Rethinking interfaces to medical records

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Abstract

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Despite being in use for years, Electronic Health Record systems (EHRs) still present fairly low usability. The users are struggling with problems like information overflow, confusing or complex navigational tools, and the content they want to access being spread over multiple screens. The purpose of this thesis was to present a design hypothesis offering a system for reading medical records allowing the medical staff to find and read data in a highly efficient way. To address this, a literature study was conducted, followed by interviews and observations conducted in Akademiska Sjukhuset, as well as a design study. To delimit the scope of the thesis, orthopaedic surgeons were chosen as a designated user group, with the final design crafted to meet their needs.

The key elements of the final design were:
- A problem list, presenting the medical issues a patient has been treated for in the past. The medical notes were grouped into folders based on that list
- A notes panel and an attachments panel - displaying content relevant to the selected problem(s)
- A patient summary section - displaying key facts about a patient, warnings, a simplified medicine list and scheduled events

The final product was an interactive prototype, which was subsequently evaluated with a small group of physicians, receiving overall positive reactions.
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1 Introduction

Various studies have shown that the transition from paper-based health record systems to Electronic Health Records (EHR) has been mostly considered a step in the right direction (Cheriff et al., 2010; Howard et al., 2013; Khajouei et al., 2011; Nguyen et al., 2014). Those conclusions are often based on metrics like overall cost reduction (Adler-Milstein et al., 2013; Zlabek et al., 2011) or increased efficiency in ordering medication due to the introduction of electronic ordering systems (Khajouei et al., 2011).

While switching to EHR systems helped to fix some problems that relying on the paper documentation was causing, such as less misplaced documentation or less time spent on finding and retrieving documentation (Darbyshire, 2004; Howard et al., 2013), it also introduced a new spectrum of problems (Ash et al., 2007; Campbell et al., 2006). Researchers studying the use of EHRs found that physicians using the system in their daily work are often unhappy with it, or at least see room for improvement. A lot of research is available aiming to identify issues regarding the use of EHR systems as well as workarounds used by doctors, with one of the studies quoting that “The amount of observed EHR workarounds is too large for all to be listed and discussed.” (Blijleven et al., 2017).

Specific problems identified in the literature vary depending on the needs of an institution and the qualities of the software itself, but many issues are with regard to usability. In this particular area, common problems are:

- Poor information structure – e.g. lack of a proper patient’s history overview, a lot of unorganised data instead (Jensen & Kjærgaard, 2010; Lium et al., 2008; Wehlou, 2014)
- Having to toggle multiple screens to find all of the relevant information required (Blijleven et al., 2017; Howard et al., 2013; Nguyen et al., 2014; Rose et al., 2005; Saleem et al., 2009)
- Overall complex navigation (Miller & Sim, 2004; Rose et al., 2005), with one study participant comparing the EHR’s interface to “an aeroplane cockpit” (Nguyen et al., 2014)
- Poor workflow support – some studies reported that introducing EHRs resulted in interrupting physicians’ workflows, or that EHRs simply lack any workflow support (Ash et al., 2007; Campbell et al., 2006; Rose et al., 2005),

Some of the other identified problems include issues like having a feeling of poorer interaction or body language with a patient during a visit due to a large amount of computer interaction required (Flanagan et al., 2013; Howard et al., 2013; Lanier et al., 2017; Saleem et al., 2009), or feeling that using EHRs creates more work or takes more time than it would have otherwise (Campbell et al., 2006; Howard et al., 2013; Miller & Sim, 2004).

Even though the paper-based records had flaws, they also had some benefits compared to EHRs when it came to reviewing a patient’s medical history. Those can include being able to flip through the files faster, visually assessing the complexity of one’s history just by looking at the size of it, and easily recognising a different type of files such as referrals or test results due to a specific layout and design (Ny gren et al., 1998). In fact, in an early research project it was found that “all the physicians regarded the [paper-based] medical record as a well-functioning instrument in their routine work” (Nygren et al., 1998). Most
of the EHR software, as indicated by research, has struggled to match up to the strategies for efficient medical record browsing that the paper predecessor was offering.

When it comes to the digitisation of healthcare, Sweden has been setting a high standard. Its introduction of patient accessible healthcare records has even earned it praise of an ‘ideal to strive for’ from some (Armstrong, 2017). Digital documentation in healthcare was introduced to all Swedish counties, including hospitals, primary care units and psychiatry facilities in 2012 (Jerlvall & Pehrsson, 2013). In 2016 the Swedish Government together with the Swedish Association of Local Authorities and Regions released a vision statement for eHealth which declares that “In 2025, Sweden will be best in the world at using the opportunities offered by digitisation and eHealth to make it easier for people to achieve good and equal health and welfare” (Ministry of Health and Social Affairs, 2016).

In order to achieve this goal, the area of usability of EHRs (and other software that physicians’ work also relies on) would have to meet the standard as well. The purpose of this thesis is to explore that particular area, with the focus put on retrieving the data from the EHR system. The final goal is to develop a design hypothesis for a segment of an EHR interface intended for finding and reading the data for physicians. The design efforts were with the emphasis on exploration of how data presentation, visual cues, and interactions can affect the efficiency of browsing medical records. To achieve this, an observational study in Akademiska Sjukhuset was conducted, as well as a subsequent design study.
2 PURPOSE

2.1 RESEARCH QUESTION
The main research question is phrased as follows:

*How could a system for reading medical records be designed to enable medical staff to find and read the data in a highly efficient way?*

To answer this, several areas were studied, further breaking down the question into more specific inquiries, such as:

- Which data to present at the given situation,
- What layout to use to present a comprehensive overview of this data,
- Which navigational tools to use,
- What level of detail should be presented,
- What interactions and visual cues to include.

Those components, when addressed accurately, should contribute to providing a possible answer to the research question.

To address the inquiries, two research activities were conducted. The first was aimed at finding out more in-depth what needs healthcare professionals have when it comes to reading data from a medical records system. This includes researching what actions they perform, under what circumstances they use the system, and which information they need in these circumstances. The latter is especially important since research has indicated that one of the issues physicians are facing while using EHRs is information overflow, or unclear structure of the data (Lium et al., 2008; Rose et al., 2005; Saleem et al., 2009).

The second research activity was a practical exploration of the design space, with an overall goal to produce design hypotheses of something novel and more usable than existing solutions.

2.2 DELIMITATIONS
EHR systems are often very broad, covering many aspects of physicians’ work, such as retrieving patients’ data, scheduling procedures, ordering tests and medicine, and billing. This thesis did not cover an entire system, but instead delimited the scope to functionalities required for finding and reading the relevant data. This is a particularly interesting module of an EHR system because while different modules might be used more or less frequently, a tool for accessing patient’s data is essential for physicians’ work (Ancker et al., 2014).

After some consultations, the decision was made to focus the research on the needs of physicians from a specific domain. Hence, the conducted interviews and observations are with physicians from the Orthopaedic ward of Akademiska Sjukhuset in Uppsala, more specifically orthopaedic surgeons. The design was drafted to suit the needs of this specific group of physicians. This limitation should not affect the utility of the provided solution for other disciplines of medicine, since the core of the findings should be applicable to various cases, with the details here adjusted for the orthopaedic doctors.
3 BACKGROUND

World Health Organisation (WHO) defines EHR as:

*Real-time, patient-centred records that provide immediate and secure information to authorized users. EHRs typically contain a patient’s medical history, diagnoses and treatment, medications, allergies, immunizations, as well as radiology images and laboratory results. A National Electronic Health Records system is most often implemented under the responsibility of the national health authority and will typically make a patient’s medical history available to health professionals in health care institutions and provide linkages to related services such as pharmacies, laboratories, specialists, and emergency and medical imaging facilities.* (World Health Organization, 2016)

Nguyen et al. in their literature review have summarised that the most commonly used functions of an EHR are “accessing, viewing and documenting clinical data, such as patient data, laboratory reports and patient visit notes and clinical admission and discharge.” (Nguyen et al., 2014) However, EHRs often offer much more functionality. The exact range varies depending on the brand of the software, but common additions can include functionalities such as billing support, e-prescribing, administrative tools, specialised modules (such as for cardiology, long-term care, birth, psychiatry, etc.) or support for telemedicine (“Cambio COSMIC,” n.d.; “Epic Software,” n.d.). Which of those services will be included is a decision up to the medical centre making the purchase.

EHRs separate to client server-based and cloud-based. The designated devices they are meant for are PCs, however, some providers offer additional versions for tablets, smartphones and smartwatches (“Cambio COSMIC,” n.d.; “Epic Software,” n.d.).

As of 2016, 47% of WHO member countries reported using National EHR systems (World Health Organization, 2016). Accordingly to a WHO report, systems most commonly integrated with the basic EHRs are laboratory (77%), pharmacy (72%), and picture archiving and communications (56%) (World Health Organization, 2016).

3.1 EHR USE IN UPPSALA

While the adaptation of EHR across the globe varies a lot, Sweden introduced EHRs to all of its counties (hospitals, primary care units, psychiatry facilities) in 2012. The EHR system used in Uppsala Region, including Akademiska Sjukhuset where the observational studies for the thesis took place, is Cosmic, a software from the Swedish company Cambio. As of 2017, Cosmic was the second most popular choice in Sweden, corresponding to 24.1% of total users (Jerlvall & Pehrsson, 2017).

Some of the services Cosmic offers integration with include e-prescriptions, digital referrals, online time booking system and the journal giving the patients access to their medical data (“Nationell e-hälsa,” n.d.).

3.2 MOST COMMON USABILITY ISSUES

The aim of the conducted literature research was to learn more about how medical professionals use the EHR, what are their needs in regard to it, and what issues do they
face while using the currently available systems. The issues listed in this section are grouped based on themes most frequently occurring in literature, and describe the problems users encounter with the functionalities of the designed software. How those design choices affect physician’s work is further described in section 3.3.

3.2.1 Workflows: bad, lack of, or interrupted

The first major common theme identified in literature was a problem with workflows, which could mean workflows being badly designed, or not implemented at all. Ash et al. found that 87% of the participants in their study expressed that switching to an EHR affected their real-world workflow (Ash et al., 2007). As described by Rose et al.: “If the information required to support this workflow was not immediately present in the Results Manager screen, it became necessary for users to temporarily shift their focus to other parts of [an EHR], making it harder to maintain system context.” In this case, to open the notes module, which was the most often used module in the system, the user had to select an option from a pop-up menu, which opened a submenu, which allowed opening the notes.

EHR workflow being misaligned with the actual workflow is a commonly described problem, but the impression found in the literature was that the real problem comes down to lack of flexibility in adjusting the workflow for one’s needs. Hospitals and clinics often have workflows they crafted for themselves during years of work, that vary from the ones used in other places. Workflows can even vary within different parts of the same institution – “while [switching to an EHR] improved workflow for some workers, it also negatively affected the workflow of others” (Ash et al., 2007). As expressed by Campbell et al., while clinical processes might appear to follow a predictable set of steps, “In actual clinical practice the process is much more adaptable, and includes a variety of checks, balances, interventions, and exceptions.” (Campbell et al., 2006). That means designing a rigid, unadaptable workflow can lead to dangerous situations, in cases such as when a clinical workflow contains double checks or other safety measures that are being neglected in a workflow implemented in an EHR.

What can further aggravate the problem is a mismatch between real-world user roles and their digital equivalents: “[...] if CPOE designers have not considered the appropriate range of workflow perspectives (e.g., those of the nursing or clerical staff; as well as of physicians), the resulting technological system cannot accommodate comprehensive, fully integrated clinical workflow.” (Campbell et al., 2006) This may result in work-shifting between users, which leads to ineffective work organisation.

Blijleven et al. presented a different example of an unexpected result of a workflow mismatch. In the case they observed, the workflow in the standardised template for inputting the data into the system required excessive up and down scrolling, resulting in users preferring to input the data through free text, unstructured notes. Such solutions increased efficiency in the short term, but in the end, made the notes more difficult to

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1 CPOE – Computerized Provider Order Entry. As explained by Campbell at al.: “CPOE systems commonly exist as one of many integrated clinical applications in larger institutions’ information systems [...] This study refers to CPOE systems as containing, at a minimum, electronic order entry capabilities, whether or not this functionality is part of a larger, more complex information system.” (Campbell et al., 2006)
browse and tougher to read. Physicians were aware of it, yet still opted for using free text notes in most of the cases. (Blijleven et al., 2017)

### 3.2.2 Information overflow

#### Lack of structure

As expressed by Rose et al., “One of the greatest identified challenges of EMR\(^2\) user interface design was balancing the clinicians’ information needs with the limited amount of available screen real estate.” (Rose et al., 2005) Since EHRs allow faster data input than the paper systems did, it is easier to generate a big amount of information to be available in the system. That can be a good thing if the data is properly structured and organised, which often is not the case:

> Several informants reported that the increased number of short notes and the lack of structure made it more cumbersome to get an overview of patient cases. The physicians missed the ability to filter out what they regarded as insignificant documents. (Lium et al., 2008)

Lack of structure in the available data is a common theme in the literature (Blijleven et al., 2017; Lium et al., 2008; Rose et al., 2005; Saleem et al., 2009; Wehlou, 2014), often accompanied with lack of ability to filter the data. This of course has a significant impact on the efficiency of browsing the medical records: “You get a lot of documents for certain patients in [the EHR], and then, if you don’t know how to filter out a lot of those documents, you can end up spending a lot of time trying to find what you want”. (Lium et al., 2008). That problem intensifies with the amount of patient’s visits and conditions being treated. Such lack of sufficient information structure and data filtering, apart from making it more annoying and time-consuming to find the relevant information, can also jeopardise patient safety and wellbeing by losing important information in the abundance of available data. In an extreme case of bad usability regarding data reading, as described by Darbyshire, users “saw very little useful information returning to them from [an EHR] in any usable form”, calling the system an “information black hole”. (Darbyshire, 2004).

