orthopedic surgery (surgeries treating musculoskeletal trauma, spine diseases, degenerative diseases, infections, tumors, ++)

The reason for selecting this hospital is that it is currently the only hospital using the Care Plan module of DIPS Arena in production. At the time of performing the field study, the wards had been using this module for a couple of months. The hospital had previously, like most Norwegian hospitals, been using a much older program that had similar yet less efficient ways of interacting with NCPs.

Due to the location of the hospital being far away from the researcher, visits for field studies and user tests were limited to roughly 3-4 trips from the start of the project, due to traveling costs. The medical wards chosen are all somatic wards – meaning no psychiatry. Only one type of ward was chosen because of limited time and capacity to gather data and test sufficiently to satisfy nurses from both types of wards, as somatic and psychiatric nurse work is quite different. Despite the wards being of a similar kind and in the same hospital, wards often have different workflows for their nurses - some differences occur due to different wards enforcing different routines for their nurses, and some differences seem to occur due to habits collectively formed by nurses within a ward over time. In addition to these differences in workflow, individual nurses also often have significant differences in how they perform their tasks. This will be explained in detail in the findings for the first iteration.

Naturally, the layout of the wards is different, though the most interesting elements are present in all: patient rooms, a medicine room, a kitchen, a doctor's office, a large break room with a large table and many computers, and one or

two smaller rooms with additional computers. A rough map of one of the wards visited can be seen in Figure 10.

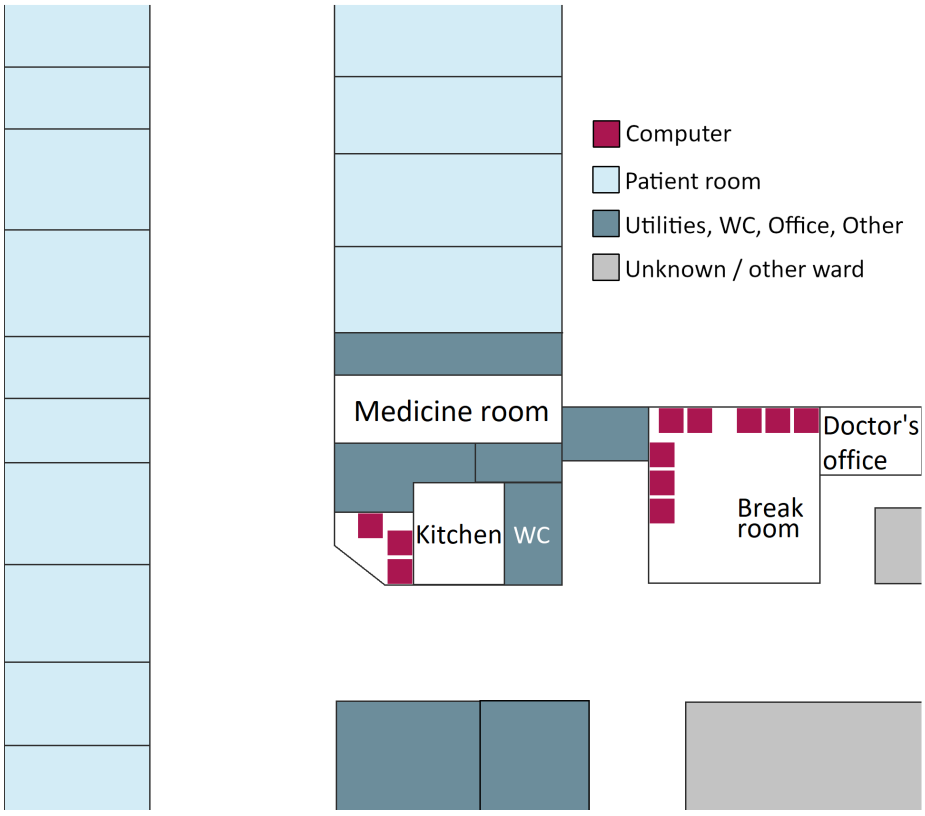

Figure 10: Rough map of one of the wards. Patient rooms can fit one to four patient beds, and during these observations most of the beds were in use.

6 Designing the mobile solution

6.1 Iteration 1: Field Study and Paper Prototype

This chapter describes the first iteration's observations, results, and impact on the remaining stages of the project. This involves a field study, the creation of a simple paper prototype, and the evaluation of this. Following that, briefly, a second paper prototype is described, as well as its evaluation.

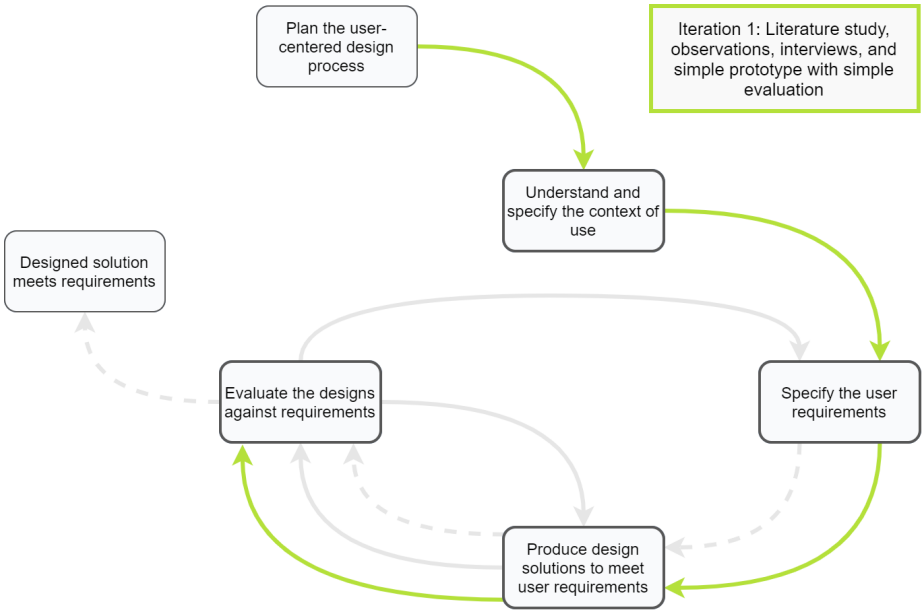

Figure 11: First iteration

6.1.1 Methodology for Specifying the Context of Use

Field studies are one of the most valuable methods for setting a design project's direction and discovering unmet user needs [28]. Field studies are research activities that take place in the user's context rather than in one's office or lab. Studying users and tasks in their context can inform design decisions and can put the focus on outcomes, not features [16]. As the pool of possible features for the mobile application was mostly known in advance, from the desktop version, the focus of this project is not feature discovery, but rather feature selection as well as how features can best be implemented to fit usage on a mobile device. The end goal, of course, is a tool as efficient and comfortable to use as possible for nurses. One of the main questions at the start of this project was: "How much of the functionality found in DIPS Care Plan should be included in the app, and how?". To answer this question, there was a need for understanding the workflow of the nurses - not just medically, and not just

the most important parts - but every detail of their movements, surroundings, and interactions. In creating the best possible product for users, one should not simply ask them, as users often "don't know what they want" [27]. Instead, watching them work is a better strategy to truly understand the context, with as little bias as possible.

Shadowing

Shadowing is a research technique which involves a researcher closely following a member of an organization over an extended period, typically the member's full working day [23]. Depending on the goal of the research and the complexity of the person's tasks, the shadowing can be of a single person, a single role, or multiple different people and roles. The goal of shadowing is to "understand the brief, fragmented, varied, verbal and interrupted nature of organizational life" [23]. Understanding the workflow of nurses is crucial in making this app, as the app focuses on being useful for the nurses, rather than covering specific technical requirements.

In this project, the chosen strategy was to shadow multiple nurses, following each one through a full shift of eight hours. Four nurses from four different hospital wards were selected. The nurses had work experience ranging from less than a year to twenty years. The reason for shadowing multiple nurses was to distinguish common routines for all nurses from habits of individuals. Nurses were asked to clarify actions when appropriate. After the first couple of shifts shadowed and a thorough reviewing of notes taken during this process, a small set of open-ended questions were formed. Nurses were later asked to answer these, and replies were recorded in audio format.

When shadowing, I equipped the white clothes required by hospital policy, and followed the selected nurse in their every activity, including events such as patient bedside visits, doctor's consultation sessions, wound treatments and medicine preparations.

In addition to shadowing, nurses were picked out for short, unstructured interviews based on a small set of questions, both regarding working habits and thoughts about the proposed app.

Observation

In addition to shadowing nurses, a simple fly-on-the-wall style observation was used for observing PC documentation. While shadowing a single nurse is an excellent tool for understanding their workflow, observing a crowd of nurses influencing each others' work also provided good understanding of their working environment. This kind of observation was conducted in break rooms or other rooms with multiple computers. Once again, white nurse clothes were worn as they help me blend in more, increasing the likelihood that nurses do their job as normally as possible. Nurses were informed at the start of their shift that

there would be an observer taking notes, but that there would not be any kind of evaluation regarding how well anyone did their job. When observing, I stood as far away from the nurses as possible while still being able to see what was done on the screen. I occasionally asked questions in order to better understand why tasks were being performed in a certain way or order.

6.1.2 Context of Use: Main Findings

Nurse workflow

While some aspects of a nurse's workflow depend on their ward, there are still major similarities in every nurse's shift. Below is a description of a typical daytime shift, which begins 07:30 and ends 15:30. The big-picture flow of a shift, as well as a more detailed example, is illustrated in figures below the list. Below that, Figure 12 provides a rough visual view of the nurse's major movements through the ward in a typical shift, and Figure 13 shows a more detailed view of 18 minutes of a shift.

1. Morning meeting in the break room. Duration: 10 minutes. The shift coordinator assigns a number of patients to each nurse, typically two or three. Then, there's a short summary of all the admitted patients' statuses and other relevant announcements – e.g. that a room is unavailable due to infection risk – are made. Shifts overlap by thirty minutes, so while the beginning shift has their morning meeting, the ending shift's nurses are still working. All nurses observed wrote down information given relevant to them on a slip of paper that they carry on them throughout the day.

2. Each nurse grabs a mobile phone. Each phone has a four-digit number that anyone else can dial to reach the possessing nurse. Nurse-to-number combinations are written down on a whiteboard. The only capability of these phones is to call the others.

3. Reading assigned patients' NCP, in order to know what treatments are necessary. This info also gives the nurse the potential to assist or correct doctors when in a doctor's consultation session. The most important parts of this information is written down on the slip of paper. More experienced nurses tend to write less than others, but every nurse observed wrote at least some information from the NCP on their paper. Time: roughly 20 minutes.

