

## A Concept Study on Tablet-based Decision Support Systems Applied in Ambulance and Palliative Care

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**Maria Rampou, Daniel Sjöström**

Department of Signals and Systems  
CHALMERS UNIVERSITY OF TECHNOLOGY  
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## Abstract

There are many areas in healthcare where decisions taken by the caregivers sometimes are based on intuition and common practice rather than evidence, established guidelines or a structured workflow. The purpose of this thesis was to perform a concept study on tablet-based DSS (Decision Support System) applied in ambulance (EMS) and Palliative Care (PC).

A digital DSS is an interactive software that compiles information from various sources and presents the user with options according to application-specific rules in order to support decision-making in a specific situation. Decision support systems have been applied in medicine for clinical decision making and have been found to improve both practitioner's performance and patient outcomes.

Regarding the EMS application a paper based DSS had been developed in a study by the University of Borås and thus a tablet application was requested. Likewise, for the PC application a solid and evidence based strategy was considered to be very helpful to them and as a result the need for a digital DSS-form arose.

Considering Human Computer Interaction (HCI) principles, focus group sessions were conducted in order to determine usability goals and minimize the amount of iterations of the applications' versions, concerning design issues.

A prototype and a demonstrator were created for both cases and were evaluated iteratively. Through the prototypes iterations process, there were various qualitative results on how to improve each application's design, appearance and functionality. The results of every iteration and evaluation session were considered for creation of the actual applications form, and each of them resulted in an almost final form before programming commenced. Moreover, the key features for each application were identified as part of the final result at the end of the project. Those key features were found to support and even propose a possible new work routine for the users according to the usage scenario created.

In conclusion, this concept study illustrated the possibilities of a tablet based decision support system in the two presented settings. This includes three main aspects of a DSS, i.e. organize and access relevant information, provide the model or algorithms/criteria used to analyse the information, as well as the user interface for interaction and presentation of the options or decisions. Moreover, findings suggested that there is common ground between current technology and legislations (especially about security), in order to use tablets. Interaction with other systems within healthcare is possible, taking into account the specifications for each system. The final outcome of the evaluation sessions was very encouraging demonstrating how the tablet device may be incorporated to support the workflow of the Emergency Medical Services and the Palliative Care Unit. There is a large potential for further development of the device and to use it as a tool to introduce altered workflow or even new work routines.



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## Abbreviations List

AHRA – All Hazards Risk Assessment  
BIF - Bastjänster för informationsförsörjning (Basic Services' Information)  
CDSS- Clinical Decision Support System  
CRC – Care at the Right Care level  
DSS – Decision Support System  
DST – Decision Support tool  
ECG – ElectroCardioGraph  
ED – Emergency Department  
EHR – Electronic Health Record  
EM – Emergency Management  
EMS - Emergency Medical Services  
ER – Emergency Room  
NFC – Near Field Communication  
NPÖ – Nationell Patientöversikt (National Patient Overview)  
PC – Primary Care  
PCU – Palliative Care Unit  
RDBMS – Relational Database Management System  
RETTS – Rapid Emergency Triage & Treatment System  
SITHS – Säker IT för Hälso och Sjukvården (Secure IT for Healthcare)



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## 1. Introduction

A Decision Support System (DSS) is an interactive software-based system or tool that compiles information from various sources and presents the user with options according to application-specific rules in order to support decision-making in a specific situation. Decision support systems have been used in medicine for clinical decision making (Clinical Decision Support Systems – CDSS) and have been found to improve both practitioner's performance and patient outcome (Garg, 2005). CDSSs have typically been implemented using large databases and relying on mainframe or desktop computers, but the event of Touch Phones and tablets (e.g. iPad) opens up for ambulatory use without losing either usability or information retrieval capabilities from distant databases.

There are many areas in healthcare where the decisions are based on intuition and not on solid strategy or evidence and thus a DSS could be of use to help medical personnel follow the care standards. The effectiveness of such a tool is supported in "Decision-Support Tool in Prehospital Care: A Systematic Review of Randomized Trials" by (Magnus Hagiwara, et al., 2011) where one can read about indications that "compliance with recommended care increased with the use of a DST particularly if the DST is computer-based and automatically gives decision support as part of clinician workflow". Two such areas have been focused on in this report, the Emergency Medical Services (EMS) and the Palliative Care Unit.

### 1.1 Tablets in Healthcare

Tablet devices have started to conquer everyday life on account of their portability, interactive interface and general potentials. They are the intermediate between a touch-phone and a computer, facilitating the workflow and the availability of information by being very light (around 0,5kg), having quite good processor potentials and internet connection.

In an interview on 2 May 2013, Bengt Arne Sjöqvist, Professor of Practice in Biomedical systems at Chalmers University of Technology, said that many healthcare professionals are requesting tablets to be a part of their work routine, as they could facilitate them when seeking or updating information easily instead of having to search for a desktop or laptop computer. This statement is supported by international literature as well. (Mace, 2013) (Adil, 2013)

The Swedish government is attempting to create the 'mobile patient', which includes interoperability between various information systems, based on the National e-health strategy. The system proposed and partly introduced is named NPÖ (National Patient Overview) (Ministry of Health and Social Affairs, 2010). This system handles huge amount of patient data that have to be updated and retrieved from different kind of software (Appendix#9). Consequently, the patient database needs to be refreshed at all times.

Security is the main concern when it comes to combining healthcare records with emerging technology. In Sweden there is national legislations regarding this matter and four systems are collaborating and are available in order to make sure of the uniformity of the security systems considering healthcare. These four systems are:

- BIF (Basic Information Services): Handles the users' authorization on the patient's data.
- HSA (Health Service Address Registry): Handles the users roles and corresponding authorization
- SITHS smart cards: Caregivers identification
- Sjunet: Makes sure of secure communication across the systems

No system is allowed to be used to store patient record, unless the system complies with this legislation. The legislation includes the authentication, authorization, identification and patient's history (Hällback & Isaksson, 2009). Regarding identification and authentication all caregivers are provided with a personal electronic ID card, called SITHS card and includes electronic IDs for secure identification and signing (see Figure 1).



Figure 1: SITHS card (Hällback & Isaksson, 2009)

All computer systems have a card slot incorporated and when the caregiver inserts the SITHS card to the device, the device recognizes him/her and asks for the password that only he/she knows. Until now, the lack of this card slot for tablets was the main issue for the incorporation of the tablet devices. This request has been evaluated by the e-health companies, which have been trying to incorporate them to the work routine, with respect to the security regulations.

## 1.2 Emergency Medical Service

The typical workflow of a patient case during an ambulance call and the Emergency Medical Service provided tasks are relatively well-known. Their tasks are to either provide instant medical help considering the conditions or to provide a safe transport to the next point of care. The current EMS model directs the personnel to transport all the patients to the Emergency Department (ED) without considering the seriousness of the case or the patient's condition (Southern Älvsborgs Hospital, 2011). For the patients brought via ambulance to the Emergency Department, studies show that 25% could be transferred to Primary Care instead (Carret ML., 2007) (Sprivulis PC, 2006) (Hjälte, 2007). This phenomenon leads to increased waiting time for patients with more dire needs and increasing mortality at EDs with overloading. (See Figure 2) (Gionfriddo, 2011) (Trzeciak, 2004) (Carret ML., 2007). Furthermore, expenses are increased for the Emergency Department and doctors' work-hours are inefficiently spent. The phenomenon of the aging population is commonly known, which increases the ambulance calls by people over 65 years old as the population is getting older) (Sveriges kommuner och landsting, 2006)

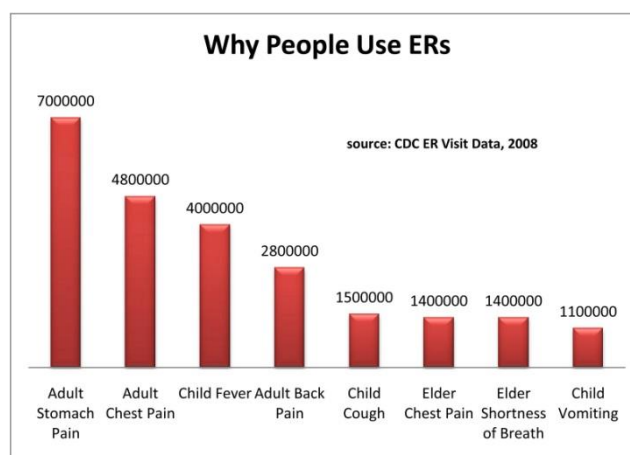


Figure 2: Why People Use Emergency Rooms (Gionfriddo, 2011)

Based on the idea of an extensive pre-hospital care in order to overcome this phenomenon and make smart use of the resources (National Board of Health and Welfare, 1999), a set of guidelines were composed. An algorithm-guideline from the Clinical aspect and based on the triage system, was designed by School of Health and Science/University of Borås, with the project name "Care at the right care level" (CRC), in order to study the impact of supporting the EMS personnel to direct the patient either to the ED or PC in case of a non-urgent patient, as stated in the interview on 12 March 2013 from Birgitta Wireklint Sundström, Senior Lecturer of University of Borås, and Gabriella

Norberg, Doctoral Student at University of Borås. The main idea is that, on the condition that it is a non-urgent situation with a patient 18 years or older, it could be determined already by the ambulance personnel whether or not the patient is suitable for healthcare unit such as the Primary Care, through a set of standardized questions. In the ongoing study the patient would then be randomized to either transport him/her to the Primary Care or to the Emergency Department. The standardized questions to decide whether primary care may be an alternative are divided in three levels, A, B and C corresponding to the Anamnes, Examination and Decision Parts respectively, and are based on the primary symptom. Thirty one (31) symptoms have been chosen from the RETTS list (explained later), preserving their original RETTS number and based on the flowchart below (Figure 3), the proposal for the right decision is taken.

Anamnes

Examination A-E

Treatment (according to RETTS and treatment guidelines, as always)

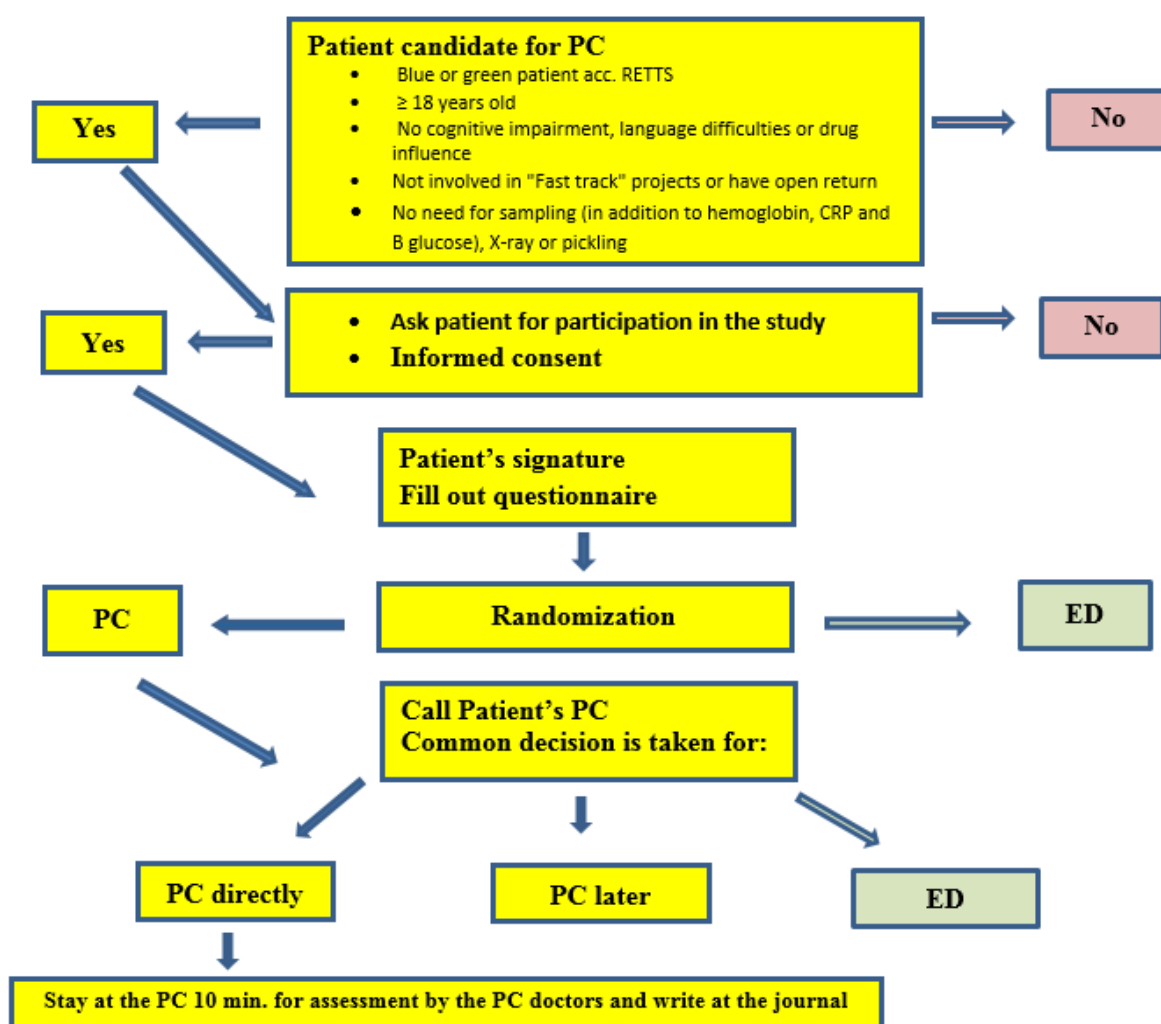


Figure 3: Flowchart of the CRC study (Norberg & Wireklint Sundström, 2013)

### 1.2.1 RETTS (Rapid Emergency Triage & Treatment system)

The word "Triage" comes originally from Latin but can be translated from the French 'trier' meaning sorting (Bloch 1932). Triage is a system for sorting patients according to severity of their status based on medical history, symptoms, and vital signs such as respiratory rate, heart rate and body temperature (Lars Sandman, 2012). It can be used in three cases, to sort patients for

emergency treatment, priority for transport or for the point of care they will be transported to. The patients are tagged with 5 different colors (Mackway-Jones, 2011):

- **Red**/Immediate
- **Orange**/Very urgent
- **Yellow**/Urgent
- **Green**/Standard
- **Blue**/Non-urgent

The RETTS is the triage system used in Sweden for sorting patients and is used in Emergency Rooms and EMS. This system involves a combination of assessment including the reasons why the patients asked for care and various vital parameters (Lars Sandman, 2012). The overall evaluation of the reason for seeking help and vital parameters lead to five different priority levels, each of which represents different kind of care corresponding to the color code above. It provides guidance in the emergency room of how the patient should be managed, how fast the patient should see a doctor and what level of monitoring is required.

In this project patients considered as 'green' or blue' by the EMS personnel were candidates for being included in the study where the DSS system is used. Moreover, after the prioritization of the symptoms the patient is having, the primary symptom is the one considered when using the DSS and secondary symptoms are documented only if the user chooses to (Norberg & Wireklint Sundström, 2013).

### 1.3 Palliative Care Unit

The Palliative Care Unit is a hospital unit existing for severely ill patients to provide end of life care. Patients usually have non-curable, chronic diseases and most of them are close to the end of their lives. The purpose is not to stall death or euthanize the patients, but to make their everyday life bearable with regard to pain, nausea, breathing problems and removal of general symptoms causing the patients to suffer (see Figure 4). Additionally, psychological support is offered to the patients and the unit supports the patient's family to go through this phase. The general aim is to improve their quality of life and after the patient is diseased to make sure his/her wishes are fulfilled. This process needs team work among various professionals that consists of registered nurses, doctors, occupational therapists, social workers, occupational therapists, physicians and pharmacists. (Wikipedia, u.d.)



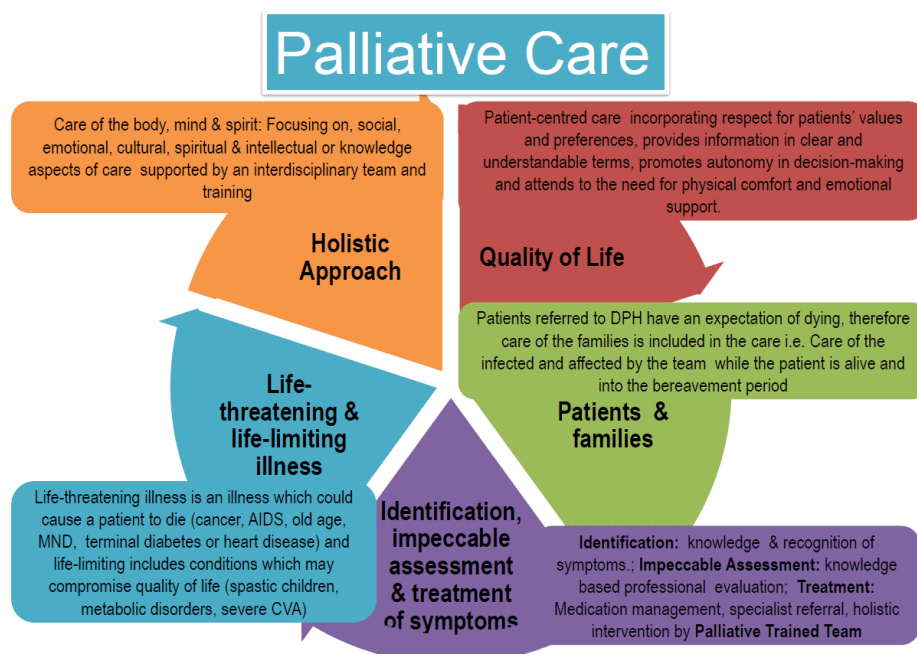


Figure 4: Palliative Care services (Hospice Palliative Care–Glory, u.d.)

In a recent project, care ideologies and action strategies were formulated by a group from the PCU at the Sahlgrenska University Hospital (SU) under the guidance of a specialist in care ethics, Lars Sandman of University of Borås. During this project it was found that the current care practice often relies on decisions made intuitively by the personnel and that there is a lack of “organizational memory” that can support the experiences of different professionals to be transferred to other members of the organization (Sandman, 2013). Focus groups made up of registered and assistant nurses were set up to discuss and document everyday situations from an ethical perspective, mainly concerning conflicting views on how to act in specific situations, in terms of patient integrity and security, and often regarding relatives or friends (i.e. “significant others” to the patient), in relation to spontaneous meetings, feelings, culture, treatment and lack of communication and understanding. Through evaluation of those meetings and discussions, various ways of handling difficult situations could be listed. Hence, the project ended up in formulating a care ideology and action strategies related to the ideology.

Considering the number and varying professionals that need to collaborate in order to come to a decision for a plan of care or action plan for incidents that may occur, the task is challenging in itself. The PCU personnel are handling very delicate and easily unruly situations based on their experiences and intuition. A solid and evidence based strategy was considered to be very useful and from a biomedical engineering perspective the “database” asked for qualifies as a decision support system (DSS) (Sandman, 2013).

## 1.4 Purpose / Aim

The purpose of this thesis is to perform a concept study on tablet-based DSS applied in ambulance and Palliative Care.

The specific aims were:

- Create demonstrators-prototypes of two DSS applications, one for each project.
- Consider HCI principles such as being effective, efficient, attractive and easy to use in the healthcare setting.

## Introduction

- Exploring possible interactions with other existing systems within healthcare (like NPÖ), as well as security issues.
- Introduce the potential benefits of such systems and devices in a healthcare system.

## 2. Theory

The Theory chapter that follows, is a chapter that includes the basic background on design principles, human computer interaction (HCI) and database technology used in this project. Accordingly, the development model is described and the theory behind the model's parts and phases, explained as well. Lastly, some database principles are explained.

### 2.1 Lifecycle model

A lifecycle model that illustrates the actions taken and how they are connected to each other is a model that could direct the general process of a project (Preece, et al., 2011). A simple lifecycle model is shown in the following chart (see Figure 5) and while during the intended process the target group and the product's utility should be considered. Practical restrictions such as cost, viability and expenses should be taken into consideration at this stage.

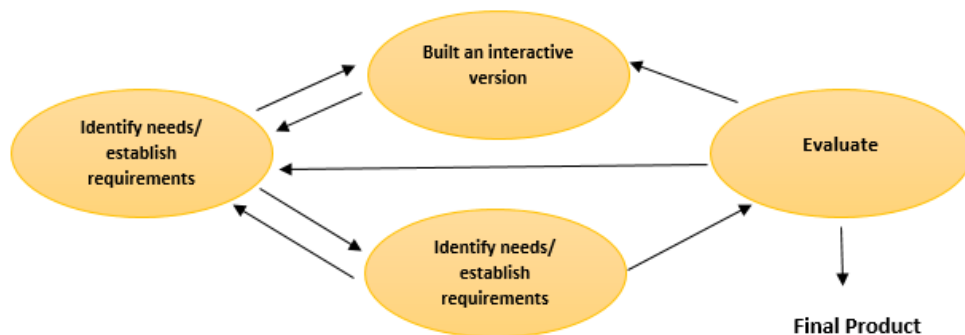


Figure 5: Simple interaction design model (Preece, et al., 2011)

In particular, the spiral lifecycle model includes iterative process of prototyping, considers risk analysis and has acceptance from the users test part (Preece, et al., 2011) (see Figure 6). Three iterations of the prototype are the main process and user testing is covered on the code developed (operational prototype), before the final product is out.

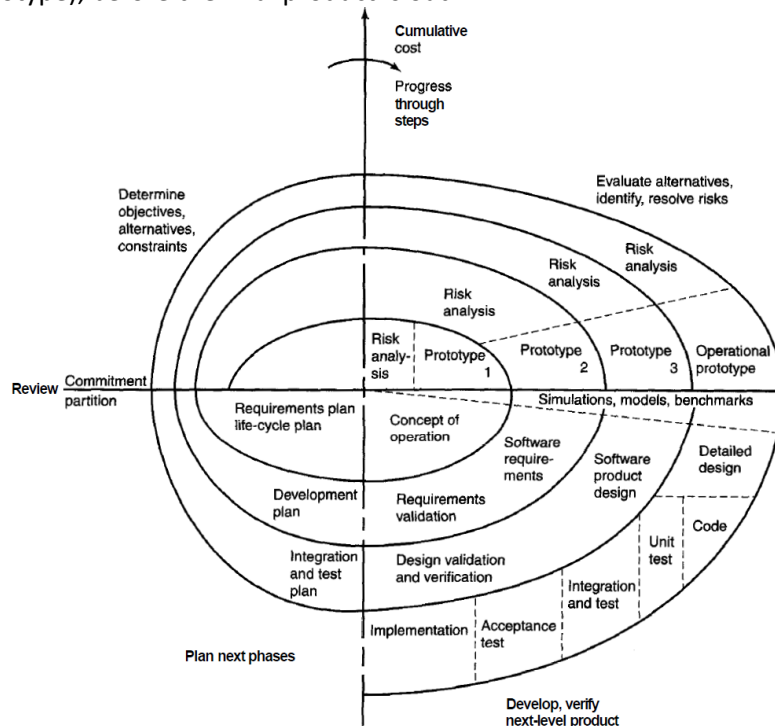


Figure 6: Spiral Lifecycle model (Preece, et al., 2011)

## 2.2 User-Centered Approach

The user-centered development can be perceived in two ways. The user-centered development, which suggests to observe users and their tasks and develop the design and the one that suggests that users should be involved during development.

The user-centered approach concept was broken down in steps by (Gould & Lewis, 1985):

1. 'Early focus on users and tasks'.  
In the very beginning of the project, users and their tasks should be the designers' center of interest. Identifying users and examining their cognitive processes, their attitudes towards various situations and their general behavior. This can be achieved by observing them in their environment or their tasks and including them in the design procedure.
2. 'Empirical measurement'.  
Users' feedback and efficacy is observed and evaluated even early in the process, through scenarios or sketches etc. Afterwards, prototypes that users can interact with (hands on or observe), are being monitored, recorded and reviewed.
3. 'Iterative design'.  
After each evaluation session from the users, the design is improved according to their feedback and the process of designing and evaluating is iterated until the users are satisfied.

### 2.2.1 Types of users

Primary users are the ones that will interact with the system in development. Secondary users are the ones that will use the system seldom or by using it as a mediator (Preece, et al., 2011). Tertiary users are the ones whose workflow will be influenced indirectly by the new system or they are likely to affect purchase.

These types of users, who have been identified as stakeholders are: "people or organization who will be affected by the system and who have a direct or indirect influence on the system requirements." (Kontonya & Sommerville, 1998)

## 2.3 Data gathering techniques

A very well-known data gathering technique is studying documentation of existing articles and material, which minimizes the risk of getting too influenced by the users' opinions (Preece, et al., 2011).

The 'Focus Groups' data gathering technique is considered to be helpful for gathering different points of views from users, but is confined to only those participants' opinions. The advantages of this technique is its validity, its low expenses, its fast results and the findings are easily interpreted and guide for more data gathering (Preece, et al., 2011). The data gathered is mostly qualitative, while some quantitative data can be acquired if designed so. Through meetings, the focus group, developers and designers come in contact with each other, which promote constructive and fruitful conversations. Within health care, applications and software generation is considered to be exceptionous and requires a lot of user involvement. The matters handled are best described by the potential users and medical professional insight is necessary. Moreover, the users feel better when increasing their amount of involvement with the project, they consider the application to be their 'creation'. Moreover, the final product has better chances of acceptance by the public. This technique decreases time of familiarization with the tasks that need to be covered by the software as well. The drawback with this method is that the focus group members' character may become a matter of dominance of opinions on decisions taken. Additionally, the meetings might not always be at a time and place convenient for all participants and an effective facilitator is required. (Preece, et al., 2011)

Sometimes, users fail to describe the procedure or the way the tasks are completed and it is better for the designer to observe them while working and get inspiration (Preece, et al., 2011). Therefore, naturalistic observation is often used for more realistic data-gathering.

### 2.3.1 Focus group meetings analysis

Various workflow issues and user behavior mentioned below, can be observed through distributed cognition analysis (Preece, et al., 2011):

- How a problem is solved among or by the users during their workflow
- The language, attitude and body language used among the users in various tasks
- Existing rules and routines decided among the users in order to be in harmony during their workflow
- The steps users follow to communicate with each other in order to complete a task and its subtasks together.
- The way the information are distributed and attained.

Afterwards, the problems are determined, where they can be partitioned and the processes currently followed to come to a solution (Preece, et al., 2011).

This analysis is used to identify how the users communicate and share information as well as how they solve everyday problems and incorporate them in the considered values when designing (Preece, et al., 2011).