#### Lack of a quick overview

A frequent users’ wish regarding the information structure, as identified by the literature, is having access to a quick medical history overview. EHRs often don’t support such functionality, meaning that to get an overview of patient’s medical history, a user needs to get through all of the journal notes assigned to the patient (Jensen & Kjærgaard, 2010; Lium et al., 2008; Wehlou, 2014). None of the papers read as a part of the literature review mentioned the possibility of highlighting a piece of information in a note to make it stand out, which could make the browsing easier. In this aspect the paper record has the users’ preference compared to the EHRs:

> I long for our previous practice with the paper record, where I could look up page 3 and find all relevant information about the patient. (Jensen & Kjærgaard, 2010)

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\(^2\) EMR – Electronic Medical Record. While some definitions explaining the differences between EMR and EHR have been offered (Garets & Mike, 2006), no clear distinction has been commonly agreed upon, leading to the terms being used interchangeably.
Journal notes are hard to find, so then the paper journal might be easier, because you often have a summary up front. And yes, you browse faster through paper compared to opening note after note on the computer, which also might be a slow one. (Lium et al., 2008)

3.2.3 Screen toggling
Having to toggle multiple screens in order to find the desired data or to accomplish a task, is a problem with a very high prevalence in the literature (Blijleven et al., 2017; Flanagan et al., 2013; Howard et al., 2013; Miller & Sim, 2004; Nguyen et al., 2014; Rose et al., 2005; Saleem et al., 2009; Wehlou, 2014). This seems to be one of the most common complaints regarding the usability of EHR systems: "Most respondents or their colleagues considered even highly regarded, industry-leading [EHRs] to be challenging to use because of the multiplicity of screens, options, and navigational aids." (Miller & Sim, 2004). This problem is closely linked with the ones described previously. The abundance of data available in the system creates a real challenge when it comes to data presentation. As a result, various data and functionalities are spread throughout different screens, significantly affecting the efficacy and ease of use of the EHR. This greatly affects intended workflows, with users often mentioning getting distracted and forgetting the reason for, or an outcome of, the action they were currently performing. This issue can be further aggravated by complex or unclear navigation of the system:

For example, information about immunizations, screening tests, labs, medications, referrals and vitals tended to be stored on separate screens. To locate and review each required that the clinician click through a series of screens that could not be opened simultaneously. In addition, alerts and prompts were either not used or noted to be distracting rather than helpful. (Howard et al., 2013)

The most common result of this problem was tasks becoming more time-consuming. But sometimes, when it is possible to use a different set of steps to perform the task faster users are likely to opt for it, even if it means a worse outcome in the end. Such a case was previously described with regard to workflow interruption, when users would rather input data through free text fields, because using a standardised template required too much up and down scrolling (Blijleven et al., 2017). Another common consequence of screen toggling is a presence of various paper workarounds (Blijleven et al., 2017; Saleem et al., 2009).

3.2.4 Complex navigation
EHRs navigation has been described as awkward and unclear (Miller & Sim, 2004; Rose et al., 2005), and interfaces as complex and containing irrelevant screen clutter (Blijleven et al., 2017), with one of the studies comparing the user interface to an aeroplane cockpit (Ludwick & Doucette, 2009). Blijleven names "inconsistent and confusing placement of user interface elements (e.g., sign or agree buttons)" (Blijleven et al., 2017) as one of the reasons why users would not use some of the systems’ functionalities.

This makes using the system more time consuming, results in decreased efficiency, increased confusion and distractions. Another consequence of unclear navigation found in the literature is that some users tend to return to a starting point (or a familiar point) of the system due to not knowing how to navigate their way through it (Rose et al., 2005), with one of the most extreme cases being "Rebooting the EHR due to not knowing
how to efficiently navigate back to the main screen.” (Blijleven et al., 2017). Having to face those problems upsets the users and discourages them from using the system: “Doctors don't like feeling dumb so when they don't know how to use the system, they get frustrated and angry” (Ash et al., 2007).

3.3 EHR USE IN PRACTICE

The aim of this section is to describe more in-depth how EHR related problems affect physicians’ daily work.

3.3.1 Influence on efficiency

The literature showed mixed opinions when it comes to EHRs impact on its users’ efficiency. An increase of efficiency has been found through improvements like less administrative or repetitive tasks: “not having to create care plans from scratch, not having to enter repeatedly the same information into a variety of forms and having to record less clinical observations manually.” (Darbyshire, 2004). Howard et al. made a similar observation, finding that the users spend less time retrieving and filing paper charts:

> Literally one Wednesday a month, all personnel would systematically go through all the charts to find all the misplaced charts, as well as if there was any chart missing from sequence... [Since] we’re in computers, we no longer have to do that. Misplacing of charts [doesn’t] happen, which is a beautiful thing. (Howard et al., 2013)

However, those improvements often come with a trade-off. For example, Rose et al. quotes increase in efficiency, while simultaneously describing workflow problems and users getting lost in the system (Rose et al., 2005). A similar attitude of ‘it increases efficiency, however...’ was found by Ash et al., which have found that “Many commented that CPOE increased efficiency [...] Often, however, interviewees noted that while it improved workflow for some workers, it also negatively affected the workflow of others, especially physicians, who must put extra time into ordering.” (Ash et al., 2007). Cheriff et al. concluded that introduction of EHRs doesn’t slow the doctors down, and has the potential to speed them up (Cheriff et al., 2010).

Additional workload, tasks being more time consuming

A common complaint regarding efficiency is that EHRs introduce more steps and actions that need to be taken in order to complete a task, creating an additional workload and making the whole process more time-consuming. Some of the commonly mentioned issues contributing to this were (Ash et al., 2007; Campbell et al., 2006):

- taking extra time to respond to alerts and notifications
- having to complete all the steps in a process or fill in all the data fields
- dealing with multiple passwords
- non-routine or more complex actions requiring more steps and thus becoming more time consuming

Additional factors that can further aggravate the problem are lack of user training (Ludwick & Doucette, 2009), or slow systems or bad infrastructure (Ash et al., 2007). Increased workload can also be caused by usability issues (“Problems with EMR usability—especially for documenting progress notes—caused physicians to spend extra
work time to learn effective ways to use the EMR” (Miller & Sim, 2004); “Manually planning (follow-up) appointments due to the automatic planning functionality providing bad visibility and oversight” (Blijleven et al., 2017).

Howard et al. have found that workload related problems can be reduced by a smart redesign of the work environment. In their study comparing the use of an EHR system among seven different clinics, they learned that six clinics finds one specific task (electronic charting) particularly annoying and contributing to an increase in their workload. One clinic, however, did not find this task problematic, quoting: “An important reason for the different experience of this practice is that the lead physician had invested significant effort in thinking through office work flow and work roles to optimally support the clinical process.” (Howard et al., 2013).

3.3.2 Most common workarounds

Workarounds performed by users while using the system are a great indication of what changes should be applied in the system. An abundance of studies analysing EHR-related workarounds exists, with, as mentioned before, one study finding that “The amount of observed EHR workarounds is too large for all to be listed and discussed.” (Blijleven et al., 2017). The workarounds presented here are the most prominent ones and include paper-based workarounds as well as those performed within the EHR.

Memory aids

Workarounds from this group usually serve as temporary reminders the users set up for themselves, such as writing notes on paper as a transitory medium before inputting the information into an EHR (Campbell et al., 2006; Lium et al., 2008; Saleem et al., 2009), making notes as reminders to input something to the EHR later (Flanagan et al., 2013) or writing down information to have available while seeing the patient (Flanagan et al., 2013). EHR-based workarounds include temporarily editing the progress note through boldfacing, italicising or underlining relevant parts as a memory aid for questions to be asked or appointments to be made (Blijleven et al., 2017), or users sending messages to themselves as a reminder to do something in the EHR later (Flanagan et al., 2013). One of the identified motivations for using this type of workarounds are users’ sensorimotor preferences. Some of the physicians write down notes or keywords from the EHR progress notes not only to serve as a reminder during a meeting but also because they prefer to have something tangible to hold on to while seeing a patient (Blijleven et al., 2017; Campbell et al., 2006). In some cases, creating memory aids was also a workaround resulting from poor information structure. Saleem et al. quoted a story of “a colleague who, to manage copied, repetitive electronic notes, used index cards to handwriting new developments so that he could refer to them at the bedside” (Flanagan et al., 2013).

Such paper-based workarounds are found to be widely persistent (Blijleven et al., 2017; Flanagan et al., 2013; Saleem et al., 2009). Campbell et al. explains this phenomenon: “[since] paper remains the most malleable, flexible, and easily transportable data medium available […] Paper-based clinical record storage will become obsolete, but use of paper in the clinical setting will not.” (Campbell et al., 2006). Flanagan et al. expressed similar view:

Retention of white boards and the use of paper-based shadow charts after electronic tools have been implemented is more than resistance to change
on the part of the users. The ability to efficiently create cognitive aids as the nature of work evolves—often in ways that are unexpected—is critical. (Flanagan et al., 2013)

Awareness about new information
As identified in the literature, the biggest reason for using paper-based workarounds was the users’ need to bring others’ attention to new information. Many of the existing EHR systems either did not provide such a service or did not have users’ trust that the important information will stand out. One reason for the distrust could be that some EHR systems already have a high signal-to-noise ratio (Saleem et al., 2009), often distracting users with pop-ups and alerts.

One of the ways to bring attention to new data was by passing a paper note to another doctor or nurse (Blijleven et al., 2017; Campbell et al., 2006). In many of those cases, there was a redundancy between information on the paper and in EHR (Saleem et al., 2009). Saleem et al. gave an example of such interaction, where the nurse, upon registering high blood pressure, hands a pink sheet with results to the patient, so it could be given to the doctor during the appointment effectively alerting them about the blood status. Another example from the same study showcases the lack of trust in the data visibility even more: “A [nurse] created new progress notes in [the EHR], printed them for physicians, and highlighted specific pieces of information for emphasis.” (Saleem et al., 2009).

Lium et al. also observed such behaviour, but based in an EHR rather than paper, where “physicians wrote a small note in the [EHR] system to update the physician scheduled to be on duty the next morning.” (Lium et al., 2008) Similar observations of users’ exploration of EHR as a communication tool (outside of the designated messaging functionalities) has been observed by Campbell et al., who said EHRs give their users an ‘illusion of communication’: “people put info into EHR and they assume that’s enough for the designated person to get it, while there might be a delay, lack of notification system etc.” As a result, “We observed many instances where emergency orders were not only placed in the CPOE system but were also (redundantly) phoned in to assure they took place immediately.” (Campbell et al., 2006)

A very interesting example related to that behaviour has been described by Blijleven et al.:

EHR users would purposefully enter patient data they perceived important for other colleagues to see in data fields other than the intended data field(s). For example, physicians and nurses entered important patient data in a data field that is strictly meant for listing patient discharge criteria. Data entered in this field are directly shown on the EHR user’s screen when opening a patient’s health record, making this an attractive field to store important data and draw attention. However, as soon as a patient is (re)admitted to the hospital and the important data stored into the patient discharge criteria field are replaced by actual discharge criteria by another clinician, these data are lost and no longer visible, thereby jeopardizing patient safety. (Blijleven et al., 2017)
Workarounds regarding data input
Flanagan et al. identified the most frequent computer-based workaround for efficiency to be copying previous progress notes into a new note (Flanagan et al., 2013). Some of the reasons for this behaviour included users finding it more efficient to paste a previous note and modify its contents rather than writing everything from scratch (Blijleven et al., 2017), or wanting to create a summary of knowledge from past notes to make it easier to search patient’s record in the future. This, of course, creates redundancy in the data set and makes it more time-consuming to browse the data.

The ease of creating a new note results with users using the progress note functionalities for different purposes, such as writing messages for other doctors, as described in the previous section. Additionally, Flanagan describes the case of a doctor copying the vitals and health maintenance information into a progress note, even though that information is already stored in different parts of an EHR (Flanagan et al., 2013). Others cases of data placed in different sections than originally intended include an example of a nurse creating a note with a progress of a colonoscopy surveillance continued over a period of 3 years in a ‘computerized problem list’, intended for listing the medical problems that patient is treated for (Flanagan et al., 2013).

3.3.3 Impact on interactions with patients
Several researchers found that physicians perceived using a computer-based system as resulting in poorer body language, thus negatively impacting interaction with patients (Flanagan et al., 2013; Howard et al., 2013; Lanier et al., 2017; Saleem et al., 2009). The main reason for this was that physicians spend more time looking at the screen, resulting in less face-to-face time with a patient and longer silence periods (Howard et al., 2013; Lanier et al., 2017). Ludwick et al. hypothesise that this can disrupt the flow of information coming from a patient, as well as “compromise the physicians’ implied and historic role as confidant.” (Ludwick & Doucette, 2009) As a result, some of the users refrain from using the system while meeting a patient, taking notes on paper that need to be transferred into the system afterwards instead (Flanagan et al., 2013).

Lanier et al. provided a list of recommendations on how to use an EHR while interacting with a patient, which includes tips like opening an EHR before patient walks into the room; when possible, involving the patient in reading the information or results displayed on the screen; or “shifting away from the computer when patients express sensitive psychosocial issues” (Lanier et al., 2017).