4. The nurse goes by the rooms of assigned patients, introducing themselves if necessary, and asking if they're ready for breakfast. Time: 10 minutes.

5. The nurse prepares and give meals to assigned patients. Depending on amount of patients and how much assistance needed, 20-30 minutes.

6. The nurse prepares and administers medicine to patients. Measuring is

done in the medicine room. There is frequently idle time because another nurse is using the necessary equipment. Nurses often collaborate in making measurements, both for practical reasons and for because it is legally required that the measurements of some drugs are observed. Time: 30 minutes

7. Doctor's consultation: The nurse is called to the doctor's office – in the same ward and hallway – in order to get instructions on whether to and how to treat assigned patients. Typically present in the session is a doctor, the nurse, a nutritionist, and sometimes an additional medically educated person depending on the ward. There might be a screen or projection on the wall which they refer to, typically displaying graphs or used to look at documents concerning the patient that are not a part of the NCP. During this session, the nurse sometimes refers to their slip of paper for information gathered from the patient's NCP. Time: 10 minutes. The timing of this session compared to the previous tasks varies. The doctor calls in one nurse at a time. Typically, all nurses have visited the doctor by lunch time. This is not how all wards do doctor's consultations, discussed in the following section.

8. The nurse gives appropriate treatments to patients. This could be anything from administering more medicine, to changing the bandages of a wound, to preparing them for transport to another medical facility. Observations from these activities are discussed further below.

9. Lunch break. Time: 30 minutes

10. Resume step 8 along with other tasks that appear. It is not unusual that a nurse is asked to assist another in some task such as wound treatment or other advanced procedures.

11. Start documenting on the computers, one to two hours before the shift ends and for much of the remaining time. Additionally, patients often have needs they ask their nurse to take care of, such as helping them go to the toilet, or bringing them beverages. In some wards, patients arrive randomly due to emergencies, and are then assigned to one or several nurses.

Sometimes there are periods of sitting down and talking to other nurses in between some of the tasks listed. Mostly though, nurses say that they are busy throughout their entire shift. One activity I sadly did not get to observe, that happens quite frequently, is patient monitoring. One possible reason for a patient needing monitoring is that they are in a critical condition and need an eye kept on them in order to prevent death or other unwanted occurrences. Another common reason is that after administering certain medications, a patient must legally be observed for a specified amount of time. During patient monitoring,

the nurse simply stays in the room of the patient and does mostly nothing, other than talking to the patient.

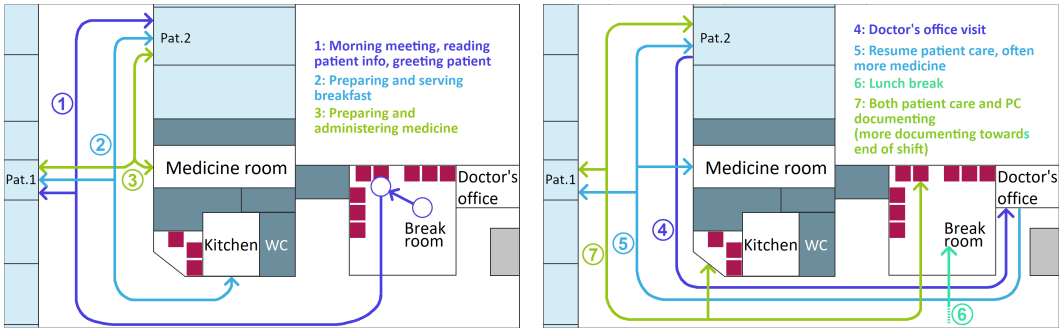

Figure 12: Major movements of a nurse through the ward. The map is a cropped part of the ward shown in Figure 10. This assumed that the nurse has been assigned two patients. This is an extremely simplified summary of the nurse's movements, only intended to be a visual depiction of the list above. As the next figure shows, the actual amount of movement is much, much higher than this figure might imply.

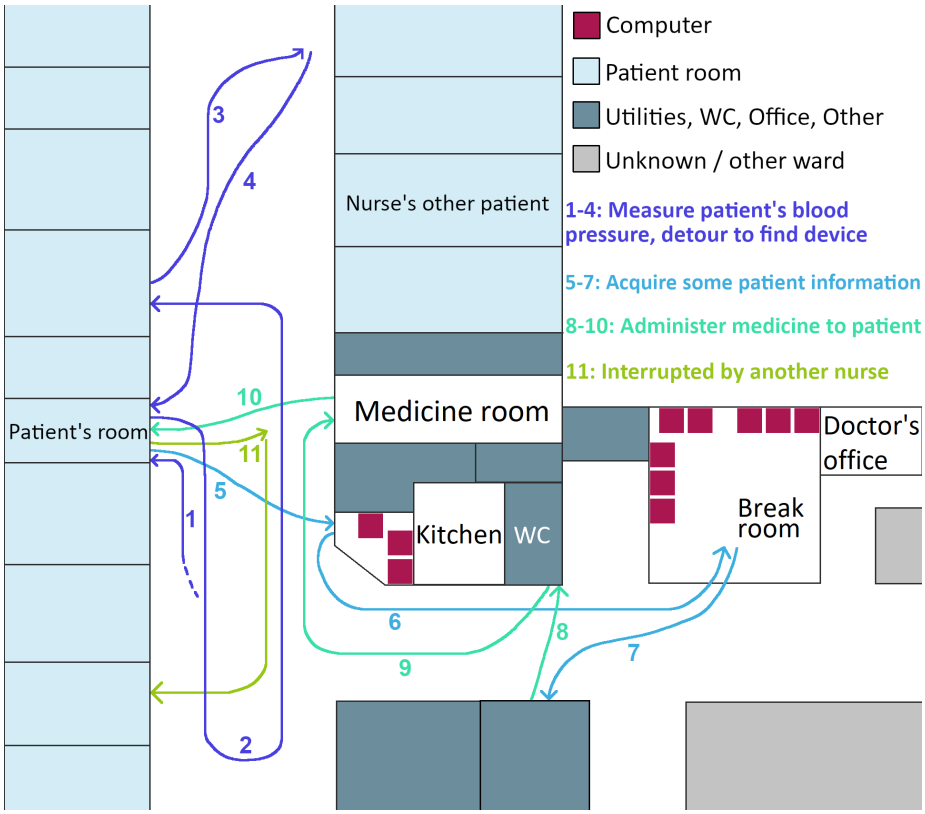

Figure 13: A detailed view of the movements of one nurse over the course of 18 minutes. Description of each movement follows below. It is easy to see that the previous findings stating that nurse work is chaotic and that accurately describing the flow of their work is impossible, as many of these events are random (missing information, looking for devices, finding another nurse, being interrupted by another nurse).

1. The nurse enters one of their patients' room to clarify something regarding planned procedures for the day.

2. The nurse exits the room in order to find a device for measuring blood pressure. As other nurses are performing the same activity, there is no measuring device immediately available in the hallway, the nurse searches and ends up peeking inside another patient's room to see if someone is using (and will soon not be using) one in there.

3. The search in the room did not pay off, but another nurse is spotted leaving their device in the hallway. This device is then taken.

4. The nurse enters their patient's room with the device and makes the mea-

surement.

5. The nurse needs to clarify some patient information relating to the previous shift in order to administer medicine. The nurse accesses the patient's NCP on a computer and finds some information, but not enough.

6. The nurse determines to look for the nurse caring for this patient the day before, and finds them in the break room.

7. Having acquired the information, the nurse clarifies something with the receptionist on their way back to the patient.

8. The nurse applies antibacterial gel to their hands.

9. The nurse enters the medicine room and quickly prepares medication for the patient.

10. The nurse enters the patient's room and administers the medication.

11. On their way to the other patient's room, another nurse asks for help with a procedure, so the shadowed nurse accompanies them to another room.

Individual and ward-related workflow differences

The previous section was a very generalized summary of a nurse's shift, though as mentioned earlier, there are differences in this workflow both individually from nurse to nurse, as well as from ward to ward. Below are some examples of some of these differences:

- Reliance on the slip of paper varies. Some observed nurses use a piece of paper smaller than their hand with little content on it, while others write significantly more.

- The fraction of documentation done at the end of a shift varies significantly, even within wards, from nurse to nurse. Some nurses spend more than twice as much time documenting at the end of their shift than others - sometimes due to differences in their assigned patients, but also due to differing workflow preferences.

- The verbosity of documentation texts vary, both due to ward policies and nurse preferences. This means that the attractiveness of documenting on mobile phones could vary from nurse to nurse based on how long texts they're used to writing.

- Perhaps the most notable difference is that some wards do not have every nurse on shift visit the doctor to discuss their own assigned patients, as described in step 7 above. In these wards, every day shift, one or two nurses are given the role of *group nurse*, meaning that they are assigned

all or an even share of the patients in the ward. The nurse must then quickly read patient info as described in step 3 above, only in this case for significantly more patients. Then, early in the shift (typically within an hour), the nurse is called to the doctor's office to do the same discussing of how to treat patients as described in step 7 above, but with significantly more patients. Then, the nurse describes treatment information received in the doctor's office to each patient's assigned nurse. The other nurses still have "regular" care duty for patients as before, but they will not do the doctor's consultation.

Shortage of computers

When the nurses from the daytime shift would like to read patient info (step 3 above), all computers might be occupied. This occurred to some extent in all shifts observed. The reason for this shortage of computers is that at the same time, nurses finishing their shift is doing most of their end-of-shift documenting (step 11 above). Nurses who do not get access to a computer mostly idle about, doing nothing productive while waiting for one to become available. This is possibly the most obvious situation in which it would be advantageous for the nurses to have access to the NCP on mobile devices - in order to read patient info even if all computers are occupied. From the observation of this, it is clear that easy access to reading is a priority feature which should be usability tested. Plans for such tests are described later.

Documenting

As described above, nurses save most of the documentation work for the end of the shift rather than documenting as they complete tasks. When asked why, the most common reasons given were:

- If they start documenting at one point, and then continue later, the "overhead" following a documentation session is doubled. This overhead includes:

    1. Finding an unoccupied computer
    2. Logging on
    3. Starting the program (DIPS Arena)
    4. Selecting the patient and waiting for the data to load
    5. Opening DIPS Care Plan and identifying where in it the relevant items are, as well as possibly getting necessary contextual information found other places in the NCP

- In addition to the quantitative overhead involved in entering and exiting

a documentation session, some nurses also express a mental overhead, as their mindset when caring for patients is different from when documenting.

- Finally, some documenting is meant to be a summary of the patient's status or changes at the end of one's shift and can't effectively be split into smaller parts.