## 2.4 Usability and User-Experience Goals

Part of the designing process is establishing the usability and user experience goals in order to distinguish the focus areas of the product in development and help choosing between alternatives. Usability goals in general are intending to direct the development of a product to be (Preece, et al., 2011):

- effective
- efficient
- safe to use
- good utility
- easy to learn
- easy to remember how to use

Contemporary technology variety available has led to usability goals not to be enough and user experience goals to emerge as a standard decision to be made (Preece, et al., 2011).

User Experience goals:

- Satisfying
- Enjoyable
- Fun
- Entertaining
- Aesthetically pleasing
- Helpful
- Motivating
- Supportive of creativity
- Rewarding
- Emotionally fulfilling

Usability can be conceptualized through the design principles as well and is a blending of theory, knowledge through practice and good sense. These design principles are suggesting or advise what to avoid when designing. Most known of those are the following:

- Visibility
- Feedback
- Constraints
- Mapping

- Consistency
- Affordances

Usability principles consist of another form of directives for designing, which sometimes overlap with the design principles. Nielsen (2001) and his team developed the ten main usability principles (Preece, et al., 2011):

- “Visibility of system status”
- “Match between system and the real world”
- “User control and freedom”
- “Consistency and standards”
- “Help users recognize, diagnose, and recover from errors”
- “Error prevention”
- “Recognition rather than recall”
- “Flexibility and efficient to use”
- “Aesthetic and minimalistic design”
- “Help and documentation”

## 2.5 Conceptual model

This model is for products that are ‘an application in which there are no clearly identifiable primary work products’ (Mayhew, 1999). In these applications the main point is to support some work processes. The conceptual design comes after the requirements identification derived from the data gathering, and is a general overview of the system intended actions, attitude and appearance (Preece, et al., 2011). The following questions should be regarded in order to make design decisions:

- What actions will the product support and offer?
- In what way are the actions linked to each other? (related for a brief or happening at the same time leading to restrictions or indicate a general arrangement for a task)
- What kind of knowledge needs to be provided in order to perform a task?

### 2.5.1 Crafting the conceptual design – with respect to human processes

In general during the process of designing, **cognitive processes** taking place in human brain (concentration, apprehension & recollection, memory, acquiring knowledge, reading/talking/listening, find solutions/plan ahead/rationalizing/choice making) are considered and how they reflect the individual’s reactions. e.g. reading through (scan) is considered to be faster than listening or talking and it is easily revised, however some people have problem reading (Preece, et al., 2011).

When considering screen design, one of the concepts to consider is **grouping** and it applies to items included at an individual screen or throughout the system. Moreover, it promotes organization, hints the users of how to interact with the application and can be defined by the groups according to the users’ notion. It can be achieved by putting elements tight, by color coding, using boxes or tab menus or by using shapes to hint for connection among items (Preece, et al., 2011). There is always the reflection of balancing between stuffy or spacey screens. It is also advised on account of the grouping concept, that if the product is a transfer from a paper format it is wise to keep them in alliance to avoid user agitation and waste of time at wandering around the system or the screen.

Apart from the individual user cognition, the designed system should be considered to coordinate the user’s moves and the information or actions shared among users. There is always the need to counteract the **human coordination** and **system coordination** (Preece, et al., 2011). In the case of the system coordination outweighing the human part, user frustration is caused, on the other hand a system too flexible causes the user to disregard it or sections of it. Among users what usually needs to be shared is the information and this is advised to be executed by having it in very clear and apparent ways in the system. The system in that way **supports awareness** between the users that work on the same objective and in the same environment (Preece, et al., 2011).

### 2.5.2 Evaluation of the conceptual design

Evaluation of the design in progress is a step that reassures or shows different paths of the users' opinion on the product in development and corresponds to the so called 'formative evaluation' (When to observe?).

There are many evaluation paradigms and one of them is the 'Quick and dirty', which does not include a strict specific agenda, more like a discussion based on questions. Approaching the users with that technique(scenario) and ask their opinion is intended to have quick feedback, focus on actual problems and get as much as possible user involvement, before going to the physical design (Why evaluate?).

Prototyping is a tool for user evaluation considered to give a better depiction of the design than a description can, gets fast feedback at each session on the draft design. "The activity of building prototypes encourages reflection in design" (Schon, 1993). With the prototype the users can have an interactive experience and express their opinion, desired option and even propose ideas on how to make the system better. On the other hand they are prone to settlements such as performance, icon quality, limited functionality is offered when it comes to software-based prototypes (Preece, et al., 2011).

A type of prototype is the 'evolutionary' one, which includes having a prototype and evolve it until it looks almost like the commercial product (Preece, et al., 2011).

**Low-fidelity** is a kind of prototype that is generated at the beginning on account of the early stage, rapidness, low cost and from its nature it promotes investigation (Preece, et al., 2011). At low-fidelity prototypes, not only does the layout not look like the final product, but the material used as well.

**Alternative designs** are generated through the process of prototyping and the development team in accordance with the users' requirements, data gathered, users' tasks and technical viability the best fitted solution is chosen (See Figures 11 & 12). Alternative conceptual designs can be presented to the users and the decision will be taken in collaboration with them (Preece, et al., 2011).

Regarding the prototypes' testing session, notes are supposed to be taken for the usability and user experience issues, as well as how attractive it appears to be to the users and the level of the requirements fulfillment at this stage. Observation and notes can be taken not only on the spoken material but also for the body language of the participants (Preece, et al., 2011).

While testing the prototype to the users, issues are likely to appear, that will require another iteration of the prototype. The team is supposed to find solutions for the issues illustrated and test them again on the users to observe their response (loop of 'design, test, measure and redesign').

With respect to the first step, more detailed directives are defined and drive the early stages of development (Preece, et al., 2011):

1. The tasks and subtasks as well as the goals are reasoning and motivation for the development procedure.
2. How the users react and the conditions the product is going to be used, are examined and by keeping these in mind supporting system is created.
3. The system is designed upon the observed users' captured attitude.
4. The development team values and considers the users' opinion from the early stages and throughout the process.
5. The choices throughout the design process are based on the users, their workflow and their working conditions.

Part of the evaluation is the way the notes/data are interpreted and how the qualitative data are presented and valued. That data are supposed to 'tell the story' of the past session of what was detected. The story can be persuasive as long as it is enhanced with examples that point out and prove the crucial matters to the programmers. The activities that take place when analyzing qualitative data are the following (Preece, et al., 2011):

- The qualitative data should be analyzed as soon as possible after each session, in order to find the main subject matters and try to group similar issues.



- The matters should be documented in an organized but adaptable way supported by examples. The main ideas/ matters should be documented on paper or electronically.
- The date and time of each analysis session should be documented, while the data should have been already documented with dates (documented in describing text, quotations, pictures, videos).
- While working on the key features and ideas it is wise to check with the participants, if possible.
- Iteration should occur until the story is depicting what happened in the session and it is supported by examples taken from the data.
- The conclusions should be presented to the development team, orally and in a report form.

## 2.6 Physical design

The **physical design** is presented in the form of interactive versions of the design prototypes (Preece, et al., 2011). The physical design includes menu structure, icons, colors, images that are going to be included, in other words it is more detailed than the conceptual design. The guidelines followed for the physical design are (Shneiderman, 1998) 8 golden rules of interface design:

1. Consistency should be sought.
2. Create shortcuts for the experienced users
3. Use feedback for informing the user about the tasks and path.
4. In order to accomplish the ending of a task, compose dialogues.
5. Make available ways to prevent an error and when an error happens make sure to have an easy way for the user to deal with it.
6. Allow the undo action when is easy.
7. Control the user's actions through the internal structure of the software.
8. Keep the short-term memory load low.

Furthermore, there are some general guidelines about physical design (Preece, et al., 2011):

- Uncomplicated and straight forward interaction
- Group interface elements suitably
- Images should be designed to be understood at a glance and to be able to be brought under same rules.

When it comes to physical design, the high-fidelity prototype is the tool that is considered to represent it better. It is supposed to set the work-flow through the application, is used for investigation, looks like the final product and is interactive and functional (Preece, et al., 2011). At this stage, the breaking down of tasks into subtasks is prominent and each one of them should have its own screen. The division can be split into steps which will support a decision or just data entry. Balance between too many simple screens and too overcrowded is an essential consideration. (Preece, et al., 2011)

On the other hand, the high-fidelity prototype is time-consuming and not suitable for requirements gathering and its development costs more.

On that account, the low fidelity requires less resources and time consuming, makes it possible to present alternative designs to the users, facilitates arrangement of the screen layout and verifies the concept developed already (Preece, et al., 2011).

The low-fidelity one though, gets restricting after the requirements specification regarding the applications' flow which cannot be fully understood, gives no possibility of detecting errors and does not give details to the programmer for development.

### 2.6.1 Evaluation of the physical design

Users are invited to 'think aloud', as it is one of the techniques of understanding the users and their feelings about the prototype, which reveals the keystrokes.



The strategy chosen to accomplish that was coarse-grained strategy, where the evaluator tries to capture critical events and review those events in detail. (During the reviewing of the videos qualitative analysis and search for incidents or patterns were conducted.)

After evaluation sessions it is advised to go through the notes or video in order to go into the details of those sessions and check moments of doubts with colleagues, not to rely on the evaluators' memory (Preece, et al., 2011).

These events can be aloud comments, silence, confusion and strokes (stuck users) (Preece, et al., 2011).

## 2.7 Database theory

The relational databases have been the ruling model for designing a database for over 30 years with many emerging ideas (hierarchical, network databases) not being able to overrule them. They are preferred on account of their properties of being a simple model. It has tables to represent the stored data (comfortable), mathematical basis (solid) and has easy query syntax. On the other hand, they are difficult to design in complicated cases and use storage techniques that are specific. (Bain, 2009)

### 3. Method

The Methodology includes the theory and methods followed, in order to proceed with this project, which is in general terms the user centered approach and the spiral lifecycle model with its 4 cycles. The first cycle includes the first risk analysis, the users' identification, market search, the description of the data-gathering techniques and the creation and evaluation of the conceptual design in form of prototype. The second cycle starts with the Risk Analysis #2 and describes the second prototype, which is the physical design and its evaluation. During the third cycle the physical design after the users input was reformed and evaluated again. Lastly, at the fourth cycle the operational prototype is introduced and its evaluation methods.

#### 3.1 User-centered approach

Both application cases belong in the health sector, where it is highly recommended to listen to what the users have to say and let them be involved in the process (Nezirevic, 2013). The users have very specific knowledge and the designer should interact with them and value their opinion a great amount. As a method, the user-centered approach that involves users was used throughout the process of development.

In order to design the two application interfaces, design and usability principles according to the book 'Interaction Design-Beyond Human Computer Interaction' by Pearce et al. were followed.

#### 3.2 Following the spiral lifecycle model-1<sup>st</sup> cycle

##### 3.2.1 Risk Analysis #1

With respect to the Academy Risk Assessment Template and the Australian/New Zealand (AS/ NZS) 4360: 2004 Risk Management Standard, the Risk Matrix was generated. This process was repeated for every prototype iteration, following the spiral model instructions.

##### 3.2.2 Identify potential type of users

Before defining the user requirements, the type of **users**/stakeholders the app is going to target was explored and identified (Preece, et al., 2011). The **primary** users are not the only ones being influenced by the system introduced. There is a requirement of identifying the secondary and tertiary users.

Throughout the project regarding the users, the facts that do not have the same capacity, idiosyncrasy and characteristics were taken into account (Preece, et al., 2011). Some typical examples are the variety in technological skills or proficiency in their work or how they complete tasks currently and how they could complete those tasks more efficiently with a different workflow.

##### 3.2.3 Seeking sources of inspiration in the Market

The process of searching prior products already commercialized or similar, is a valid method in any design development (Preece, et al., 2011). At this project, searches on the 'Google Play store' were conducted for similar or just medical applications, in order to scout what is on the market already and try to be consistent with these apps. Four keywords were used for searching, 'EMS', 'Ambulance', 'DSS', 'Medical', 'Palliative' and they yielded different kinds of applications (see details in Appendix #3). Through testing the downloaded applications under the search categories, some features (see Appendix#3) were evaluated as useful for the prototype and application creation.

Following the same method, a person with deep knowledge and experience of the e-health Market in Sweden was interviewed and his proposals, thoughts and considerations were taken into account throughout the project (Appendix #8). (Sjöqvist, 2013)

### 3.2.4 Data-gathering techniques

In order to determine the user requirements, the **focus group** was used as the most prominent data gathering technique.

Another data gathering technique used was **studying documentation**, which includes the DSS's paper format. More familiarization with the DSS procedure was acquired through this document and for DSS systems in general through literature and web search. Following the concept of studying documentation, designer guidelines for Android and iOS were investigated as well.

Efforts were made to use the **naturalistic observation** method as well.

#### 3.2.4.1 Focus Group sessions

In general, the interviewees were treated with respect and actions were taken in order to make them feel at ease (Preece, et al., 2011). Both members of the development team were facilitators during the sessions and tried to guide the discussions and at the same time avoiding irrelevant issues to be analyzed.

#### *Agenda*

Following the (Robson, 1993) guidelines, an 'introduction' and a 'warm-up session' was the initiative of the first session in both app cases, with the warm up session to remain as an initiative at the next sessions. The 'main session' followed with questions in a coherent way and by placing difficult questions at the end. The main session was followed by the 'cool-off period' with some simple questions. The final part was the 'closing session' where the interviewers thanked the participants and notes were put aside to hint that the session is over.

During the focus group sessions, **scenarios** of everyday issues and routines were tried to be composed with the users in order to identify their workflow, needs, and break down the tasks to subtasks. In the design process they were used as the foundation of the general design, to identify the way the ideas would be implemented, as a communication basis for the development team and in the end at the evaluation sessions where the scenario is transformed to a script that the user will follow (Preece, et al., 2011).

The discussion was coordinated through **semi-structured interviews** and it served the way to interview the participants. Before each session, a set of questions was prepared to drive the interview. The questions were mostly used as topics of discussion, still they were designed in the way that fruitful dialog would occur between the participants and the developers team (Preece, et al., 2011).

Questions and the general interview was planned carefully bearing in mind the (Robson, 1993) guidelines. These guidelines advise the interview designer to try to compose short questions (long ones are not easy to remember), try to break down combined sentences into questions, use easy to understand language, skip questions that are syntaxed to influence the user and to be careful for biases with the questions (be neutral).

The questions were addressed to the group, not to individual users, allowing all kind of users to raise their opinion and create dialog between them and between them and the development team. These sessions were used for pointing out the stages of the procedures that were agreed upon on and stages of ambiguous points of view (Preece, et al., 2011).

#### *Participants*

The number of people involved was usually from three to ten people. Participants were chosen with the condition that they are representative and typical users as much as possible (Preece, et al., 2011).

## Method

Participants were invited to think aloud, communicate with each other, with the development team and were encouraged to take their own notes or note on the paper prototypes presented at most sessions (PCU app) (see Figure 7).



Figure 7: Photograph from a session with the PCU focus group at the MedTech West premises

### *Location*

The focus group sessions took place in three main locations, the Palliative Care unit of Sahlgrenska Hospital, the Department's of pre-hospital care in University of Borås and the meeting room at MedTech West.

The first meeting with the Palliative care took place in their premises (Palliative Care Unit of Sahlgrenska Hospital), to get familiarized with the conditions they are working in and make them feel more comfortable since they are in their comfort zone. The rest of the meetings were held at Medtech West's meeting room.

All sessions for the ambulance app were held at the University of Borås, except for the evaluation of the prototype session, which was held at MedTech West's premises. There were hindrances as mentioned before to hold sessions in their work environment.

### **3.2.4.2 Data Recording**

Recordings of data gathering were various, but mostly notes were taken on paper, especially when interviews were conducted. Pictures were taken during the focus group sessions and video recordings were taken during evaluation of the prototype tasks, with the users consent.

## **3.2.5 Prototype#1**

### **3.2.5.1 Conceptual Design**

The **conceptual model** used in this project, was the process-orientated according to Mayhew (Mayhew, 1999).

Both scenarios and prototypes were used for the conceptual design to be developed. Scenarios were created often with the stakeholders help and they were used to describe situations that needed to be supported by the system and facilitate the conceptual design process. The feedback included

testing an idea for its technical viability, to define ambiguous requirements and quick user testing early in the process and evaluation.

A **low-fidelity** kind of prototype was generated at the beginning that included a paper-based prototype for both applications with a general layout and a storyboard behind, which in this case were electronic pictures, such as screenshots of the system. The screens were not very detailed, as it was quite early in the design process and creating and establishing details before agreeing on the general layout would be forward.

### Crafting the conceptual design

Except the goals and the conceptual model, the following principles and guidelines were taken into consideration for the conceptual design.

Apart from the interaction design guidelines, the **Android UI guidelines** were considered even at this early stage. The guidelines that were consulted at this stage were the more general ones, such as the existence of the 'navigation' and 'combined bar' (which was considered for navigation between screens) and the partition of the applications screen to 'Main action bar', 'View Control', 'Content Area' and 'Split Action Bar'. Each one of them have a categorization of actions and displacements at their section, supporting organization and consistency between apps (Android.com, u.d.).

In extent of the Android categorization, the **grouping** concept was in general taken into account in the designing process as part of good organization quality.

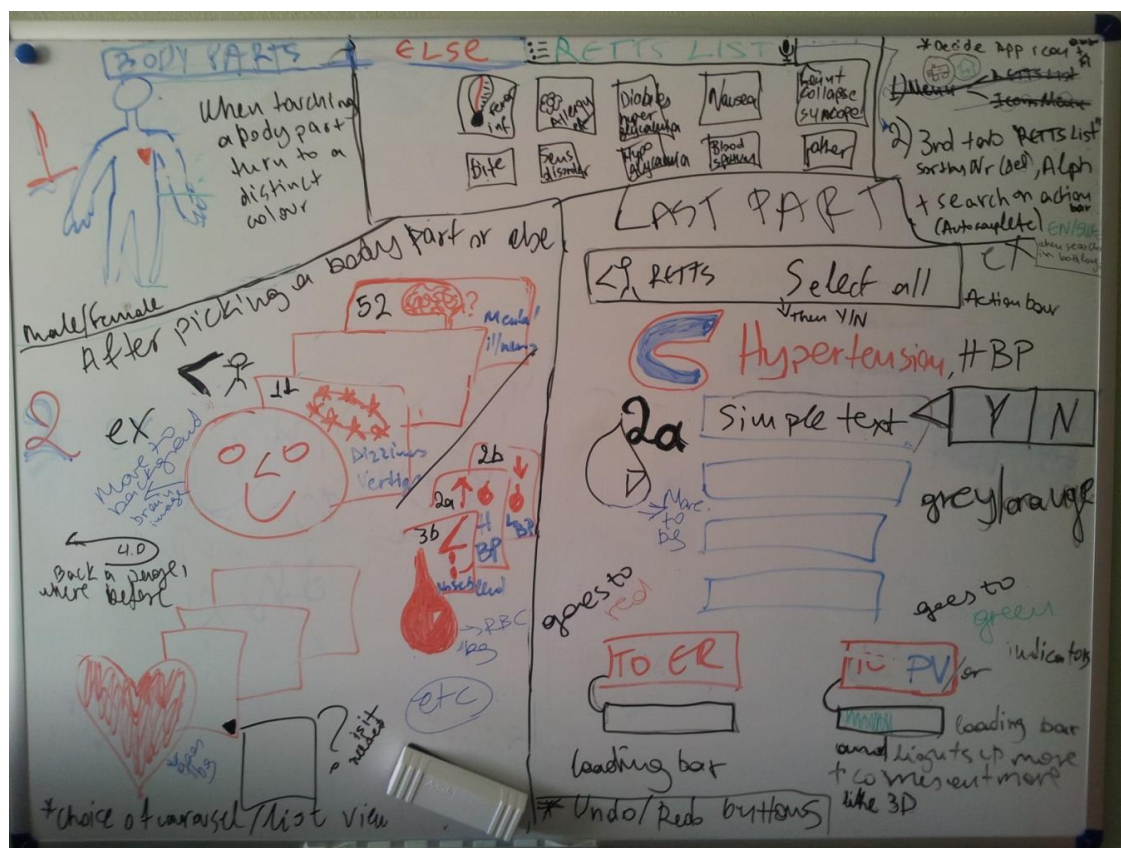


Figure 8: Conceptual design for the ambulance application on the whiteboard





Figure 9: Conceptual design for the PCU application on the whiteboard

### Evaluation of the conceptual design

Before the meeting, goals of this evaluation session were set and some questions for guidance were formulated, according to **DECIDE** (framework to direct evaluation) (Preece, et al., 2011).

A problem to consider was the participants' attendance, selecting the right ones, experience on technology or their subject. Additionally, the way the participants are going to be involved in the session was also an issue to examine.

The session for the low-fidelity prototype was quite informal and followed the evaluation paradigm 'quick and dirty'. The task-scenario picked to present them as typical workflow was described to them and the screenshots were shown to follow that description (What to observe?). Alternatives were presented to them in the form of a scenario.

## 3.3 Following the spiral lifecycle model-2<sup>nd</sup> cycle

### 3.3.1 Risk Analysis #2

The methods followed were the same, yet not in that detailed way on account of the early stage of the project, not many changes in the estimation appeared.

### 3.3.2 Prototype #2

As far as the **menu design** is concerned, the principal of grouping was always considered, while for the icons they were created based on standards or traditions for each case (Preece, et al., 2011). Furthermore on icons, they were designed based on cognitive aspects and so that the user can tell them apart on account of their small sizes on the screen.

Moving along, the **screen design** was based on the visual communication principles (Preece, et al., 2011). e.g. screens were designed in a way that when the user first lays eyes on it, he/she will be drawn to elements that have to do with the task in their mind.

Whereas, for the screen design not only the mere screens were considered, but how a **task** is separated **through** the **screens** as well (Preece, et al., 2011).

**Interactive versions** of the design were constructed in the form of **prototype**, while always making sure that users will enjoy using them and feel comfortable (Preece, et al., 2011). Moreover, two different kinds were constructed. For the PCU DSS the low-fidelity prototype for the ambulance DSS the high-fidelity one.

The **high-fidelity prototype** was developed on one of the software tools available (Axure Pro 6.5) and it was designed to look similar to the final product with some details left aside.

### 3.4 Following the spiral lifecycle model-3<sup>rd</sup> cycle

In order not to be repetitive, for the third cycle, only the new steps followed considering the maturity of the prototype are going to be described. The prototype as the **physical design** is evaluated through focus group meeting ('quick and dirty') for the low-fidelity one (PCU application) and through usability study for the high-fidelity one. The usability study was focused mainly on observing the users and the technique used to record the session was to video record them and keep notes. The usability testing involved video recording and keeping track of interaction actions such as clicks, aloud comments and moments of stalling and later the user's actions were analyzed and how long it took them to complete specific tasks. A script was distributed to them which described the aim of this study, duration of the session and explanation of their rights; a consent form was attached as well. The location of the users was determined before the session, as well as the feasibility of the technical equipment, so that their reactions and part of the screen will be recorded (Preece, et al., 2011). The users were invited to 'think aloud' and in case the participant was silent, the evaluator in the room was encouraging him/her to think aloud. During the reviewing of the videos qualitative analysis and search for incidents or patterns were conducted, following the coarse-grained strategy.

### 3.5 Following the spiral lifecycle model-4<sup>th</sup> cycle

During the 4<sup>th</sup> cycle as it is advised by the spiral life cycle mode, the actual application was programmed and tested on actual users. The method chosen for testing did not alter from the high-fidelity prototype and by following a scenario the participant was video recorded and notes were kept of him/her using the application. Evaluation of this session was conducted with the same strategy and conclusions were determined after the examination of the video data.

## 4. Analysis

In this chapter, some general principles and/or early overall goals/decisions are described, as these contributed in the project at very early stage, without being the final result. Needless to say that there were goals that were focused on more than others, depending on the application or priorities. In general, the goals that applied for both apps were that they should be aesthetically pleasing with a minimalistic design, take advantage of the tablet portability and touch screen by finger and being efficient.

These goals were the drivers for the designing choices made in the development process. More specifically for the ambulance app was chosen to be primarily efficient to use, to achieve visibility, be interactive and with a small learning curve, whereas the Palliative care app was chosen to be flexible, professional, easy to navigate and consistent.

### 4.1 Usability Goals Analysis

Based on the book 'Interaction Design-Beyond Human Computer Interaction' by Pearce et al. the following goals were given priority in this project:

Design and Usability goals:

- Effective
- Small learning curve and easy to remember how to use
- Easy to know how to interact with
- Achieve Visibility
- Appropriate feedback for the status
- Consistency (internal and with other applications)
- Take advantage of the tablet portability and touch screen by finger
- Develop characteristics to provide more freedom and efficiency to experienced user
- Recognition rather than recall
- Efficient to use
- Respect guidelines for each platform
- Secure to use
- Easy to navigate
- Interactive

### 4.2 User Experience Goals Analysis

In particular at this project, the DSS system and the tablet device have led to picking the following user experience goals.

User Experience goals:

- Serious
- Professional
- Phrases and words used familiar to user
- Aesthetically pleasing and minimalistic design
- Helpful



### 4.3 Analysis of potential type of users

The target group of the two applications is limited in numbers and variations, as they are both focusing on the healthcare sector and in a particular section of that sector. Next thing to consider is the roles of every user in the workflow, as it can yield categories/types of stakeholders (see Table 1).

Table 1: Table for identifying the users, (P) – Primary, (S) – Secondary, (T) – Tertiary

| Ambulance app stakeholders | PCU app stakeholders       |
|----------------------------|----------------------------|
| (P) Nurse                  | (P) Nurse                  |
| (S) Driver                 | (P) Occupational Therapist |
| (T) Patient                | (P) Physicians             |
| (T) Doctor                 | (P) Social Workers         |
| (T) ER                     | (S) Doctor                 |
| (T) Vårdcentral            | (T) Patient                |

The representative users involved vary between the two applications. In the case of the ambulance ones more men are occupied than women (Open Universities Australia, u.d.) (as it is considered to require heavy lifting and appalling conditions), while in the PCU app case the users are mostly women. In both cases the users are quite familiar with digital systems, since there is a journal kept for every patient electronically (patient file).

In the PCU app case, the focus group was already picked due to the project already going on at PCU of Sahlgrenska Hospital regarding the action plans.