3.3.4 Users’ attitudes
EHR users represent a full spectrum, from being highly negative to highly positive, with Ash et al. describing the observed experiences as “Pick your favourite terms of praise or profanity. They are all used.” (Ash et al., 2007). Studies have found, however, that while often the initial reaction of users’ to switching to an EHR system is apprehensive, with some users showing resistance, the conviction to the system raises with the time amount of time spent using it (Ash et al., 2007; King, Patel, Jamoom, & Furukawa, 2014).

Despite that, some percentage of users remains unconvinced. Darbyshire described users’ attitude as “some clinicians had positive experiences of [EHR], most described their experiences of using [EHR] with a mixture of cynicism, passive acceptance or weary resignation at yet another burden that had been foisted on them.” (Darbyshire, 2004). This
negative mindset is not without significance since it can often lead to reduced efficacy of system use (Ash et al., 2007).

Part of this group were users who could be described as technophobes. Ash et al. described that those users “identified each additional minute [they] spent because of the system” (Ash et al., 2007). Not being comfortable with computers and the technology itself can lead to prejudices against the system and rejection of it altogether: “The [X software] package is horrible. I don’t use it. I use [paper] notes instead; I hand notes to the secretary personally. It’s too easy to mess up in [X]. I use paper because I’m not comfortable with [X].” (Saleem et al., 2009) Lack of trust not only in the system but also in one’s skill with the system is not uncommon. Khajouei et al. have found that 54% of physicians and 40% of nurses taking part in their study were concerned that using an EHR system could cause additional errors in their practice, such as wrong medication names or wrong dosages (Khajouei et al., 2011).

Jensen et al. identified one more reason causing some of the users to dislike the system, which was feeling that “their professional identity as ‘someone you ask for advice’ was undermined, leading to a loss of authority and status.” This can be caused by having to rely on others in navigating the system, due to not feeling competent with it. Additionally, some of them “considered the [EHR] system to be mainly an administrative tool, which on occasions was found to hinder their real work as craftsmen.” (Jensen & Kjærgaard, 2010) Lium et al. hypothesizes that doctors who have previous experience in using the paper system may be reluctant towards EHRs since from the beginning of their work they were drilled in using paper and ‘old habits die hard’. Meanwhile, residents and new doctors who never experienced paper systems adapt to the EHRs more easily, which results in senior doctors using EHRs for fewer tasks compared to junior doctors (Lium et al., 2008).

3.4 COMPARISON TO PAPER RECORDS

3.4.1 EHR design mimicking the paper
A shared belief among EHR researchers is that some of the systems were built in a way that mimics the paper system (Darbyshire, 2004; Jensen & Kjærgaard, 2010; Lium et al., 2008). Some assume that while researching the use of health records, EHR creators focused on documenting paper artefacts and their use rather than physicians’ workflows and processes, as a result producing digital equivalents of those paper artefacts: “Even if electronic workflow, ordering of lab results or other functionality has been introduced, the core components of Norwegian EMR systems are still electronic documents containing clinical narratives, bearing strong resemblance to its paper ancestor.” (Lium et al., 2008).

As a result, in those cases EHRs didn’t provide as much of an upgrade to physicians’ work as they could have, leaving some of its users with a feeling of a somewhat unfulfilled promise. “Clinicians’ experiences suggested that the use of [EHR] had not led to any real changes in their thinking or practice. The [EHR] was simply an electronic way of doing what was previously done, a keyboard version of the previous pen and paper system.” (Darbyshire, 2004). The researchers seemed to agree that creating an EHR system by simply transitioning the old working methods into their digital versions was not an improvement. This approach can also stop users from exploring the system and learning other ways in which it could support their work, thus enforcing old habits (Jensen &
Kjærgaard, 2010; Lium et al., 2008). Lium et al. called this approach of transferring paper-based procedures to an electronic medium a ‘paper metaphor’:

Our overall impression is that to this day, EMR system implementations in Norway have focused on gradually automating existing manual processes rather than supporting more radical changes. [...] We strongly believe that an EMR that builds on the paper metaphor does not fully leverage the potential benefits of Information and Communications Technologies. (Lium et al., 2008)

3.4.2 Visual and tangible advantages of a paper record

It may seem like the paper was a cumbersome tool for browsing data, especially data as important as medical records, but that was not necessarily the case. As described by Sandblad et al.:

When [paper-based] medical records are [...] used, this is done by a number of different and in many respects, very advanced manners. The medical record consists of a set of different documents in a specific order. The documents have different shapes and can be marked with different signs and colours in the margin. It is possible to overview several pages at the same time, and to very rapidly browse through a large number of pages. The medical record can in this way be seen as multi-dimensional, coded in terms of shapes, colours and pictures and structured but not strictly formalized. The speed an experienced user can achieve in ‘zooming-in’ the relevant parts is remarkable, and the amount of information covered by a glance is enormous. (Sandblad, Lind, & Schneider, 1986)

Nygren et al. analysed in detail the use of paper records by physicians, with a focus on the use of visual elements and structure of the paper. They have found that “all the physicians regarded the medical record as a well functioning instrument in their routine work” (Nygren, Johnson, & Henriksson, 1992). Some of the identified visual cues include:

- Colour of the paper – if a note is old, the paper changes colour and ink fades, allowing users to recognise old data at a glance
- Visual elements unique to specific documents – e.g. lab results were easy to find because of a distinct red-coloured edge of the paper
- Thickness of patient’s data folder – allowed to estimate the complexity of a patient’s record at a glance
- Graphical layouts - “Different types of documents have different graphical layouts thus giving visual clues where to find them in a bundle.”
- Date stamps – in this case, date stamps were marked in a bright red colour, which made them easy to spot on the page. Glancing at the distance between the stamps helped the user judge the significance of the note – if a note is short, the patient meeting was probably uneventful, longer notes are more likely to contain new information

They have concluded that positioning of the elements and structuring the notes is what allowed users to learn how to quickly scan through the available material and find the data they needed (Nygren et al., 1998). Learning that skill allows doctors to become super-users of the paper system, something that was not as observed in papers studying
the use of EHRs. Lium et al.’s findings agree that some doctors perceived browsing paper records to be more efficient: “Journal notes [electronic notes] are hard to find, so then the paper journal might be easier, because you often have a summary up front. And yes, you browse faster through paper compared to opening note after note on the computer, which also might be a slow one...” (Lium et al., 2008).

Additionally, paper allows more flexibility and adaptability:

[Using paper] users can quickly and easily create prospective memory aids for non-routine events, reconfigure data to highlight elements that are important in a specific context, or track data over time that may become important later in solving a specific problem. (Flanagan et al., 2013)

Those qualities make paper a more ‘approachable’ medium. Physicians can cross things out, add notes, highlight, attach post-its and use multiple other easily accessible means to adapt the content of a record. It is also an easier choice when it comes to adding temporary data since paper notes can easily be discarded when not needed while data put into a medical record is by default permanent.

3.5 RELATED WORK

To the best of my knowledge, the number of papers on designing an EHR interface is scarce, especially with comparison to the number of papers evaluating existing EHRs.

One of the papers found on designing an EHR system from a scratch was written by Kamadjeu et al., and described a design process of an EHR system for a medical unit in Cameroon (Kamadjeu, Tapang, & Moluh, 2005). Even though the paper offered some interesting insights, their findings were mostly inapplicable to this project since the emphasis of the paper was put on the technical aspects of designing and implementing an EHR, rather than an interface.

Rose et al. conducted qualitative studies analysing the usability of an EHR, and offered the system’s redesign based on their findings (Rose et al., 2005). The changes included updating the colour scheme, rearranging the placement of elements and altering the interface’s structure. The final design offered a user interface with a higher degree of usability, while keeping the original functionality.

Nygren et al. analysed the use of paper records in a hospital setting, and based on those findings, offered a design of a digital system for reading the medical records (E Nygren & Henirksson, 1992). The gist of the findings was previously described in section 3.4.2. The design was based on the concept of stacked documents. On the right of the screen a digital version of a paper document was displayed, and on the left side of the screen three scrollable list were presented, each corresponding to a type of a medical documentation (i.e. journal notes, X-rays, lab results). Next to each list was an icon of a stack of paper, with each stack representing the number of items included in the list, allowing the user to judge the amount of content at a glance. Additionally, the positions on the lists corresponding to the currently previewed document were highlighted. The top left corner of the screen contained a box with most important basic facts about the patient.

Wehlou did not offer a design or redesign of an EHR system, but instead conducted a thorough analysis of modern EHR systems and proposed suggestions on what a redesign
of such systems should include (Wehlou, 2014). The suggestions included grouping the notes by the issues they concern, including a short medical history summary that, among others, contains the most important past diagnosis, as well as incorporating a decision support system and knowledge support system into an EHR.

### 3.6 Implications for Design

This section gathers implications for design as identified during the research process. The results have been separated into two sections, each describing different users’ requirements for the system.

#### 3.6.1 Users’ requirements - Knowledge-based

In order to address the knowledge-based users’ requirements, a deeper understanding of the actual data the users are trying to retrieve from the system is needed. In his book, Wehlou provided a list of information physicians want to have access to while meeting with the patient, which includes:

- The main problems the patient has or has had over the years.
- Which problem or problems we as doctors need to consider and manage today.
- Which other problems are of importance when considering the current encounter-related problems.
- Which plan is being followed for each of the problems and where those plans are coming from.
- What has been done and decided so far concerning our encounter-related problems.
- What has happened that isn’t in the record but is relevant. Those are the things the patient should be able to tell us about. (Wehlou, 2014)

Additionally, he provides a more detailed description of what the patient’s history should consist of:

The doctor should quickly and painlessly be made aware of the patient’s history in general, i.e. those aspects not tied into a single healthcare issue, but rather related to the whole patient. Things like general well-being, ability to lead a normal life, and the major obstacles to that, including social and financial. This history should not be fragmented and contradictory, but be presented as a consistent whole, where not only the different aspects, but also the evolution over time is clearly shown. (Wehlou, 2014)

This corresponds with the previously described issue of a patient’s history being spread between various notes, without having the functionality of a short, comprehensive overview.

#### 3.6.2 Users’ requirements - System-based

Literature showcased many suggestions and wishes users had expressed regarding what an EHR system should include, some of which were already touched upon in previous sections. However, the most commonly repeated findings could be clustered into three themes that will be discussed in this section.

**More data customisation**

This primarily concerns the systems that have more rigid data input, to an extent that it
limits physicians’ ability to add relevant data. Blijleven et al. explains this problem using the case of a field for inputting the patient’s race: “The EHR offers a range of possible races from which 1 option can be selected. Although the available and applicable option mixed race could be chosen, the physician argued that ‘mixed doesn’t really tell us anything. I’d rather just write down that her father is Moroccan and that her mother is Dutch’.” (Blijleven et al., 2017). In this specific case, the user’s solution was to input that data into a free-text progress note, which in the end would not accomplish the task since the number of notes grows quickly making it more likely for this note to be overlooked. Saleem et al. shared similar findings, mostly with regard to standardised data entry templates not allowing sufficient level of specificity (Saleem et al., 2009).

The issue of data customisation also relates to the previously discussed need for being able to edit the data in a way that would allow emphasising the information the user perceives as relevant (Lium et al., 2008; Saleem et al., 2009). Both of those problems come down to current systems’ not giving their users enough flexibility and plasticity in creating the content.

**Visualisations and other forms of data presentation**

Another one of the findings was a need for more options for data visualisations and representation. Some of the possible examples of such options include:

- Graphs to track metrics and look for trends over time (Blijleven et al., 2017; Flanagan et al., 2013; Saleem et al., 2009), instead doctors were drawing graphs on paper
- A functionality to compare values in a spreadsheet-like manner (Saleem et al., 2009), instead doctors were using a paper spreadsheet
- A visual representation of a body or a body part (Blijleven et al., 2017), instead doctors were textually describing the location of an injury/problem, or drawing a body on paper and later scanning the drawing into an EHR

The common lack of those options is somewhat surprising, considering how easy it is to digitally generate visualisations of data that’s already in the system and how helpful they can be.

**Better data structure and navigation**

This relates heavily to issues already described in section 3.2. Nygren et al. in the conclusion of their paper provided the following implications on how to structure data in an EHR:

a) **Expose lots of information to the user, but with a high degree of positional and textural structure. Enable information items to attract the reader’s attention even if it is not asked for.**

b) **Orientation and navigation is essential. Attention must be paid to graphical and textural features of the text presented. These should be controlled to indicate logical relations in order to enable effective limitation of search space. Make it possible for the user to use positional clues in re-reading and in search. It should be effortless to go both forwards and backwards and also to trace a referral form and then return to the page being read.**

c) **Let the user see the whole record in the sense that what is there is all there is. Thus make it possible to reflect upon what is not there. This means that the record should have no concealed levels. (E Nygren et al., 1992)**
3.7 Final Comments

There is a discrepancy in the literature regarding how the use of EHRs is addressed. A lot of papers seem to be stuck in something that feels like a previous stage, which is researching whether EHRs are beneficial in general, or comparing efficiency of EHRs to the paper counterparts. There is less literature addressing how good EHRs are themselves, without comparing them to paper, and what can be improved about them. One of the reasons for it could be that many of those papers are addressing situations of hospitals and clinics in the US, where adaptation of EHRs is still ongoing, and the EHRs’ prevalence is not as significant as it is in Sweden.

Additionally, it can be problematic to judge the relevance of the problems described in the literature since medical technology is constantly being developed and updated, making some of the described issues no longer applicable to the current systems.

What the literature study has shown is that no single most dominant EHR problem can be pinpointed. EHR systems are very broad and often very complicated, and the issues affecting their efficacy are diverse. However, some define usability issues as the most prominently problematic area – “Usability and usefulness were commonly agreed to be critical features of EHR implementations, and despite continuous improvements, they required further improvement” (Nguyen et al., 2014).