This mental overhead is also found in other research, as "An increasing body of research on information workers using personal computers shows that there is a significant mental and manual overhead associated with the handling of parallel work and interruption" [7, 18, 32].

In Table 2 are some gathered numbers on documentation text length. The numbers were gathered during four shifts, from in total more than 30 nurses.

Text length (words)	**Times observed**	**Fraction**
0	102	34%
1-5	59	17%
6-12	74	21%
13-30	45	15%
31+	41	13%

Table 2: Documentation text lengths

It is unknown how many of these instances in theory could have been documented right after a task was performed, versus how many are necessary end-of-shift documenting. Constantly asking the nurses this would have been too distracting in a setting where there's already pressure to finish by the end of one's shift.

The nurses' thoughts

Every nurse interviewed expressed either a positive or a neutral attitude towards the idea of the proposed app. The degree and ways in which the nurses thought they would use the app varied; some, when initially interviewed, said they thought they would use the app to document while at the patient's bedside. However, after shadowing and asking further questions, it became clear that most of the documenting is done at the end of the nurses' shifts. Additionally, 'blindly' accepting input from users regarding what they *may* do in the future is not recommended [27].

Nurses identified certain scenarios in which they said they would want the proposed app:

- When a patient needs to be escorted to a bathroom and back again, there

is idle time for the nurse while the patient is using the bathroom

- When administering certain types of medicine, the patient needs to be observed for up to fifteen minutes afterwards, creating idle time for the nurse
- Similarly, there is a fifteen-minute observation period after administering blood to a patient
- One nurse said that a mobile app would be useful while pushing a patient around in their wheelchair

In addition to everything described above, nurses and nurse practicioners were asked what they thought about the device of this potential app - specifically, whether they believed they would prefer a tablet or a smartphone. 10 out of the 12 nurses asked said they would prefer a smartphone, while one was uncertain and one preferred a tablet. This smartphone preference aligns with Bardram's finding [7]:

> The workshop clearly revealed that the clinicians preferred not to carry a tablet PC around; it was too heavy it was too large to fit into a white coat pocket, and it was difficult to handle it in front of the patient—the most obvious thing was to drop it in the patient's lap, which was clearly inappropriate. A PDA was considered more suitable, but due to its limited display size, limited battery lifetime, and lack of keyboard, it was perceived as useful only for certain simple tasks, such as checking off medicine intake or doing a simple data entry.

The battery lifetime aspect considered in 2010 is irrelevant today. As for the lack of keyboard and limited display size, attitudes towards this should have changed significantly during the past decade, now that most people use smartphones for everyday tasks. Because of these findings, a smartphone is chosen as the target hardware for this thesis' app.

6.1.3 Initial Requirements

Initially, there were no requirements other than the general idea of the mobile solution having mostly a subset of the features of DIPS Care Plan. However, after the field study, a short list of probable and possible needs was made:

- Nurses must be able to find patients and save them for quick access later
- Nurses must be able to view the NCP elements of a patient
- Nurses must be able to efficiently read the patient's entire NCP history
- Nurses must be able to view one specific NCP element's history

- Nurses must be able to filter elements as in the desktop version (by tags, name search, and element state)
- Nurses must be able to change between episodes of care as in the desktop version
- Nurses *could* be able to document (make changes to the NCP) with text
- Nurses *could* be able to document without text - that is, marking ordinations as performed, or changing an element's state (typically from *active* to *terminated*)

Adding new elements to the NCP via the mobile solution was never thought to be desirable, as the screen real estate of a mobile phone is simply not big enough to make this efficient. This was never asked for by any nurse later in the project either. Unsurprisingly, printing the NCP in paper format was not deemed necessary. The final main feature not added as a requirement is the reusing of elements previously marked completed - this is essentially always done once per episode of care, along with lots of other work that, again, a mobile phone is too small to make efficient.

6.1.4 Paper Prototype

After gaining a thorough understanding of the context of use and workflow, the next major step in the chosen design process would be to create an interactive prototype and evaluate it with nurses. However, to ensure that time and money was not wasted by creating a prototype with easily avoidable flaws, a simple sketched paper wireframe was created and shown to a nurse located in the office, and therefore easy to reach. The wireframe was also shown to the mobile development team. This process did not take more than a day, and provided useful feedback used to create the interactive prototype later on. Pictures of parts of the paper prototypes can be found in the appendix.

Procedure

The paper wireframes were drawn by pen on regular, white paper. Various views of the app were sketched, some headline texts were written in actual text, while other texts (such as titles and specifications of NCP elements) were just illustrated with squiggly lines. Arrows indicated transitions between screens. The first version of the wireframe was simply shown to the nurse and mobile team, with explanations added by the presenter - no role-playing or other interactive methods were used. The viewers were told to interrupt at any point if they found something they disagreed with. Following this, a second paper prototype was created based on feedback received. The same procedure was run for this one.

Findings

From the first prototype, there were two main findings. The first was regarding how the app should behave when documenting multiple items. In DIPS Care Plan, as can be seen in Figure 8, nurses can have multiple NCP elements in a documenting state at the same time, before finally approving all the documentation they've done at once. In the first prototype, the same idea was sketched. The nurse pointed out that the value of having multiple NCP elements in a documenting state at the same time is vastly reduced, and might even lead to errors, when all elements cannot be seen on the screen at the same time. This feedback resulted in the change that can be seen in Figure 14. When selecting an element for documenting, the documenting view for this element is opened as a pop-up, which is either approved or discarded. That means that only one element will be documented on at a time, as is more befitting a smartphone screen.

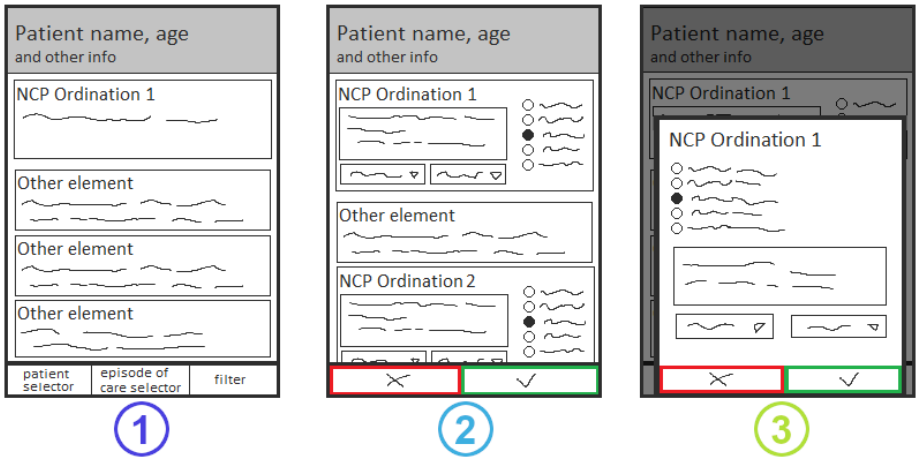

Figure 14: Illustrated changes to documentation from the first to second paper wireframe, recreated digitally because the original sketches were of very poor quality. (1) shows the NCP prior to any documentation. This view is unaffected by this change. (2) shows documenting in the first prototype, where one can document many elements simultaneously, with approve/cancel buttons at the bottom. (3) shows the second paper prototype's idea, with a pop-up for a single element, requiring approval/cancellation before documenting more.

The second major finding from the first prototype was that the scrollable Vital Signs at the top (Figure 15) was thought too hard to reach and too small relative to how important it is to nurses. "If vital signs are going to be in this app, they shouldn't be this small", the nurse said. So, for the second paper prototype, this part of the app was made into a tab alongside the rest of the NCP, making all its contents easy to reach. The change is illustrated in Figure 15. The need

for tabs at the bottom also meant that the buttons previously located at the bottom needed a new home. The mobile team, when hearing this, suggested a pop-up menu with fixed positioning. It was also pointed out that an option for showing or hiding tags on elements had been left out. This was added to the new menu, as seen in 2b of Figure 15.

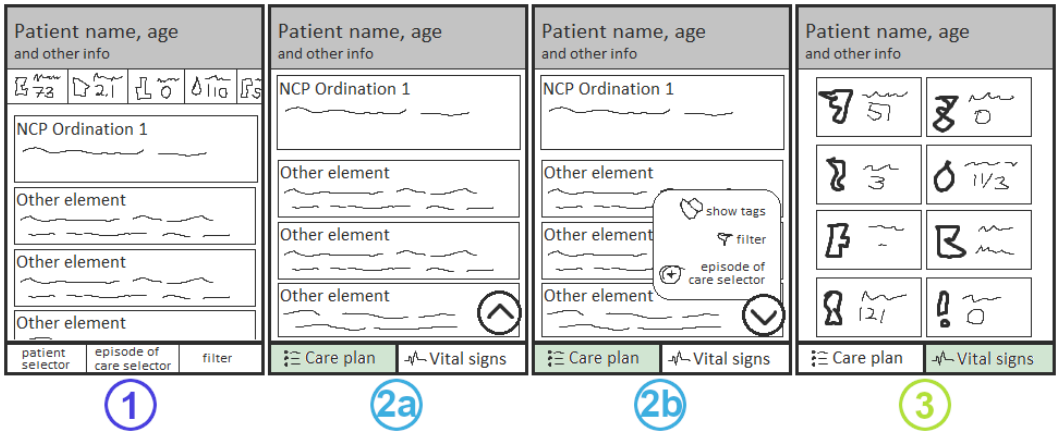

Figure 15: Changes made to vital signs from the first to second paper prototype, again recreated digitally because the original sketches were of very poor quality.

The first paper prototype is seen in (1), with vital signs near the top. The user scrolls through the vital signs horizontally and taps one to select it (for registering new values or seeing details of the selected one). The tiles consist of an icon, the name of the "sign" (for example blood pressure, oxygen level, etc.), and the actual status, often a number.

(2a) shows the second paper prototype with the new menu (bottom right) closed. (2b) shows the same, but with the menu open. The previous buttons at the bottom are put into the menu, and tabs have replaced them.

(3) shows the new full-screen view for vital signs in its own tab.

For the second prototype, a few changes were suggested by the nurse. The episode-of-care-selector (essentially, a list for selecting which hospital stay one would like to see the NCP for) could be merged with the other filters, reducing the number of buttons in the menu seen in 2b, Figure 15, from three to two. Additionally, it was suggested that the button for the patient selector be removed, as this is reached by going "back" with native phone functionality already.

Other than this, the prototypes received no major criticisms. The mobile team assisted by providing some visual design guidelines which were used in the next

iteration. The nurse agreed that adding or reusing elements is most likely a feature that will not be used. The second paper prototype, with suggested changes in mind, became the basis for creating the prototype in the next iteration.