### 4.4 Workflow analysis (documents and interviews)

#### 4.4.1 Ambulance application

During research and analysis for the ambulance application, it was made clear that the questions of Part A and B are so standardized in the personnel's work routine (they know the questions by heart), that only new personnel is not totally familiar with them. Moreover, it was observed that all the part C questions can be answered by YES or NO only, while some questions existing in part A and B needed an answer that could not be standardized. e.x. 'How long have the symptoms been going on?' Additionally, regarding the last part, two patterns of qualifications for PC were distinguished, the 'All of the following must be met' and 'Any of the following must be met', which implies that the answers should be 'YES' to be regarded as positive. Lastly, throughout the questionnaire CRC document it was detected that not all 'NO' answers were negative, which was an important observation during the designing process.

#### 4.4.2 PCU application

Likewise, for the PCU application through the documentation analysis, it was realized that the action strategy of the ideologies did not exist for many of them. Another phenomenon observed was the absence of the second level at few cases. Through the interviews it was realized that the third level should be left open for additions and that the final action strategy (third level) is almost always

going to be a mixture of the action plans chosen. Moreover, it was realized as the design development was evolving that it was essential to have very short titles for each ideology and its subsets, which in many cases proved to be very difficult.

## 4.5 Target System Analysis

Several different kinds of software and hardware were used in developing the applications. Appropriate hardware for testing the application during development and demonstration of the application for target users was essential.

### 4.5.1 Software

When it comes to software for the development of the application many options were considered. Even if Android devices were the main target for the application, the possibility of using the application on a variety of platforms was preferred. Thus, a software environment for cross platform development was sought after. Since many such environments exist, search was conducted and reviews and features were compared. Many alternatives use “lowest-common-denominator approaches such as HTML5” (Kindel, 2012), however in this case a “cross-platform tool that creates native apps” (Anderson, 2013) was seen as more appropriate. This realization narrowed down the alternatives and in the end Xamarin Studio was chosen as the best, in part because it is a “compelling mix of cross-platform development and rich tooling” (Bright, 2013).

Images were needed for icons, backgrounds and other visual parts of the application design and these were acquired through various sites but mostly through (Shutterstock, u.d.) and (Masterfile, u.d.). However, most of them were edited and many of the visual parts were created from scratch. Editing of images and creation of early design demonstrations was done in Microsoft Paint and Adobe Photoshop.

For prototyping and testing of early design choices Axure in combination with Photoshop for icon generation were used. All preliminary designs were created on a whiteboard, since it facilitates the erase and redesign process, as well as the collaborative thinking.

Further in the prototype process, in the ambulance app case, the digital prototype was thought as the best choice in order to have a design prototype, before starting programming. That choice was made on account of the fact that this application had a straightforward structure given the paper-based DSS. In addition, the focus on this application was on the functionality and quick moves to complete the tasks. Therefore, a digital prototype was created on Axure, in order to demonstrate the functionality and let the users evaluate the prototype by laying hands on it.

In the PCU app case, paper prototype was preferred since the procedure was vague even on the paper DSS. Considering, ethics decisions are always very delicate and need extra-caution when handling them, the paper prototype was established as more flexible and less time consuming. It was expected that many iterations were going to be created, so time spent in between the meetings was essential. In the beginning only Photoshop was used to create the preliminary sketches, so as to have a more appealing look to the focus group and let them judge the choice of colors, as well. Later on, as the functionality started being an issue as well, many of the pages for demonstration were created on Axure. As soon as the functionality was considered competent, they were exported to images for the meetings and the functionality was demonstrated by using pieces of paper.

### 4.5.2 Hardware

As far as the tablet devices are concerned, an online search was conducted for comparison articles on blogs, e-magazines, forums and websites about mobile devices. An article from Wikipedia (Wikipedia, u.d.) was used, where there was a comparison of Android devices in general.

An article regarding the 15 best Android tablet devices available (TechRadar, 2013) came up during the search and was used in conjunction with a website called (tabletnation, 2013), which had a

feature where 4 tablets could be chosen to compare their characteristics, to choose the most appropriate devices.

None of these tablets had a price tag of more than 4500 SEK. The comparison was conducted through the website's comparison table, YouTube videos and by searching through e-stores. Models were excluded by comparing several criteria that were considered relevant concerning the use of tablets in a medical setting.

More detailed in our search, these criteria were inputs for choosing the three most preferable tablets:

- **Price** for what they offered ex. SONY XPERIA Tablet S 9.4", expensive compared to others with similar specifications
- **Size**, not less than 7" and not more than 10.1"
- **Availability** ex. NEXUS 10 was not available for purchase in Sweden.
- **Presence or absence of built-in software** ex. Kindle Fire built in Amazon software which did not allow usage of the Google Play store.
- **Usability** ex. ASUS Eee Pad Slider with a slide keyboard, which in the beginning was considered a usable feature, however after going through reviews (text and video), it was realized, and that it is quite heavy and impractical for ambulatory use.
- **Processor and RAM** ex. The Quad Core was considered a beneficial feature, though a dual-core was thought to be sufficient for this application. Likewise, the RAM was decided not to be less than 1GB, yet if 2GB were available it was considered an advantage.
- **Screen resolution** ex. The Nexus 10 (2560x1600) and SAMSUNG Tablets (1280x800) were the best, exceeding specifications of the others as far as this criteria is concerned.
- **Connectivity** ex. All ASUS Tablets had their own connectivity port system, via the additional keyboard instead of the standard connection.
- **Storage expansion**, its presence was not considered a requirement for the prototype, though for real life databases and general use it might be useful to have such option.

## 5 Results

The results of this concept study will be presented in the following chapter. The Target system that was decided on, the prototypes which are described as a result of the designing process and the demonstrator application that resulted from programming and is based on the prototype.

### 5.1 Target System

After the analysis on the tablet models available at that time, it was decided that ‘Google NEXUS 7’, ‘SAMSUNG Galaxy TAB P7310 8.9’ and ‘SAMSUNG Galaxy Tablet 2 P5110 16GB 10.1’ would be the best options for the current applications. After the research online, a need to hold the three candidates and see what is like to hold them and work with them was felt. The next move was to go to a store and observe them in reality. After testing them, estimating their weight, observing the screen resolution and trying to operate them with one hand, the conclusion was that:

- 10 inch tablets were quite heavy and somewhat cumbersome (most suitable for use while sitting down)
- 7 inch is quite small which makes it easier to carry, however it might make it harder to see the icons etc., while in motion (considering the ambulance use)
- Around 8 inches seemed a good compromise between the screen resolution, size of icons and usability with one hand.

The design of this application has to consider all of currently the available tablet sizes though, so as to be flexible. However, the opinions of the prospective users, i. e. the staff, should also be considered. For example, the Palliative care might feel more comfortable with the larger 10 inch tablets as they will be using the tablets in a more stationary environment, while the ambulance might prefer a slightly smaller tablet on account of their mobile work environment. In the end it was decided that two different tablets should be used for testing and demonstration and thus the Google NEXUS 7” and the SAMSUNG Galaxy Tablet 2 P5110 16GB 10.1” were used (see Figure 10).



Figure 10: Google Nexus 7inch tablet device at the left, Samsung Galaxy 10.1 inch tablet device at the right.

## 5.2 The Resulting applications structure (Prototype-Demonstrator)

Following the method described in the 'Method' chapter, the resulting proposed prototypes and demonstrators have the following layout, features and database structure. The prototype is the result of the focus groups and usability test and proposes the desired design and functionality as well as intended use, while the demonstrator is the programmed application for the Android tablet device based on the intended prototype. The prototype (result from the 5th stage) and demonstrator (result from the 6th stage) are for both applications described in the same way. First, the features used throughout the applications such as navigation and search function. Afterwards, the primary pages are explained in terms of layout and features, which include the pages that the user meets when first entering a section. Afterwards, the secondary pages are described in the same way, which include pages that are appearing dynamically after a certain selection on the primary page. The pop ups description is following, with most of the times, layout and features to be described together. Last but not least the database structure, which is the core of each application, is introduced.

### 5.2.1 m-EMSS (mobile-Emergency Medical Services System) usage scenario - From Symptom to Decision

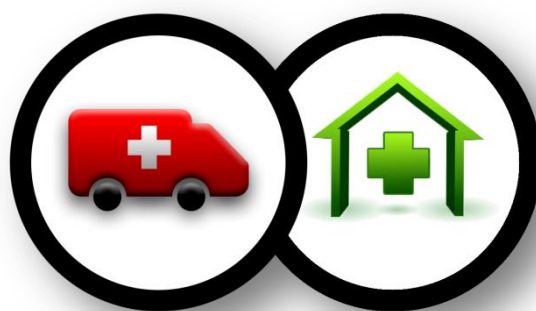


Figure 11: Logo of the m-EMSS application

In order to explain a work flow through the application m-EMSS (see logo in Figure 11 and flowchart in Figure 12), a simple task will be described step by step to its completion by introducing a persona.

**USAGE SCENARIO:** Patient, Male, 80 with signs of hypertension (High Blood Pressure) has called for help. The goal is to find out if he should be taken to Emergency Department or to Primary Care.

The persona is called Fredrik, 38, male, an experienced paramedic with some knowledge of technology. This experience comes from using the journal software and having a touch phone, which he does not only use as a phone but also explores its features regarding the internet connection, such as email and social media.

The user first chooses the application icon from the tablet's desktop, which loads with the splash screen appearing (could also be referred as the loading screen), the logo, name and CRC's project quote appear in a kind of transparent background. Afterwards, the login pop up shows up asking the user for credentials. The user fills out the fields and enters the application.

The first page the user is introduced to is the three tab page to choose the primary symptom and the Main and secondary action bar on the top. The user can identify the next action suggested from the application simply by looking the action bar, which is stated as 'Choose symptom'. However, the avatar shown is inviting enough and if the symptom is located on the body, the user interacts with it, without much processing. Next to the path/task indication the user will interact with the 'add patient' icon to document information about the patient. The user is navigated to a page for filling

data about the patient such as personal number, age etc. After saving the information, the user is navigated back to the main page and the patient's name is shown on the right top of the page in white text. Afterwards, the user interacts with the avatar by touching the part of the body, the symptom is located, for example the chest on account of the hypertension as primary symptom occurring at the patient. The buttons for changing the gender and rotate are not used since the patient is male and the symptom is located at the front side. The avatar's chest will change color to yellow and after a second, the user is navigated to the 'Carousel-Category' page.

The action bar still implies the path of the procedure the user is at by having the text 'Choose symptom, Category: Chest'. The user chooses the right symptom '2a) Hypertension' among the icons of the carousel and he is transferred to the Decision part A 'Anamnes'.

At this part, since the user is an experienced paramedic, he realizes that he does not need to go through the identifying questions and answers them, he prefers to skip to Decision, Part C by the 'shortcut button' located at the left bottom of the screen.

He is then navigated to the decision page, where he needs to answer the corresponding questions to the symptom by moving the seeker bars to negative or positive symbol. He slides each button to the right i.e. positive answer and the button becomes green, while the 'TO PC' button changes its state by gradually becoming lighter green with each positive answer. When answering all the questions, which were positive 'green', the latter button will be lighter green and ready to be chosen. He then adds the colleague accompanying him at the mission by choosing the right icon from the action bar and filling one of the two fields (username, name) as the other one will be filled automatically and by choosing ok he is returned to the previous page. The user chooses the proposed decision by pushing the button and a pop up appears informing him that he can add the secondary symptoms if he wishes to. He chooses 'Finish', completing the main task and he is navigated back to the main page while at the bottom of the screen a small toast 'Case completed' appears.

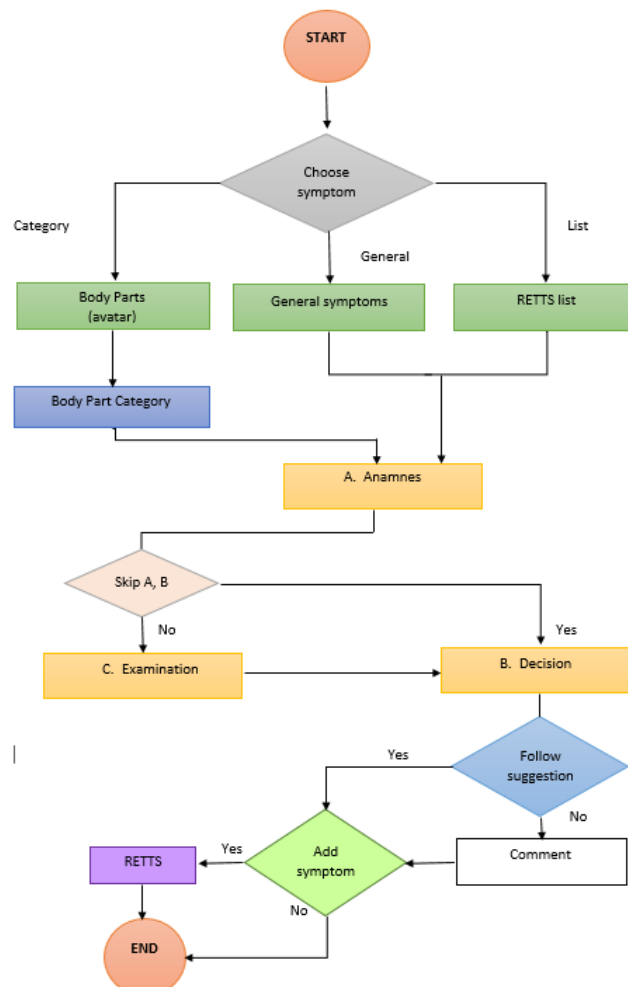


Figure 12: Flowchart of the m-EMSS application.

### 5.2.2 Input from focus group

A number of meetings with focus groups were conducted in stages during the course of the project. Input and insights resulting from those meetings were essential in the creation of the final design. Those results are listed below. It has to be noted that the first and second stage listed below correspond to the 1<sup>st</sup> cycle of the spiral lifecycle model, the third stage is the 2<sup>nd</sup> cycle, the fourth and fifth stages are the 3<sup>rd</sup> cycle and the sixth stage is the 4<sup>th</sup> cycle.

1<sup>st</sup> stage:

- Paper format of DSS was handed and the project CRC was described
- The ambulance routine was explained

2<sup>nd</sup> stage: The conceptual design was presented to the focus group.

- Questions in the form are answered by YES or NO, thus a swiping motion to left or right could be used to answer such questions
- Add symptoms functionality wanted
- A and B parts are not always important, user may want to skip to C
- Idea of a list of past cases was liked by the group
- The screenshots of the conceptual design were appreciated.
- 3<sup>rd</sup> stage:
- Advice on the key feature of how to answer the questions and help functionalities for it, by the group. The need to separate primary symptom from secondary symptoms where secondary only needed to be chosen, not specified was explained

4<sup>th</sup> stage:

- A task with a scenario was given to the group and the results were video recorded
- In general they liked it. According to them it was easy to use and they loved the new help functionality

5<sup>th</sup> stage:

- The final prototype was created

6<sup>th</sup> stage:

- The actual app was created and consequently tested in an ambulance with task and scenario which was video recorded, similarly to previous occasion
- The personnel found it easy to use and they liked the interactivity

### 5.2.3 Prototype description

#### 5.2.3.1 Throughout the application

##### Navigation

Navigation between the pages is succeeded mostly through the combined bar, where the back button will take the user to the previous navigated page and the home button will navigate the user to the designated home page, the First-Main Page. Navigation can be also achieved through the application icon on the action bar that navigates the user also to the previous page. At parts A and B pages the two buttons at the bottom of the question-buttons are considered also for navigation purposes, since they invite the user either to move to the next page or to the decision page directly.

##### Main action bar-Action bar:

##### Layout

The former has the application logo on the left side, shows the path and the patient working on at the moment. The latter includes icons for actions such as, 'Search', 'Add patient' etc. When the tablet is turned to landscape mode, the two bars incorporate to one.



## Features

**Search:** Search option is located always last at the action bar and it is available for all pages and the icon is a magnifying glass. When the icon is chosen, a field for typing with a microphone icon at its end, is appearing and the rest icons on the action bar disappear (see Figure 13). The field indicates the action of typing in order to search by the text 'Type your search...', while the microphone icon is depicting the function of speech recognition search.

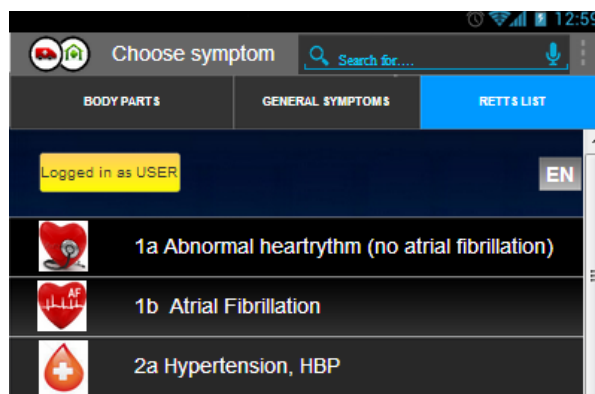


Figure 13: Search button chosen at the tab RETTS LIST.

**Undo:** This action icon is located at all pages' action bar, is depicted by an arrow pointing to the left and reverses the action previously taken by the user.

**Select All:** This action button exists only at the decision parts, is illustrated by a grey check and offers a shortcut to the user for answering positively the decision questions with one action.

**Buttons for adding information:** The options for adding information are to add the patient's demographics, the doctor's data and the colleague accompanying them at the case. The patient demographics page is appearing after choosing the 'Add patient' icon, depicted by a person and a cross, available only at the Main-First page (see Figure 14). The 'Add doctor' icon illustrated by a person with a medical, appearing only at the decision pages and will open a page for adding few information about the doctor (see Figure 14). Lastly, the icon representing the second member of the team is depicted by two persons and a cross (see Figure 14).



Figure 14: Left 'Add patient' icon, middle 'Add colleague' icon, right 'Add doctor' icon

### More button menu

**Past Cases/Statistics:** This is an option that shows the user to a new page, which presents the patient data gathered so far in a list (see Figure 15). These data include the date and time the case was documented, patient's age and sex, symptoms, users, doctor, the three parts of the decision and the final decision in colored cell. The latter cell is supposed to provide the user with statistics of the percentage number of patients decided to be sent to the Emergency Department versus the ones decided for Primary Care.





| Date & Time         | Age | Sex | Symptoms                               | Users          | Doctor                        | Decision Part A | Decision Part B | Decision Part C | CHOICE |
|---------------------|-----|-----|--|----------------|-------------------------------|-----------------|-----------------|-----------------|--------|
| 2013_04_29_11.31.02 | 23  | M   | 43. Allergy<br>44. Shortness of breath | User 1, User 4 |                               | Y,Y,Y,Y         | Y,N,Y,Y         | N,Y,Y,Y         | TO PV  |
| 2013_05_01_14.35.12 | 64  | M   | 49. Diabetes                           |                | Doctor1, Vårdcentral Frolunda |                 |                 | Y,Y,Y,Y         | TO PV  |
| 2013_05_01_18.56.22 | 31  | F   | 34. Knee Injury                        |                |                               |                 |                 | N,N,Y,N         | TO ER  |
| 2013_05_01_08.40.12 | 81  | M   | 11. Dizziness<br>19. Blood sputum      |                |                               |                 |                 | Y,Y,Y,Y         | TO PV  |
| 2013_05_03_07.10.30 | 55  | F   | 5. Chest pain                          |                | Doctor2                       | Y,N,Y,Y         | Y,N,Y,N         | Y,N,Y,Y         | TO ER  |
| 2013_05_06_11.20.14 | 41  | F   | 20. Syncope                            |                |                               |                 |                 | Y,Y,Y,Y         | TO ER  |
| 2013_05_07_20.04.32 | 74  | F   | 41. Animal sting                       |                |                               |                 |                 | Y,Y,Y,Y         | TO PV  |
| 2013_05_08_02.13.92 | 18  | M   | 47. Fever                              | User 1, User 6 |                               |                 |                 | Y,Y,Y,N         | TO PV  |

Figure 15: Past Cases/Statistics page, navigated through the more button.

Settings: Not included at the prototype

Help: Not included at the prototype

**Change Avatar:** This option is designed with the function of changing the avatar appearance and background (see Figure 16). There are two available avatars, the one that looks transparent and in a dark blue background and the one in light blue gradient background and black sketch with grey hair, a red heart (front) and a grey spine (back). The user is free to choose the most preferable avatar and the application will remember the avatar chosen for this user.

**Sort alphabetically/ Common symptoms/ RETTS list number:** The secondary 'Category-Carousel' page and the two tab-pages 'General Symptoms' and 'RETTS List' can be sorted with this option in three different ways. All three have default views and the sorting of symptoms can be changed to Alphabetically, Common symptoms and by RETTS list number. The text that illustrates the option is accompanied with icons, such as an A and Ö with an arrow pointing down describing the alphabetical sorting.

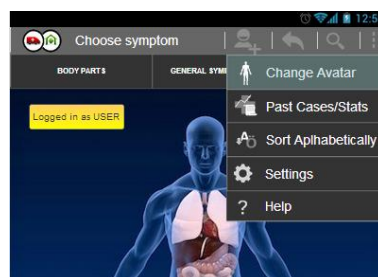


Figure 16: More button menu, 'Change Avatar' is picked.

### 5.2.3.2 Main-First Page

#### Layout

Three tab pages 'BODY PARTS', 'GENERAL SYMPTOMS', 'RETTS LIST'.

- **'BODY PARTS':** depicting an interactive Avatar chest front; this is the default tab chosen when entering the app (see Figure 17). The Avatar is standing with his legs and arms in an open position for easier interaction. In case the patient is documented, his/her name will appear at right top in white letters.

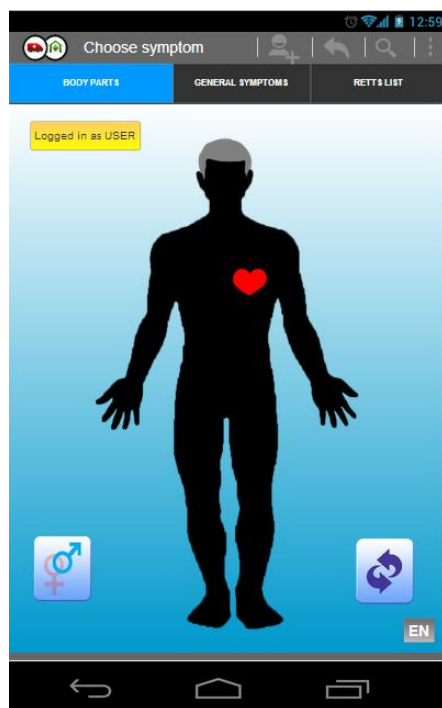


Figure 17: 'BODY PARTS' (Avatar) tab screen

- **'GENERAL SYMPTOMS'**: illustrating the page with the symptoms icons which are not easily put in a body part category (see Figure 18). They are accompanied by text description, in case the icon was not fully understood. Indication of the user logged in, patient name and language are at the same place as the 'BODY PARTS'. A text in white color is placed below the user indication as a text of brief help.



Figure 18: 'GENERAL SYMPTOMS' tab screen

- **'RETTS LIST'**: Contains the RETTS list with the symptoms' icons and description (see Figure 19). The symptom icons were decided to be of maximum three colors and as simple sketch or not so detailed. User indication is put at the same place as the previous tab screens. Indication of the user logged in and patient name are at the same place as the 'BODY PARTS'. The language indication button is located at the top right corner in this tab screen.

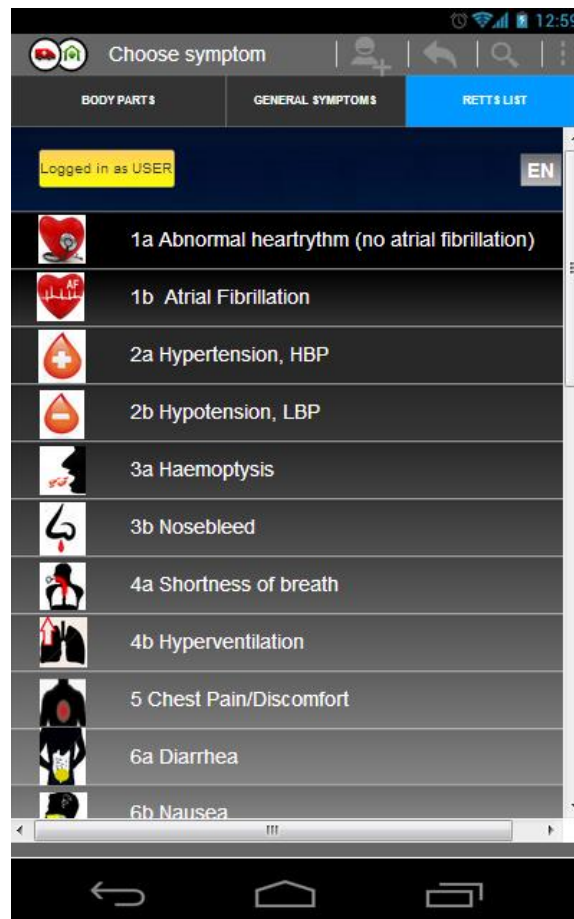


Figure 19: RETTS LIST tab screen

### Features

The three tab pages are navigated by clicking on each tab, which will turn to light blue, to show the tab the user is at the moment. These tab pages are the user's freedom of choice in order to find the patient's primary symptom and continue the procedure. The avatar depicted at the 'Body Parts' tab is interactive and already broken down in nine sections front and back (Appendix #1). On the occasion that the user will interact with the avatar, the avatar will have a layer of another color (yellow) on the body section picked. Afterwards, the user will be navigated to the page 'Category-Carousel' for choosing a specific symptom. The buttons located diametrically are referring to actions that can be administered to the avatar. The icon 'Rotate' at the bottom right part of the screen, depicted by two arrows pointing at opposite directions, has the functionality of turning the avatar from chest front side to back-spine side and the other way around. Whereas, the 'gender change' icon, illustrated by blue colored male symbol and red female one, changes the avatar to the opposite sex and indicates the gender the user has in front of him/her by fading away the symbol that the avatar is not responding to gender wise. The language button is interactive and by pressing it, the function of changing the text from English to Swedish and the other way round and that is illustrated by the text on it 'EN' or 'SWE'.

### 5.2.3.3 Primary Pages

#### Carousel-Category Page

##### Layout

Supposing that the user chooses the avatar to find the primary symptom, an intermediate page between the avatar and the decision questions, is a carousel with icons of symptoms (see Figure 20). The background of its category varies and illustrates the section of the body already chosen.

e.g. Category 'Chest' chosen, the background will be red with a heart in the middle and an ECG along the screen. Icons are symptoms connected with the body section (arm, chest etc.) along with symptoms that are always present in any section such as fever, sensibility disorder etc. and sorted by the most common in front. The RETTS list numbers are placed at right up corner in a grey rectangular box and the RETTS number along with description are placed at the bottom in the same form.