This can have its roots in the relationship between paper- and electronic-based health records. In the worst cases, poor adaptation of a paper-based record to an electronic version brings the worst of both worlds – it strips the ‘electronic paper’ from its visual and tangible advantages and adds the information clutter and abundance of options topped up with unclear navigation.
4  INTERVIEW AND OBSERVATIONAL STUDY

The studies conducted for this thesis were separated into two stages. The first stage was an interview and observational study, the second one was a design study. The studies were conducted in succession, with the design study taking the findings from the preceding interview and observational study as its input. The studies are therefore described in separate chapters, with their own method, results and analysis sections.

4.1  METHOD

The study consisted of two interviews, two observational studies conducted using contextual inquiry methods, as well as a training session of the EHR system used in the hospital. All of the interviewed physicians worked in Akademiska Sjukhuset in Uppsala, all of the observations as well as the training session took place in this hospital as well.

4.1.1  Interviews

Both interviews were conducted in English. Insights from the first interview are based on taken notes, while the second interview was audio recorded and later transcribed.

4.1.1.1  First interview – setting delimitations

The first interview was conducted with an anaesthesiologist working in Akademiska Sjukhuset. The interview lasted under half an hour and its goal was to help set the delimitations for the thesis.

The interview was mostly unstructured, with a couple of discussion points prepared. Those included possible circumstances for using an EHR system, as well as differences in use between various types of medical practice.

4.1.1.2  Second interview – insights into practical use of EHR system

The second interviewee was an orthopaedic surgeon working in Akademiska Sjukhuset in the field trauma surgery, which involves dealing with fractures, wounds and injuries. His usual work settings include:

- Surgery
- Ward - where post-operation patients are staying until they can be released
- Polyclinics – which includes visits of post-operation patients come for follow-ups, as well as other patients from a waiting list, usually treated for longer-lasting problems like old fractures

The interview was about an hour long. The first part of the interview took place in a conference room and later proceed to an office room with access to Cosmic.

The interview was conducted in a semi-structured way. The main point was to find out more in-depth what are the most prominent circumstances under which orthopaedic surgeons use the EHR system, and what kind of data they need to conduct their work.

The questions were constructed based on the literature findings. Some of the example questions include:

- In what setting do you usually need to use the medical record?
- Is there some knowledge you need or would prefer to have visible at all times while meeting with the patient?
A full list of prepared questions is available in Appendix A – Interview Questions. Additional questions concerned the EHR system used in the hospital (Cosmic), namely how it is structured and how do physicians use it.

4.1.2 Observations
Observations took place in the outpatient clinic of the orthopaedics department in Akademiska Sjukhuset, one week apart from one another. In both cases, the observations lasted around three hours, from 9 am to 12 am.

Both observations took place in a staff room, where the physicians were preparing themselves for a visit before seeing a patient in a separate examination room. The room had five computer stations, three of which had two monitors attached to them. The observations did not continue into the examination room since the goal was to study how the physicians interact with an EHR system, and in this specific setting, physicians were using the system only in the staff room.

In both cases multiple physicians worked simultaneously in the staff room, some joined by medical students. That gave the opportunity to observe interactions of multiple users with the same system and later compare the findings.

Even though the physicians were conducting their work in Swedish, all of them spoke English and were able to explain their work and reply to questions in that language.

The sessions included physicians explaining their work process, as well as answering opportunistic questions regarding the task they were currently performing. The insights were saved by note taking and occasional audio recording.

4.1.3 Cosmic training session
The session took place in a training room on the hospital grounds and was about an hour and a half long. It was conducted partially in Swedish and partially in English.

The training session was run by two hospital employees, one of them being a proficient user of Cosmic and leading the presentation, the other one providing the supporting information. Part of their work responsibilities included representing the hospital in the communication with Cambio (the company developing the Cosmic system).

The purpose of the session was to get some hands-on experience with the Cosmic software used in the hospital. The room in which the session took place was a computer lab, with each computer being connected to two screens to mimic the working conditions in the hospital.

4.2 Results
The main objective of the first interview was to help narrow down the delimitations for the thesis. The interview helped to conclude that the focusing point of the study would be the use of the EHR system by physicians from speciality clinics within the hospital, rather than e.g. General Practitioners. The chosen speciality was orthopaedic surgery, and from this point on the interviews and observations were focused on physicians working within this clinic.

Findings from the second interview and the two observation sessions are described together. The reason for it is that they were found to be complementary, often offering a different level of detail, or a different perspective, on the same issue.
The findings were grouped based on themes that emerged while combining the research notes. The sections cover the areas of:

- Physicians’ working environment and work process
- Analysis of some of the Cosmic functionalities
- Their interaction with the EHR system Cosmic
- System-related issues
- Other relevant factors that came up while conducting the study

The last section contains insights from the last stage of research, Cosmic training session.

4.2.1 Setting
During the first observation, there were five to six doctors in the room as well as two medical students. There were over 20 patients scheduled for that time slot, with no patient directly assigned to a specific doctor. Instead, the doctors took on patients as they showed up in the clinic. The second observation was a bit different – each doctor had patients assigned directly to them, usually from the referrals from General Practitioners (GPs). The doctor observed during that time had four visits scheduled, each 45 minutes long.

4.2.2 Circumstances of use of the medical records
The research identified the two most common ways in which medical records are typically used, which included getting the big picture and a case-specific preparation for the visit. The two cases are described in more detail in table 1.

As a variation of those two cases, an example of a patient with scoliosis was given. In this specific case, a check-up usually takes place yearly to monitor if the condition is progressing and if surgery needed. Preparation for such check-ups requires getting through a couple years’ worth of notes.

In order to prepare for the visit, the general pattern of steps taken to prepare for the visit was:

- Finding the patient in Cosmic – usually through choosing a patient list, and then pasting the patient’s personal number into the journal
- Locating and reading the relevant information in Cosmic
- Finding the relevant X-ray file in the X-ray software – by pasting the patient’s personal number from Cosmic, and then choosing the relevant file from the list of X-ray assigned to the patient. Since the observed physicians were orthopaedists, a big part of the preparation, usually about half of the total time, was studying the X-rays in a separate software system.
### The big picture

| When an extensive knowledge of medical history is required in order to make an informed choice on patient’s further treatment, such as planning a surgery |

### Case specific

| When only a knowledge of recent events is required, for example preparing for a six-weeks follow-up after a surgery |

### The scope of information needed

| Information on patient’s overall health status |

| Only the most recent information: “Because, why is he here now? He had a dislocated shoulder so it’s not very interesting what happened [earlier].” |

### What information is needed

| Current medical problems; Previous medical problems; Patient’s general status – such as are they an elite athlete or an older person using a walker, do they do a lot of manual work, do they drink substantially etc.; Any things of particular interest – e.g. allergic to some pharmaceuticals, any adverse events in prior surgeries, bleeding disorders or any other important factor that could lead to complications during a surgery |

| Fracture details; Were there any difficulties during a surgery; Is there anything in particular to look for |

### Steps taken to find the data

| Checking the patient’s overview, to find patient’s previously made diagnosis, looking for the relevant notes in the journal; speaking to the patient |

| Reading one or two first notes in the journal, analysing the X-rays |

### Comments from the observations

| Showcased by one physician |

| The most frequently observed type of search |

### Table 1 – The ‘big picture’ and ‘case-specific’ circumstances of use of the medical record

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Questions to be answered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis and background</td>
<td>Why is the patient here, what kind of surgery has been performed, is the diagnosis fixed</td>
</tr>
<tr>
<td>Patient’s current status</td>
<td>How do they feel, are they in pain</td>
</tr>
<tr>
<td>Vitals</td>
<td>The latest blood samples, blood pressure, pulse, general bodily status</td>
</tr>
<tr>
<td>Bodily fluids</td>
<td>Does the patient have enough blood, do they need blood transfusions</td>
</tr>
<tr>
<td>Medication</td>
<td>What is it now, does anything need to be adjusted, do they have antibiotics or painkillers</td>
</tr>
<tr>
<td>Plan</td>
<td>What needs to be done from now on, should the patient go to rehab, do they need surgery etc.</td>
</tr>
</tbody>
</table>

### Table 2 – Information needed for the post-operation patient check-up

The second observation session consisted entirely of visits initiated by referrals from GPs. In those cases, the physician’s preparation would start with reading the referral. If
the case was simple and the referral descriptive enough, just reading the referral and checking the X-rays was sufficient. Otherwise, if the referral was vague or the case complicated, physicians would also read the relevant progress notes. Sometimes, if the case was simple, physicians would opt for asking the patient about the problem’s background rather than read the notes.

4.2.3 Notes – the main source of information
The journal with the notes is the main tool when it comes to documenting the information in the EHR. The notes are written as a summary of each medical event, together creating a medical history file for a patient. They are free text-based, with text separated into fields marked with corresponding headings. The headings vary depending on the type of a note, which is selected to match the current medical setting, for example a surgery note, a follow-up note, a note after a phone call with a patient etc. The notes use the International Classification of Diseases codes (ICD codes), usually for specifying the diagnosis.

The structural organisation of notes
The notes are separated into folders with regard to the hospital’s administrative unit rather than with regard to a disease or medical issue. This doesn’t mean that each clinic has its own folder since multiple clinics can combine to a unit. This way of arranging the notes makes it more difficult to efficiently browse the record, as explained by one physician:

*If we treat someone with cardiological condition, then the note will of course be an orthopaedic note, so the cardiologist won’t find it without having a look at the orthopaedics stack of information. It’s like having a library where you have sorted the books after [which] librarian put them on the shelf and at what date, but not what the book is about.*

Relating to the previously described case of preparing for a yearly check-up with a patient with scoliosis, the task of finding all the previous relevant notes would be easy if the patient stayed relatively healthy and didn’t have orthopaedic-related visits in the meantime, but if there have been any more surgeries happening in between, there could be tens to hundreds of additional notes.

By default, upon opening the journal physicians see notes from their own department in the hospital. If patient’s previous appointment also took place there, they don’t need to perform any additional actions. However, if the previous visit took place somewhere else, physicians had to locate the folder containing notes from the unit or clinic in question.

Privacy
For privacy reasons, the folder list does not contain any visual cues on whether or not there are any notes actually in the folder. As explained by one of the physicians, “You’re not really supposed to read everything. I mean, if he’s here for the shoulder, why would I read his psychiatry notes?” Additionally, patients can block folders from the physicians’ access if they want for some information to stay private. Physicians can then access those notes only if there is an emergency situation. Since the folders don’t follow an issue but an administrative setting instead, if the patient wants to block some notes, the entire folder needs to be blocked. This had in the past led to confusing situations: “That means, and that has happened, that I have seen a patient at the infection clinic and made my own
Strategies for browsing the notes
The physicians usually know what they are looking for, so they scan the notes until they find it: “Usually it comes to a point when you’re satisfied with the information and you don’t have to keep on looking.”

If they want to get a bigger picture of patient’s medical history, physicians can access a folder that contains all of the progress notes together, sorted chronologically, with the most recent note on top of the list. This is a good way to get an overview of a patient’s most important or most recurring health problems. However, it requires getting through a lot of text, including both the relevant and irrelevant information: “So this can show me everything. Maybe too much [...] So, she’s been to the gynaecologist 50 times, or to the psychiatrist and I don’t really want to see this.” The folder containing all notes is one of the positions on the list of all available folders, it’s placement on the list is determined alphabetically and there is no visual element distinguishing it from the rest of the list.

Multiple physicians mentioned that it is common to find among the progress notes a summary note condensing all the previous medical history, created to make the search for information easier for the next physicians searching through this file. This workaround helps them to browse the record faster, but in the end leads to redundancy in information and increase of the total volume of the record, further aggravating the problem in the long term.

There is no functionality affording searching or filtering of the notes. To find information, physicians need to scroll long enough until they reach it: “Some patients have a lot of notes. So, if I know I’m looking for something from 2007 it could be a few hundreds of notes before, so [I need to scroll through it all], I can’t go back and tell the computer [to show me the notes from 2007].”

Creating new notes
In the clinic where the observations took place, the physicians did not write the notes, but instead they dictated them using audio recording devices attached to the computers. The audio recording is saved together with information like who is the patient and when did the visit happen and is later transcribed by the secretaries. The physician can mark the note as important, then it is usually transcribed on the same day, otherwise it can take around a week. When the note is transcribed the physician gets notified with a message. They then can check it once more, make changes if those are needed, and finally approve it (sign it), before it’s officially visible in the system. After signing the note, the audio recording gets deleted.

As mentioned before, the content of a note is separated into fields marked with assigned headings, often very detailed. Separating the text so it fits into those fields is done by the secretaries, since the physicians dictate the notes freely, without addressing specific fields. It is also the secretaries who chose the type of a note suitable for the situation, out of the list containing hundreds of possible types. Other secretaries’ responsibilities include assigning ICD codes to the notes.

All of this means that secretaries are significantly more fluent than the physicians in the notes’ structures, most importantly in the ICD coding. Because of that, occasionally the
secretaries correct the codes the doctors have dictated. While this can be helpful, since secretaries are the ones that are trained in the use of ICD codes, sometimes it can lead to problems. One physician explained it on the example of the Swedish fracture registry. Every fracture treated in a hospital needs to be registered, therefore a note on a visit concerning an already registered fracture would be coded as ‘the control after a registered fracture’. Otherwise, if the secretary changes it to a code representing a visit about a new fracture, the information in the fracture registry will be updated to look as if the patient had two separate fractures, rather than one fracture attended to twice.