6.2 Iteration 2: Interactive Prototype

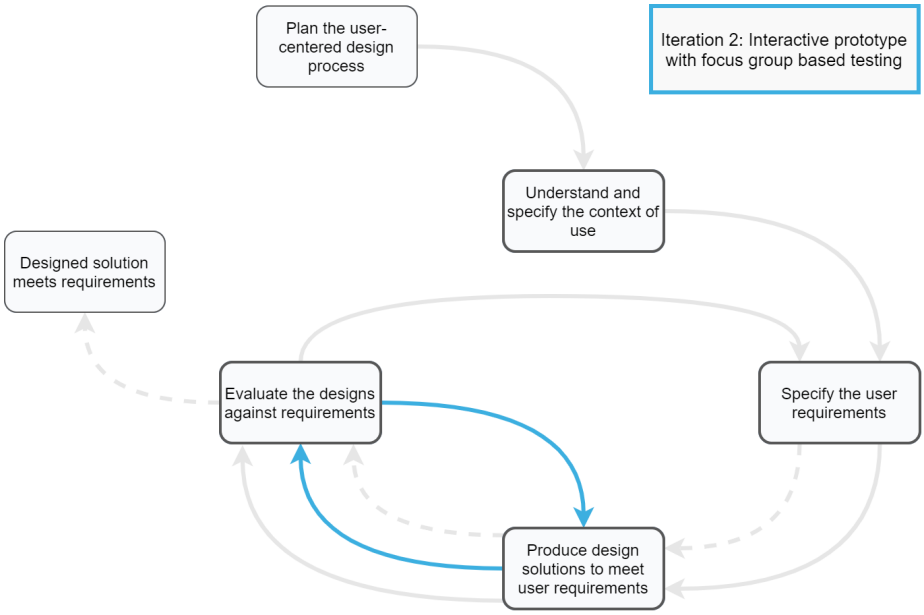

Figure 16: Second iteration

6.2.1 Methods

Interactive prototype

An interactive prototype is something that changes state based on how test subjects interact with it. The long-term benefits of higher fidelity prototypes are much like those of for instance paper wireframes; mainly saving development time by iterating to ensure that the goal when starting proper development is as close to what the users *actually* want as possible. The main questions an interactive prototype of medium or high fidelity can help answer is[17]:

- How would users interact with the product?
- What is the sequence of screens or pages?
- What could you do to optimize the user experience?
- Are there any better alternatives for representing a particular interaction?

Today, there are incredibly many available products that enable rapid interactive digital prototype creation [6]. The chosen tool for this project is Figma[2]. Figma is web-based, easy to use, supports collaboration between multiple designers, and enables creation of prototypes for any device. In Figma, one creates multiple *screens* as well as overlays that are reusable and can appear over any screen interactively. Elements, such as buttons, can be duplicated and reused. The interactivity aspect comes in the form of *navigations*, which are rules for transitions between screens or overlays, triggered when the user taps or clicks in defined regions of the screen. When testing on mobile devices, test subjects may install an app on their phone and enter a code to launch a specific prototype. Alternatively, prototypes may be accessed via a web browser, resulting in slightly worse performance but less setup time. This project utilizes the former of the two options. Figures 17 and 18 show Figma in the development environment, and as seen by test subjects, respectively.

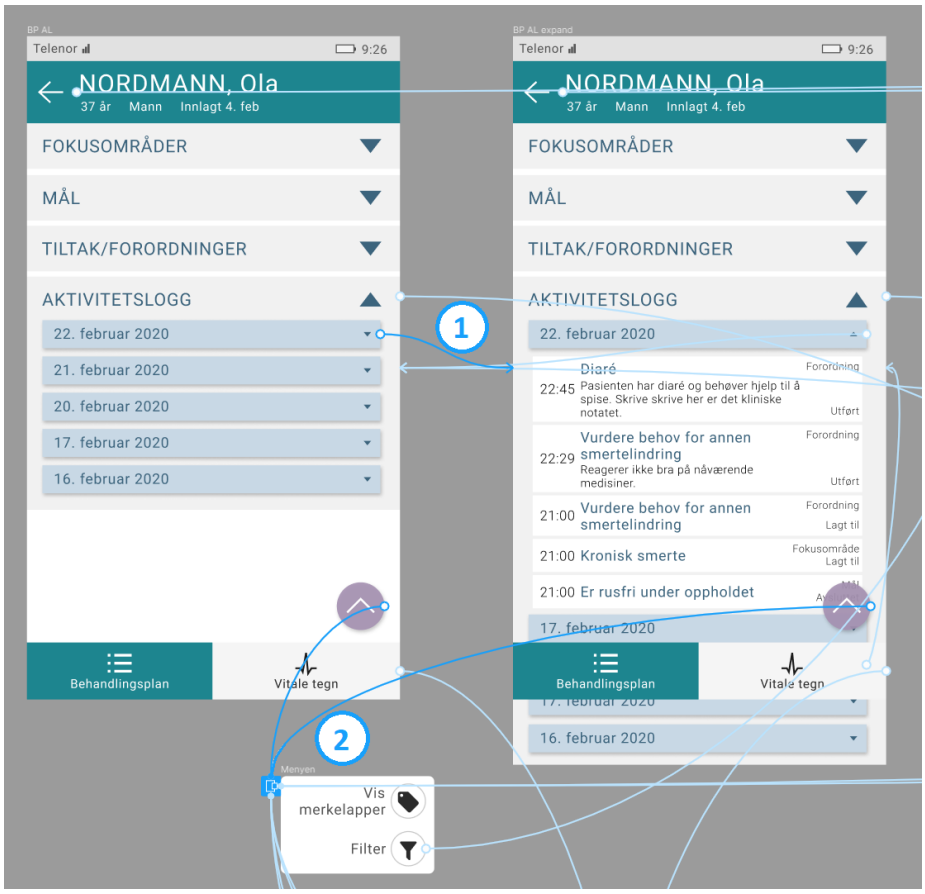

Figure 17: Two screens and one overlay as seen in Figma's working environment. Transitions to and from other screens are light blue arrows. Highlighted transitions in dark blue are (1): The transition from one screen to another, simulating the expansion of an item, and (2): Two overlay transitions to the same reused overlay, displaying a small pop-up menu (bottom) above the purple arrows in each screen. In total, 24 screens and overlays were used in making this prototype.

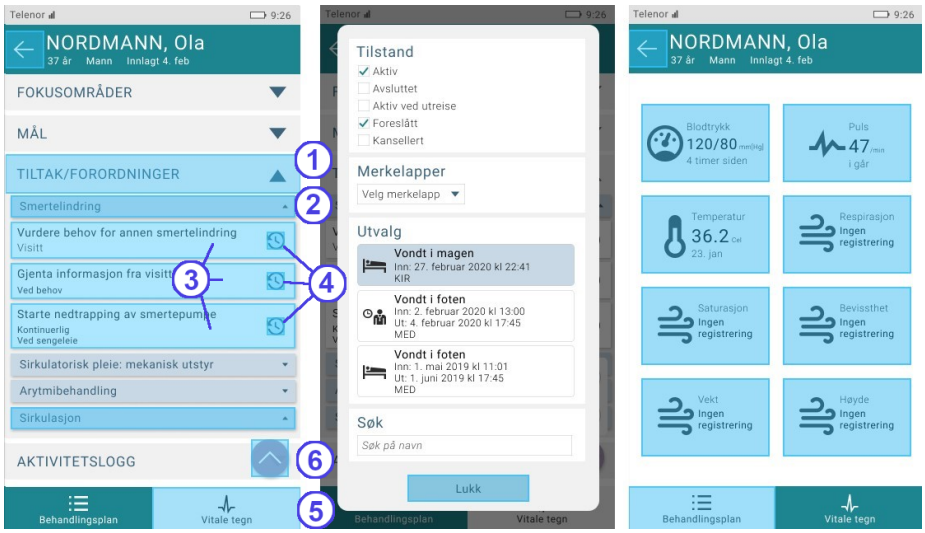

Figure 18: Three of the views encountered in the prototype as seen in test mode. Interactive regions are highlighted in light blue - this is what a tester sees if they tap any other place on the screen than the indicated regions. Otherwise, the blue highlights are not shown.

The leftmost screen is part of the default NCP view when selecting a patient, with *ordinations* expanded. The ordinations tab can be tapped to close it like the others are above (1), an ordination group can be tapped to reveal or hide its ordinations (2), an ordination can be tapped to enter documentation mode (3), or the history-icon can be tapped to show an ordination's history (4). Finally, (5) will take the user to the rightmost screen, and (6) will open a menu with two options, one of which opens the center screen pop-up.

The center screen is an example of showing that functionality exists (ability to change filter), without spending lots of time implementing this into the prototype. The user cannot change the filter, only see how the filter selection looks and close it.

In the rightmost screen, the *vital signs* tab is selected. All eight center elements lead to the same pop-up (not shown), showing the testers that one can register values, but again without spending time creating a unique pop-up for each type of measurement.

Focus group assessment/evaluation

Focus group research is a form of qualitative method used to gather rich, descriptive data in a small-group format from participants who have agreed to 'focus' on a topic of mutual interest [40]. Focus groups are selected as the setting in which to perform the usability test in iteration 2. This is because of the varia-

Figure 19: Photo from one of the focus group sessions, in the first stage where nurses explore the prototype. Following this is a group discussion, guided by questions when needed, as in an unstructured interview. On the laptop, the prototype's access code is displayed.

tions in workflows between wards and between individuals as described earlier. As [40] discusses, focus groups often result in richer, deeper and more honest feedback when participants have different experiences or viewpoints.

The alternative to testing this non-functional prototype in focus groups would be one-on-one testing, either by letting the nurse freely navigate, or by setting up specific scenarios. However, the features of the prototype being tested can be used throughout the entire shift of a nurse, and in many different settings. It is therefore difficult for one nurse on their own to immediately think of and relate the prototype to all of these situations. With the scope of this project it is also impossible to construct tests for all, or even many of, the use cases discovered. Thus, a focus group setting is beneficial for getting as much feedback and discovery as possible. Three focus group evaluations were performed, the groups having 5, 6, and 5 participants respectively. In two of the focus groups, one nurse practitioner or other personnel with a leading role participated. The work experience of the nurses ranged from two months to thirty years. This spread ensures a richer discussion.

When designing the interview stage of the focus group session, four important questions from [5] were considered:

- **Why the questions are being asked**: In order to ensure feedback on what was believed to be the most essential features, as well as the discovery of potential new ones, a small set of questions was formed. If the group did not talk about any of the questions on their own, I would prompt the

discussion of this by asking.