##### Features

This page appears after choosing a body part of the avatar and is a carousel of images-icons that are interactive in terms of movement and choice wise. Any of the icon chosen will navigate the user to the corresponding questions for decision making, Part A.



Figure 20: Carousel-Category screen, Category chosen: Chest

#### Decision Part A or B Page

##### Layout

- 'Anamnes': The background appearing is customized almost to every symptom, e.x. for 'Hypertension' and 'Hypotension', the background is a sphygmomanometer with red as the main color, slightly faded. At the top middle of the screen, the title of this page is illustrated in a black button-like gradient black box with white text 'Anamnes'. Diametrically put in white text and large font are the indication of which part of the Decision the user is (A, B or C) and on the right is the RETTS list symptom number. At the bottom of the screen, if documented, the doctor and primary care center will appear in white text. The questions are in a rectangular interactive gradient black button with the text in white color. The number of these button-questions varies with the algorithm used. Two interactive navigation buttons

are placed beneath the questions diametrically in light grey and light blue gradient color in rectangular shape and text in black color.

- ‘Examination’: This screen in terms of layout is the same as the ‘Anamnes-Part A’ one, except the text title that is in different color, red gradient.

### Features

There are two kinds of interactive buttons at this page and a data entry field appearing in specific questions. The first kind is navigating through the pages, which are there to skip to decision part C or continue to the next Part B with or without the questions answered. The question seeker bars have three ways of interaction:

1. When pressed the ‘help’ part appears showing the way the button needs to be moved in order to be answered positively or negatively.
2. When they are swiped to the right side towards the plus sign, the button becomes green, to show the user the answer is positive towards the decision being the patient to be transferred to Primary Care.
3. When they are swiped to the left side of the seeker bar towards the minus sign, the button will turn to orange, giving feedback to the user that the answer is negative and the decision can lead to the patient being transferred to Emergency Department.

The last but not least is the data entry option, when questions like ‘How long’ or ‘When’ come up and the button then has a field ready to be filled and stored in the database. The application advises the user to be brief by saying ‘Type a Quick answer...’ and save him/her time.

### Decision Part C- Final

#### Layout

Mostly the layout of this page is the same as the Part A/B page, with the question-buttons, indication of part and RETTS number and doctor to remain the same. The difference in this page is that the title button is gradient green with black text indicating which conditions have to be met for the patient to go to the Primary care (see Figure 21). Instead of the navigation buttons, this screen has one orange and one green rectangle interactive buttons with black text. The former indicates the choice for Emergency Department and the latter the choice for Primary Care.



Figure 21: Decision Part C of symptom Hypertension in English. The first two questions are answered positively, the third one is just pressed on the question-button and the last one is not answered. The loading bar ‘TO PV’ is half full.

## Features

This consists of the last part of the decision and it is here that the application proposes the final decision about the patient being transferred to the ED or PC. The same kind of seeker bars are used at this screen, with the difference that every answer influences the two buttons at the bottom of the screen. The 'TO PC' button is behaving like a loading bar, which either lights up (using lighter green) at once or gradually whenever a positive answer is given. The way the bar is 'loading' depends on the algorithm behind each block of questions i.e. if all the conditions should be met or if at least one of the conditions is met. Likewise, the 'TO ER' button is dependent on the algorithm, so for example if the conditions should all meet the positive answer and one negative is given, then the 'to ER' button will become lighter orange, resembling the lighting up action. Any answer given is reversible and the 'loading bar' or the lighting up effect will return to previous state. Those two are also interactive buttons, so the user has the freedom to choose a decision, contradicting the application's proposal or not answer the questions at all and choose. These buttons need to be pressed in order to finish the case and store the final decision.

### 5.2.3.4 Secondary Pages

#### Layout

#### Add patient

This page emerges from the Home Page, in the case the user chooses to 'Add Patient' information (see Figure 22). The background is the Android's default grey as well as the text has the default blue color. The screen has the title at the top left and the patient icon underneath, while on the top right the NPÖ cross is placed. Data entry boxes, drop down list, and checkbox are placed after each title depending on the data to be documented.

Figure 22: Add patient secondary page (The field 'Age' is in three different formats (number, sliding button with age intervals, full date))



### Add doctor

This page has the same concept and layout of adding information as the ‘Add patient’ page, with the difference at the type of data to enter, the absence of the NPÖ symbol and the patient icon is replaced by the doctor’s icon (see Figure 23).

Figure 23: Add doctor secondary page.

### Add colleague

Same layout apart from the existence of only two fields to fill in and the icon of adding a colleague is placed under the title.

#### Features

The secondary pages have little functionality, as they are mostly data entry fields, drop down lists and checkbox. The drop down list supports auto fill, in case the user chooses to search by typing, not scanning and finding the right option. Last but not least, the NPÖ symbol is supposed to be linked to the NPÖ system and changes according to patient’s history.

#### 5.2.3.5 Pop ups

##### Login Pop up

##### Layout

The login pop up is a quite small standard Android grey window with a white frame and the rest of the background is an almost transparent grey (see Figure 24).

Figure 24: Login pop up

#### Features

The login pop up is supposed to check the identification of every user trying to login with a username and password. In the case that the user fails to identify himself/herself, the application



informs him/her with a message in red text 'Username or Password appeared to be not correct. Please try again.' The pop up comes at the beginning of the application after the loading screen.

### *Add symptom pop up*

#### *Layout*

This pop up follows the same layout as the login one, with the difference of a whole human body icon located top left, the content of the text and the existence of two buttons at the bottom. The data entry fields are not part of this pop up.

#### *Features*

This pop up appears always after the final decision, in case the user judges that one or more secondary symptoms need to be documented (see Figure 25). It has two options, one to 'Finish' the case at that stage or 'Add symptom' which will navigate the user to the RETTS list. This list is similar to the one used at the tab page, but with the appearance of a checkbox at every symptom.

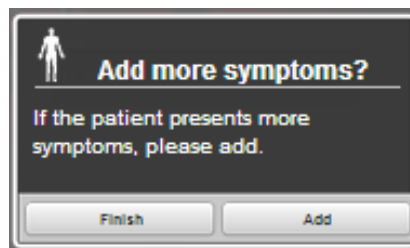


Figure 25: Pop up: Add more symptoms.

### *Add comment pop up*

#### *Layout*

The same layout is presented with this pop up besides the whole body icon, replaced with a comment icon, an added data field entry for writing comment text and the text content in general.

#### *Features*

This is a conditional pop up and appears only when the user will choose the decision opposing to the application's suggestion. The pop up asks for a comment on the case, mostly to describe the reason but gives the opportunity not to leave a comment as well by having two buttons 'Ok' and 'Continue without comment'.

### *Choose one symptom pop up-toast*

This pop up has a quite different layout as it is a pop up for choosing between options. Radio buttons are put next to every option and two buttons exist at the bottom of the window (see Figure 27).

For experienced users there is a light blue triangle, that if pressed reveals a toast (dropdown list), with the list of symptoms to pick one (see Figure 26).

## Results



Figure 26: Choose a symptom pop up left, toast right

### 5.2.3.6 Database structure

Below (in Figure 27) is a chart of the relations between the different tables in the m-EMSS database structure.

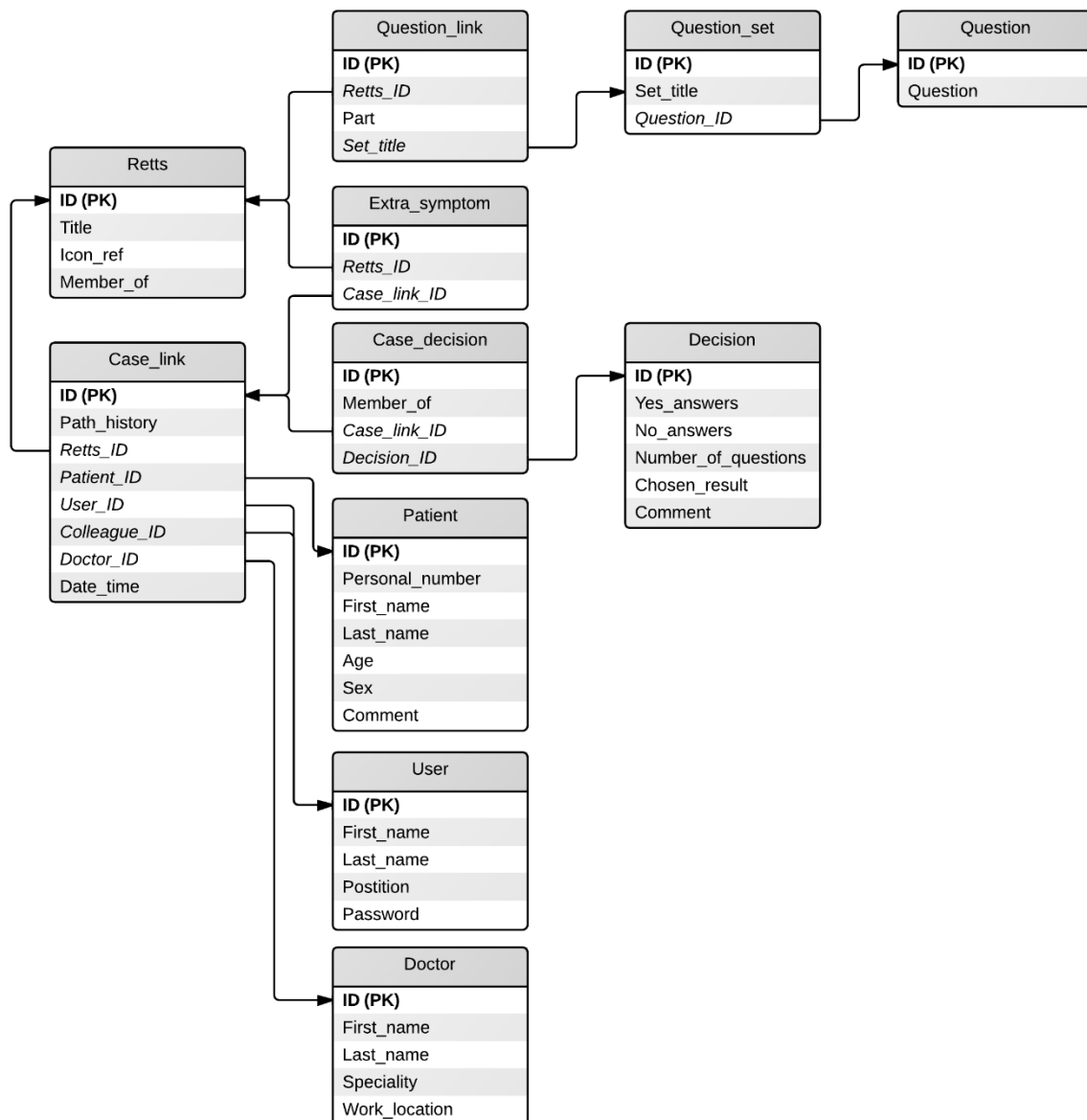


Figure 27: Database structure for m-EMSS

#### 5.2.4 Demonstrator-Resulted Application on Tablet-m-EMSS

The development on the cross platform software Xamarin, resulted in an application that in the time available is as close as possible to the prototype proposed previously. Some of the solutions created to solve design issues used classes and methods already present in the development environment while other were completely or partly created by the developers, like the seeker bars used for question representation.

Considering the existing variety of android tablet devices' screen resolution and size, resulted in creation of several versions of each image to certify their visibility and clarity on any tablet device used.

##### 5.2.4.1 Description of the application

The loading page of the actual application is shown in Figure 28 with the app's logo and the CRC's project quote.

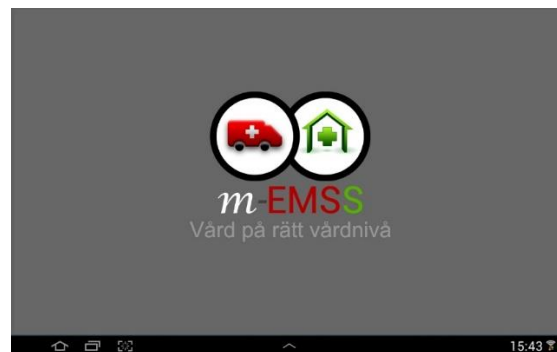


Figure 28: Loading page on m-EMSS

The three tabs exist as in the prototype 'BODY PARTS', 'GENERAL SYMPTOMS', 'RETTS LIST' and the avatar appears at the home screen (see Figure 29 and 30). When a body part of the avatar is chosen, the user is navigated to a list of the symptoms belonging at the body part category (see Figure 51).

## Results

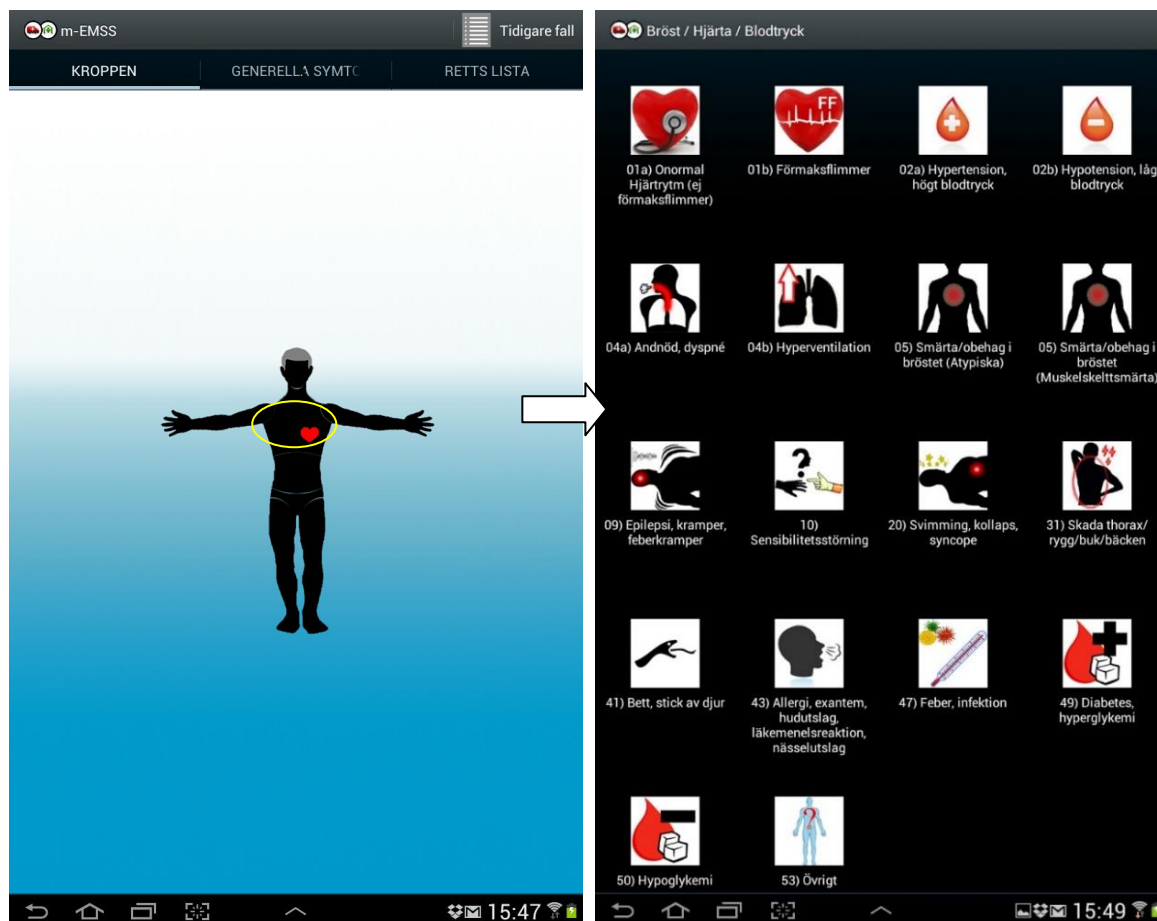


Figure 29: 'BODY PARTS' page at left, right page comes after choosing the chest part of the avatar

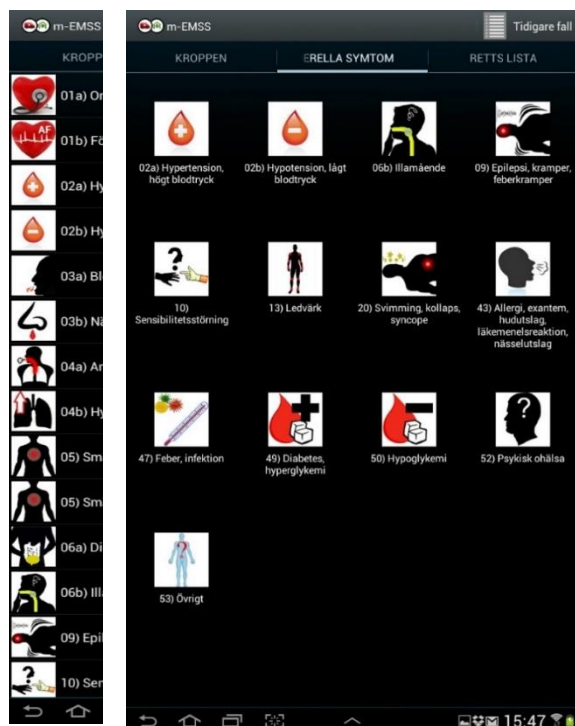


Figure 30: 'GENERAL SYMPTOMS' page left, 'RETTS LISTA' page to the right

## Results

As far as the decision part is concerned, the background is black and the questions on the seeker bar are not refined to fit the size of the bar. The seeker bar changes color when moved, orange towards the negative answer and green towards the positive answer (see Figure 31).

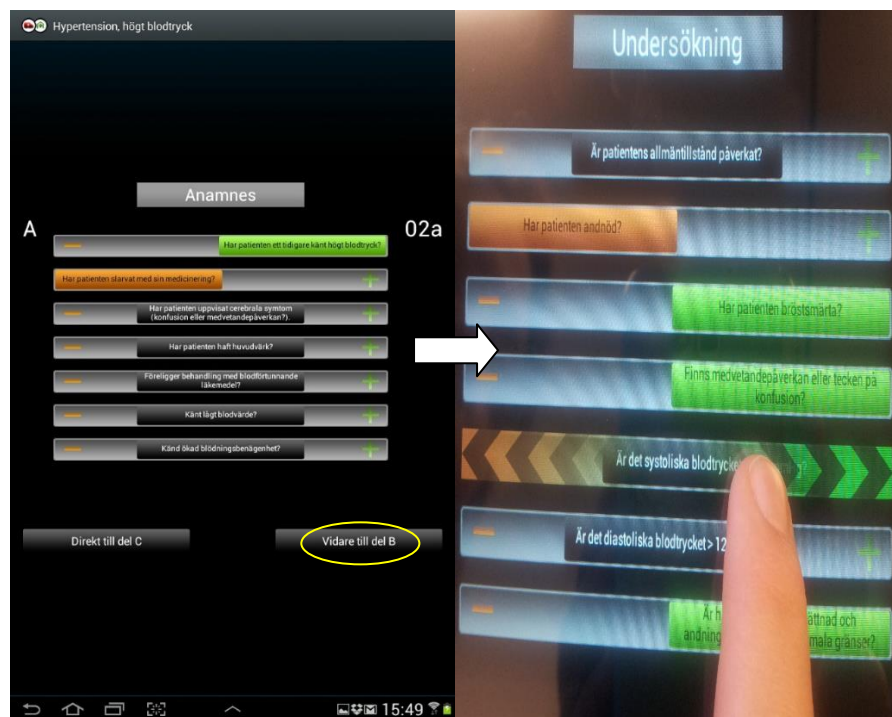


Figure 31: Left is the Anamnes, Part A page with the first two questions answered. Right is depicted the 'Examination' page and 2nd, 3rd, 4th, last questions are answered while Q5 is being answered at the moment

Moreover, at the Decision part C, the 'TO PC' button becomes green to propose to the user that the patient should go to Primary Care (see Figure 32). On the other hand, the 'TO ED' button becomes orange when according to the algorithm the patient should go to the ED (see Figure 32).

## Results

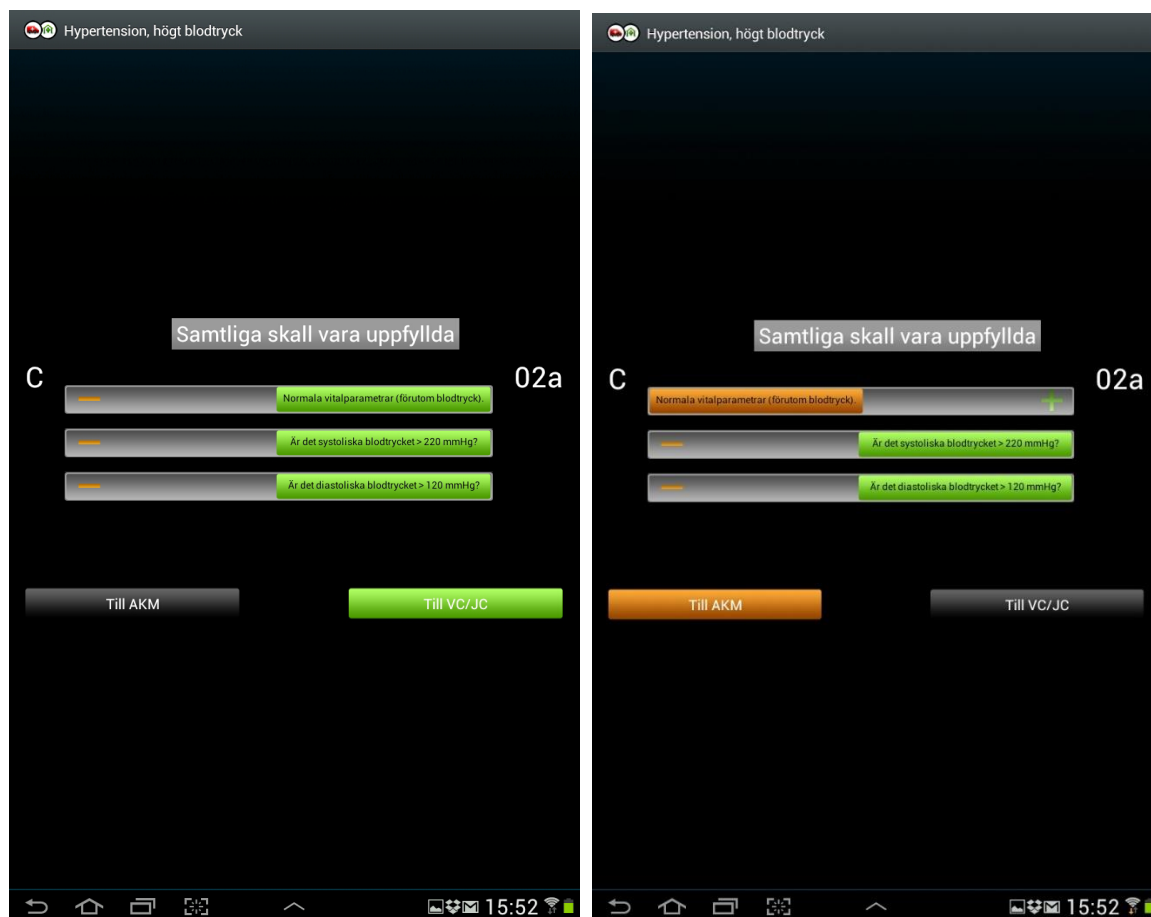


Figure 32: Left is the Decision part C having all questions answered positively. Right is the Decision Part C but with the first question answered negatively

Afterwards, supposing that the user chooses the 'TO ED' button, a pop up appears asking the user if he/she would like to add secondary symptoms and if they choose so, a list with the symptoms appears having a checkbox for each symptom (see Figure 33). Otherwise, the user chooses to end the case there and he/she is navigated to the home page.

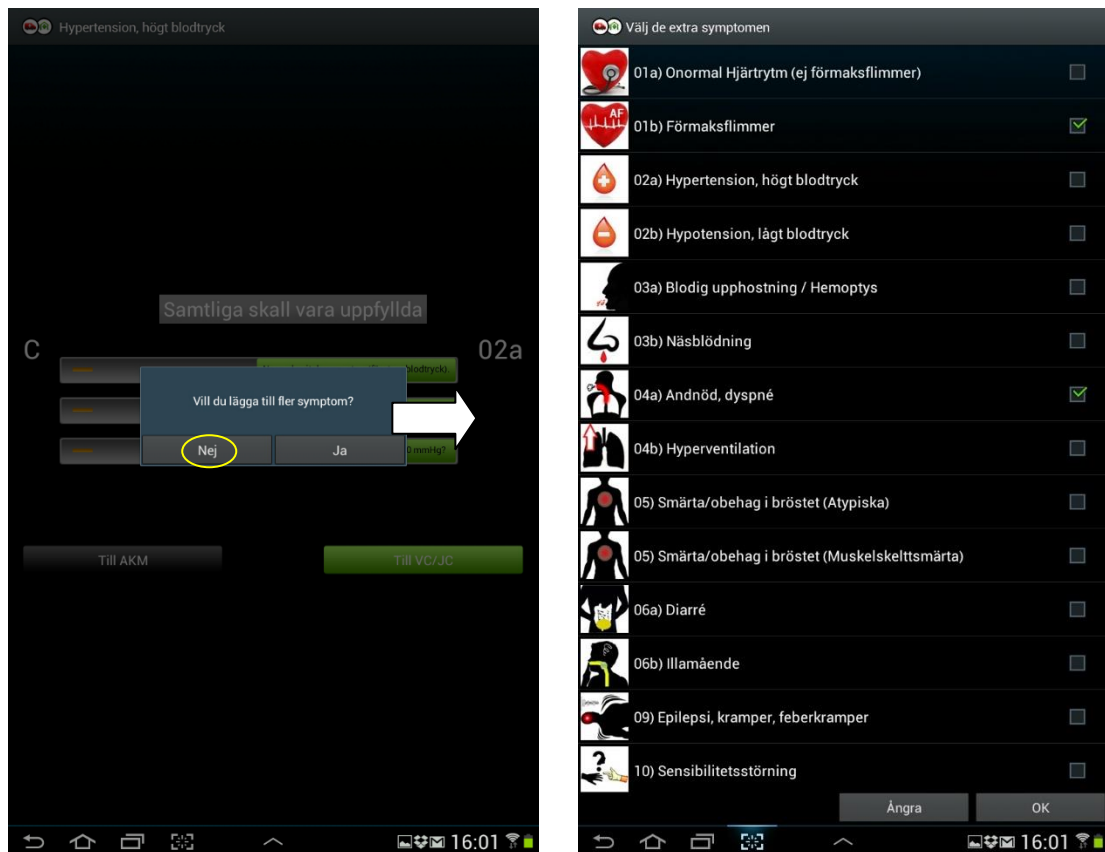


Figure 33: Left: Pop up for adding the secondary symptoms. Right: After choosing 'Ja' the user is navigated to this page for choosing extra symptoms.