4.2.4 Cosmic – some of the functionalities and interactions
Cosmic offers a big number of functionalities and settings, the ones described in this section are only the ones most prevalent during the observations.

Logging in
Multiple physicians stressed the importance of having a short password since they’re required to log in multiple times per day. The users can log in either by typing in their passwords or by scanning their access cards in the scanner connected to the computer. However, the observed physicians seem to rely on their password visibly more than on the access card. The reason for that could be that they need to log in to multiple systems during the day, and the access card can be used only to log in to Cosmic.

“My shortcuts” panel
At the very top of the screen, Cosmic offers a toolbar with all of the possible screens listed in a dropdown, as presented in the figure 1. The dropdown contained nested options, sometimes on multiple levels, and on a very bottom had an arrow allowing to switch to the second page of the dropdown. Each position on the list, unless it contained nested options, had a screen assigned to it, making the total number of available screens most likely well over hundred.

Figure 1 – A mock-up of the dropdown containing navigation shortcuts to the screens available in the system (author’s reproduction. The dropdown on the right presents the state visible after clicking the ‘next’ button on the bottom of the dropdown on the left.
To get quicker access to the most frequently used screens, the user can mark an option on the list with a star, which makes it visible in the panel called *my shortcuts*. *My shortcuts* is a list that is full-screen length, on the far left of the screen.

Choosing a position from the *my shortcuts* panel loads the selected screen, and marks the position in a different colour on the list. In the majority of the cases, only one screen is visible at the time. However, only distinctively closing a screen will unmark the position on the list. This means that selecting a new position on the list without closing the previously opened screen will leave multiple options marked on the *my shortcuts* panel. This leads to ambiguity, making it impossible to know which screen is currently viewed by just looking at the *my shortcuts* panel. When asked about it, the physicians said that different colour of the position on the list means that this screen is loaded.

The contents of the panel are customised and vary depending on the user, but some of the most commonly recurring positions included:

- Journal
- Medicine list
- Patient’s overview
- Create new dictation
- Write new note

The contents of the panel were not sorted alphabetically and did not seem to be sorted in any particular way, possibly the order of items reflected the chronological order of being added to the panel.

**Patients list module**
The list of patients assigned for the day had its own, separate screen. The list contained information like patient’s details and scheduled time slot. The positions on the list were colour coded: green background meant that the patient has not arrived yet, red background meant that the patient has arrived and is waiting. Two more colours, beige and yellow, meant that either the visit is ongoing or that the visit is completed. The colours were rather pale and had low contrast, but were distinguishable from one another.

**Patient’s overview module**
The patient’s overview module consisted of a set of widgets:

- *Diagnosis* – most recently made diagnosis for the patient, a non-scrollable list showing 21 positions. The diagnoses were extracted from all of the available notes, rather than being bound by an administrative unit as notes were. There was the possibility to sort them by a body region, such as respiratory organs, circulatory organs etc.
- *Lab results*
- *Clinical parameters* – such as breathing frequency, pulse, body temperature, etc. This widget shows the most recent values, together with a date and time of when the parameters were measured. In the case showcased by the physician demonstrating the use of patient’s overview module, the parameters were two weeks old
- *Medication* – the most recently prescribed
- *Scheduled visits*
This module is a relatively new addition, at the point when the observations were conducted it was about six months old. It was not a commonly used tool during the observations, likely because it is more relevant for monitoring a patient’s status while they’re admitted to the hospital than it is for the outpatients. A physician described the tool as: “When you’re at the ward, when you want to follow someone from day to day, this is very good. And in this [the clinical parameters] you can also get the log, if he’s checked two times a day you can see how it varies.”

This module was very interesting to discover because lack of any sort of patient overview was a commonly mentioned complaint in the literature. However, it still does not offer an overview of the patient’s general medical history.

**Referrals**
The referrals were available from the list of scheduled patients, which is a separate screen from the journal where the notes were kept. There is no linking between a referral and a medical unit from which the referral was sent. To find the progress note relevant to the referral, first a folder which contains it had to be found. To do that, the physician had to read the name of the unit on the referral, then find the corresponding folder in a list of all the medical units from Uppsala Region, sorted alphabetically.

**Medicine list**
The medicine list was presented in a form of a timeline, with the time marked horizontally, and each medicine being marked with a separate line going above the timeline. When certain medicine was to be taken, a glyph was placed on a line representing the medicine name, above the corresponding time on the timeline. The glyphs represented a type of medicine, which included injection, pill, inhalation, infusion and a drip. The colour of the glyph represented the current state of that medicine intake, red meaning that the medicine has not been taken yet and blue that it has been taken. Another glyph with a different colour was used if the medicine intake was cancelled, and one more if the medicine was ready to be picked up. Additionally, a symbol of half of a pill represented part of a dose instead of a full one. The list was interactive, allowing the physician to click on a glyph to perform actions, including skipping the medicine, changing the dose etc.

What makes that module interesting is that it presents a rich use of glyphs, which otherwise was not common in the system. However, the exact way in which the module should be used is a bit unclear. The medicine view is available for every patient, most of which are not admitted to the hospital, therefore their medicine is never being marked as taken. The glyphs are placed on a specific time, such as 8:00, while the actual time of medicine intake by patients who are taking the medicine at home can vary a lot, especially since medicine prescriptions rarely come with a designated intake time slot. Similarly to the patient’s overview module, this functionality seems to be useful only for the patients who are currently admitted.

**The alerts symbol**
The symbol was visible in the journal, close to the patient’s name. By default the symbol was empty, the presence of the shapes inside suggested that there is an important piece of information to be known about the patient. Placement, colour and shape of the element contributed to how the warning should be interpreted. The legend for the symbol is presented in the figure 2.
Hovering above the symbol showed a description of the problem being represented, clicking on the symbol allowed editing the content of the description. Most commonly noted reasons for use of the symbol during the observations included allergies and blood-related issues.

![Legend of the symbol containing alerts about the patient. Author’s reproduction based on original.](image)

**Figure 2 - The legend of the symbol containing alerts about the patient. Author’s reproduction based on original.**

The symbol fulfils its purpose partially. The colourful elements catch attention in an otherwise mostly white and blue interface, but in most cases, the users didn’t seem to be able to distinguish the coding that placements of elements in the symbol offered. They would be notified that there is a problem but would have to hover the symbol anyway to learn about what the problem was exactly.

### 4.2.5 Strategies for using the system

Similarly to the EHR systems described in the literature, in Cosmic the knowledge is spread between different modules and multiple screens, requiring its users to do a lot of navigating through the system. There is no workflow affording efficient data browsing, which as described by the users, requires them to develop their own strategies: “It’s like a big forest, you can’t just wander around and cover all the areas, you have to follow your known trails. And you can see that if you sit next to a doctor at the policlinics or performing rounds, you can see they have this special sort of ‘look for this there’ way of working.”

Users tend to not rely on filtering and searching tools, making it even more difficult to navigate through the abundance of data: “The filter setting is complicated and there’s always a risk that you filter out the information you’re interested in, because the system doesn’t understand what you’re looking for.”

Both of those factors make browsing through patients’ medical history a cumbersome task. In the end, users are choosing which screens to switch to based on their own habits and preference:
You usually have a set of questions that you want answered, and that’s sort of what you enter to the EHR system and look for. And since the EHR system contains a lot of information, a lot of values, you have these set of questions, you know where to find the answer, you pick them [up] together and you sort of just screen through the rest.

Over time users create their own checklist for searching data similar to the lists described before, either remembered in their heads or written down on paper. This practice is especially needed in the Emergency Response (ER) units, where physicians often get interrupted in their work.

This can make information browsing a time-consuming process, although physicians learn the system over time and get progressively faster. In simple cases it’s usually the top couple of notes that are needed, the finding of which doesn’t require much time, but the physicians described that the process gets longer with more complex and spread over time problems:

I remember, there was one little guy, 8 years old, had 8 prior surgeries in his back because of a severe scoliosis. So, I thought [I will] just make a short, condensed version of why, when did the surgery get performed, for what reason. [...] And this, just scrolling through [the notes] as fast as I could, and it took me 50 minutes, just to make this small note for the surgeries. Because there wasn’t any way to sort of filter information.

The physicians’ personal workflows will also vary depending on the circumstances the work is carried out in. For example, work in an outpatient clinic is relatively easier compared to other environments, since the physician needs to remember data on only one patient at the time. While working at the ward though, amount of data to be handled requires the physicians to create supporting memory aids:

At the ward, there’s a different story. Because usually you go through the bunch of patients with the nurse, and then you walk around to the patients, and then you forgot everything you talked about. So, then you need to make small notes, what to ask the patient, what issues and needs to be handled. And also, you’ll get interrupted many, many times. So, you need to take notes [...] so you don’t forget it.

4.2.6 Effect on workflows

Lack of workflows was one of the most recurring issues throughout the first interview. Similarly to the abundance of data offered by Cosmic, it also offers multiple functionalities regarding various aspects of physicians’ work, including ordering medicine or tests, writing prescriptions, referrals, etc. Those functionalities, however, are not connected to workflows nor do they afford any form of workflow creation. For example, the equivalent of a patient discharge workflow has been described as follows:

If we do the same work [discharge a patient] in Cosmic then we need to flip to the prescription view, we need to flip to this other view, we need to flip to the dictation what we do, so we need to flip it between all those different kinds of views in order to perform this very simple task which is discharging a patient. There’s no sort of unified view where you can do all of this.
Having a way to customise one’s own workflow in Cosmic was named the feature that was most lacking from the EHR software. However, while it would be very beneficial to have the workflows implemented in the software, customising those workflows to fit the needs of various hospital employees would require a lot of research: “It would be extremely difficult to make workflows because they all vary. So that’s why people have these papers and notes [instead.]”

4.2.7 Overall usability
The EHR system used in the hospital gave an impression of being difficult to navigate and not intuitive enough. Many of the observed physicians occasionally took quite some time to locate buttons, functionalities or just navigate through a process. The interfaces contained close to no visual cues or elements supporting efficient visual search. The system’s usual pitfall was that the user couldn’t go any further in a given process, such as ordering medication, but no sufficient supporting information on what’s wrong was being given by the system, leaving the user alone to figure out what should be attended to. Occasionally, the system would surprise users with unexpected pop-ups, either caused accidentally by the users themselves, or ones programmed to be there, such as a pop-up showing while ordering an X-ray for an elderly man asking if the patient is pregnant.

While over time the users get used to the most commonly performed actions, the rarely performed or the unusual ones were described as being troublesome: “You need to ask if anyone else knows how to do it, and you have these notes on the walls that say like if you’re going like this make this referral, and here you have to do like this.”

The problem gets further aggravated considering that physicians are required to use other software during their work, each having its structure and navigation tools: “If you talk to people that are sort of experts on the system they would say “oh, you need more education, there’s so much you can do here!” But it isn’t, because we have [X-ray] system also, and we have several more systems with their own logic so just doing some basic actions here is quite enough.”

4.2.8 Main requirements towards the system
Having the possibility to in some way highlight the data that’s especially important was one of the things identified as lacking in the system. Since a lot of data is being inputted to the system and no sufficient way of organising and filtering it is provided, missing an important piece of information is likely, and can have real-life consequences and lead to additional costs:

It’s been many times that the information has been lost just two or three notes down and no one reads it, very common. We have a patient that needs an MRI, but then we find out that she has metal in her spine, old implants. So, we couldn’t do an MRI, so I wrote down ‘Not possible to make an MRI’. Next week, same thing happens, she needs an MRI, they order the MRI, they find out that she has metal in her spine, and it can’t be done.

Similarly to the literature findings, there is lack of trust that information considered important will be noticed, leading the users to taking additional steps.

And if you have something that’s really important, what you do is you write it in the EHR, you make a big, shiny post-it sign and put on the papers [...].
And what I do then is I write down in the EHR, I write it in the operation planning program, so everyone in the OR will see this, I make a post-it note that follows the patient down, and if I have the chance I tell it to the people also. You have to do at least those three things. EHR, paper and talk, to be really certain that it happens.

One more example of similar behaviour was observed when a physician accidentally dictated a note for the wrong patient. He has then written a note attached to the recording informing the secretary to which patient the recording should be correctly assigned to, and sometime later also called the secretary to make sure she got the information.

Additional functionality that the system is lacking is including pictures as attachments to the notes, which are a very useful and commonly used tool for orthopaedic surgeons. The users are being discouraged from uploading the photos into the system in general, in order to save space. That leads the users to email and text the photos to themselves outside of an EHR. In practice, that means that photos that should be attached to patient’s file, are instead kept in physician’s personal phones. This workaround is commonly used by orthopaedic doctors.

Finally, a big problem and safety hazard is lack of information exchange between Cosmic, which is the hospital's main EHR system, and another EHR used in the intensive care unit. The problems arise when a patient is being transferred multiple times between intensive care and other units in the hospital, and the information doesn’t follow. As an example, a case of a post-operation patient was given, who after the surgery got transferred to an intensive care unit. The initial unit gave the patient a dose of a strong antibiotic, and because of lack of access to information flow, the intensive care unit also gave the patient a dose of that antibiotic, leading to an overdose and kidneys shut down.

### 4.2.9 Paper workarounds

Observing the paper workarounds performed by physicians during their work gives a very interesting insight into what could be improved in the system.

Overall two main workarounds were observed. The first one concerns the first observation session when patients were not assigned directly to a specific physician. To manage the distribution of patients to physicians, the nurse printed out from the EHR system the list of patients scheduled for that time period and hung it on the wall in the staff room where physicians were preparing for visits.

Once a patient arrived, the nurse would write down on the shared list the number of the examination room that the patient was taken to. That would prompt a free physician to ‘claim’ the patient, by writing their initials next to the room number. Once the visit was done, the physician would scratch out the position from the list.