- **Who the results are for**: The designer - in this case, me.
- **What you expect to find from the answers**: The hypothesis was that most of the designed app would be accepted, but that a few elements or interactions would be unexpected and/or unintuitive. It was also expected that the participants would occasionally drift off to discussing features outside of the scope of the app - that is, features that are not related to the NCP. The chosen solution to this would be to gently remind them of the scope of the app.
- **How you are going to analyze the data when you get them**: As the role of the facilitator in this focus group session is mostly passive, taking notes on a laptop was chosen as a strategy. It should be noted that this is only deemed acceptable because the facilitator in this case is a fast typer and can maintain eye contact and focus while simultaneously typing. The notes from various sessions would later be aggregated into a few categories, mostly being the same as the prepared questions. These, and the results of the analysis, are described later.

6.2.2 Evaluation of the Prototype

Physical setting
The focus group was seated around a table in a formation roughly resembling a circle, to create a good discussion environment. The facilitator sat/stood at one end of the table. No medical equipment or other efforts to make the experience immersive was utilized, as the benefit of having a more immersive setting was not deemed worth it, and would hinder the 'group' aspect of the focus group.

Prototyping materials
Nurses were asked to bring their own phones, and used these to access the prototype via the internet. Other than this, the facilitator brought a laptop placed on a table to display an access code, and to later take notes.

Workshop structure
All three focus groups followed the same structure:

Introduction
The facilitator introduced himself, letting the nurses know that this was a part of a master's thesis and that the research was being done in cooperation with DIPS - which they are all familiar with - and the hospital itself. The nurses were briefly introduced to the idea of an app with functionality similar to that of DIPS Care Plan. The nurses were informed of the project's life-cycle; that there had been a field study, and that this was the first draft of the layout and functionality of the app, that there would be more tests later, and that the

purpose of the evaluation was to find flaws and improvement potentials.

Furthermore, participants were informed of the structure of the focus group session: that they would first explore a prototype using their phones, and then discuss it as a group. The group was informed of the prototype's features and limitations - most importantly that the data should not be expected to be real, that nothing they do in the prototype has any impact on real patients, and how the highlighting of possible actions works, as shown in Figure 18. They were told that they should explore the prototype and its possibilities, and make a mental note of anything they found particularly interesting or problematic and present this during the discussion afterwards.

Exploring the prototype
The nurses were asked to install the Figma app on their phones. When everyone were ready, the laptop with an access code was placed on the table, facing the nurses. Then the nurses were allowed to explore the prototype freely, without any interruptions, for about seven minutes, or until everyone seemed to be done. After the first group was done, it was discovered that some nurses had not explored two parts of the prototype, so for the subsequent groups, the facilitator specifically asked whether everyone had checked these at the end of this phase. In both the remaining groups, one nurse had not.

Group discussion
In this final phase, participants were asked to discuss anything they found interesting or problematic with the prototype. There were some questions that needed to be discussed, and if the group did not naturally discuss these, the facilitator urged the conversation toward them:

- Are there any specific situations in which you think you would use the app?
- Which feature do you perceive as most important?
- Is there anything you feel is missing from this app?
- Do you think there will be challenges to implementing this in your ward? If so, please elaborate.

Many times in every group discussion, participants veered off into discussing functionality not related to NCPs, but rather that of other modules or even functionality that does not exist in DIPS Arena at all. When this happened, the facilitator gently reminded them of the scope of the project, and the participants mostly changed topics. An example of such a reminder is "This is a good point, and could be considered for another app we're developing. I'll write it down, but for this prototype and project, we're only concerned with functionality found in DIPS Care Plan". The part about another app is true, of course, as DIPS is developing multiple apps.

Data collection and analysis
Quotes and other relevant information was written down on the laptop by the facilitator as the group discussed. In hindsight, audio recordings could have been useful, but if any information was lost, it was only minor details. Points were later organized and conclusions were drawn from them.

Evaluation findings

Flow of information gathering
During this evaluation, a previously unknown part of the nurses' workflow was revealed. When initially reading a patient's info, as nurses do at the beginning of a shift and at random times otherwise during their shift, the information is not read top-to-bottom, but rather based on what elements are in the NCP. The assumption of a top-to-bottom reading flow, as well as the similarity to DIPS Care Plan, is the reason the app was designed using the same collapsible lists found there. A patient has some number of *problems*. For each problem, there exist some number of *goals* and grouped *ordinations* that are directly related to this problem. For instance, if the problem is "Pain in left shoulder", a connected goal could be "Reduced feeling of pain", and ordinations could be anything relating to discovering, relieving, or removing the reason for the pain. There are typically many ordinations for each problem. The flow of reading is illustrated in figure 20. After the test participants quickly discovered the usability issue of the collapsible lists, it was discovered through talking and a little bit of additional observation that nurses most often read the plan problem by problem - that is, they start with one problem and read the specifications and often histories of all elements related to that problem, repeated for every relevant problem. This became troublesome with the prototype's expandable lists, as nurses lost track of where they had been reading when expanding or collapsing some list. The proposed solution to this is to rework the bottom tabs as shown in Figure 21. When switching tabs, the previous scroll position is remembered. This introduces the question of what should be on the screen when the NCP in the app is initially opened? One option is that no tabs are selected, and that the main part of the screen is empty. Alternatively, the most frequently used element type, or the activity log, can be opened by default.

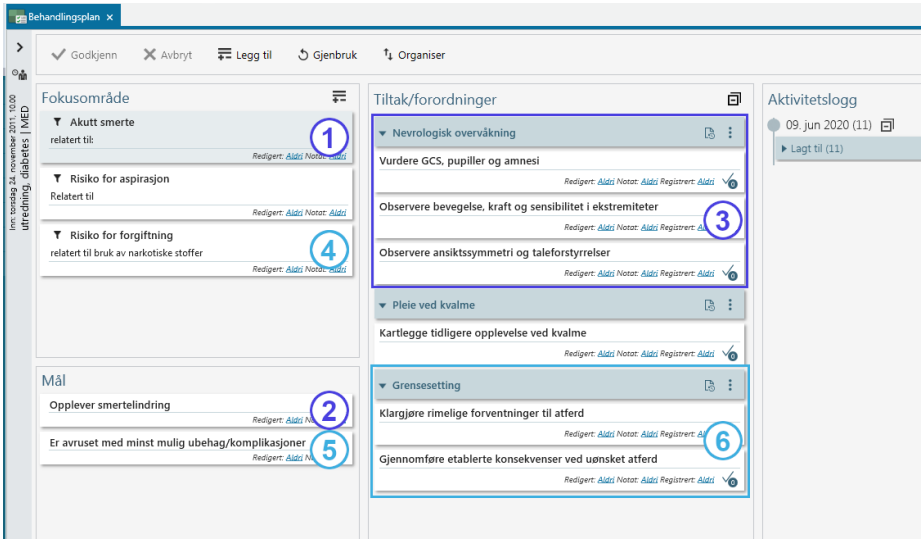

Figure 20: An example of a NCP, with elements belonging together having the same color. A typical order of reading the information is indicated by the numbers. In this scenario, the nurse is only concerned with two of the problems - the remaining problem could for instance only be relevant to a nurse on an evening shift.

Purple arrow menu usability issue

Another usability issue discovered was that the purple arrow (Figure 18, item 6), which reveals a menu with items for showing/hiding tags and opening the filter popup, was overlooked by many of the participants. A few quotes from the groups: "Oh, that? I didn't even really notice it at all.", "I think this is unintuitive. I mean, even if I knew what it did I think it's in the way of other stuff". Roughly a third of nurses never tapped the arrow, indicating that some change is needed. Such a change would have been implemented in the next iteration.

Slip-of-Paper-Like Feature

One nurse said: "I'd like something like a notes list. There should have been a notes or to-do list that I write myself somewhere in the app that is not connected to the patient, but to me for my current shift." This is a novel and interesting idea. When this was said, other participants nodded in agreement. While not technically part of the NCP, the slip of paper nurses carry with them is such an important part of their day that including a functionality like this could be warranted. The idea would be to implement an unstructured note-taking section both in the app and in DIPS Care Plan. Notes would be synchronized between the two environments, and be connected to the user. There could be some checkbox-support to enable a to-do list functionality, but it is important that nurses be able to take notes in an unstructured way, as this is mostly what

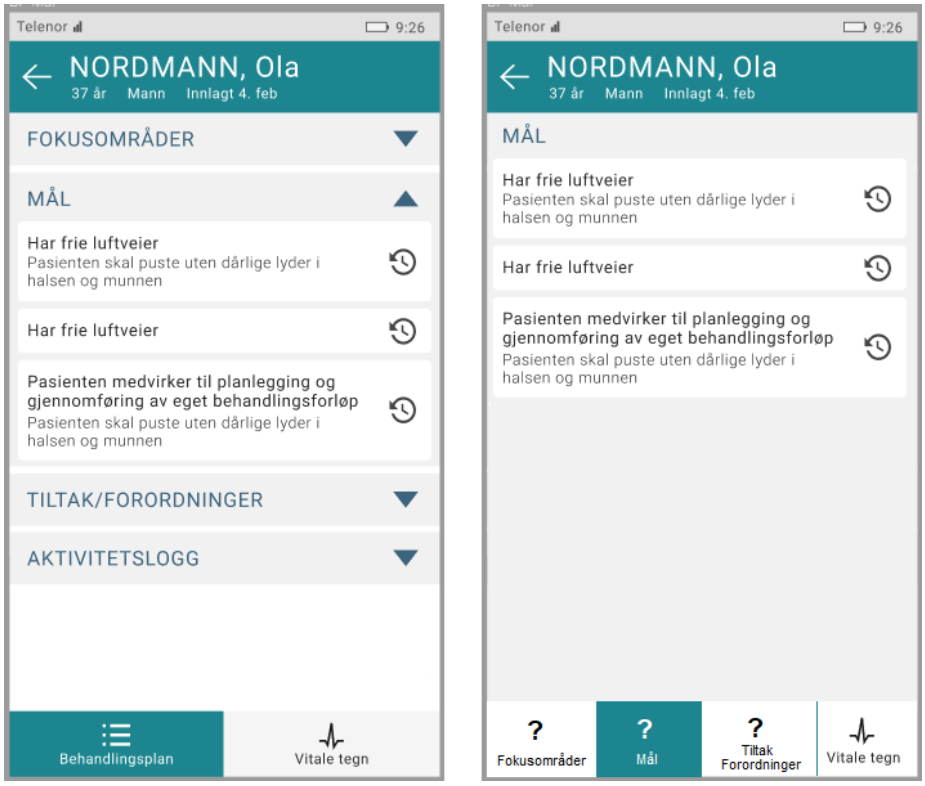

Figure 21: Left: The tested prototype's expandable lists, one list for *problems* ("fokusområder"), *goals* ("mål"), and *ordinations* in groups ("tiltak/forordninger"). Attempting to switch back and forth between reading different types of elements proved to be cumbersome.