The user can ignore the DSS suggestion and pick 'TO ED' instead of the suggested 'TO PC'. Then a pop up appears that asks the user to leave a comment for that choice opposite the suggestion (see Figure 34).

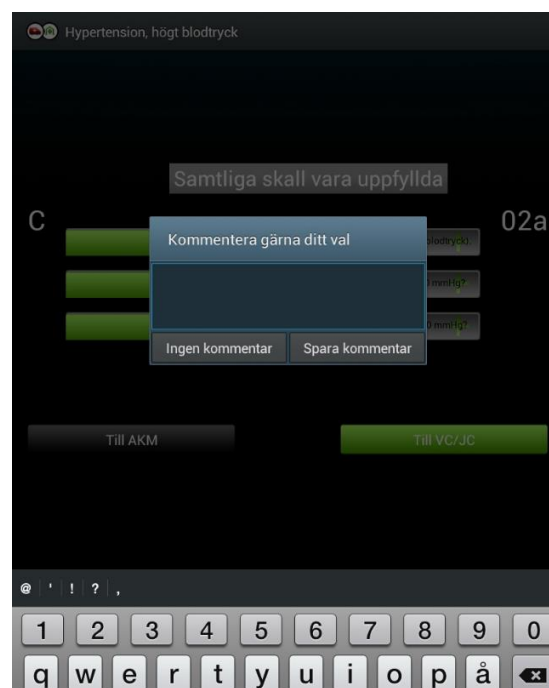


Figure 34: Pop up comment on opposite decision than the DSS proposed.

## Results

The Past Cases/Statistics page navigation was changed on account of easier programming and a button was placed at the top right of the action bar. By pressing that button the following screen appears (Figure 35).



**Left Screen (Default View):**

| Datum och tid       | Symptom                                     | Slutgiltigt Val | Beslut del A | Beslut del B | Beslut del C |
|---------------------|---|-----------------|--------------|--------------|--------------|
| 31/07/2013 10:00:30 | 02a) Hypertension, högt blodtryck           | Till VC/JC      | -            | -            | -            |
| 31/07/2013 10:02:06 | 02a) Hypertension, högt blodtryck           | -               | -            | -            | -            |
| 31/07/2013 10:05:25 | 04a) Andnöd, dyspné                         | -               | -            | -            | -            |
| 31/07/2013 10:28:18 | 02a) Hypertension, högt blodtryck           | Till VC/JC      | -            | -            | -            |
| 31/07/2013 10:31:39 | 19) Huvudvärk                               | -               | -            | -            | -            |
| 31/07/2013 15:40:20 | 04a) Andnöd, dyspné                         | Till VC/JC      | -Y,-Y,Y      | N,N,Y,Y,Y    | -            |
| 31/07/2013 16:16:30 | 01b) Förmaksflimmer                         | Till VC/JC      | Y,N,-,-,-    | -,-,-,-,-    | -            |
| 31/07/2013 16:18:54 | 53) Övrigt                                  | Till AKM        | -,-,-,-,-    | -,-,-,-,-    | -            |
| 31/07/2013 18:01:26 | 44) Halsont                                 | Till VC/JC      | -,-,-,-,-    | -,-,-,-,-    | -            |
| 02/09/2013 15:49:10 | 02a) Hypertension, högt blodtryck           | Till VC/JC      | Y,N,-,-,-    | -N,Y,Y,Y,-Y  | -            |
| 02/09/2013 16:01:00 | 02a) Hypertension, högt blodtryck           | Till VC/JC      | -,-,-,-,-    | -,-,-,-,-    | -            |
| 02/09/2013 16:01:52 | 01a) Onormal Hjärttrytm (ej förmaksflimmer) | -               | -            | -            | -            |
| 02/09/2013 16:01:56 | 02a) Hypertension, högt blodtryck           | -               | -            | -            | -            |

**Right Screen (List Dragged Left):**

| Slutgiltigt Val | Beslut del A | Beslut del B | Beslut del C | Användare         |
|-----------------|--------------|--------------|--------------|-------------------|
| Till VC/JC      | -,-,-,-,-    | -            | Y,Y,Y        | Christer Axelsson |
| -               | -            | -            | -            | Christer Axelsson |
| -               | -            | -            | -            | Christer Axelsson |
| Till VC/JC      | -,-,-,-,-    | -            | Y,Y,Y        | Christer Axelsson |
| -               | -            | -            | -            | Christer Axelsson |
| Till VC/JC      | -Y,-Y,Y      | N,N,Y,Y,Y    | Y,N,Y        | Christer Axelsson |
| Till VC/JC      | Y,N,-,-,-    | -,-,-,-,-    | Y,Y,Y,Y,Y,Y  | Christer Axelsson |
| Till AKM        | -,-,-,-,-    | -            | Y,Y,Y,Y      | Christer Axelsson |
| Till VC/JC      | -,-,-,-,-    | -,-,-,-,-    | Y,Y,Y,Y      | Daniel Sjöström   |
| Till VC/JC      | Y,N,-,-,-    | -N,Y,Y,Y,-Y  | N,Y,Y        | Christer Axelsson |
| Till VC/JC      | -,-,-,-,-    | -            | Y,Y,Y        | Christer Axelsson |
| -               | -            | -            | -            | Christer Axelsson |
| -               | -            | -            | -            | Christer Axelsson |

Figure 35: Past Cases Page in two parts. Left is the default view and right is if the user drags the list to the left



### 5.2.5 e-THICs usage scenario - From Situation to Action Plan and Evaluation



Figure 36: Logo for the PCU application

For the PCU application (logo shown in Figure 36), named e-THICs the workflow is explained by introducing a task conducted by a persona and an overview is given by Figure 37.

**USAGE SCENARIO:** Patient, Male, 68 diagnosed with cancer in terminal stage and the staff is facing a mix of ethical issues that conflict with each other, with respect to the patient's significant others, the goal set for his treatment and his autonomy. The goal is to find an action plan suiting all the separate ethics situations (Significant others, Goal and Autonomy) and evaluate its application afterwards.

The persona is called Emma is a 43 years old female nurse, who has been working in the PCU for seven years and has very limited knowledge about modern technology. Her knowledge about mobile technology is mostly through her touch phone, which she is using for basic functions. Emma is a member of the mirroring session team consisting of a doctor, an occupational therapist, a physiotherapist and another nurse. The team supported by the application, are examining and discussing upon the situations arising regarding patients and reflect on their action plans during the past week.

Emma, starts up the application through the icon from the tablet's desktop, which loads and the application's logo is presented in a grey background. Afterwards, the user or team identification pop up shows up asking the user for identification or continue without it. She types the first two characters of the team's name, chooses the right one from the proposed list and enters the application.

Before entering the application's main page, the reminder pop up is presented, reminding her that there are five cases still waiting for evaluation. She chooses not to navigate to 'Past Cases' and finish those cases, instead she presses the 'Continue' button to the Home page. The page for adding a patient's information and continue with him/her is presented with the option of ignoring that feature and continue by pressing 'NO'. Emma decides to add some information regarding the patient in debate.

Afterwards, she is navigated to the home-main page by pressing 'YES' and she starts this case by pushing the buttons describing the situation, 'Significant Others', 'Goal' and 'Autonomy'. As soon as the first situation button is pressed, specific list options fade away according to the algorithm and a button saying 'OK' at the bottom of the situation buttons appears to show that if the user wishes to, the selection can stop here. When hitting the 'Significant Others' a pop up shows up that asks for specification of the relationship type 'Relative', 'Spouse', 'Siblings', where she chooses the 'Relatives' option and presses 'OK'. Emma continues with the two more situation buttons and presses the 'OK' button, which causes the first pop up to appear which informs her and the team that there have been two past similar cases and gives them the choice of reviewing them in case they would like to be informed of what actions have been tried in the past.

They decide to go to 'Past Cases' and view the similar situation action plans taken and their evaluation. They come across with the 'Past Cases' page and a list of only those two cases appear on the list. They view all comments through the side button on the right and realize how the action plan picked influenced the situation. They decide to choose one of them and examine it more in detail, as it seems to fit well with the current situation. The case page appears with all the steps taken and evaluation. After viewing the case, Emma hits the 'Past Cases' button, then the 'Ok' button located at the past cases page and she is taken back to the situation tab.

When returning, another pop up appears that asks whether the user wishes to add a relevant and complementary comment regarding the situation, where Emma chooses to close the pop up and not comment, after reviewing it with the team. The list on the situation page has now shrunk to only ideologies filtered by the algorithm, with the levels expanded and in the position of the 'Ok' button, the button asks for continuation by the text 'Continue'.

Emma chooses to continue and the application goes to the 'Overview page', where they can see the options filtered by the application, with the text accompanying them, so they can decide which ones they will choose to follow. The page indicates the ideologies and their subject ones, shown at the side tabs. Each ideology has three levels and they examine each subject level by pressing the arrow with the circle button, which reveals the text for that level at this particular ideology and so on with the rest of the side tabs. Emma and the Team choose the appropriate ones by clicking on the text box, without commenting and press 'Continue'.

They are then taken to the 'Choices Overview' page, where the choices made for each level are available with the comments and the action plan (3rd level) is obvious and is read by the team. They decide to comment on each of the action plans suggested by pressing the speech bubble with the cross icon and after examining the action plan Emma presses 'Continue'. A pop up appears, that gives the option to Emma and the Team to evaluate now or evaluate later or not to evaluate at all. She and the team decide to evaluate later, after the action plan would be activated. The application then navigates Emma to the main page.

One week later:

Emma accesses the application with the same team and they see at the reminder page, that they should evaluate and finish with the case from the previous week. She chooses the 'Past Cases' button and at the list she finds the situation. She chooses that one by pressing on any cell at that row on the list and the case file appears. They decide to press the tab 'Evaluate' and proceed with it, through the page. This page asks for evaluation of the action plans documented to be taken. There are two questions to be answered, considering how well the situation was handled and which were the results. The questions are answered positively by Emma swiping to the left, towards the plus green side in the seeking bar. Afterwards, she drags the rating dot towards the number 4, as the action plan fitted very well the situation and solved the ethical issue.

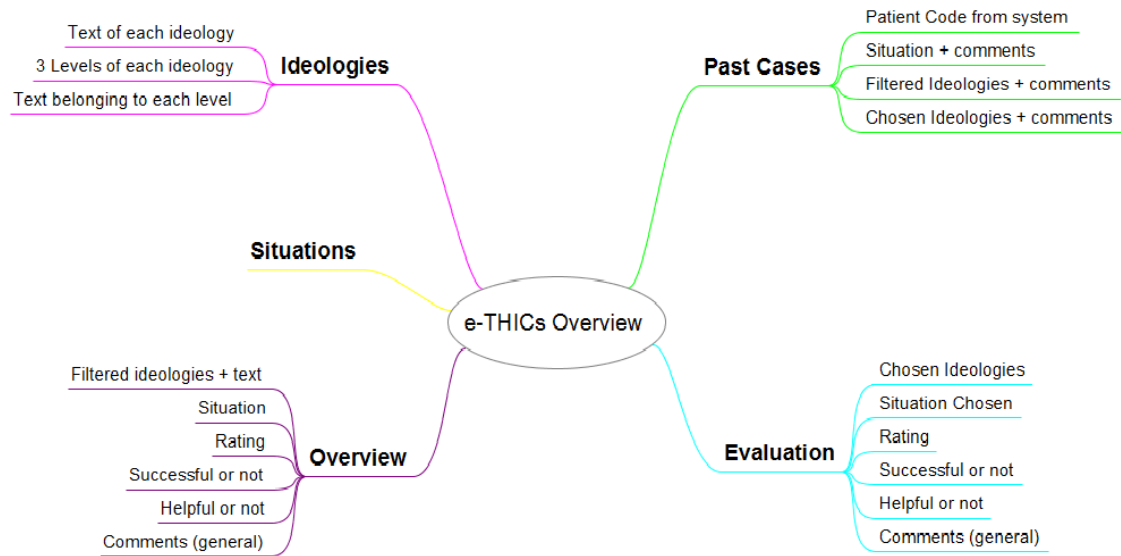


Figure 37: e-THICs overview

### 5.2.6 Input from focus group

Likewise, for the PCU app there were focus group meetings that evolved the e-THICs application.

1<sup>st</sup> stage: A semi-structured interview was conducted in all 3 meetings of the first stage (See Appendix #6).

1<sup>st</sup> meeting:

- The project and some of the general routine at the PCU was explained by the ethics expert of the Sahlgrenska Hospital PCU project.

2<sup>nd</sup> meeting:

- No patient file
- The idea of having a “pool” of options arose
- Input on block diagram created by the developers-> Lars Sandman would help us with the titles of each ideology and subset of it.
- Similar cases use

3<sup>rd</sup> meeting:

- The routine was explained by the PCU personnel (round visit, mirroring; where the group pictured that the app would be used mostly)
- Appreciated and approved the idea of the ‘pool’.

2<sup>nd</sup> stage: The conceptual design (result of the previous meetings) was presented as a paper prototype and the conversations that took place were based on it:

1<sup>st</sup> meeting:

- Lars Sandman and the developers decided on 14 situation buttons.
- The colors chosen are not visible for the color blind.
- The user should be able to give feedback on the case later.

2<sup>nd</sup> meeting (Lars Sandman and PCU):

- Commenting everywhere
- Patient data should be saved (very limited information though).
- A scale 0-5 at evaluation page should be included and the two questions should be as such to answer by YES/NO.
- Availability of adding a new action plan.

3<sup>rd</sup> stage:

- The changes made by the developers on the prototype received good reaction

- It was realized that more things on the workflow using the tablet should be figured out (overview and overview of choices ideas arose)

4<sup>th</sup> stage: A paper prototype was presented with shades of grey for color choice, as well as the conceptual design on whiteboard for the two new pages 'Overview' and 'overview of choices'

- The shades of grey were not appreciated and shades of purple was decided.
- The conceptual design for the two new pages was decided to be a mixture of two of the four designs presented.
- The algorithm for filtering according to the situation buttons was received and explained.

5<sup>th</sup> stage:

- Feedback on the icons created for the situation buttons.
- Agreed on the workflow with the application, as well as the new overview pages.
- Comment on Comment requirement.

6<sup>th</sup> stage:

- The actual app was created and consequently presented to the focus group.
- Good comments generally (easy, helpful etc.), however they would like to see it used.

## 5.2.7 Prototype description

### 5.2.7.1 Throughout the application

#### Action bar

#### Layout

Has the application logo on the left side, shows the path and the patient working on at the moment. Includes icons for actions such as, 'Search', 'More options', 'Expand', 'Select All' etc.

#### Features

**Search:** The search function on the action bar is present at the LIST tab and the icon is a magnifying glass. When the icon is chosen, a field for typing with a microphone icon at its end appears and the rest of the icons on the action bar disappear. The field indicates the action of typing in order to search by the text 'Type your search...', while the microphone icon is depicting the function of speech recognition search.

**Add patient:** The patient information page is appearing after choosing the 'Add patient' icon, depicted by a person and a cross, available at the Main-First page or when entering the application, after identifying the user. It navigates the user to the 'Patient Case' page.

**Select All:** This action button involves two kinds of actions and its icon is a check in white color. One action is when pressing it to select all the ideology choices at the Overview page. Whereas, when the user selects an ideology this 'Select All' will become '1 selected' and so on, if the user continues with choosing more ideologies it will increase in number of selected.

**Expand:** Appears in the Main-First page on all tab pages, in order to expand the lists available at those pages and has an icon like a tree view and an arrow pointing down. When pressed the list available should expand for all entries by one level, or in case of past cases it will show all the comments for all available cases at once.

**Retract:** This icon appears always next to the 'Expand' one and has similar icon with the difference of the arrow showing up. It acts on the contrary of the 'Expand' one and retracts at all entries by one level, or in the case of 'Past Cases' hides the comments for all cases.

**More options menu**

**Settings:** Language option, colorblind option, 'About'.

**Help:** Not included at the prototype

**Sort alphabetically/ by number:** The Situation tab on the Main page has the situation buttons sorted almost by category at each line of buttons (ex. first row illustrates the people's category) and numbers are given to each one (S1, S2 etc.). The default view is sorted by number and it can be

changed to alphabetically. The text that illustrates the option is accompanied with icons, such as an A and Ö with an arrow pointing down describing the alphabetical sorting.

### Combined bar

The combined bar was used only for navigation between the screens.

#### 5.2.7.2 Main-First Page

##### Layout

Three tab pages 'SITUATION', 'LIST', 'PAST CASES':

- **'SITUATION'**: depicting a pool of situation choices in the form of buttons on one side of the screen and the numbered list of ethical issues on the other side, which is the default tab chosen in green color, when entering the application's main menu (see Figure 38).



Figure 38: 'SITUATION' tab screen

- **'LIST'**: illustrating the list of ethical issues expanded to all three levels, presented by gradient of purple color and indentation of the title button-option (see Figure 39).



Figure 39: 'LIST' tab screen

- **'PAST CASES':** is a list of the past patient cases, with numerous columns and each row is a case (see Figure 40). At the right part of each case-row, there is a grey rectangular button with and a white speech bubble icon, stating the action of viewing all comments on each column. The column titles are 'Code', 'Situation', 'Evaluation', 'Level 1', 'Level 2', 'Level 3-Action Plan'. Each row, except for the data appearing on the right bottom of each cell, there is a speech bubble, either with an add symbol or with lines, either indicating that there is no comment or the existence of comments. Furthermore, there is a side bar indicating that there are more data than the one displayed at the moment.

| Kod        | Situation  | Utvärdering          | Nivå 1                                     | Nivå 2   | Nivå 3                              |
|------------|--|----------------------|--|--|-------------------------------------|
| 130507-011 | S1: Närstående<br>S2: Patient<br>S4: Mål<br>S8: Integritet<br>S9: Autonomi | 1) N<br>2) N<br>3) 2 | 6) Patientens personliga sfär              | 6.2) Patienten godkänna Informationsutlämning                  | 6.2.1) Ta reda på patientens syn    |
| 130508-010 |  |                      | 14) Etisk kompetens                        | 14.3) Realistiska mål  | 14.3.1) Anpassat till stöd          |
| 130508-029 | S4: Mål<br>S5: Livskvalitet<br>S9: Autonomi<br>S14: Döendet                | 1) J<br>2) J<br>3) 5 | 3) Dö i frid<br>4) Anpassa efter patienten | 3.1) Patientens egen uppfattning<br>4.1) Viktigt för patienten | 3.1.1) LCP (Liverpool Care Pathway) |

Figure 40: 'PAST CASES' tab screen

### Features

The main page has three tabs that when pressed become green, to show the change of tab page. The 'SITUATION' and 'LIST' tabs are for the user to choose one or more ideologies to follow their corresponding action plans and they are designed with features that facilitate that goal. The buttons at the 'SITUATION' page, when pressed are surrounded with a green outline to show their choice and as soon as the first one is hit a button 'Ok' appears. The list page can be used to just browse through the ideologies and their subsets, as well as to choose ideology freely, without the automation of the situation buttons.



## Primary Pages

## Overview Page

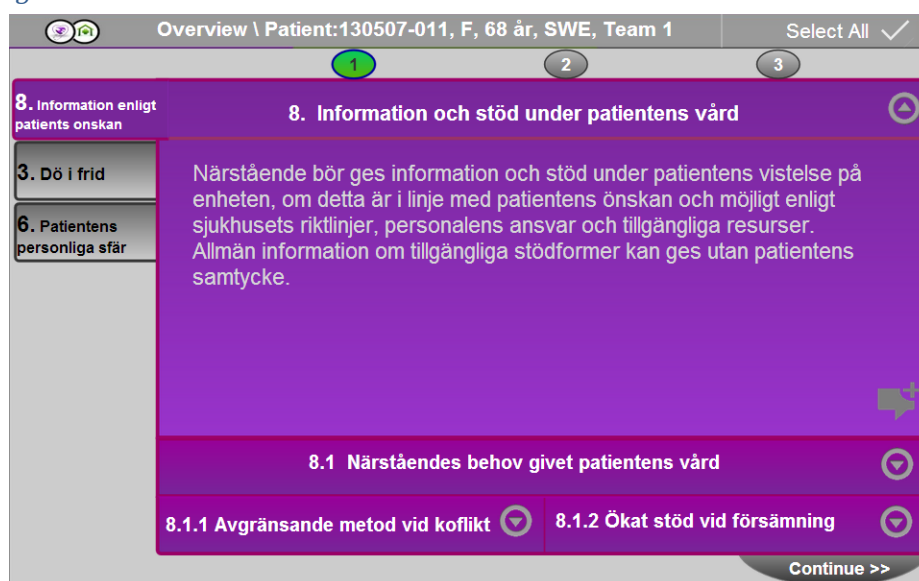


Figure 41: Overview page, with three ideologies filtered from the 'situation' screen and #8, level 1 is presented.

## Layout

This page's information is displayed in a rectangular box with side tabs (see Figure 41). On the top of the box there are 3 ellipse grey button indicators of the ideologies' level (1,2,3), with the level shown at the moment depicted in green color. The selected and displayed tab and page is in purple, while the other tabs are grey. The box consists of three levels as stated previously and every title has at the right end an arrow in a circle that points downwards or upwards. Every box with the ideology's description has light grey text and has at the right bottom side a grey speech bubble with an add symbol icon for commenting. In the case that a level has more than one subset of ideologies, the rectangular button will be split according to the number of the subsets.

## Features

The side tabs with the ideologies are the ones filtered from the application at the situation page. The tabs are sorted by the ideology's number and by default the first level's text is displayed.

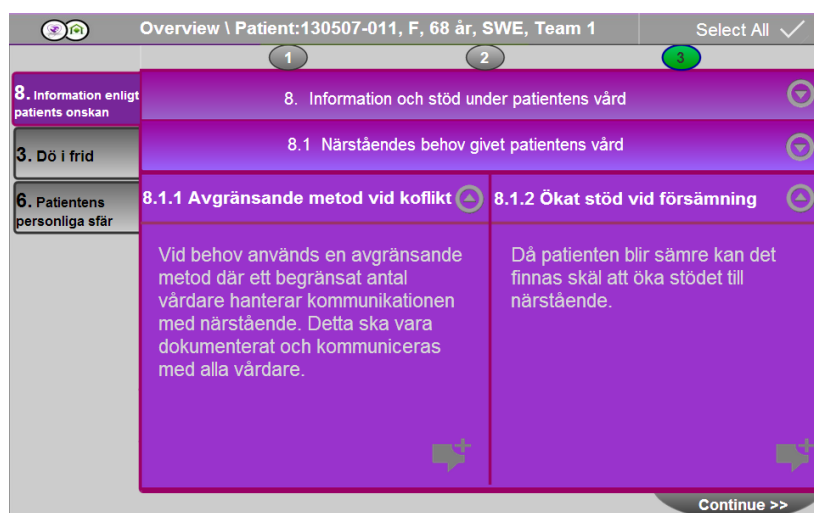


Figure 42: Overview Page, with level 3 of #8 ideology is displayed



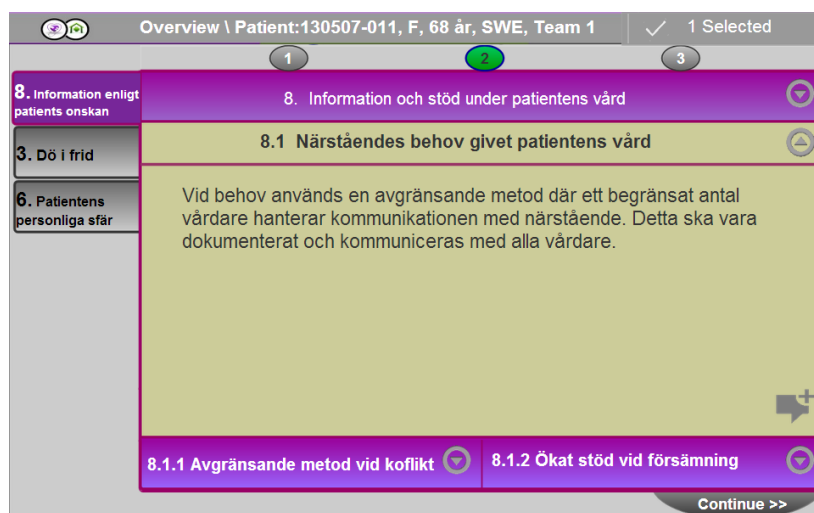


Figure 43: Overview Page, with level 2 of #8 ideology is displayed and level 2 is chosen by the user.

All titles work as buttons for displaying or hide the full text describing the ideology, which same action can be accomplished by the button looking like arrow facing upwards or downwards according to the action to be done (see Figure 43). On Figure 43 is shown the way the ideology's color is changed after choosing that specific level.

### Overview of choices

#### Layout

The choices overview page is designed in shades of grey, there are side tabs indicating the levels by three shades of grey (see Figure 44). The first and second level ideologies chosen are illustrated only as titles (having the arrow in a circle icon at the right side always), while the third level titles are expanded and their accompanied text is shown. Following the previous page, this one also shows the ability of commenting on each title or view the comments already documented depicted in two different kinds of speech bubbles (one with a plus symbol and one with lines in it).