That same list was available in the EHR system, but during work structure like this one, the staff opted for the paper workaround. They gave a couple of reasons for it, which included:

- Some of the physicians joining might not have access to the list in the system
- This way of working is easier for the nurses. Additionally, a nurse walking into the room better notifies the physicians about new patient arrival than a change in the system would.
- The nurse later relies on this document to fix the documentation if anything is out of order, and to validate the online state of data with the one on the document.

It’s worth noting however that this way of working was used only during this type of setting, which is multiple physicians meeting a big number of patients without having them directly assigned to themselves. In other occasions, they would rely on the EHR version of the patient list.

Another interesting paper workaround involved referrals. After writing a referral to a physiotherapist, a physician would print it and carry it to the physiotherapist room, which was next door. The referral was also sent digitally – the printed version wasn’t a substitute, but an additional way of communicating. As explained by the physician, that was the way the therapist preferred to work, with printed copies over the digital versions. “It’s much easier. She’s not old, she just doesn’t like computers.”

Both of those examples show that the digital versions of the previously existing paperwork procedures did not offer enough improvements and advantages to convince users to rely on them instead.

### 4.2.10 Other software

This section briefly presents other software orthopaedic doctors were relying on during the conducted observations. As mentioned before, some of the units within the hospital use another EHR system called Metavision, which however is not presented here since it is not a part of orthopaedic doctors’ work, and its use in the hospital is limited.

**Radiology viewing software**

The use of this software was very prominent among all of the observed physicians, and it was not uncommon to see them spend more of their preparation time viewing the X-rays than reading the notes.

The X-ray scans were often accompanied by the radiologist comment. The software allowed the users to calibrate the scan, as well as offered tools including measuring the distance and measuring the angle. To find the relevant scan, the physician would first paste the patient’s personal number from Cosmic, and then choose an X-ray file from the list. The list was sorted chronologically and some of the positions were marked with different colours, such as blue and red. When asked, the physicians said they don’t know the reasoning behind the colour coding.

**Surgery planning software**

The software was browser-based, and very much outdated looking. The physicians described it as a very close copy of paper surgery planning records, just digitalised: “It’s basically paper but on the computer, so you can’t do anything with it”. The system offered a long page of information, not allowing much interaction.

Apart from the presentation of that system, its use in real context has been observed once. To schedule surgery two physicians were working on two computers simultaneously, discussing the input together before confirming the changes. One of
them inputting the information to Cosmic, and the other one to the surgery planning software.

Software for viewing scans of older documents
The use of digital journal notes in the orthopaedics clinic dates to a year 2006, meaning that medical documentation done before that was scanned and inputted to the viewing software. The software has been presented by one of the physicians, its use has not been observed in a real context.

The scans included both full documents as well as post its or pieces of paper with scribbles on it. The system provided additional information if needed, but the physicians did not treat it as an unquestionable source: "You can’t count on it that it’s complete. Many times, they’ve been in another part of a country or... Most of the times, it’s not complete."

4.2.11 Cosmic training session
The training session has confirmed that the vastness of Cosmic makes it almost impossible to fully master the system. The instructor leading the lesson was confident in navigating some parts of the system, but had to take her time and explore before being able to navigate other, not as frequently used parts. The number of screens and options available overall was overwhelming, and the instructor occasionally had trouble navigating through it. The session also confirmed that the use of glyphs and visual aids is scarce.

That problem is further aggravated by inconsistent navigation and layout of screens, making it impossible to become a fluent user, since mastering some section of the system doesn’t necessarily make it easier to learn other sections.

The two hospital employees running the session were also working as hospital representatives in communication with Cambio, the Cosmic manufacturer. They have confirmed that the hospital cooperates closely with the company, and that it is possible for them to suggest changes to consider for the future versions of the software. They have also said that since the hospital’s cooperation with Cambio is so close, it ends up using most of the modules Cambio is offering, one of the employees referring to the hospital as ‘Cambioland’.

Akademiska Sjukhuset is a very big institution, with multiple and often very specialised units. Therefore, it is likely that the extent of options currently available is actually needed and made use of. However, the users definitely don’t need access to all of the functionalities at all times, and it’s hard to escape the feeling that tailoring the subset of visible screens to reduce its number based on who the user is would be beneficial to effective use.

4.3 Analysis
Overall, many of the issues identified in the literature have to some degree also been observed in the hospital’s setting. The most prominent ones that had the most impact on the final design include:

- Physicians commonly perform a workaround of writing a progress note containing the summary of patients’ medical history
- The navigation is difficult, because of the relevant information and pieces of action being spread through different screens
- There is a need for highlighting the data considered most important
- Amount of data available in the notes is too vast for the physicians to get through efficiently, that problem being aggravated by the content of the progress notes being repeated
- There is lack of trust that information inputted into the system will be noticed and will reach the people it's meant to reach
- Various usability problems exist in the system. Some of the issues must be well known to the health care providers, since interestingly on their website Uppsala Region offers a document titled covering known issues with Cosmic, which as of May 2018 lists about 30 positions (“Known errors,” 2018)

The issues identified in the literature that were not confirmed by the interview and observation study include:

- Using the EHR system gives worse body language to the patient – not applicable here, since in the observed clinic the physicians were using the system in a separate room. When asked about it, the physicians said it is more likely this is a problem concerning GPs
- Forms in the EHR system limit doctor's input – not applicable with Cosmic, since the fields are free text-based.

Additionally, some of the interviewed physicians seemed to share the way of thinking that currently existing medical software design is too influenced by previously existing paper-based systems.

I think they started with a kind of use cases where they observe users sitting with the paper-based system. But they didn't dig deeper to find the real needs, the real processes. They just stopped that at the surface saying 'Ok so now they're doing this and now they're looking at the samples, the blood samples, now they're looking at this document, the medical record', and so on. And this [Cosmic] is actually the paper, the digital paper system. And my theory is that it isn't because they didn't do their homework of talking to the users and looking at the users, but they didn't understand what they saw. And the users couldn't either describe what they were doing because, I mean, doctors and nurses don't know anything about digital systems before they had it.

While it’s impossible to know if that was the process, this statement does corresponds with similar opinions found in the literature (Jensen & Kjærgaard, 2010; Lium et al., 2008).
5  **DESIGN STUDY**

5.1 **METHOD**

Work on the design study was performed iteratively. Sketches were often evaluated, creating input for the next iteration. Sections in the chapter represent the most significant stages of the design process.

![Timeline of the design study](image)

*Figure 3 – The timeline of the design study*

5.1.1 **First Sketches**

The findings from the literature study as well as the interview and observational study were used as an input to the first sketches. The sketches were created using Balsamiq³.

The objectives of this stage were to create a general concept of how the system should work, and what kind of data should be represented. This stage consisted of about three iterations.

5.1.2 **Design Workshop**

The second stage of the design study was conducting a design workshop. The participants were thesis supervisor, two HCI students and the author. The objective of the workshop was to further brainstorm ideas for the interface design.

The meeting started with a briefing introducing the topic, which covered the following areas:

- Introduction of the concept of the EHR
- EHR’s use, including the most commonly occurring problems and workarounds
- Visual aspects of paper-based health records that users found helpful
- List of data sets identified as potential content to include in the sketches (presented in section 5.2.1.2)
- Sketches created by the author so far (presented in section 5.2.1)

The full content of the design brief can be found in Appendix C – Design brief materials. Participants asked questions through the briefing, which was later followed by a short discussion. In order to not influence participants’ design choices, the design brief did not include any pictures or representations of existing EHR systems.

Afterwards, participants separated into two working pairs sketching independently. Participants used pens and paper as sketching material, as well as a whiteboard. Work in

³ Balsamiq – mock-up and wireframing tool, allowing to create sketch-like mock-ups. [https://balsamiq.com](https://balsamiq.com)
pairs took approximately 50 minutes and was followed by the presentation of the ideas and a discussion.

### 5.1.3 Further Sketches and evaluation

In this stage new sketches were produced, using as an input the sketches made in previous stages as well as concepts that emerged during the design workshop. Afterwards, an evaluation with a physician was conducted, about 45 minutes long. During this session, the physician was presented with sketches and gave his feedback.

Majority of the sketches were done using Balsamiq. In a later sketching phase, the online tool Figma\(^4\) was used for designing the problem list element, in order to work out the concept in more detail than what Balsamiq allowed. The goal of this phase was to finalise the concept for the interface and improve on the sketches until enough detail was achieved to move to the prototyping phase.

### 5.1.4 Prototyping

The prototype mostly recreated the final sketch, with occasional changes. The main objective of this part was to create an interface that would visually resemble more the real solution compared to the previously drawing-like sketches, as well as adding interactions. The prototype was created using Axure\(^5\).

### 5.1.5 Final Evaluation

The final evaluation took place in the hospital and lasted around 45 minutes. The participants were three orthopaedic surgeons, two out of which participated in the previous stages and were already familiar with the project.

The prototype was presented on one of the computers available in the hospital. A short introduction of the system was conducted first, explaining the concepts behind the prototype. After this the participants explored the prototype, providing their insights and asking questions. The first two physicians provided feedback together, the third physician gave feedback alone.

### 5.2 RESULTS

#### 5.2.1 First Sketches – the general concept

Sketches for two screens were created during the process. The first one was the preview visible while browsing the patient’s data, and the second one was the dashboard containing a bigger overview of available options.

#### 5.2.1.1 First Screen: Patient’s preview

Several layouts of this screen were created, mostly following the same concept. The first sketch for this screen is presented in figure 4, additional ones can be found in Appendix B – Sketches.

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Figure 4 – The first version of the patient’s preview screen

The layout of this screen is based on a concept of threads. The idea was to group the notes not by the administrative setting, but by the medical issue the note relates to. The threads, i.e. the patient’s main medical issues, are listed on the column on the left. They are placed in a chronological order of when they were last attended to, with the outdated threads marked in a paler background colour and font. This design choice was grounded in the fact that when physicians would use the journal, they would do it almost exclusively to follow a specific problem, and notes concerning other problems were irrelevant to them.

A switch button on top of the column allows choosing whether only threads from the orthopaedic clinic are visible, or whether all of the threads are visible. The reasoning behind it was that physicians were seen to preview notes concerning only their department, or the ones in the folder that included all of the notes. Access to a specific department different than their own was not noted or mentioned.

Selecting a thread on the column on the left would have a direct impact on the content of the middle and right column. The middle column contains a scrollable list of notes that are part of this specific thread, while the column on the right contains a list of attachments that are attached to the notes in this thread.

The two areas above the columns hold a place for the patient’s history summary and vitals. The area with vitals is very similar to what was presented in Cosmic. The area with the patient’s history was aiming to address the often-mentioned wish to have a short overview of a patient’s medical history without having to go through the notes.

The question could be raised whether users would take the time to actually fill in the history summary section. The section could be at least partially edited automatically, and
I would argue that users would input the data into this section if it was beneficial to them in the long run. This claim can be supported by both literature research findings (Blijleven et al., 2017; Saleem et al., 2009) and the observations, which have shown that users were already writing history summaries in different parts of an EHR, such as progress notes.

5.2.1.2 Second Screen: Dashboard

The Dashboard screen was created after the first iteration, in order to create a space for accessing the options that would not fit in the patient’s preview screen. The initial sketch of the dashboard can be found in Appendix B – Sketches (sketch 3). That screen was then iterated upon, resulting in the screen presented in figure 5.

The main objective of this sketch was to create a general concept for how a layout of such a screen could work. Deciding what should be the actual content of the screen was not an objective of this sketch since it is outside of the scope of the thesis. Therefore, the content of the screens can vary from real users’ needs, especially since it is based on the findings from the observational study, which was limited only to a certain setting.

The white bar on top of the screen represents options related specifically to the user, such as your messages, referrals to you, etc., while the orange part of the screen represents the rest of the options available. The idea was that the screen containing all of the available options throughout the hospital would be crowded, therefore the screen is aiming to represent functionalities used within the orthopaedic clinic, excluding functionalities that would not be used in this setting. The buttons ‘show for different department’ and ‘show all’ were included in case a user would like to access a functionality outside of this scope.

![Dashboard Screen](image)

Figure 5 – The Dashboard screen
The main content of the dashboard is very similar in both sketches of this screen, the difference being that after the evaluation of the initial dashboard sketch the data was analysed and reorganised into new sets. The sets were created to mimic the parties involved, which in this case are the patient, the ward in which the visit takes place, and the physician. The set of items surrounded by red border represents items that would only be visible if the patient was currently staying at the ward in the hospital.

Clicking on an item would open a list of methods available for this object, or a subset of more items with their own methods as presented in sketch 4 in the appendix.

The field for inputting a patient’s personal number was added to the screen based on the concept that user is most likely to open a dashboard while having a specific patient in mind. That solution would allow using a functionality with patient’s data already inputted, such as ordering a test for a specific person.

5.2.2 Design Workshop
Workshop participants produced a total of four sketches. Two presented a full patient’s data preview, and two focused on details regarding the design of a progress note. The outcome of the session was later used as an input to further sketching.

The suggestion regarding the note itself included adding details such as:

- The note’s number, serving as its’ unique identifier, allowing linking within the notes
- A button for marking the note as important
- An icon symbolising that there are attachments available concerning this note
- Adding a possibility to highlight sections or words within the note

Suggestions regarding the changes in the layout included putting three menu bars on the sides of the screen. The menus would incorporate the shortcuts presented in the dashboard view in figure 5, separating them by the shortcuts concerning the user, the patient and the ward. Another layout suggestion included presenting one note at the time in the middle of the screen, and having a list of thumbnails of the notes concerning the thread on the bottom of the screen, scrolling horizontally.