Right: Suggested alternative, with tabs. When making this illustration, the *activity log* ("aktivitetslogg") was forgotten, but that could also be a tab alongside the other four.

they currently do with their slip of paper. Bardram also acknowledges the value of being able to suspend work in one location and resume it later on another, specifically in mobile hospital situations [7].

Vital Signs
The question "Which feature do you perceive as most important?" was mostly asked in order to discover how important the nurses perceived *vital signs* to be, without directly asking about it. If enough nurses mentioned vital signs, this feature would be included in the app. Indeed, the most received answer to this question was vital signs. Numbers were not recorded, as there is ambiguity surrounding what should count as an answer - sometimes, nurses nodded their agreement. Either way, this confirms that this feature should indeed be a part of a solution for mobile NCPs.

Other findings and reflections
Aside from the above, there were no major usability issues discovered, nor were any features that were excluded from DIPS Care Plan in this prototype (such as adding or reusing NCP elements) brought up. Below are some of the more interesting translated quotes from participants, that do not relate to the previously mentioned findings. Some reflections follows each group of related quotes. Many nurses said essentially the same things, so much of the focus group conversations is still left out.

- *"This is good, but it would be better if I could also view PLO messages (messages from external institutions)."*
  "Will this app also allow us to view lab results, but this is left out of this demo to save time?"
  Participants desiring features outside of DIPS Care Plan, like this, happened frequently. As this functionality is not in the scope of this project because of its narrow approach, patients were gently reminded that this won't be in the app.

- *"This seems like an excellent tool for reading patient information."*
  "Honestly, even though our days can be hectic, there are still many periods - not necessarily long periods, but still - where we wait for one thing or another. Sometimes during these waits I actually look at my phone anyway, so if I could do something useful on it instead.. yes please!"
  "When a patient's family visits us, you won't have to go to the PC to find "What was the result of the blood sample?" - you can just open the app and answer immediately!"
  Many nurses expressed their optimism for reading patient NCPs in various situations using this app, as seen above. This further indicates that this functionality will probably be the most used one.

- *"I think this will work for ordinations where all I have to do is mark it performed, but not as well for documentation where I have to write."*

"I don't think I would use this for documenting when I'm with the patient, but I could definitely quickly do it when I have just left the room, even if I have to write a little"
"Honestly, no offense, but I won't be writing clinical notes on my phone. Too slow, I'd rather do it on my PC when I'm already there."
This shows that nurses have different opinions about writing on mobile phones - some see the use of it, others don't believe it will benefit them. Whether the former group of people are overly optimistic would have been further studied in usability tests in the next iteration.

- *"I think patients might be annoyed if we just sit and write on our phones."*
"This reminds me of something I used in Denmark, where some stuff was done on the phone. I enjoyed that. I actually ended up having more eye contact with the patient that way than when writing things down on paper."
While most nurses seemed skeptical of actually writing at the patient's bedside, a few seemed open to the idea. Documenting while caring for the patient should be made as easy as possible to cater to nurses who wish to do so.

- *"I assume this will be covered, but there is a security aspect to all of this that needs to be considered."*
"I think the phones need to be able to take some hand sanitizer or water, because we often wash our hands. The phones we use how can handle it at least."
Some participants brought up security and hygiene aspects, but these are not quite in the scope of this thesis. They are issues that can be dealt with - logging in via, for example, facial recognition, and utilizing phones that are water resistant.

- *"Overall, I'm positive! Five out of five positive!"*
"(From one of the main nurse coordinators at the hospital) I think people will use this to a varying degree. I definitely foresee many using it a lot, but I also think some won't use it at all."
To conclude the quotes from the focus group, most nurses were happy with the prototype and positive about the future app. As this is a supporting tool, it is not expected that all nurses adopt the app. As long as a decent amount of them do, the cost of development is warranted - and even if the cost of development is not warranted, it could still yield improved results for those that adopt it.

6.3 Iteration 3: Partially Functional Prototype

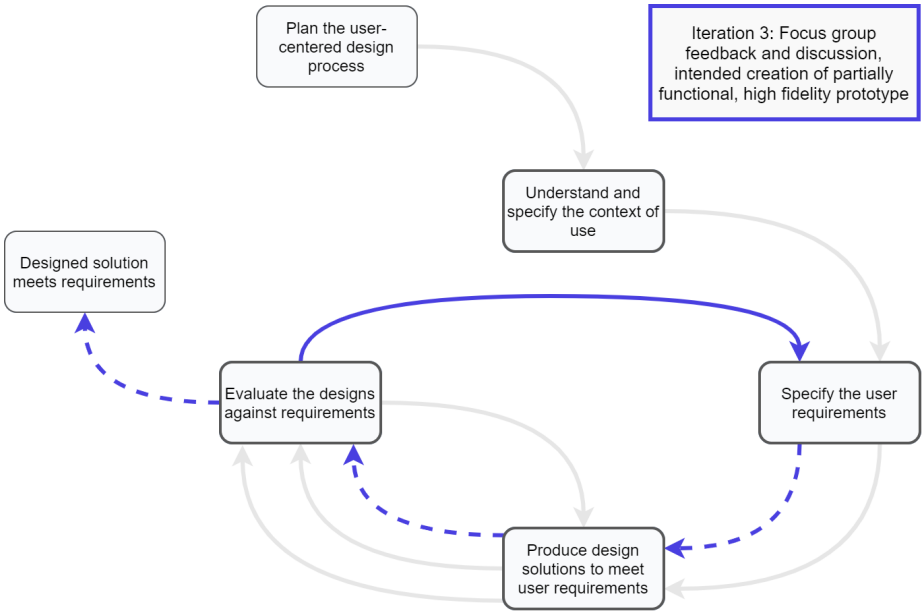

Figure 22: Fourth iteration

As described earlier, this final iteration was cut short. Regardless, this chapter will briefly describe the plans that were made for the iteration, in the hope that others who perform similar research, as well as those who will continue this specific project, can use this information.

The goal of this iteration is to produce a partially functional prototype, with actual code which will be part of the final product. The prototype will have a connection to the (already existing) server, and will have read-only access, as this is much faster and easier to implement than write-access, and can thus give usability feedback as early as possible in the development phase of the project. The prototype will be made with changes from the one in iteration 2, based on the feedback received in the focus groups. Following this, the prototype will be tested using simulation-based usability assessment methods found in [12]. As quoted from the article:

> In particular, when addressing hospital settings where the technology is likely to be used as part of work activities requiring manual labor with hands and feet in addition to high situational awareness, elements of the use context become vital components of the total system being simulated.

With a prototype this advanced, it is recommended to make an effort to recreate

realistic environments when performing the usability tests in order to achieve the best results.

6.3.1 Usability Test: Reading Patient NCP

One of the scenarios to test would be the reading of assigned patients' info, as described in step 3 in Chapter 6.1.2 (Nurse workflow). According to inferences from prior iterations, this will be one of the most frequent scenarios in which the app is used. The motivation for doing a usability test in this scenario is that the flow of seeking out and reading the patient information matters, and needs to be explored in further detail. In the previous iteration, it was discovered that the prototype at that point did not present NCPs in an ideal way for this reading, so this is a test to assess whether changes based on that feedback provide a good reading experience.

As can be seen in Chapter 4 (The Existing Desktop Solution), the NCP features an activity log, as well as three element categories. There is also the possibility of filtering elements and viewing each element's activity log individually. The aim of this test is to uncover how nurses complete the information gathering given the current design of the prototype. If potentially improving changes or new features are discovered, these should be incorporated into this prototype's next version. This test should be carried out in different wards, due to workflow differences discussed earlier.

With permission granted by the hospital, this test could be carried out in natural conditions, because with reasonable precautions taken, it will not impact the patients' care significantly. The test also plays nicely with the constraints of the prototype - having read-only access to patient data is not an issue when the only activity to be done is reading. In short, nurses are asked to perform their regular information gathering for a realistic number of real patients, using the prototype. The behavior of the nurse within the prototype is recorded, and the test ends when the nurse has gathered sufficient information, or feel like they cannot continue without using a computer. The nurse should be given a brief tutorial of the app in advance, as the goal of the test is not to discover how a new user reacts to the app, but rather how a regular user gathers information and any shortcomings they might find while doing so.

6.3.2 Simulated Usability Test: Writing

Another aspect of the nurse workflow that would be tested with the functional prototype is documentation. Previous results indicate that documentation where writing is involved might not be an important use case for this app. Whether this is true needs to be explored. With a read-only prototype, this test is planned to use real patient data, in simulated settings. The nurses may enter documentation texts and perform other actions, which will simply not be saved. If this test were to be performed in a real environment, it would lead to a significant waste of time, as the nurse would have to do *actual* doc-

umentation on a computer afterwards. Therefore, simulating the situations is the best approach.

The findings from this evaluation will guide the design of the app. For instance, if it becomes clear that most nurses strongly dislike typing documentation in the app, text input fields could be hidden by default and have to be expanded or shown with the click of a button. Scenarios in which this functionality can be tested are:

- Documenting during bathroom assistance: A waiting scenario that occurs often. The nurse is asked to document in various ways throughout a few repeats of the scenario.

- Documenting at the patient's bedside. This requires one person to play the role of the patient - ideally another nurse, as they know typical patient behavior well.

- Unstructured note-taking: Taking inspiration from the findings from the previous iteration, tests should be run to assess the usefulness and usability of the first version of such a feature. This could be tested both in the morning meeting scenario where patients are hearing, reading and memorizing information, as well as in a scenario simulating taking measurements at the patient's bedside.

These tests would all use the simulation-based assessment methods found in [12], partly maintaining the control associated with normal laboratory experiments, whereas retaining some of the realism associated with experiments conducted in the field.

6.4 Further Iterations

At least one round of general usability testing of the entire app should be performed before the app can be deemed finished. This is future work outside the scope of this iteration and this thesis, while still being a crucial part of the UCD process for the app.