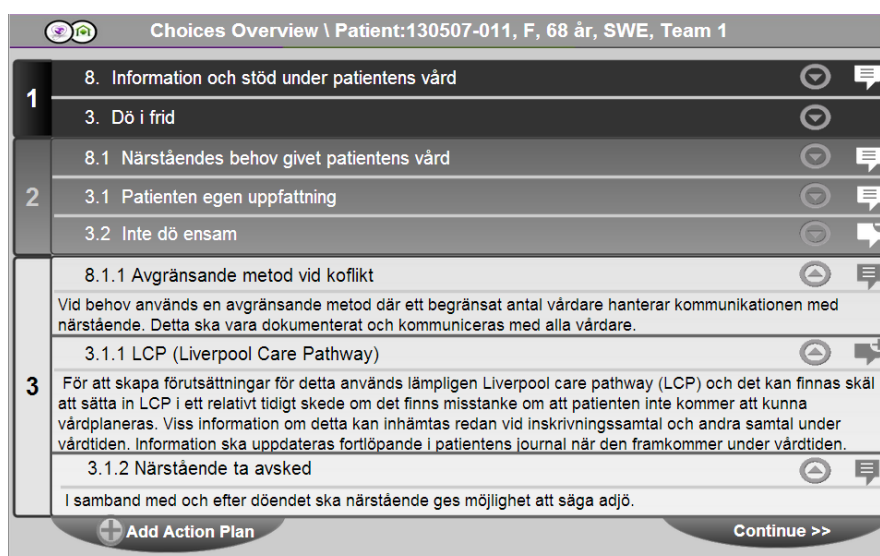


Figure 44: Choices Overview page

## Features

The ideology titles act the same way as the previous page, as buttons for revealing the text for that ideology. The comment speech bubble with the lines, when pressed unveils the comment text in a white rectangular box and black text, with the possibility of adding a new comment also. When chosen, the cursor blinks on the left side of the box and the options 'OK' and 'Cancel' appear underneath the box on the right side. When the 'Add Action plan' button is chosen at the level 3 part of the screen, the ideologies are pushed down by two new blank lines appearing (see Figure 45). Those two lines suggest the user to write on the top one the title for this action plan and the other one for the text accompanying it. The authorization to do such an addition is given by the user credentials, which in this case asks for administrator password at a pop up or to just to submit the action plan and letting the user know that is only submitted by a toast message ' Action plan submitted' . When the 'Continue' button is pressed, a pop up appears and asks the user how he/she would like to proceed by three options 'No Evaluation', 'Evaluation now' and 'Evaluate later'. Depending on the choice, the application navigates the user to the corresponding page, 'No Evaluation' and 'Evaluate Later' take the user to homepage, while 'Evaluate now' to the 'Evaluation Page'.

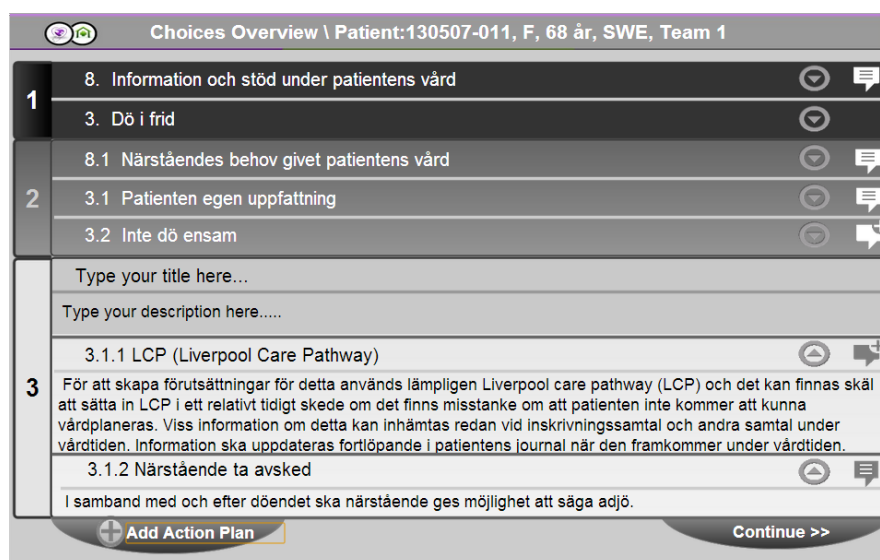


Figure 45: Choices Overview page after pressing 'Add level 3' button

## Evaluation Page

### Layout

The background is dark grey and on the top are the ideologies and their subsets chosen keeping the colors presented at the list at the main page and in one line with arrows showing the subject level (see Figure 46). Below there are two seeker bar buttons like the m-EMSS application. A third element exists under these buttons which includes a slider bar, having the question on top of it, numbers 0-5 equally spaced underneath and on its left and right, the text 'Not satisfied', 'Very Satisfied'. Underneath lies a data entry field and the text 'Write your text here' and the title 'General comment'. At the bottom of this screen, there is a tab bar with all the situations in tabs and the ones picked in the beginning are more apparent than the other ones by having the not picked faded away and the picked surrounded by a green line.

Utvärdering \ Patient: 130507-011, F, 68 år, SWE, Team 1

3) Dö i frid ➤ 3.1) Patientens uppfattning ➤ 3.1.1) LCP (Liverpool Care Pathway)

4) Anpassa efter patienten ➤ 4.1) Viktigt för patienten

1) Fick du hjälp av att följa ideologin? +

2) Förbättrades situationen? +

3) Hur nöjd är du med åtgärden?

Inte nöjd 0 1 2 3 4 5 Mycket nöjd

Allmän Kommentar:

Skriv text här...

Närstående Patient Vårdare Mål Livskvalitet Livs-förhållning Relation Integritet Autonomi Inställning Hindra Behov Rättvisa Doendet

Figure 46: Evaluation Page, the text is translated in the description above.

## Features

All the ideologies' titles are interactive and reveal the text describing them by expanding a grey box with text and the rest are pushed down. The seeker bars presented at the m-EMSs application have the same features applying at this application as well. Provided that either of the two first questions are answered negatively, a textbox appears with the text 'Why not?' accompanying it underneath the seeker bar (see Figure 47).

The rating bar has a radio button that can be moved by the finger and can be left at the 6 points (0-5), to show the rating. Below the bar there is a general comment for the case textbox, later appearing at the 'Past Cases'.

Utvärdering \ Patient: 130507-011, F, 68 år, SWE, Team 1

3) Dö i frid ➤ 3.1) Patientens uppfattning ➤ 3.1.1) LCP (Liverpool Care Pathway)

4) Anpassa efter patienten ➤ 4.1) Viktigt för patienten

1) Fick du hjälp av att följa ideologin? +

Varför inte?: Skriv text här...

2) Förbättrades situationen? +

3) Hur nöjd är du med åtgärden?

Inte nöjd 0 1 2 3 4 5 Mycket nöjd

Allmän Kommentar:

Skriv text här...

Närstående Patient Vårdare Mål Livskvalitet Livs-förhållning Relation Integritet Autonomi Inställning Hindra Behov Rättvisa Doendet

Figure 47: Evaluation Page with first question answered negatively

### 5.2.7.3 Secondary Pages

#### Patient Case

##### Layout

A box with 5 tabs on the top, 'Patient info', 'Situation', 'Overview', 'Choices Overview' and 'Evaluation' (see Figure 48) and the chosen tab is purple.

Figure 48: Patient Case page

##### Features

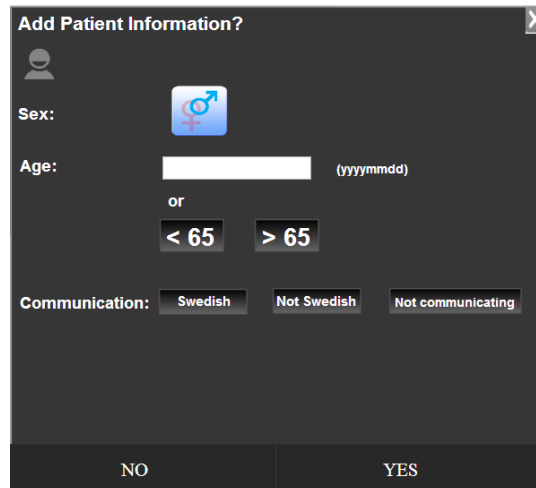
The main feature of this page is the fact that for each tab, the layout appearing is the same as the corresponding page but changes cannot be made, except adding comments (see Figure 49).

Figure 49: Patient's Case Page, 'Situation' tab selected



#### Add patient information

##### Layout

The title is on the top left corner 'Add Patient Information?' and underneath an icon depicting the person/patient (see Figure 50). Following there is a button for choosing the patient's gender, which is the same as the one at m-EMSS. The Age data entry field lies underneath. Lastly, choice in the form of 3 buttons is given with text 'Swedish', 'Not Swedish', 'Not Communicating'.



**Add Patient Information?**

Sex:  

Age:  (yyyymmdd)  
or

Communication:

Figure 50: Add patient information page

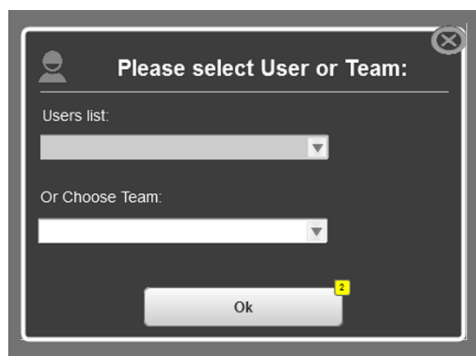
## Features

Provided that the case is being documented with the patient's information the data saved at this page are presented at the action bar as information of which patient they are working on.

### 5.2.7.4 Pop ups

#### Identification

This pop up asks for the user to identify himself/herself or his/her team, without asking for password (see Figure 51).



**Please select User or Team:**

Users list:

Or Choose Team:

Figure 51: Identification pop up

#### Reminder: Unfinished Cases

It appears when entering the application, before the main/first page and acts as a reminder to the user in order to finish-evaluate cases and being reminded and encouraged to continue with them, before creating a new one (see Figure 52). It looks a lot like the list of Past Cases, but some features are removed, on account of their redundancy. It is still a list of the cases, without being able to see the comments all at once or expand and retract.

**Reminder: Unfinished Cases!**

The table below shows the Unfinished Cases. Access the cases by clicking on one or through 'Past Cases', otherwise Ignore.

| Kod        | Situation   | Nivå 1                                  | Nivå 2   | Nivå 3                                   |
|------------|---|---|--|--|
| 130509-029 | S4: Mål<br>S5: Livskvalitet<br>S9: Autonomi<br>S14: Döendet | 3. Dö i frid<br>Anpassa efter patienten | 3.1 Patientens egen uppfattning<br>4.1 Viktigt för patienten | 3.1.1 LCP                                |
| 130508-101 | S5: Livskvalitet<br>S14: Döendet                            | 3. Dö i frid<br>Anpassa efter patienten | 3.2 Inte dö ensam<br>Viktigt för patienten                   | -  |
| 130511-035 | S3: Vårdare<br>Hindra<br>S11: S10: Behov                    | 10. Rättvis fördelning                  | -  | 10.0.1 Patientens behov inte efterfrågan |
| 130509-068 | S1: Närstående<br>Mål<br>Autonomi<br>S9: S4:                | 6. Patientens personliga sfär           | 6.2 Patienten godkänna informationsutlämning                 | 6.2.1 Ta reda på patientens syn          |
| 130509-068 |   | 5. Delaktighet                          | 5.3 Patientens eget ansvar                                   | 5.3.1 Stöd till ansvar                   |

Continue Past Cases >>

Figure 52: Reminder: Unfinished Cases secondary page

### Specify situation

It was suggested that the situation buttons sometimes are not enough for describing the situation and more specific choices should be given, provided that these situation buttons were chosen. The situation button 'Significant Others' was the only one explored and was described by a pop up which gives the choices of 'Relative', 'Spouse' and 'Siblings' (see Figure 53).

**Specify Relation**

Relatives ☒

Spouse ☐

Siblings ☐

Cancel Ignore Ok

Figure 53: Specify Relation pop up, 'Relatives' is chosen.

### Similar Cases

Provided that the user will choose the situation buttons to proceed with the choice of the action plan, after he/she hits the 'Continue' button, a pop up appears reminding the user that there have been a number of cases in the past that have had the same situation buttons chosen (see Figure 54). The pop up gives the user the opportunity of reviewing them by pushing a button for navigation to those past cases or continuing with the case.

**Similar Cases found!**

There have been 2 similar cases in the past.  
Would you like to see them?

Continue 1 Ok 2

Figure 54: Similar Cases pop up

### Comment situation

There are two circumstances that this pop up appears, after the 'Similar Cases' pop up or after having reviewed the similar cases and being navigated back to the main page (see Figure 55). It proposes the option of adding a comment complementing the situation being described by the chosen situation buttons.

The dialog box is titled "More on situation?". Below the title, it says "If the situation menu is not enough, please comment below:". There is a text input field labeled "Add comment...". Below that, it says "Change User or Team?". There are two dropdown menus: "Users list:" and "Teams list:", separated by the word "Or". At the bottom, there are two buttons: "Cancel" and "Ok".

Figure 55: Comment situation pop up

### Evaluation pop up

This pop up appears after choosing 'Continue' at the 'Overview of choices' page and asks the user how he/she would like to proceed by three options 'No Evaluation', 'Evaluation now' and 'Evaluate later' (see Figure 56). Depending on the choice, the application navigates the user to the corresponding page, 'No Evaluation' and 'Evaluate Later' take the user to homepage, while 'Evaluate now' to the 'Evaluation Page'.

The dialog box is titled "Hur vill du fortsätta?". It has three buttons: "Utvärdera Ej", "Utvärdera Senare", and "Utvärdera Nu >>".

Figure 56: Evaluation pop up. The Swedish text is translated at the description above

### Change user

The user or team being documented in the beginning can be changed through this pop up which appears if the person hits the icon with the person and key (see Figure 57). It offers the alternative of changing the user or switch to a team.

The dialog box is titled "Change user ?". It has two dropdown menus: "Users list:" and "Or Choose Team:". Below the dropdowns, there is an "Ok" button.

Figure 57: Change User or Team pop up

#### 5.2.7.5 Database structure

Below (in Figure 58) is a chart of the relations between the different tables in the e-THICs database structure. Since commenting capabilities were required in many different parts of the application, most of the tables in the database have a relation to the comment table either directly or indirectly. Another clarification on the schema that is worth mentioning, is the field 'Chosen' on the tables 'Links\_level\_1', 'Links\_level\_2' and 'Links\_level\_3', which characterizes the ideology or subset of it as 'chosen' by the user and not only filtered by the application (at the situation page). In that way, the user can comment on ideologies that are not chosen and even if they choose them the comment will follow the ideology to the 'Chosen Overview' page.

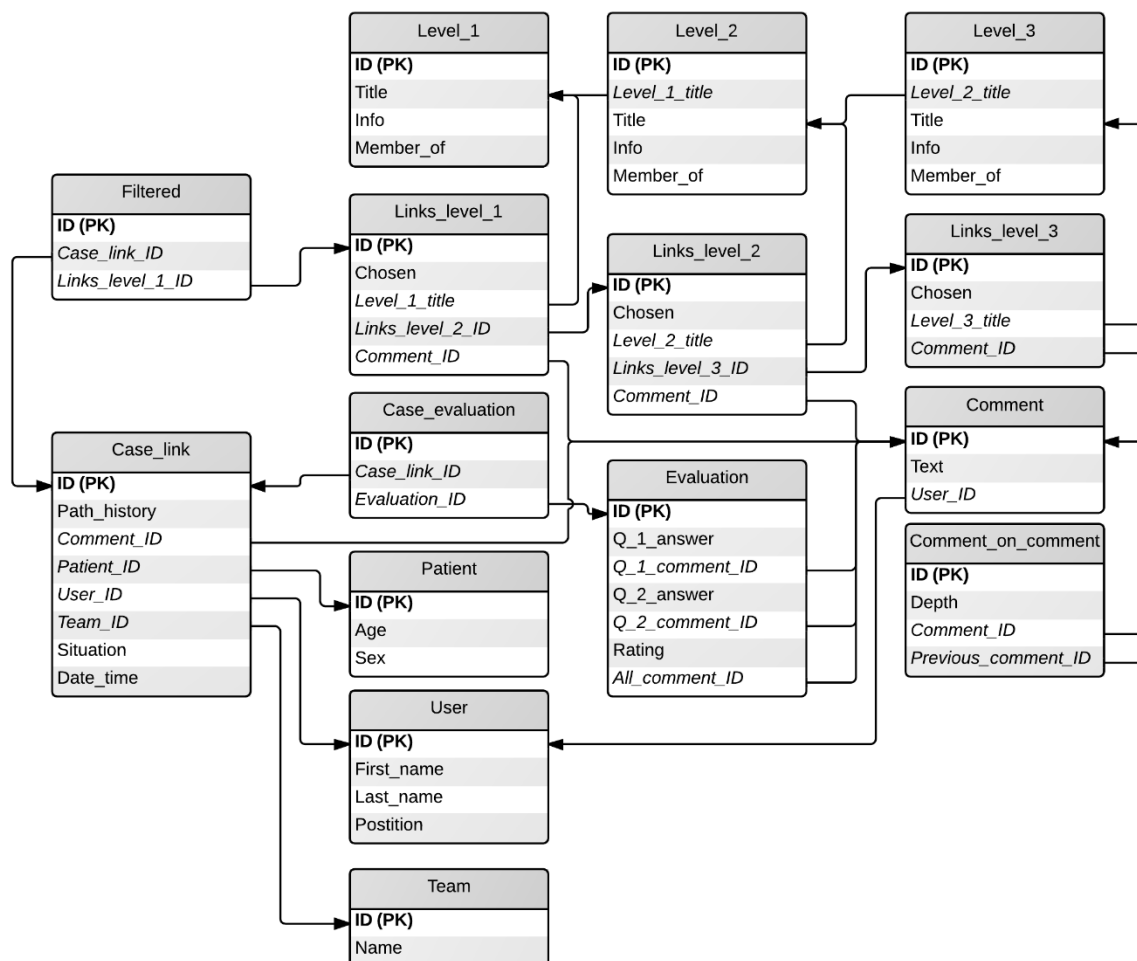


Figure 58: Database structure for e-THICs



### 5.2.8 Demonstrator-Resulted Application on Tablet - eTHICS

In the case of e-THICs application, Xamarin was used for implementation as well and resulted in an application which includes the basic structure of the prototype proposed previously. There were solutions used to recreate the proposed design that were again completely or partly created by the developers, like the two levels list and the divided screen functionality.

#### 5.2.8.1 Description of the application

The loading page of the actual application is shown in Figure 59 with the app's logo.

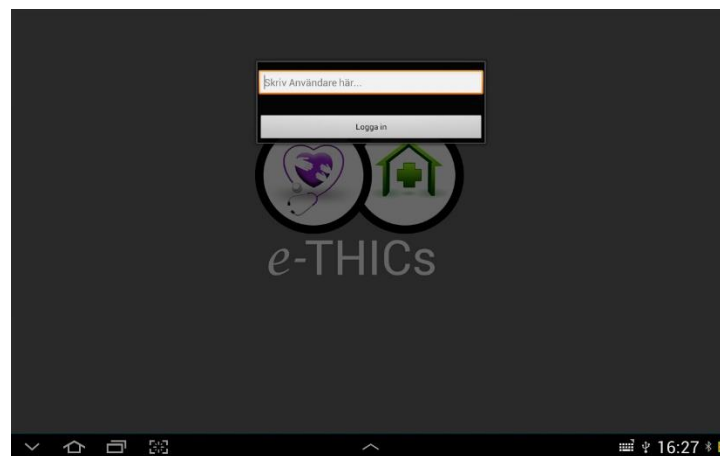


Figure 59: Loading page of e-THICs

The three tabs exist as in the prototype 'SITUATION', 'LIST', 'PAST CASES' and the situation buttons on the left side and the list of ideologies at the right side of the home screen (see Figure 60).

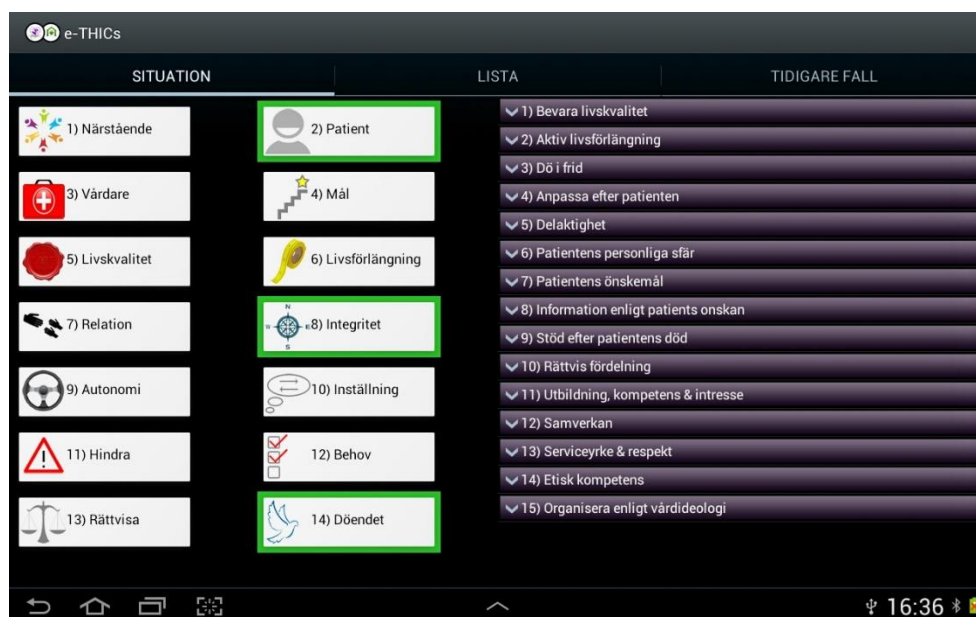


Figure 60: 'SITUATION' tab page

## Results

The 'LIST' tab depicted at Figure 61, shows the ideologies list and the second level of the 1<sup>st</sup> ideology is expanded. The third level is not included in the demonstrator.

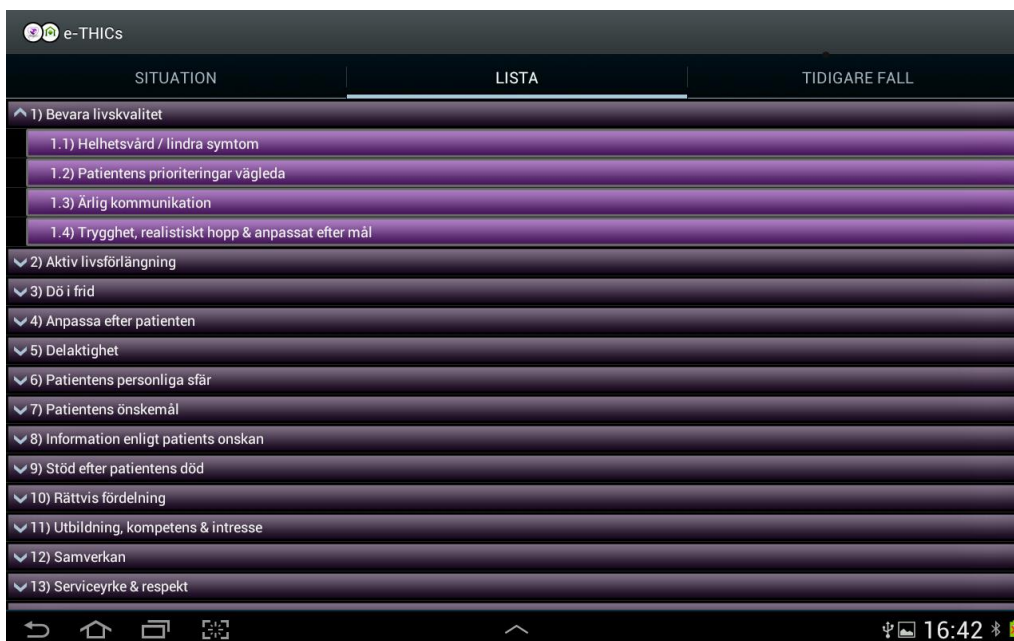


Figure 61: 'LIST' tab page

Lastly, the third tab as shown in Figure 62, illustrates the 'Past Cases' with three entries shown at this screenshot.

| e-THICs   |  |                      |  |   |  |
|-----------|--|----------------------|--|---|--|
| SITUATION |  | LISTA                |  | TIDIGARE FALL   |  |
| Kod       | Situation                                    | Utvärdering          | Nivå 1   | Nivå 2  | Nivå 3   |
| 20130204  | 2) Patient<br>10) Inställning<br>14) Döendet | 1) Y<br>2) Y<br>3) 5 | 3) Dö i frid<br>8) Information enligt patients önskan                            | 3.1) Patientens egen uppfattning<br>8.1) Närståendes behov givet patientens vård                      | 3.1.2) Närstående ta avsked<br>8.1.1) Avgränsande metod vid konflikt |
| 20130510  | 4) Mål<br>7) Relation<br>9) Autonomi         | 1) N<br>2) Y<br>3) 3 | 5) Delaktighet   | 5.1) Tydlig & ärlig information   | 5.1.1) Förstå alternativ   |
| 20130816  | 11) Hindra<br>12) Behov<br>13) Rättvisa      | 1) N<br>2) N<br>3) 2 | 1) Bevara livskvalitet<br>2) Aktiv livsförlängning<br>4) Anpassa efter patienten | 1.3) Ärlig kommunikation<br>2.1) Patienten delaktig i beslut<br>4.2) Acceptera patientens uppfattning |  |

Figure 62: 'PAST CASES' tab page

### 5.3 Real settings evaluation

The real settings evaluation was the last part of the spiral lifecycle model, regarding the method used. Moreover, the ambulance in particular is an environment that cannot easily be reproduced in a usability study and by testing the application in a real setting, the system's weaknesses and strengths would be amplified or revealed. Lastly, the prototyping software Axure had no ability of testing the prototype on a tablet device at that time.

In addition with the request for real setting evaluation, a project involving an 'Assessment Ambulance', an experienced nurse in EMS field (Christer Axelsson) that will be available in Gothenburg for ambulance calls that seem standard or non-urgent cases was initiated this summer through Västra Götalandsregionen in cooperation with University of Borås. A test of the resulted application on tablet was conducted with Christer Axelsson as the user for the trial in four situations (see Appendix#4). General comments were positive as far as the design is concerned, however it was observed that the user was confused about the +/- symbol that they meant positive/negative answer. Moreover, it was noticed that in all 4 trials the user used the avatar.

Unfortunately, for the e-THICS application that was not possible, as with the developed demonstrator, it was not possible to complete a patient's case. However, an evaluation session was conducted with the focus group on the demonstrator available and the comments were very positive.

## 6 Discussion

The aim of this thesis was to explore how the interactive interface of a tablet device could help facilitate the usage of DSS systems in healthcare by introducing two application demonstrators for two DSS projects. In the beginning of this project, it was thought that the two DSS systems will have similar structure and that the PCU was going to be more challenging regarding the database and flow design. The two applications proved to be very different regarding the flow and navigation, while on the other hand solutions or improvements for one application were used for the other one, when suitable.

E.g. the seeker bar changed several times until its final form based on both focus groups observations and remarks.

Following the same path, the database structure task encountered was approached as one database with additions or replacements of columns or tables.