The general patient data, previously spread in different sections of the screen, was suggested to be connected into its own. That data would include information such as patient name, personal number, ‘must-knows’ from the medical history, etc. A version of this concept can be seen on the left side of the screen presented in figure 6.

Other ideas pitched during the design workshop include adding checkboxes to the threads listed on the list, in order to afford selecting multiple problems to preview at the same time, as well as including a temporary type of note, similar to a post-it. This idea was based on the literature findings (Lium et al., 2008), showing that users sometimes used the progress notes to communicate something temporary to other users.

The idea for a visual representation of the statistics, such as showcasing the total number of notes, was presented. The concept was based on an icon that’s gradually filling up with colour, with the level of fulfilment reflecting the number it is representing. A version of this idea can be seen in figure 7.
5.2.3 Further sketches and evaluation

5.2.3.1 Redesign after the design workshop

Materials gathered during the design workshop were used to create a new sketch. It was still based on the threads (now called problem list) → notes → attachments structure but has merged the functionalities of the two previously created screens – the contents of the dashboard were now placed on the top and right bars. An important adjustment was setting the mock-up size to match the size of the screens used by physicians in the hospital.

The main ideas taken from the design workshop and incorporated into the sketch include:

- A vertical bar with the patient’s most important information, as seen on the left of the screen
- Menus with action shortcuts on two sides, the right and the top
- ‘Mark as important’ button on the notes – the note marked as important has been given a yellow background
- Changing the objects on the problem list into checkboxes

![Figure 6 – Sketch of the second version of the patient’s preview screen](image)

The decision to place the bar with patient’s information summary on the left was to make the strategy for visual search simpler – the assumption is that when preparing to see a patient, a physician would first want to learn basic information about them, then choose the medical issue, then look up the notes and attachments that go with the notes. The placement of the elements as presented in figure 6 affords this search by ordering all the relevant pieces on information in one row, starting from the left.

Other changes include adding more details to the problem list segment. The number of notes was added in the brackets next to the problems name, as well as the total number of threads and notes on the bottom. An important addition was the ICD codes, added to represent the main medical issue of the thread. The codes used in the sketches and later
in the prototype are cited from a Medical Coding Reference website (World Health Organization, 2018).

The list of attachments was redesigned, allowing to sort the attachments by a type (such as an X-ray or a referral), and highlighting the attachments connected to the currently selected note. The selected note and selected attachments were marked with a dark blue border. Additionally, the list of patients scheduled for the day was added in the top left corner. Changing the patient previewed in the journal would be done by selecting the patient from the list, or typing in the personal number in the field marked as 'select other'.

5.2.3.2 Evaluation
Once the sketches reached enough level of detail to start heading to the prototyping phase, a short evaluation session with a physician was conducted. Apart from getting overall feedback, the main goal of the evaluation session was to validate the core concepts of the design, which included the problem list → notes → attachment layout, and the use of ICD codes as the main structure for the problem list.

The meeting was very informative, and a lot of input was collected. To findings are separated into sections based on the interface elements discussed during the meeting.

The layout
The vertical layout of problem list followed by notes and attachments was considered a good idea. The display of related attachments on the same screen as the notes would save the users from having to change screens, compared to the current system.

The use of ICD codes
It was confirmed that physicians commonly use the ICD codes in their work, often using them to mark the diagnosis code in the note. One more type of ICD codes used in the notes was brought to attention - the ICD-PCS codes for marking the performed procedures.

It was mentioned that the codes are mostly handled by the secretaries who are trained in their use rather than by the physicians, however, the physicians are familiar with the codes that are most commonly used in their domain.

The problem list
The problem list was found to be very informative. The physician was able to make some conclusions at a glance, such as judging which issues are the most prevalent, based on the number of notes in a problem and its position on the list. A comparison was made to the paper journals, where one-line summaries per contact with a patient were written, giving a physician a quick overview of the patient. The statistics on the bottom of the list were compared to the thickness of the binder in the paper journals, indicating the amount of data in the record.

It was suggested that more details on the problem could be included in the list, such as the number of surgeries, or the amount of epicrisies created for the problem.

The patient’s information summary column
Change of the content of the history summary was suggested. Initially, the history summary section was to contain the key events from the patient’s medical history, as well as patient factors, such as allergies etc. It was suggested by the physician that
instead, the section should contain just the patient factors, specifically the ones that are not likely to change over time. The key events from patient’s medical history were said to be better represented in the problem list, therefore putting them into the summary section would be redundant. Some of the suggested examples of data to be for the section included information like weight, height, allergies, whether there is a need for an interpreter, does the patient have a disability, do they use a pacemaker, do they have a synthetic valve or any special implants. Consequently, the name of the section would be affected.

The vitals section was suggested to be moved to the attachments area since it is context dependent. Adding a section representing administrative context was suggested, including information about scheduled visits and tests.

**The menu bars**
Instead of having two menu bars, one on the top of the screen and one on the right, it was suggested to use only the top bar. A reference to the MS office navigation bar was made, naming it a good example to follow since physicians are used to relying on it in their hospital work.

**The patient list**
The need for a field for inputting the patient’s personal number was confirmed since physicians often need to visit a patient’s profile out of context.

The physician also outlined the most commonly used patients lists. That included:

- Patients admitted to the ward
- Patients scheduled for the day, but not assigned to a particular physician
- Patients scheduled for the day, assigned specifically to the user
- The list of most recently previewed patients

**The mark as important button**
The button was said to be probably good to have in the system, and interesting to observe how it would end up being used.

### 5.2.3.3 Final sketching
Following the insights from the evaluation session, the updates were made in the sketch which included:

- Splitting the patient list into four separate lists, including ward patients, patients assigned directly to the physicians, patients for the day and last active ones
- The menu bars on top and on the right were merged into a top bar
- Upcoming events table was added

Additional changes include making the buttons included in the note smaller and placing them on the right side of the note rather than on the bottom. The functionalities of the button were, starting from the top, editing a note, marking the note as important, sending the note as an attachment in a referral.

Since the feedback from the evaluation session indicated that the problem list has a potential to convey a lot of information, the decision was made to further explore that concept. Some of the ideas are presented in Figure 7.
The sketch on the left incorporates the use of ICD Procedure Coding System, visible in the left column. The other two sketches explore the hierarchical aspect of the ICD codes, the middle one using the sunburst layout and the right one presenting the hierarchical nesting of the codes.

The colours used in the sketches represent different medical specialities that the medical problem concerns – the orange one being orthopaedics, the blue one cardiology, etc. However, the idea of using colours for that purpose was later abandoned, since the limit of colours that can be used for coding and still remain visually distinctive is quoted to be between six and twelve (Ware, 2008), and the total quantity of clinics in the hospital would significantly surpass this number.

The boxes on the bottom of the list were the visual representation of the statistics concerning the total number of notes, based on the idea pitched during the design workshop. The level to which the box was filled up indicated the number of notes in a scale of two hundred. That idea was later abandoned on the grounds that the number of progress notes will always be significantly greater than the number of surgery notes, lab reports or epicrisis, making it difficult to convey useful information while keeping the boxes in the same scale.

In the end, the idea of a static list was chosen. The emphasis was put on including more details in each position, in order to convey more meaningful information using a fairly simple structure.
The information included in each list position consist of:

- ICD code of the main diagnosis, together with the diagnosis name
- When did the issue first start and when was it last updated
- The number of progress notes, surgery notes and epicrises concerning the problem – represented by the three numbers next to the icons, starting from the left respectively
- Whether it is a chronic disease or not - represented by the symbol next to the G80 code in the second row
- How recent is the problem – represented by the background colour of the note. Figure 8 shows three background examples, starting from the most recent, fairly recent and older case

Additionally, if there were no notes of a certain type, such as surgery notes, the icon and the number would be paled out. Figure 9 presents the final sketch from the sketching phase, which was later used as an input to the prototyping phase.
5.2.4 Prototyping

In the prototyping phase, the ideas created during the sketching were polished and given an additional level of detail. Some of the changes include removing the search bar from the problem list and placing it in the notes section instead. The attachments section was redesigned, from a list of thumbnails to a simple text-based list, in order to allow more positions to be visible on the screen at the same time.

Changes in the patient list include adding the ‘select all’ button on the bottom, as well as adding some details to the icons for the different types of notes. Four versions of each icon were produced, representing the number of notes of this type, as showcased in figure 11.

On the contrary to the first three icons, the icon on the far right had no definitive meaning, symbolising that there are four or more notes of this type. The reasoning for this approach is based on the theory of subitizing, which says that people can recognise the amount of three to four objects instantly, without having to count them (Logan & Zbrodoff, 2003).
During the prototyping phase, four icons acting as warning signs were selected, as visible on the left of figure 10, under the name and personal number. The letter A represented allergies, the drop icon represented blood-related problems, the exclamation point represented other warnings, and the last icon of a person lying in bed represented whether the patient is admitted to the hospital. The icons were grey colour by default. If any of the warnings was applicable to the patient, the icon would turn red.

<table>
<thead>
<tr>
<th>Part of the interface</th>
<th>Action</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient lists</strong></td>
<td>Selecting a patient from one of the patient lists</td>
<td>The data displayed in the journal changes to represent the selected patient. The patient list in Last active tab gets updated, putting the name of the selected patient on top of the list</td>
</tr>
<tr>
<td><strong>Warning signs</strong></td>
<td>Hovering on of the signs</td>
<td>A description of the meaning of the sign is shown, as well as its status (e.g. the patient is admitted to the hospital or the patient is not admitted to the hospital)</td>
</tr>
<tr>
<td><strong>Problem list</strong></td>
<td>Selecting an all or Orthopedics radio button</td>
<td>The content of the problem list is updated, showing either all of the problems or only the ones concerning Orthopedics, respectively</td>
</tr>
<tr>
<td></td>
<td>Clicking a position on the list</td>
<td>The position is marked as selected with a blue frame. The notes and the attachments panels are updated to display the content related to the problem. Any previous selection on the list is unselected</td>
</tr>
<tr>
<td></td>
<td>Clicking a position on the list while holding shift</td>
<td>The position is marked as selected with a blue frame. The notes and the attachments panels are updated to display additional content, without removing the previous selections</td>
</tr>
<tr>
<td></td>
<td>Clicking the Select all button</td>
<td>All of the positions are marked as selected, the content of the notes and attachments panels gets updated accordingly. The label on the button changes to Unselect all</td>
</tr>
<tr>
<td></td>
<td>Clicking the Unselect all button</td>
<td>All of the positions are unselected, the notes and the attachments panels are empty</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>Hovering over</td>
<td>The hovered note is marked as selected, so are the attachments in the attachments panel connected to the note</td>
</tr>
<tr>
<td></td>
<td>Clicking the star button in the top right corner of the note</td>
<td>If the note was previously not marked as important – the star on the button is filled in with black colour, the colour of the title bar on top of the note changes colour to red, the label on the top bar change colour to white. If the note was previously marked as important – the star button is filled with white colour, the top bar changes colour to pale pink, the labels on the top bar change colour to black</td>
</tr>
<tr>
<td><strong>Attachments</strong></td>
<td>Clicking the Type label or the sorting button next to the label</td>
<td>The content of the attachments panel gets sorted alphabetically by the type of the attachments, each click toggles the sorting direction</td>
</tr>
<tr>
<td></td>
<td>Clicking the Date label or the sorting button next to the label</td>
<td>The content of the attachments panel gets sorted by the date of the attachments, each click toggles the sorting direction</td>
</tr>
</tbody>
</table>

*Table 3 – Description of the interactions in the prototype*
To add more of a real feel to the prototype, several interactions were implemented. The description of the interactions can be found in table 3.

A bigger picture of the prototype can be found in the Appendix D.

5.2.5 Final Evaluation
The physicians were positive about the interface, they seemed to quickly grasp the general concept and the interactions, such as the connection between the notes and the attachments. The information visible in the problem list panel, even though mocked up, prompted them into making a first analysis of the patient’s health status.

The feedback has been separated into sections based on the part of the interface it is concerning.

**Patients lists**
Overall the physicians liked the lists. One of the participants found the concept for your list, the ward list and the recently viewed list to be useful, but suggested changes for the today’s patient list. She explained that a work setting where patients are not directly assigned to a specific physician (i.e. setting from the first observation) is an unusual one, and usually applies only to trauma clinics. She suggested renaming the list into *trauma*, and making it visible at all times even to physicians who are not working at the trauma clinic at the moment, in case they were asked to provide a consultation.

The field underneath the lists for inputting the personal number of a patient was considered very helpful for providing consultations for a colleague.

**Problem list**
The participants were very positive about the problem list. One of the participants named it the most useful feature out of everything the prototype offered, another compared it to a document used in a paper journal containing one-line descriptions of the patient’s every visit, which was a popular item. They especially appreciated the information about surgery notes and epicrisés concerning the problem, with one of the participants expressing that “It gives me as a surgeon directly what I need to know”.

One of the physicians suggested that a filtering option allowing to see just surgery notes or just epicrisés would be useful. Another physician disagreed, saying she prefers to read the surgery notes in the context of other notes, so she would not have a need for filtering. Another suggestion was including an option for filtering the problem by most recent, e.g. last five years, as well as privacy concerns. One physician raised a question about the privacy concerns, and patients being able to hide problems not relevant to the current medical context.

**Patient summary section**
The *Important information* section was named good to have, with all of the participants agreeing that data displayed there should be something that’s constant in a patient’s life.