7 Discussion

7.1 Design Considerations

7.1.1 Impact on Nurse Workflow

Documenting on the phone

Without having the results of iteration 3, it is difficult to make any claims about documenting on the phone with certainty. From Table 2 we see that 34% of documentation is done without writing anything, and another 38% is done with writing 12 words or less. In total, this is more than two thirds of all documenting, and may indicate that documenting on the phone can be adopted to some degree, as the main impairment of doing so is the slower typing speed which is especially impactful in longer texts. The results from tests in iteration 3 could determine whether a text box for documenting should be visible by default, and if so also the size of this, or if it should be hidden in some way to make room for other elements on the screen.

Practicality of smartphones

Naturally, for all nurses to have access to the mobile solution, all nurses will have to possess a smartphone while at work. Due to the sensitivity of the data, these phones will most likely belong to the hospital and be handed out and deposited before and after shifts. This means that the blocky phones the nurses are currently using could be replaced and their single function that is calling other nurses could be merged with that of the smartphones required for the proposed app. Assuming each nurse logs on and registers the phone to themselves for the duration of the shift, this could eliminate the need to know a nurse's temporary number in order to reach them. These smartphones could also be used to look up medicine information online, which a few nurses were observed doing on their private smartphones when in the medicine room. One study [25] finds that 90% of physicians use mobile devices to access drug information. The general benefit of having a smartphone in clinical work has been widely studied and will not be a part of this thesis.

Correctness of data

A benefit of documenting on the go is a reduced risk of entering incorrect data. For instance, none of the observed nurses manually set the correct time for ordinations they completed, despite this being a simple procedure in DIPS Care Plan. There is a dedicated time picker, shown in Figure 23, which is by default set to the current time, and can be adjusted. Not setting the correct time leads to inaccuracy in the patient's medical history as elements end up being shown as performed at an incorrect time. In cases where this timing is especially important, most nurses recorded the time by writing it in the text field used for general comments, rather than using the time picker. In addition to the data being incorrect, it also leads to structured information ending up in an

unstructured description field. When asked how they knew at what time they had completed such tasks where timing was important, some said that they vaguely remembered, while others had written it down on their sheet of paper. If the completion of tasks were to be registered on a mobile device just after it happened, inaccurate timestamps would not be an issue.

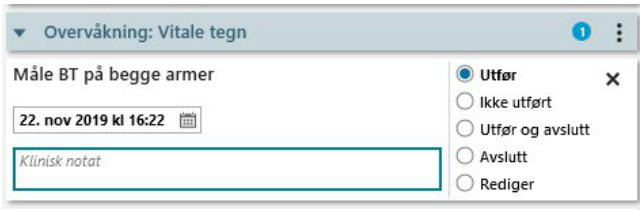

Figure 23: The view when documenting the performing of an ordination, with the time picker shown in the center left region. Nurses often use the bottom text field to specify time when this is of particular importance.

Doctor's consultation session

Several nurses said that it could be beneficial having their assigned patients' NCPs available during the doctor's consultation session. With it they would be able to answer question or give details they had forgotten or not predicted to be relevant when reading the NCP at the start of the shift. When asked why the doctor, who is typically in control of the computer whose screen is being displayed, could not look said information up, one nurse said: "That becomes inefficient and awkward because the doctor isn't familiar with [DIPS Care Plan] and you'd have to try to get them to click the right items by telling them where to click, many times".

Slip of paper

Like all manual work, writing information down is prone to errors. If some of the information the nurses currently store on their slip of paper can be easily accessed on their phones instead, the risk of such errors is reduced. Whether or not the app will be able to partially or fully replace the slip of paper remains to be seen - but given the quick nature of taking a note on paper, it is unlikely that the slip of paper will be replaced for all nurses. Planned tests from iteration 3 will help answer this question.

Summarized, hypothesized impact on workflow

While the actual impact on the nurses' workflow cannot be determined at this stage, some hypotheses can be formed:

- Not having access to a computer will no longer cause lost time during the early shift reading, as most of the information found on a computer will

be easily reachable on the mobile device

- Nurses will walk fewer steps during a shift, as there will be no need to use a computer to check information or document as one goes
- Nurses will spend less time documenting at the end of a shift, spreading it more evenly across their day. End-of-shift documenting will still happen, but will not last as long.
- Some documenting will be done at the patient's bedside. Some of this will be click-only documentation, and some of it will be written
- Nurses will use their phone for aid when necessary looking up information during doctor consultation sessions

7.1.2 TAM Evaluation

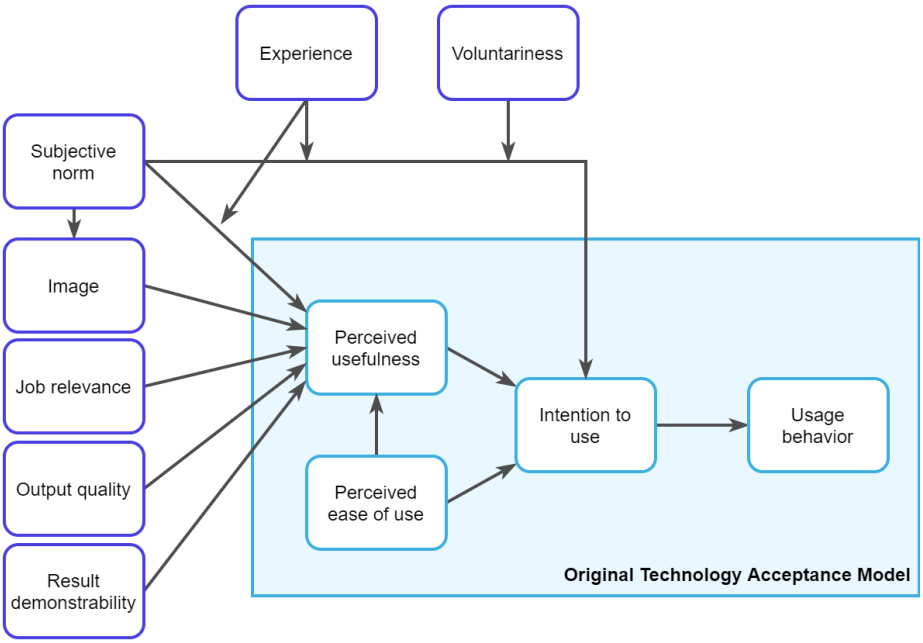

Figure 24: TAM 2, copy of Figure 3, shown closer to discussion for the reader's comfort

Voluntariness

Voluntariness proved to be high. No nurse expressed a negative reaction to the proposed app (though they might have had some in mind that remained unspoken to avoid conflict). In addition, two of the three nurse practitioners

spoken with (nurses with experience who have a significant role in leading the ward) said, without being prompted, that they would gladly be willing to both test and pilot the proposed app.

Subjective norm and Image

Subjective norm is theorized to be a strong factor in contexts where the system's use is mandatory and during early usage but will weaken over time [7]. As a functional version of the app was not finished before the completion of this project, this factor as well as its dependent factor Image cannot be used in the evaluation of the app.

Job relevance and Output quality

Seeing as this app will focus as directly as possible on the tasks of the nurses, these factors are very high, promoting perceived usefulness.

Result demonstrability

There are a few results of using this app, some more tangible than others. If used to document at the patient's bedside, changes in nurse-to-patient communications would be quite clear. Whether these changes are perceived positively or negatively is hard to tell without further testing, so it is unclear how this will influence perceived usefulness.

As discussed in section Chapter 7.1.1, nurses prove, by their style of documenting at the end of their shifts rather than at correct times, that they are not too concerned about correctness of data in the NCPs. Therefore, this somewhat tangible result (having more correct data in the NCP) is predicted to have a low impact on perceived usefulness.

Perceived ease of use

This is possibly the most important independent factor in the TAM 2 framework, as it not only influences perceived usefulness, but also the intention to use the app. This has therefore been a priority throughout the project. It is promoted by using the same designs as the other mobile applications created by DIPS, which in turn use the same color schemes and many other UI elements as the desktop applications, like DIPS Care Plan. Trying to make the users' mental models from the desktop version applicable in the app, by having similar elements and to some degree layouts, also makes the app easier to use. Ease of use is further strived towards by conducting multiple usability tests. Despite not being able to perform the tests planned for iteration 3, results from the test performed in iteration 2 indicate that perceived ease of use will be high.

TAM conclusion

All signs point towards both perceived usefulness and intention to use being high. Perhaps most interesting is the positivity regarding Voluntariness, which is often a negatively impacting factor in the adoption of new systems. Having TAM predict acceptance is a sign that this proposed app is indeed valuable and worth investing in for stakeholders.

7.2 Key Design Recommendations

Below, the main scientific contribution of this paper is presented as a list of design recommendations for others making a similar mobile solution in a hospital already having a desktop solution in place. Hospitals differ greatly, so it should be kept in mind that some items might not be applicable in some instances.

- **Provide a way to mark tasks, in whatever form they appear, as completed in as few taps as possible**.
  The study shows that nurses intend to do this while moving, in which case it is essential that it can be completed quickly, because while a nurse moves a lot throughout a day, most of the movement comes in very short intervals.

- **Provide a way to perform documentation with text as well**.
  Findings indicate that this feature will be used by some, but not all nurses. How visible this form of documentation should be depends on how heavily it will be used - if only a smaller portion of nurses use it, it could be hidden behind an extra tap in order to conserve screen real estate for other elements.

- **Do not strive to include *all* NCP functionality from the desktop solution - complex functionality can be excluded**.
  Some features don't translate well onto small screens, are too complex, or are not befitting a mobile context. For instance, adding new or reusing old NCP elements can be cumbersome on a small screen, in addition to typically being done in a setting where the nurse does many other actions to the NCP, making it much more efficient to do on a computer. Hiding such a relatively complex feature also reduces the complexity of the app, making users less likely to reject the app due to low perceived ease of use.

- **Provide some form of unstructured note-taking, ideally synchronized with the desktop solution**.
  This feature could partially or fully replace the slip of paper commonly used. This feature must be easily accessible from any part of the app, and also be easily dismissed without losing the previous context. If possible, having these notes synchronized with the desktop solution would strengthen the feature, allowing nurses to rapidly enter information on

desktop computers early in their shift when they typically read patient information, and then later access this on their phones. Provide an optional checkbox-feature as well to supplement.

- **Select touch-enabled mobile phones as the physical medium**. Previous work as well as comments from this study reveals that this is preferred to tablets in highly mobile contexts. Mobile phones enable nurses to interact with the solution on the go with only one hand.

- **Pay particular attention to the flow of information gathering in the NCPs, and use this to inform the design of the app.** The findings indicate that this will be the most frequent use case for the mobile solution. NCPs can have varying structure in different CIS, and nurses may not read an NCP in the same way the designer might initially think. Field studies and/or tests specifically targeting this is encouraged. If the NCP implementation has multiple NCP elements (such as *Problems, Goals, Ordinations, Interventions*), a tab-solution is suggested.