### 6.1 Methodology reasoning

The book used in this project to follow directives on the HCI issues was chosen among others, as it is not only describing principles on 'Interaction Design' but shows the way they can be applied, providing a valid directive on how to proceed with the project.

As far as the focus group is concerned, the users were not invited as actively co-designers, but the level of involvement was in form of evaluation sessions. That decision was on account of the time limitations present at this project as well as the users' background needed would limit more the number of participants.

During the focus group sessions there were alternatives presented in form of scenario. It was decided not to be presented as an electronic picture, like the primary design in order to shorten the time of meeting them after the first data gathering meeting.

When it comes to the development method, comparing with other development methods, like the waterfall, the spiral model allows the existence of alternatives and in each step to make assessment of the issues or probable problems in each step (Preece, et al., 2011).

Regarding the database design, the relational database (RDBMS) was chosen upon others not only because of its dominance, but also mostly considering its flexibility, speed and compatibility.

Furthermore, the software development was selected to have properties such as flexibility on implementation -on account of the three operating systems on the market, android, iOS, Windows 8- and performance when running the apps. The solution chosen (after web research) offers the possibility of creating a core code that will fit all platforms whereas adapting the design to each platform with platform specific code. The other options were to write on native code for each platform (better performance) or write on HTML5 based environments which is cross-platform coding, although with lower performance.

On account of the time frame, development and design guidelines were considered only in the case of Android system (Android.com, u.d.). Developing for iOS required the cost to increase and Windows 8 is not widely accepted by the users yet.

Lastly, there were numerous hindrances for naturalistic observation, in order to follow the personnel at their working site, as there were patients involved and their consent was required at all times.

### 6.2 Focus group sessions

The importance of including the users to establish requirements and for data gathering was highlighted throughout all the report and it was the first consideration of the designers and developers. The challenge encountered with this consideration, was that sometimes the users did not have a clear vision or they thought that a feature was needed, though they needed something

else or not that feature at all. There were times when the designers had to read between the lines and think what the users meant and what their real request was.

E.g. In the case of the PCU application, the design of the overview page was described as 'We want to be able to read everything that was chosen at the situation page, with the text readable in one page and to choose from those the subsets of the ideologies that fit in our situation'. The designers were troubled as the tablet has a very confined screen space and the users are mostly middle aged and their eye capacity is reduced. At the next session, four solutions were presented to them on the white board, two of them were describing the notion of what the stakeholders thought they wanted and two solutions thinking in a completely different concept and the result was them requesting of a combination of the two latter solutions.

There were other incidents when the users insisted on some feature or navigation, though through discussion on some designing rules that needed to be followed (consistency, android UI) the designers achieved to find common ground with them.

In the case of the PCU application, the list tab was proposed by the designers for the users that would not like to use the situation tab to find out about the action plan and wished to navigate through the list of ideologies. On the other hand the stakeholders proposed that the list should appear when they have chosen to browse through the ideologies and not add any patient. The designers explained to the focus group that, in that way the freedom is taken away from the user and it is not intuitive to reveal the list only after certain steps that make sense only to the ones that know the application and the ideology DSS very well.

A phenomenon was observed among users that dominant characters or participants that believe they are more familiar with software to influence the decisions taken and overshadow less bold participants.

Another issue considered troublesome was the variance of focus group participants' number, which resulted in non-consistent gathering of quantitative data. That was noticed mostly at the Palliative Care sessions, as there were many participants and the meetings could not always fit their schedule.

## 6.3 Suggested Workflow

Possible influence in the workflow for each unit, ambulance or PCU was accomplished through the constant communication with the stakeholders and resulted in two applications demonstrators that can change their work routine:

### 6.3.1 m-EMSS

This DSS comes as an extension of the triage system, which means that this demonstrator could be included in a triage system as the final decision part accompanying the color given on account of the Triage. There have been suggestions of including the driver at the task of the DSS, as it is advised to use the system on the same time as the intuitive routine of questions and decision, so as to get the support at the right time, not after the patient is already driven somewhere as a confirmation of the right decision. This can change the routine of the driver whose participation is limited and in general include a computerized system in their paramedic routine while examining the patient.

### 6.3.2 e-THICs

In the case of the PCU application, the workflow could be altered and new stages could be introduced to their routine according to the demonstrator designed.

- The situation categories, which automatically filter the strategies already available on a list, instead of doing it intuitively
- The chance of similar cases retrieved automatically through the database when choosing the same situation buttons, hence introducing the evidence-based strategy by reminding the user the existence of past similar cases.
- The process of evaluation for each case and the chance to work on it again until the evaluation is positive.

- The evaluation generated the reminder for 'unevaluated cases'.  
The features mentioned above are being developed for a tablet device.

## 6.4 Similarities and Differences between the two applications

### 6.4.1 Similarities

Both of the applications were designed to be Decision Support Systems (DSS), were based on a paper based algorithm and there was no clinical evaluation conducted to examine them. In both cases, the personnel's workflow could be altered and new ways of working were introduced.

When it comes to the applications, both had a three tab initial menu and the first tab was chosen to be the default one. Moreover, they both had a list menu at their tabs which existed for the users that did not care for the avatar or situation facilitators. They both used the seeker bar that moves towards a negative or a positive answer. Pop ups were used to remind or to specify information, e.g. the specify relation pop up was based on the specify symptom pop up.

The language used was throughout both applications simple, short and suitable for the healthcare personnel. Past cases information in table format is present for both applications and the columns positioning were influencing each other during the designing process. The action bar was used in both applications for adding patients, more options, add doctor, search and showing the path and location at the application. Regarding their names, the 's' at the end means 'system' for both cases. Both application icons were based on the same concept of two circles combined and in general numerous button-icons were used at both applications.

The user-centered approach and spiral lifecycle model was used for both of them, as well as the focus groups and as evaluation paradigm the 'quick and dirty' for the low fidelity prototypes.

### 6.4.2 Differences

These two applications had many differences, maybe more than similarities. Despite the fact that both of them were DSSs, the ambulance app included a straight forward problem and the decision was either 'to PC' or 'to ED', while the PCU one proved to be very complicated regarding the final decision-action plan and has no distinct final decision, just suggestions in form of a combination of strategies.

Moreover, due to the nature of the applications -one more direct regarding requirements (Ambulance DSS), while the other one's requirements were quite vague and indecisive regarding the work-flow (PCU DSS) - to proceed with two different kinds of prototypes. The low-fidelity prototype was chosen for the PCU DSS and the high-fidelity one for the ambulance DSS.

The choice of symptom for the ambulance app was confined to two pages maximum, while in the PCU app the choice had to go through two stages and being overviewed two times before following the action plans suggested.

The PCU app included far more pop ups, reminders or options for adding information than the ambulance one, which resulted from their workflow which is not instant and by the patient, but in mirroring sessions and the evaluation might take a lot of time to be documented.

In the case of the PCU application comments needed to be present everywhere, while in the ambulance one only under certain circumstances and in form of pop up a comment would be documented.

The ambulance app was designed to be very quick and interactive, facilitating even novice users of the system or tablet, to use a DSS during work routine. Whereas, the PCU one was designed to give the opportunity of reviewing different strategies at all times, intuitive as much as possible and act as a reminder for many cases.

Another difference spotted, is that the PCU application used the past cases to remind the user of similar cases in the past, while at the ambulance one, this was not an issue as the evidence-based strategy is not so important, as the algorithm is straight forward.

The patient's data gathered were surprisingly quite different, since the PCU personnel is very discreet and needs only certain variables to help them with the case, not for identification and for statistical reasons.

The mere existence of an evaluation page, to reflect on the action plan suggested from the DSS, at the PCU application is another difference between them. Likewise, the existence of the overview page, the overview of choices and the case record in form of tabs at the PCU application are differences.

The symptoms were described by icons and a small description underneath or next to them, while the situation buttons were a mix of icons and description next to them incorporated in the button, as they were very difficult to be represented by a picture and the text was considered essential. The symptoms and the ideologies were presented as a list, though in the case of the PCU app, the ideologies were described by a text and each ideology had levels to accompany it, which made the list very different.

## 6.5 Security and connections with other systems

The technological advancement was thought to be inferior to the present situation, regarding tablets in healthcare, when started. Regionally and nationally tablets are not widely accepted in the healthcare sector, on account of security issues and it will take time to incorporate them into the national legislations (VITALIS, 2013). Research revealed that the e-health companies are striving to introduce the tablet to the healthcare environment and are all trying to have a tablet version of their software along with a solution for the SITHS cards. The manufacturers have just come up with solutions, which include either a case with the card slot at the back part of the tablet or by using the NFC reader incorporated on most of the tablet devices (VITALIS, 2013).

Another option for overcoming the security issue during this project was explored; the fingerprint authentication, since the tablet devices are made of touch screens. Web research revealed that without some kind of fingerprint reader as an external hardware, it is not yet possible for the tablet to repeatedly read a fingerprint correctly, as the resolution of their screen is still relatively low for this kind of demand. (Mobile Security London, 2013) (Carlström, 2012) (VITALIS, 2013) (King, 2013) (SIC Biometrics, u.d.) (Milian, 2013)

This project explored the technological possibilities for the identification on tablets (SITHS cards, fingerprints), without implementing any complex identification protocol, other than a username and a password, on account of time limitations and there was no intention of storing or accessing real patients' data.

Moreover, the connection with other systems and databases was also explored, mostly for the NPÖ and the hospital's database. Through research, it was acknowledged that any software developer can create a connection with the database just by following the guidance available on Intersystems S.A. company website, responsible for the NPÖ system. However, it was revealed that in spite the fact that NPÖ was considered one of the major concerns, the regional database" was more important and far more used in real life than NPÖ. Synchronizing with the hospital's database in order to transfer the data and path to the final decision remained an idea, since authorization was never given and the regional database included the hospital's database, the implementation was not explored.

## 6.6 Recommendations to other researchers

There were many variables that if they would have been handled differently, could enhance the project and the final products. Increasing the focus group's number of participants, may have yielded more fruitful and differential discussions and more input on the design choices made. These participants would also not have any knowledge of the paper-based format, which would give more feedback on the navigation through the application. That angle was attempted to be explored by the trial on the actual ambulance and a paramedic person not familiar to the project.



The usability study of the ambulance Axure prototype would preferably have more participants than three, in order to have more feedback and input on the final prototype. Increasing the number of participants in the ambulance trial would have been very useful on the evaluation process of the application.

The time frame was at all times an issue during this project, as there were numerous aims and goals to be fulfilled and most of them referred to both of the demonstrators. The fact that the PCU application remained at the paper prototype stage, was on account of the time limit issue. Moreover, the lack of completeness regarding the ambulance app on the tablet was also due to lack of time, as the designing part took a lot more time than expected. The designing process especially in the case of the PCU application was more time consuming than expected, as a result of this application being more challenging, and mainly regarding the navigation and workflow.

The base material used to create the ambulance application, when tested under real circumstances and physical representation seemed to be clinically limited, since it covers patients who are older than 18 years of age and a limited number of symptoms according to the users. On the other hand, the CRC study was created only in order to assess the impact of driving patients to the PC/ED.

## 6.7 Future work

Following this thesis project, the proposed DSS demonstrators for the ambulance and PCU can be envisioned. In order to reach the "Google Play" store and become available applications to the public, many tasks remain to be fulfilled.

General tasks:

1. Stronger identification of the user, primary the protocol for the SITHS cards, since the project is aiming primary for the Swedish market.
2. Registration of the application names, m-EMSS and e-THICs.
3. Make it available for all platforms, as far as design is concerned.
4. Translate in English the parts (text appearing at the application) that are in Swedish and vice versa.
5. Icons reformed to be available for all tablet sizes.
6. Create a touch-phone version of the two applications.
7. Create queries in the database for the search functions at the columns of the Past Cases.

Ambulance application future tasks:

1. Reforming all the questions to be simple, direct and short, in order to be readable at the scale of the seeker bar, especially on the run.
2. Finalize the programming to meet the prototype's suggestions.
3. Test the final product in a larger scale usability study on the field.
4. Connection with the regional database and synchronization with it via 3G network.
5. Automatically obtain the vital parameters from the medical devices and incorporate them into the DSS algorithm.

PCU application future tasks:

1. Write the code for the application, in order to match the prototype and the navigation description.
2. Create the complete schema database.
3. Conduct a focus group session and then a usability study, when the application will be ready.



The DSS structure introduced in this thesis has the potential of being used with some small modifications to other CDSSs, not only with the design choices but with the database structure as well.

### 6.8 Final Remarks

This thesis has demonstrated that by using Human-computer Interaction principles and technological knowledge, e-health can be of great assistance to healthcare personnel and overcome the hassle of only keeping patients' journals and coming to their aid when decisions can be supported by an algorithm and not just intuition. The need for such systems has arisen lately, on account of the maturity of the journal systems and people asking more from the e-health sector than just documenting and finding information. By making the DSS systems very intuitive, inviting and easily accessible to the user, the stakeholders will realize the existence of a 'right hand' which they did not know they could count on for advice. Despite the fact that laws are relatively slow compared to the technology rush, this thesis showed that there can be common ground for introducing the tablet to the healthcare system, making available and easy to access technology for the healthcare personnel.

### 6.9 Conclusion

This concept study has demonstrated the possibilities of a tablet based decision support system for the ambulance and the Palliative Care Unit. This includes three main aspects of a DSS, i.e. organize and access relevant information, provide the model or algorithms/criteria used to analyse the information, as well as the user interface for interaction and presentation of the options or decisions.

Through qualitative evaluation of the two demonstrators, it was indicated that they meet the HCI principles, such as being effective, efficient, attractive and easy to use in the healthcare setting.

Moreover, findings suggested that there is common ground between current technology and legislations (especially about security), in order to use tablets. Interaction with other systems within healthcare is possible, taking into account the specifications for each system.

Apart from the usability qualities, the demonstrators could support the existing workflow of those two healthcare areas and it may even be influenced by the DSS apps.

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## Appendices

### Appendix#1: Categories-areas of avatar

The avatar was divided into several different category areas depending on location on the body. A set of symptoms from the RETTS-list related to each area was decided on. Those category areas and the RETTS-list numbers for the symptoms in their respective sets are listed below.

#### *Avatar Front side*

##### A - Head/Shared

2a,2b,3a,3b,4a,6b,9,10,11,19,20,30,41,43,44,45,47,52,53

##### B - Neck/Shared

2a,2b,3a,4a,4b,6b,10,30,41,43,44,47,53

##### C - Shoulders/Arms/Shared

9,10,13,15,33,41,43,47,53

##### D - Chest/Heart/BP/Shared

1a,1b,2a,2b,5,4a,4b,9,10,20,31,41,43,47,49,50,53

##### E - Abdomen/Shared

6a,6b,9,10,14,31,41,43,47,49,50,53

##### F - Pelvis/Shared

6a,10,13,34,41,43,53

##### G - Legs/Shared

10,13,15,20,34,41,43,53

#### *Avatar Back side*

##### H - Head/Shared

6b,9,10,11,19,20,30,41,43,47,52,53

##### I - Neck/Shared

4a,4b,6b,10,30,41,43,44,47,53

##### J - Shoulders/Arms/Shared

9,10,13,15,33,41,43,47,53

##### K - Back/Shared

4a,4b,9,10,14,20, 31, 41,43,49,50,53

##### L - Pelvis/Shared

6a,10,13,34,41,43,53

##### M - Legs/Shared

10,13,15,20,34,41,43,53

##### N - General

2a,2b,6b,9,10,13,20,43,47,49,50,52,53

## Appendix#2: Risk analysis

The AHRA (All Hazards Risk Assessment) process is a risk assessment method by Public Safety Canada (Public Safety Canada, 2013) (see Figure 7), containing five steps which can be used in a development process:

- 'Setting the Context',
- 'Risk Identification'
- 'Risk Analysis'
- 'Risk Evaluation'
- 'Risk Treatment'

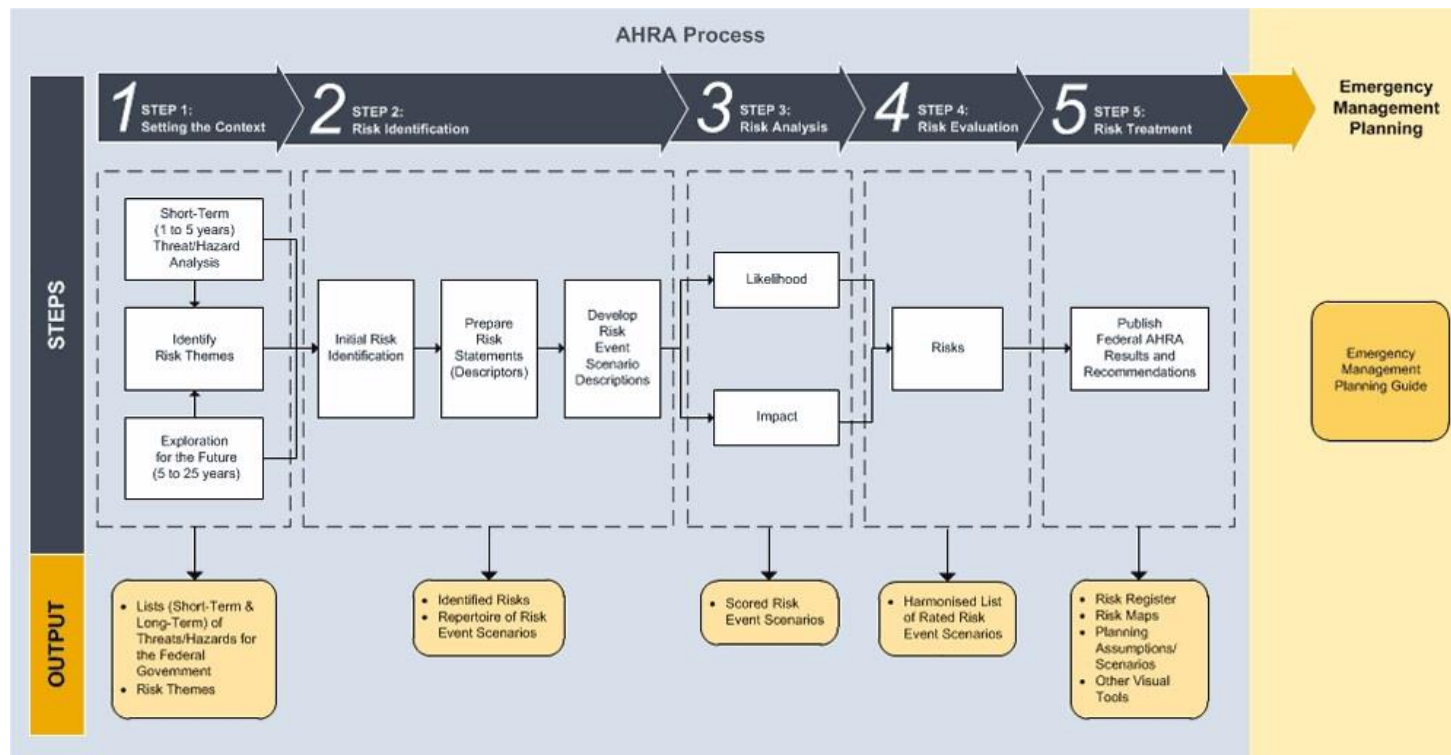


Figure 63: AHRA Process and Linkage to EM Planning (Public Safety Canada, 2013)

A risk matrix is a tool used during risk analysis to define the risks involved. The matrix consists of two axis, namely the likelihood of an event occurring and the severity of the consequences if it occurs. Each axis is divided into a number or levels (usually around 5) and the value of each element in the matrix is the result of a multiplication of its two levels. This value then represents total risk of the event, a higher number means a higher risk. Color coding with colors ranging from green to red are usually used to group the risks with regards to their levels to make the risks clearly visible, where red is high risk and green is low risk.

|            |                                       | Consequence  |               |                 |                 |                 |
|------------|---------------------------------------|--|---------------|-----------------|-----------------|-----------------|
|            |                                       | How severe could the outcomes be if the risk event occurred? |               |                 |                 |                 |
|            |                                       | 1  | 2             | 3               | 4               | 5               |
| Likelihood | What's the chance the risk occurring? | Insignificant  | Minor         | Significant     | Major           | Severe          |
|            | 5<br>Almost Certain                   | 5<br>Medium  | 10<br>High    | 15<br>Very high | 20<br>Extreme   | 25<br>Extreme   |
|            | 4<br>Likely                           | 4<br>Medium  | 8<br>Medium   | 12<br>High      | 16<br>Very high | 20<br>Extreme   |
|            | 3<br>Moderate                         | 3<br>Low   | 6<br>Medium   | 9<br>Medium     | 12<br>High      | 15<br>Very high |
|            | 2<br>Unlikely                         | 2<br>Very low  | 4<br>Low      | 6<br>Medium     | 8<br>Medium     | 10<br>High      |
|            | 1<br>Rare                             | 1<br>Very low  | 2<br>Very low | 3<br>Low        | 4<br>Medium     | 5<br>Medium     |

Figure 64: Risk analysis (National Museum Australia, 2012)



## Appendices

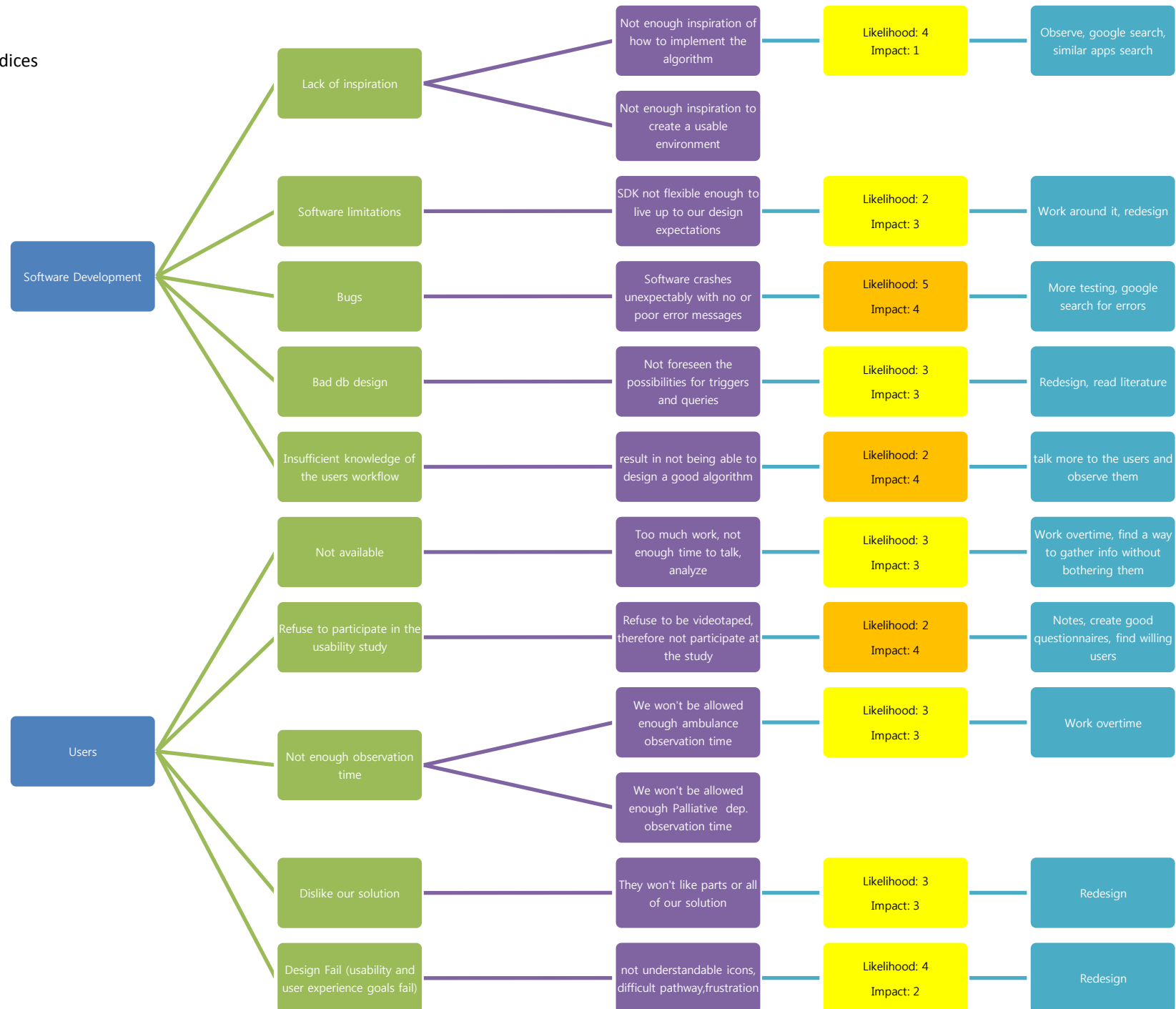


Figure 65: Project risk analysis part 1

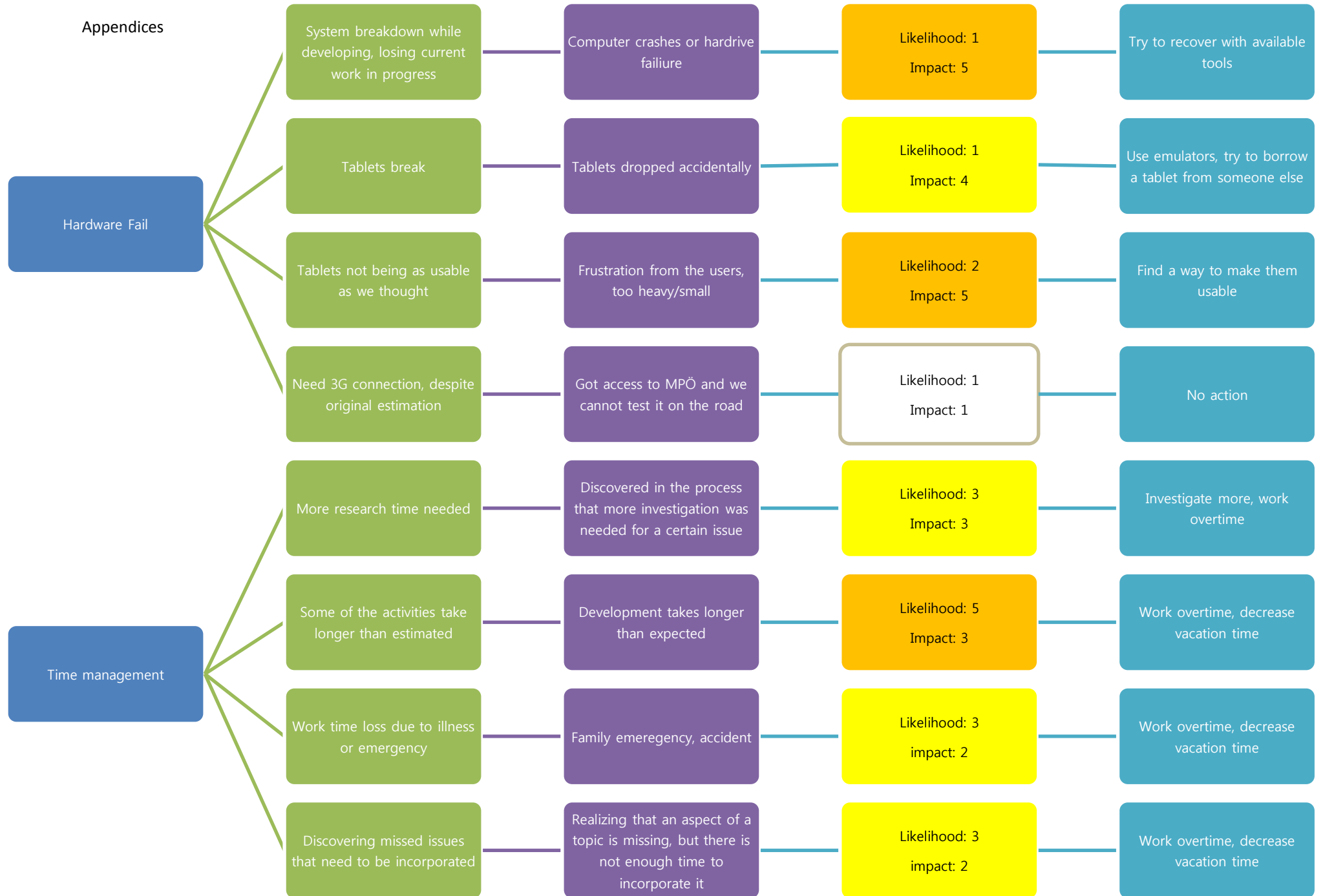
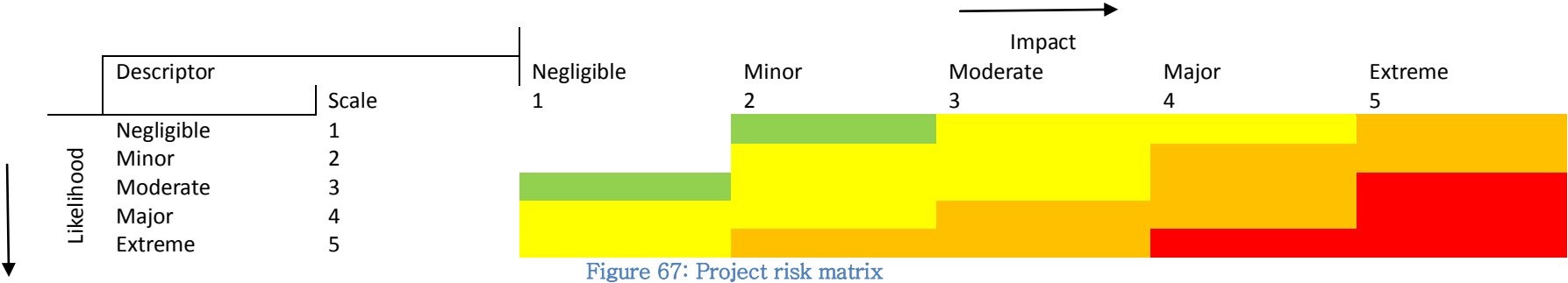