A suggestion was made that a button allowing quick editing of the data should be included, visible only to certain users, e.g. just to the doctors. The button allowing editing of the data was included in the previous sketches, but later was removed due to the unclear legal status. The physician explained that users should be allowed to make the changes freely, as long as the changes can be backtracked, and the system remembers which user made the update and when did it happen.
The *upcoming events table* was found beneficial by the physician, so was the *medicine* table. One of the users suggested that if there is space, the *medicine* list should be made longer since those lists are usually very long. The participants liked the four warning signs, although the A letter sign initially got confused for a blood type.

Overall the physicians liked having the information that the section was showing easily accessible: “You have everything you want in one overview. That’s really good.”

**Notes**

One of the physicians liked the space savings the two-column layout was affording, allowing them to preview more notes on one screen at the same time. Another physician commented on the intuitiveness of the paper clip icon, representing the attachment for a note. The *send* button was found to be useful, since physicians often reply to the referral they got from a GP, either repeating what is already said in a progress note, or more commonly referring them to a progress note existing in the system. A functionality of adding a note as an attachment would simplify that process.

Similarly to the *important information* section, a suggestion was made to include tracking of the changes done in the notes.

**Attachments panel**

The users seemed to quickly grasp the role of the panel, including the use of the sorting buttons, and correctly assumed that the list would be used for opening the attachments by selecting an item.

The physicians suggested that the attachments panel would be useful for accommodating a functionality for renewing the attachments. For example, a right click on an item such as a sick leave or the referral, could produce a dropdown of available options, including reusing the existing file as a template for a new document.

**Other comments**

The physicians’ comments suggested that the next step should be incorporating the most frequently used functionalities into the interface, such as ordering an X-ray, in a way that would make them quickly accessible from the journal screen. One of the physicians expressed that the interface could be customisable, allowing the users to adjust the size and positions of elements, as well as which elements should be included in the screen.
6 CONCLUSIONS

The aim of the thesis was to offer a design hypothesis for a medical records reading system that would enable medical staff to read the data in a highly efficient way. The first part of the task was to assess what data physicians need to have at hand when preparing for a meeting with a patient. Conducted interviews and observations helped gather enough insights on that matter to proceed with the design study and produce a prototype. Since the study was focused on a specific group of users in a specific setting, the gathered results felt like the tip of the iceberg and showcased that much more research would have to be performed to get a comprehensive dataset needed to design a system applicable to various user groups. The needs for medical record reading systems were found to be highly dependent on the context in which they are accessed; the specialisation of the user accessing the data, such as whether it is a general practitioner, surgeon, doctor in the emergency ward, etc.; as well as the domain of medicine the user is working in.

The studies conducted as part of the thesis have shown that the relevant information and action shortcuts should be accessible together with the performed action, in contrast to the currently used system where the information is based on the system’s internal structure. The interviewed physicians state that this would make their work more efficient. One of the challenges in the thesis project was finding a balance of the amount of that displayed data while keeping the interface simple and easy to navigate.

The design part of the study explored the impact of layout and navigational tools on enhancing the process of reading the medical data. It showed that clear and efficient ways of navigating the processes are a necessity for such systems in order to help the users get through the big amounts of available data effectively. Creating the interactive prototype further examined how involving visual cues can help the users make sense of information faster, and how involving the interactions can accelerate finding the connections between elements.

The final solution was built on the structure consisting of three main panels: the problem list, the notes, and the attachments. The problem list contains medical issues patient is or has been treated for in the past. It includes details such as when did the problem start, when was it last updated, and how many notes are available for this specific issue, with the distinction of progress notes, surgery notes and epicrises. Selecting an item from the problem list prompts a display of notes related to this problem in the notes panel, as well as displaying a list of attachments related to the problem in the attachments panel. Hovering a note in the notes panel highlights the attachments that are connected to this specific note, clearly showing the connection between the elements. The described elements are showcased in appendix D.

The design offered in the thesis was crafted to meet the needs of orthopaedic surgeons. Physicians from other domains will have different needs and in order to work for them, the design would have to be accordingly adjusted. It is my hope however, that the underlying concept of the interface (problem list → notes → attachments) could be successfully applied in other medical work environments.
Many issues could be brought up in this chapter. The reason for it is that even though the thesis had set delimitations, it touched upon many other areas and consequently many other problems. The work could be continued in various directions, and it is almost impossible to list all the insights that came up during the design process. As a result, the issues touched upon in this chapter are primarily the ones most related to the thesis scope as set in chapter 2.

One of the aspects to consider regarding the final design is patient privacy. Cosmic, the EHR system used in the hospital, addressed privacy to some extent. The notes were separated into folders representing the administrative unit of the hospital. The list of folders was very long, and there was no visual indication whether there are any notes in a folder. That made it impossible to get an overview of a patient’s health status based on that list, but it did grant more privacy to the patient. However, when a physician would like to get an overview of patient’s medical status, they would open a folder containing all of the notes, usually getting more information and details than required, negating the privacy granted previously.

The problem list as presented in the final prototype partially solves this issue by helping in getting an overview of patient’s health status without forcing the physician to get into the problem’s details. However, it does show this overview constantly, regardless of whether it is currently needed or not. Even though the problem list got positive reactions from the physicians, as part of the future work more research could be put into how to judge which information are not relevant to the physician at the given context, and consequently hiding it.

Another issue that might require further research concerns the threads, so the items listed in the problem list. The idea was that the title of the thread should be based on an ICD code of the main diagnosis. However, problems may arise if the diagnosis changes over time – e.g. what was initially frequent headaches was later diagnosed as a neural disease. Since the notes concern the same issue, they should be kept together, and it should be possible to read them in chronological order. Therefore, some system for updating the threads title and main diagnosis code while keeping the notes with the new code together with the older notes should be offered.

Furthermore, as part of the future work the use of ICD codes could be further explored. ICD codes are created in a hieratical way, with each additional digit in the code making the diagnosis more specific, e.g. H25.01 stands for cortical age-related cataract, while H25.011 specifies that the cataract concerns the right eye (World Health Organization, 2018). Including the hieratical nature of the ICD coding could be incorporated into the design, one of the ideas being grouping or splitting the threads based on what level of ICD code is selected (for example 2 digits). Additionally, the use of the procedural ICD codes could be further explored. In contrast to the standard ICD codes, the procedural equivalents are always seven alphanumeric characters long, with each character standing for a different piece of information regarding the procedure, such as a which body part it concerned, which method was used etc. The structural character of the procedural coding system offers interesting possibilities regarding potential browsing and grouping functionalities that could be incorporated into the system, such as displaying all the
procedures performed on the abdominal area, all of the performed radiation treatments, etc.

A couple of elements included in the prototype could be further addressed. The first one is the search bar on top of the notes panel. The research has shown that searching within the journal is a much-needed functionality. However, more research would be needed to know exactly how the search function should work, e.g. should the search be conducted based on a free-text input, the ICD codes, the name of the physician who created the note, etc.

The second element to be further addressed is the top bar containing the action shortcuts. The idea behind the bar is that its contents would be customisable, but how to construct the customisation process is not so straightforward. In Cosmic, the users can access a long dropdown list, containing multiple nested options and an arrow button on the bottom for accessing the second page of the dropdown. The contents of the dropdown represent the screens available in Cosmic, and the list is so vast that I would hypothesise that an average Cosmic user does not have a full grasp of what Cosmic has to offer. The concept behind the screen designed in the thesis is that the user should be able to easily access the most frequently used functionalities. To achieve that, the list of available options should be presented in a more accessible way, and the top bar might have to be more elaborate, e.g. resembling the ribbon toolbar design from MS Office.

As mentioned before, many other areas outside of the scope of this thesis remain to be addressed. Some of the directions in which the research could be continued include:

- Exploring the medical staff’s workflows and how to successfully incorporate them into an EHR design
- Adapting the proposed design for physicians working in other areas of medicine
- Designing an interface for inputting the data – this task would include having to address the self-perpetuating problem of information overflow and finding input constrains that would limit the length of the notes while allowing for all of the important information to be included
- Constructing mechanisms for highlighting the relevant data in the system and for allowing the users to communicate important information in a way that they would trust, and that would not prompt them to use additional workarounds such as calling or writing post-its

Overall, the work on the thesis has confirmed one important finding from both the literature and interview study, which is that since physicians’ work is so complex, just observing their work and what artefacts they use is not enough to design a well-adjusted system. As expressed by one of the study participants “My theory is that it isn’t because they didn’t do their homework of talking to the users and looking at the users, but they didn’t understand what they saw”, and it is the understanding part that remained this project’s biggest challenge.
8 References


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9 APPENDICES

APPENDIX A – INTERVIEW QUESTIONS

- In what setting do you usually need to use the medical record? *For example: with the patient one-on-one in the examination room, in a medical ward, before/during the procedure?*

- In this setting, do you use the system before, during or after performing the task you were supposed to do? *Performing the task - could be meeting with a patient, performing some procedure, whatever comes up.*
  - Why?
  
  *When do they use the system could be affected by how the system is constructed and how does it constrain them. So maybe if the system is reconstructed the ‘when’ could be changed*

- What type of knowledge do you want to have before the meeting?

- Is there some knowledge that you need/would prefer to have visible at all times while meeting with the patient?

- Is there some set of data that is needed in every case (e.g. family history, results of some tests) or is everything case-specific?

- Is there something you need to look out for, or some kind of mistakes are you trying to avoid?

- Do you manage to find everything you need in the time you’re given?

- Are there things you’d rather ask the patient about than search for them in the system (or maybe they’re not in the system)?
  - Why?

- Apart from the patient data, is there some other info you need? *Such as referrals, available tests, available medicine*

- Is there some information visible that is useless?

- Could you take me step by step with what you need to do? (in order to prepare yourself for the visit?) *What data do you need, what tabs do you*
need to find the data, how often do you need to swap the tabs, do you do need workarounds like writing things down

• Are there some actions you would rather do on paper than use the EHR?

• To what extent do you trust the system? Reasoning: during a tag along people gave an impression on trusting more that the doctors will mark their name and the progress on the paper list more than the electronic list in the system

• Apart from the system that you’re using now, in an ideal world, what is the knowledge you would like to have or actions you would like to perform? Doesn’t have to be limited by the system, just if you could design how the doctor-patient meeting was to happen, what would you change?

• Could you name three things you like about the system (in regard to reading from it) and three things you don’t like about it?

• (From Saleem et al. 2009) Have you ever experienced frustration in viewing or combining information from EHR (e.g., patient data) during your clinical work? If so, please give example(s).

• Other:

• Is it on PC only or smaller screens as well?

• Is there anything you think I have missed?

• Is EHR fully adapted or are paper records still used in some parts of the hospital?
APPENDIX B – SKETCHES

Sketch 1
A different concept for the Patient’s preview screen created during the first sketching stage. This screen includes attachment’s preview instead of a list of attachments.

Sketch 2
A different layout for the concept presented on Figure 4 and Sketch 1, created during the first sketching stage.
Sketch 3
A first version of the Dashboard screen, created during the first sketching stage.

Sketch 4
A later version of the Dashboard screen, with an item’s submenu visible.
APPENDIX C – DESIGN BRIEF MATERIALS

Intro:
- EHR - Electronic Health Record - Software doctors use in their daily work
- Content varies, can be broad:
  - Viewing electronic records, billing, ordering, prescriptions, medicine, scheduling
  - It all depends on what the system has to offer and what they choose to have
- My focus: viewing medical records
  - What doctors use before they meet the patient

Issues:
- They build up on one another
- Progress notes:
  - Not organised well enough, things hard to find
  - Too much data to display
  - There is no such thing as history overview
- Complex and unclear navigation
  - Abundance of data and options
  - Constant screen toggling
    - Users getting lost
    - Users would prefer to have what they need in one place
  - On top of that, usability issues, inconsistent navigation
- Workflows:
  - Mismatched, interrupted or lack of workflows altogether.
  - Means a person needs to find all the options needed for the steps in this huge base of all the options possible, getting confused etc.

Workarounds:
- Pasting the progress notes
  - Rather than writing them, they copy and adjust
  - Writing summaries of the previous knowledge in the new note so people don’t have to scroll that much,
  - That leads to repetition of knowledge in the system, there’s even more text because text is easy to produce
  - More often than not there’s no searching options
- Memory aids:
  - Writing down on a piece of paper key info to have with you during the encounter with the patient, post-its as reminders etc
- Alerting about new information:
  - Doctors often worry important things won’t be seen since often your tool is a plain text with no enhancements
  - Again, post its, nurse writing things on paper and giving it to the patient, doctors writing additional notes in user’s journal that’s just a notification for the next doctor etc.
- Doctors want something tangible.
Relation with paper system:

- EHR mimicking the paper
  - But paper had good things about it:
    - glancing at the volume
    - consistent placement of elements, you glance at it and you know where to look for
    - Visuals: specific documents had specific layouts or recognisable elements
    - fast to browse and scan through (faster than EHR)
    - More flexible. Easy to adjust, make notes, stress things using different pens etc. (what I mentioned before about alerting others about important things)

- EHRs took the paper, mimicked its structure and way of working, but took away the good things about it, and added the abundance of options and unclear navigation

Data to consider:

Patient related:
- summary (important ongoing diagnosis, special information like blood disease or allergies)
  - Problem list?
- For more details - progress notes
- test results
  - separated on the ‘threads’ they concern
- Referrals
- medicine the person is taking
- vitals, fluids and other metrics they’re tracking for when a patient is in the hospitals

Ward related:
- medicine that is available
- available dates for surgeries etc
- Tests
- Patients admitted to the ward
- Patients scheduled for visit
- Knowledge support (descriptions of other cases, textbooks etc)
- their schedule, patient list

Doctor related:
- messages
- patient list
- Notes to sign