- **Even though the existing solution has *Vital Signs* as a separate module from the NCP, include this in the app as well.** Vital is the measurements of vital patient data such as blood pressure, pulse, oxygen levels, etc., and the historical values of these. Nurses in this study, when asked, believed this to be the most useful feature of the app.

7.3 Methodological Considerations

The main limitations in performing this project has been time and funding. This has led to fewer iterations than ideal, because every visit to the hospital has been expensive. Additionally, the findings have only been gathered from one hospital - while I have strived to make the findings applicable to as broad an audience as possible, it might not quite cover all hospitals in the same technological situations. As mentioned earlier, research has only been done in somatic wards, so others pursuing similar solutions may want to perform field studies or evaluate in psychiatric wards as well. Not being able to perform most of the final iteration due to COVID-19 somewhat weakens the strength of the findings. Both *triangulation between methods* and *triangulation within a method* as described by McFee in [24] have been used to some extent - the former in that various research activities have been performed, reducing the possibility of unsubstantiated findings, and the latter in that different wards were selected for observation and nurses with varying work experience were selected for shadowing and focus group participation.

8 Summary and Conclusion

This project has followed a user-centered design approach to answer the research question "**What key design considerations should be taken into account in the development of mobile nursing care plans?**". The outcome has been a set of design recommendations which can guide designers of similar applications:

- Provide a way to mark tasks, in whatever form they appear, as completed in as few taps as possible
- Provide a way to perform documentation with text as well
- Do not strive to include *all* NCP functionality from the desktop solution - complex functionality can be excluded
- Provide some form of unstructured note-taking, ideally synchronized with the desktop solution
- Select touch-enabled mobile phones as the physical medium
- Pay particular attention to the flow of information gathering in the NCPs, and use this to inform the design of the app
- Even though the existing solution has *Vital Signs* as a separate module from the NCP, include this in the app as well

The study has found that an app with a narrow approach is desired by nurses, and tests and evaluation methods indicate that the app will be accepted by users. The thesis makes no claim that this approach is *better* than the more commonly seen larger applications that cover more users by having a wider set of features - only that this can at least be a good solution. The design recommendations suggest that some, but not all, functionality of a desktop solution should be implemented in the app, as well as possibly one or two features that might not be a part of a normal NCP program. The study has also provided more insight into nurse workflows, mostly reinforcing the view that finding a flow in nurse work is challenging due to its ad-hoc nature.

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9 Appendix

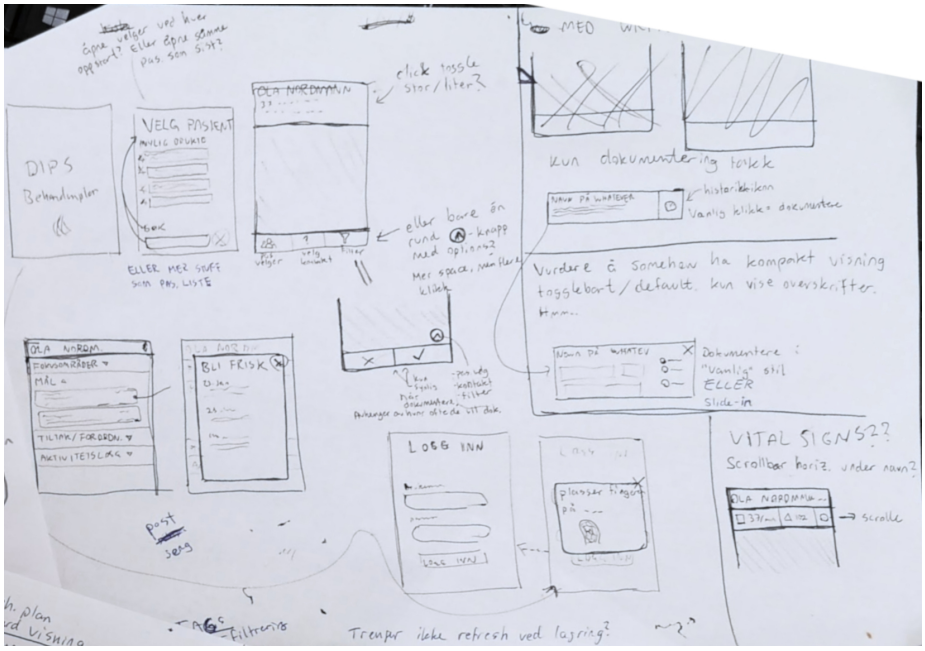


Figure 25: One of the sheets of the first paper prototype, as it was presented to the nurse and design team

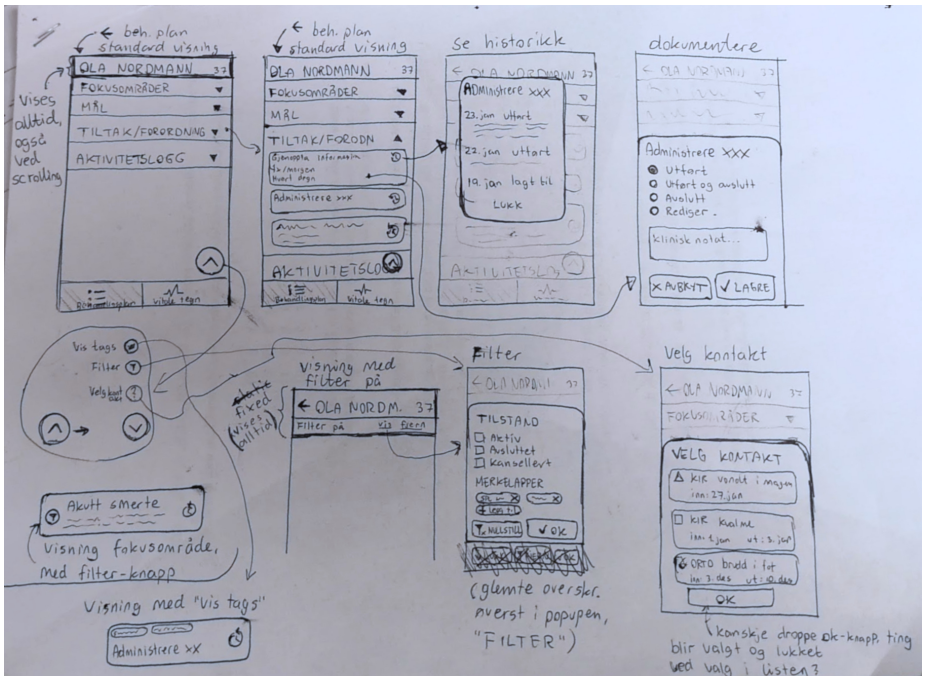
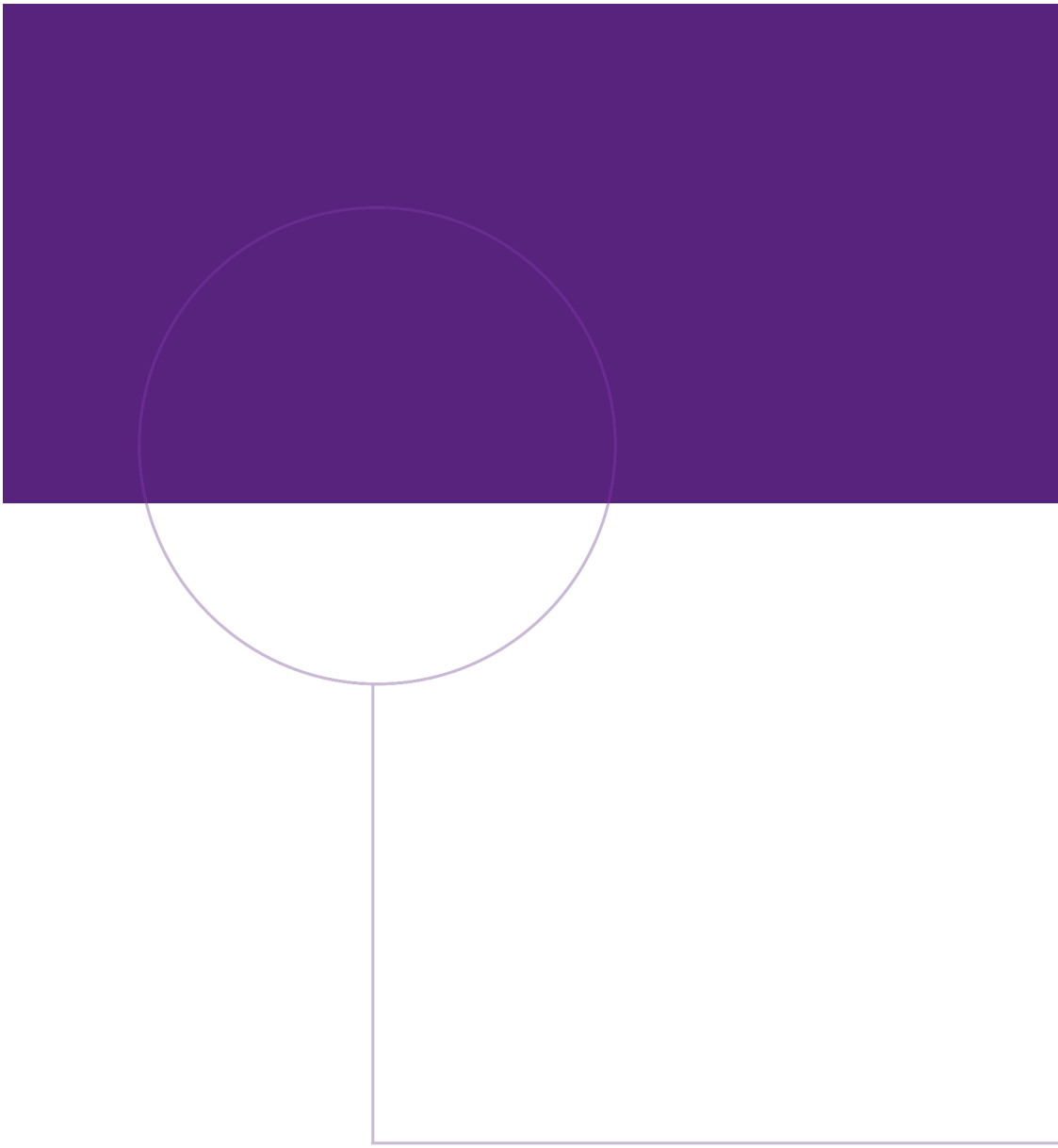


Figure 26: One of the sheets of the second paper prototype, as it was presented to the nurse and design team



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