Figure 66: Project risk analysis part 2





### Appendix#3: Market search

Applications that had a price tag were decided not to be downloaded, although they looked good on preview

Table 2: Market search result table

| App                              | Motive for downloading   | Good features  | Bad features  | Inspirational | Evaluation   | Resulted Feature   |
|----------------------------------|--|--|---|---------------|--|--|
| <b>AHRQ ePSS</b>                 | It is a DSS for Preventive Services Selector                       | 1. Nice filter search at loading page  | 1. Long & difficult name                                    | No            | Good for its purpose (ePSS)  | -  |
| <b>AHS EMS Medical Protocols</b> | It is related to EMS   | 1. List by Alphabetical order, the way distinguished the different Letters.  | 1. Many info on one page.                                   | Yes           | Quite good for its purpose, with some refining it could be good  |  <ol style="list-style-type: none"> <li>At the tab 'RETTS LIST', we included a similar list sorted alphabetically, chosen from the more android button.</li> </ol>  |
| <b>Calculate by QXMD</b>         | It is a CDSS and a calculator of physical parameters               | <ol style="list-style-type: none"> <li>Language (simple, straight forward), small texts, little but necessary info</li> <li>Path always shown on action bar</li> <li>After answering the question given, automatically changes to the next one</li> <li>Summary of answers</li> <li>Clear indication of calculators' levels (grayscale) at start page</li> </ol> | 1. Needs verification of your specialty in order to use it. | Yes           | Very good for CDSS, written by professionals, it is obvious by the language used. Focused on its target group. |  <ol style="list-style-type: none"> <li>Tried to use the same kind of language.</li> <li>The Path is always shown on the action bar.</li> <li>Past cases, shows a summary of answers</li> </ol>  <ol style="list-style-type: none"> <li>The levels were indicated by scale of colors.</li> </ol> |
| <b>i-Triage</b>                  | It is a CDSS and it covers all Triage classification & information | <ol style="list-style-type: none"> <li>Loading page (only app icon and name, transparent for the rest of the screen)</li> <li>Use of an Avatar. The way presented (with open arms,</li> </ol>  | 1. The placement of the list with the symptoms,             | Yes           | Very good for CDSS, reviewed by Harvard University. Can  |  <ol style="list-style-type: none"> <li>The second Avatar available is simpler and gender change and rotation buttons were used.</li> <li>Mostly the same body sections were</li> </ol>   |

|                            |  |   |  |     |   |  |
|----------------------------|--|---|--|-----|---|--|
|                            | for EMS personnel.   | <p>simple, both genders and rotate function)</p> <ol style="list-style-type: none"> <li>3. The way the Avatar changed color and the body sections when interacting with it.</li> <li>4. The button placements and icons for gender change and rotation.</li> <li>5. List sorting with 'Common/Uncommon' symptoms.</li> <li>6. Search by voice recognition.</li> <li>7. The way the buttons reveal the detailed text. e.g. Symptoms</li> <li>8. Search, always available.</li> <li>9. Age interval with slider bar.</li> <li>10. Proposed accompanied symptoms (max 3) with the primary symptom chosen.</li> <li>11. How the list changes or shrinks when choosing more details for the patient, like age, sex and proposed symptoms.</li> </ol> | icon.  |     | <p>be used by professionals for color coding with Triage, but also by the everyday user to get a preliminary diagnosis of his/her symptoms.</p> | <p>used. Tried to mimic the interaction with the Avatar.</p> <ol style="list-style-type: none"> <li>4. Inspired by the placement, created something similar.</li> <li>5. List sorting change on Category/Carousel page from #RETTS to common/Uncommon.</li> <li>6. Implemented everywhere with search option.</li> <li>8. Search everywhere available.</li> <li>9. Age interval with slider bar.</li> <li>10. After the decision taken, when adding the secondary symptoms, a list with proposed ones appears.</li> </ol>  <ol style="list-style-type: none"> <li>7. The level buttons are revealing their details the same way.</li> <li>11. The list is filtered by the situation buttons chosen and it moves in a similar way as the iTriage app.</li> </ol> |
| <b>Maine EMS Protocols</b> | It is related to EMS   | <ol style="list-style-type: none"> <li>1. Color coding in all pages, which gives instant feedback on the page working on.</li> </ol>  | <ol style="list-style-type: none"> <li>1. At every category the symptoms have no distinct sorting</li> </ol> | Yes | Good for its purpose, with some refining it could be really good  |  <ol style="list-style-type: none"> <li>1. At every category or symptom chosen, there is a blurred background image indicating the page they are working on.</li> </ol>  |
| <b>Mini Nurse Lite</b>     | Medical application an informative db (drugs, lab values, medical terms) | <ol style="list-style-type: none"> <li>1. The calculator menu was interesting.</li> </ol>   | <ol style="list-style-type: none"> <li>2. Some of the icons.</li> </ol>                                      | No  | Good app for its purpose.   | -  |

## Appendix#4: Ambulance trial

Four trials with ambulance personnel were conducted for the m-EMSs application. Description and results from those trials are shown below. The prepared case description is shown in Appendix #5.

### *Trial 1*

Using the prepared case description

The trial was video recorded and thus no notes were taken.

### *Trial 2*

Using case 1 of the real cases as example

Done almost immediately after trial 1. Because of time related issues no detailed notes were taken, but the usage of the system (this time also utilising parts A and B) went smoother than the first trial and the resulting suggested decision matched the decision made in the real case.

### *Trial 3*

Using the prepared case description

The trial was conducted with a medical co-worker to the original test subject.

#### **Time taken**

Login: 17sec

Choosing symptom: 13 sec

Jumping to C: 21 sec

Answering C + checking ES: 1 min 55 sec

Did not use avatar, went straight for general symptoms.

Some confusion about Y/N and +/-.

“Hard” to find what she wanted in the Retts-list, sorting by name asked for.

Suggested having some predefined answer trees for “comment” questions.

### *Trial 4*

Using case 2 of the real cases as example

This time the Retts-list was used to find the symptom

#### **Time taken**

Login: 21 sec

Choosing symptom: 42 sec

Finish part A: 35 sec

Finish part B: 29 sec

Finish part C: 30 sec

Some confusion about Y/N on “comment”-questions.

“Hard” to find what she wanted in the Retts-list, sorting by name asked for.

## Appendix#5: Evaluation Tasks

During the evaluations of the software and prototypes a description of the task they were supposed to perform were given to the testers. Those tasks are shown below.

### Prototype Evaluation

#### Task description:

In front of you you have a prototype for a Decision Support for EMS. You are already logged in. Please fulfill the following tasks. You can skip to the next task if we say so.

Case: Patient, Male, 80 with signs of hypertension (High Blood Pressure) has called you for help. Your goal is to find out if you should take the patient to ED or to PC.

Find your way to the Decision by finding the patients symptom in any of the 3 tabs.

THINK ALOUD PLEASE!

Thank you for our cooperation

### Ambulance trial

#### Task description:

In front of you, there is a tablet version prototype for a Decision Support system for EMS in Swedish, based on the RETTS system and its list of symptoms. The decision taken by this system is whether the patient should be transferred to Vårdcentral/Jourcentral or Akutmotagning.

The decision support is consisted of three Parts A, B and C, which include questions on the patient's condition regarding his primary symptom, mostly answered by a simple YES or NO. The parts A and B are the standard questions asked by paramedics for each of the primary symptoms, while part C includes the decision part.

Choose the icon on the desktop with the name m-EMSS and once you enter the application, consider the following as username and password:

Username: Christer

Password: axch

Please fulfill the following tasks.

Case: Patient, Male, 80 with signs of hypertension (High Blood Pressure) has called you for help. Your goal is to find out whether you should take the patient to VC/JC or to AKM.

Find your way to the Decision by finding the patients symptom in any of the 3 tabs. You are welcome and advised to skip Parts A and B if you are an experienced paramedic.

THINK ALOUD PLEASE!

Thank you for our cooperation

## Appendix#6: Palliative Care Semi structured Interviews-Focus Group

Most interviews conducted during the project followed a semi structured method, which includes preparing a set of questions each time. Those sets for the meetings with the Palliative Care Focus group are shown below.

### 1st meeting with Lars Sandman

Palliative care:

- provides relief from pain, shortness of breath, nausea, and other distressing symptoms;
- affirms life and regards dying as a normal process;
- intends neither to hasten nor to postpone death;
- integrates the psychological and spiritual aspects of patient care;
- offers a support system to help patients live as actively as possible;
- offers a support system to help the family cope;
- uses a team approach to address the needs of patients and their families;
- will enhance quality of life;
- Applicable early in the course of illness, in conjunction with other therapies that are intended to prolong life, such as chemotherapy or radiation therapy.

There are five principal methods for addressing patient anxiety in palliative care settings. They are counseling, visualization, cognitive methods, drug therapy and relaxation therapy.

1. Why does he want the application?
2. What results does he expect?
3. In what way will it help the department?
4. Menu structure, are they Y/N, Question edit, mc?
5. Is the DSS referring only to the terminal patients?
6. Is there anything on paper? DSSs
7. Any history with DSSs?
8. Are there any known CCDSSs concerning palliative care at any other hospital?
9. Are there any laws and legislation or are they driven to their actions by guidelines? Is history with same kind of patient affect the decisions taken (evidence-based)?
10. Are the relatives included at some point of the decision? Which cases?
11. QALY or QALE? Are both used?
12. Is QALE used often? Will it be included in the DSS?
13. Is the personnel on the run?
14. Will they want it to be incorporated with the patient's file?
15. We guess ESAS will be used in our DSS?
16. Will the DSS support choice of drugs and dose?
17. Which part of the staff is going to use the DSS?
18. Any suggested literature in mind?



## Palliative care questions vol.2

1. General perspective, would he like to introduce the evidence based strategy? Or these are just guidelines? Or by evidence he just means new cases that they are going to document in addition to the existing ones?
2. Documentation, our idea so far. What is the first impression?
3. The layout of the structure with the list and details list, what does he think?
4. What will the patient will be able to see and how? since it is not on the NPÖ
5. Are we going to be able to observe patients or it is too complicated? Because we wanted to conduct a field study, otherwise we need to change our method to interviews and questionnaires
6. Are we going to use the 4rth level?
7. Input on the block diagram.

## Meeting at Sahlgrenska PCU Questions

1. How does the round visit work? Would they imagine the system being used there?
2. How does the mirroring session work? How could the system work there?
3. What do they mean by having a db of terms and concepts from the Ministry of health? We visited the site with no success in finding this db. Anyhow, do they want it showed all the time or is it ok if it is in the 'more' menu?
4. Propose what we have thought so far, with the situation buttons and the list underneath, list and past cases, their opinion.  
Thoughts: Collection of examples. Questions instead of categories, or maybe in addition to them at a lower level. Is the question about...? Suggestion based on time? Who's making the decisions? Icons as answer choices? Predefined alternatives when making new decisions maybe, to make it more structured? Saving the date for the decision is important, make it searchable.  
Design thoughts: Easy-to-use, Intuitive, Easy to undo and back up. Large undo and redo buttons. No rolling bars, stable interface (Like action bar) for important buttons. Always show where in software you are.
5. Ask them about the size of the tablet, are they satisfied with the 10.1 inch?

## Appendix#7 Ambulance questions on prototype sessions

Most interviews conducted during the project followed a semi structured method, which includes preparing a set of questions each time. Those sets for the meetings with the Ambulance Focus group are shown below.

### Questions vol.1

1. At the C questions are we supposed to document only the YES answers or we should document both YES and NO. Would they like the swipe and the pop up button or only one of them?

Answer: Swipe for Y/N but have some help text to indicate how to use it

2. Would they need to add symptom and from many symptoms to have a decision or they are covered by the already structured questions?

Answer: YES. All answers are PV-> final answer PV . If one is ER-> final answer ER. In order to continue adding symptoms or finish with the case, when clicking one of the PV or ER, pop up message to continue to add symptoms or finish with the case.

3. A and B part should it always be shown and documented or have the ability to go to C directly?

Answer: A and B should be there but have the option to skip and go to C.

4. Would the answers from the A and B parts need to be put in and saved or are they just there as a reference?

Answer: Should be stored.

5. Documentation: A button at the start pages for entering info, age or personnummer. If only age, it will have two options, one for number and one for interval. What do they think?

Answer: Yes and should have the option of the date of birth also. Two entry fields for the age interval.

6. We thought of having a list that shows the cases in some time interval or number of cases (date and time last 24h, last 8h, last 10 cases) search by PN,Name,User

| Date&time  | Age | Pn | A   | B   | C   | CHOICE<br>40%PV 60% ER |
|------------|-----|----|-----|-----|-----|------------------------|
| 2013-04-01 | 25  |    | YES | YES | YES | TO ER                  |
|            |     |    |     |     |     |                        |

Answer: Nice idea, one more column with USER. Show it at the more options menu. Not sure what to do with the search options. We proposed to have every column as a search field and agreed on that.

7. There are some options that have more than one locations of pain. Should they specify which one and document it? Later on, to be shown at the list?

Answer: They should be specified and shown later at the list.

### Comments on the screenshots and notes from the meeting:

BODY PARTS: Login option, mandatory though. The male, female icon, change color of the male icon. Extra button for documentation with some kind of list icon. PN, Namn/efternamn, Age 2 options

ELSE: numbers on the icons. Login and documentation button

RETTS list: Bigger Font. Decrease search button and put documentation and login

Carousel: The number to the right up place and write it also at the description.

C Decision: Document the 2nd user and change the 'all must be met' indication to lighter green

Add symptom button

ER->ED, PV-> PC

## Questions vol.2

1. What was easy and what was difficult to do?
2. What was easy and what was difficult to find?
3. Which are the parts that need different representation in your opinion?
4. Were there any steps you did not realize what to do next?
5. Were there times you did not get enough feedback when fulfilling a task?

### *Evaluation from users:*

#### User1:

General comments: Satisfied with the result. He said we wanted to wonder around the application before starting the actual task (he did not have much knowledge on the CRC project). Likes the swipe function for answering the questions.

1. It was difficult to see the icons on the 'ELSE' tab, found the avatar function very easy.
2. Regarding the button 'change gender', he suggested to have some indication, like fade away the one symbol and make more visible the gender the user is looking at. Moreover, the 'Select All' icon, was too discreet. It was easy to realize the suggested answer.
3. He would like to have carousel at the 'ELSE' tab also and as far as the existing carousel, to have a representation for the 'landscape' mode. We suggested the 3D carousel available from Android at showing the 'Gallery' of photos and agreed on that.
4. The 'ELSE' naming of the tab was not clear and took time to realize, is not a next step, just some other way to choose symptom.
5. Not really.

#### User2:

General comments: She said she was really impressed. It is much easier to use, than she could ever imagine and she liked it very much. The help when answering the questions, was hard to imagine on account of the mouse use instead of the finger. She was anticipating to see the tablet version.

1. The pathway through the application was easy to follow. Many ways to choose the primary symptom. It was hard to read some of the questions. Bigger seeker buttons and bigger font on the text. Most of it was easy.
2. She wanted some indication of yes and no sides and in the end + or - was suggested. The icons were easy to identify and the indication of the suggested decision PC or ED, she did not have to search around. Most of the functions were easy to find.
3. She thought it served well the representations, maybe change the button that is for adding the colleague, to having some ambulance and plus icon.
4. She understood everything, she realized easily what to do next.
5. Not really.

## Appendix#8: Questions on the interview with Bengt Arne Sjöqvist

Most interviews conducted during the project followed a semi structured method, which includes preparing a set of questions each time. Those sets for the meeting Bengt Arne Sjöqvist are shown below.

Questions:

1. Input on our prototype.
2. What is out there already regarding apps
3. The security matter
4. The connection with NPÖ
5. Documentation for the Palliative care app, what we've thought so far and input
6. Documentation for the Ambulance app, input.
7. The idea for the Palliative's draft design, input.

Answers:

1. Think about maintenance and study about CDSSs 'why is it good to have such a system'. Would information about the decision be stored at their journal? Think of some way to connect, like a note at Melior?
2. There is a regional attempt with SAAB to implement Triage journal system and it was suggested to connect our DSS with their Triage system. Ortivus is a small company that has the 'Mobimed' Triage software on laptops with touch screens which is already at most of the ambulances in the region. We should study/search if we should be incorporated to already IT solutions in the market.
3. SITHS cards from National guidelines, the only acceptable way.
4. Connection with NPÖ is quite not useful yet. On the other hand connection with the regional database (VGR IT) should be investigated. ePR system available from Siemens 'Melior' mostly at the VästraGötaland Region. Incorporate an update function for the new cases.
5. Timestamp on everything, make sure to meet the users' requests while having in mind the storing at the database and the search of cases afterwards.
6. It is a nice idea, include alarm
7. Think of some way to alter the routine. Old way vs new way and make a difference in the outcome. Think of how to show the data gathered, make chance for free text limited. (From this question the 'Evaluation' page was captured as an idea to alter the routine)

General comments: Tablets have been requested from doctors to be utilized in the healthcare setting, on account of their portability.

## Appendix#9: NPÖ system

### NPÖ system

Sweden has 21 self-governed/regions, which are responsible for the hospitals and Primary Care and 290 self-governed local municipalities responsible for the elderly after hospitalization care. However, the rules and legislations are steered nationally through the parliament (Ministry of Health and Social Affairs, 2010). On account of the National e-health strategy a system was required to connect all the different infrastructures and their data:

- Electronic Health Records (EHR), which include the care process, prescriptions, decision support and lab results
- Booking system for visits, operations, tests etc. and cost documentation
- PACS (Picture Archiving and Communication Systems) for X-ray, CT,MR, laboratory systems
- Systems manufactured specialized to several hospitals, even units

Considering the huge amount and variety is obviously a very difficult task. Nevertheless, Sweden has a great facilitator to this project: the personal number, which every citizen has from the moment they are born and it is connected to every electronic system available in the country. This number is unique and the person is identified by it, connecting all information to one code.

The system proposed based on the personal number and currently in use is named NPÖ (National Patient Summary) (Ministry of Health and Social Affairs, 2010) according to which:

- The patient's full medical file is immediately accessible by the caregiver provided that he/she consents.
- Patients can access securely their record regarding results and medication
- There is no discrimination between public and private sector or between municipal or regional service.

### NPÖ warning symbol

The NPÖ warning symbol was inspired by the Asclepius cross and it appears at the right top of the screen, to warn with color coding about patient's allergies etc. (Lövström, 2009). This symbol was thought to be incorporated to the application at the patient's file, when patient's data would be retrieved through NPÖ.

Examples of the NPÖ symbol can be reviewed at the picture below (Figure 4):

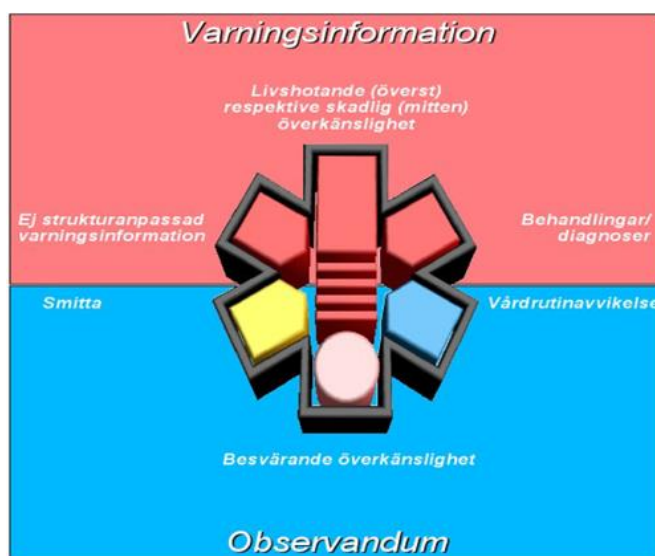


Figure 68: Warning symbol cases (NEPI, 2009)

## Appendix#10: Deciding Tablet devices

First and foremost, the tablet had to be powerful enough to handle the applications and functions it would be running. Nowadays though, this usually is not a matter of concern with the currently available technology, since most modern tablets have at least 1GHz dual core processors and 1GB of RAM (Wikipedia, u.d.).

Secondly, it had to be of an appropriate size. In the case of a large size, it could be cumbersome leading to the medical personnel avoid using it. However, in the case of a too small screen, it might be difficult to see menus and texts on the applications (especially while moving or in a moving vehicle), thus making the applications hard to use. Furthermore, the resolution of the screen was an important issue, yet most of the commonly used tablets have a resolution of at least 1024 x 600 pixels (Wikipedia, u.d.), which should be enough for most medical applications.

Another aspect that had to be taken into consideration was the fact that the tablet has to be available to the region it is supposed to be used in.

None of these tablets had a price tag of more than 4500kr, which was advantageous considering that more expensive options might not be viable in a hospital setting.

Furthermore, any of the Ipad series was excluded, on account of cost, both for buying and developing on MAC computers.

Consequently, the models picked were:

1. Google NEXUS 10''
2. Google NEXUS 7''
3. SAMSUNG Galaxy Tablet 2 P5110 16GB 10.1''
4. SAMSUNG Galaxy NOTE 16GB 10.1''
5. SAMSUNG Galaxy TAB P7310 8.9''
6. ASUS Transformer Pad Infinity 10.1''
7. ASUS Eee Pad Slider 10.1''
8. SL101'
9. ASUS VIVO Tab 10.1''
10. SONY XPERIA Tablet S 9.4''
11. Amazon Kindle Fire HD 8.9''

## Appendix#11: Paper forms of DSS projects examples

### Palliative Care document example:

8. Next of kin should be given information and support during the patient's stay at the unit, if this is in line with the wishes of the patient and possible according to the guidelines of the hospital, responsibility of the personnel and available resources. General information about available form of support may be given without the patient's consent.

- The needs of the next of kin should be fulfilled as much as possible with regards to the care of the patient.
  1. A method where a limited number of caregivers handles the communication with the next of kin should be used when needed. This should be documented and communicated to all caregivers.
  2. Decline in the patient's health might be cause for increased support for next of kin.
- The next of kin's thoughts about their own role towards the patient should not be evaluated or judged by the caregiver.

### 'CRC' document example:

#### 2a) Hypertension, high blood pressure

##### A. Anamnes

- 1) Has the patient previously known High blood pressure?
- 2) Has the patient been careless with medication?
- 3) Has the patient shown any cerebral symptoms (confusion or impaired consciousness)?
- 4) Has the patient had headache?

##### B. Examination

- 1) Is the patient's condition unaffected?
- 2) Has the patient had trouble breathing?
- 3) Has the patient had chest pain?
- 4) Is there any confusion or impaired consciousness?
- 5) Is the systolic blood pressure > 220 mmHg?
- 6) Is the diastolic blood pressure >120mmHg?
- 7) Are heart rhythm, oxygen saturation, respiratory rhythm within the normal limits?

##### C. Candidate for PC

All must be met:

- 1) Patient is unaffected.
- 2) Vital parameters (besides blood pressure) are normal.
- 3) The systolic blood pressure is over 220 mmHg.
- 4) The diastolic blood pressure is over 120mmHg.