Master Thesis

Design Principles for the Interface of an Automated Medical Reporting System: a User Study in Preoperative Screening

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Abstract

This qualitative research was initiated to establish user-centered interface design principles for an Automated Reporting System. Automated Medical Reporting was already proposed as a solution to the administrative burden in healthcare and to increase patient-doctor contact. This solution yields recording a consultation and generating a report automatically, which supports care providers in performing administrative tasks. In order to expand this vision by including interface design principles without overlooking the usability aspects, a case study within the preoperative screening was conducted. In this research, the current situation of this case study was first investigated according to a task analysis, a heuristic evaluation of the Electronic Health Record system in use, and stakeholder interviews. Then the knowledge gained on preoperative screenings and the findings of the interviews were translated into design choices. Based on these design choices and IT expert feedback, a treatment design in the form of a high-fidelity prototype of an Automated Medical Reporting system for preoperative screenings was developed. This treatment was evaluated by conducting think-aloud sessions, a focus group and an expert interview. According to the evaluations, the following can be concluded. Medical specialists find it hard to envision their workflow using an Automated Medical Reporting system, and many individual preferences exist. However, the design of an Interface for an Automated Medical Reporting system should be built around system status visibility, care provider control, consultation traceability and patient privacy.

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Chapter 1

INTRODUCTION

In healthcare, the focus should be on providing the care the patient requires (Bremmers, 2019). To do so, during consultations care providers need to document their observations and findings. This documentation process is done carefully, which takes time. Time a care provider does not always have because of the current workload in the healthcare sector. Care professionals face staff shortages and the rising demand for care on a daily basis. These two challenges are not likely to be solved in the near future, because of the grey line. The proportion of elderly people will increase, which is the group that generally needs more care. On the other hand, the group of people who are able to provide care is not likely to be increased. Currently 1.2 million people in the Netherlands work in the healthcare sector (Planbureau, 2018), but to provide the care needed, more employees are desirable. This rising demand and the lack of a concrete solution is a problem that society as a whole needs to solve.

Not only the deployment of more employees can help to solve the issue of the rising demand for care. Improving the efficiency of care to lower the workload of care professionals can contribute to a solution to this issue too. Advanced ICT systems can be implemented in the healthcare sector in order to support care professionals in administrative tasks. Research into technological solutions in the field of healthcare has already been done. For example, integrating speech recognition technology to enable dictating for generating a report after a medical consultation was studied by Ajami Ajami (2016). However, this only dissolves the process of typing out the conclusions of the consultation. In order for the care provider to save more time, an Automated Medical Reporting (AMR) system is proposed as a solution by the Care2Report team of Utrecht University. The researchers present this solution "to be a novel integration of state-of-the-art speech and action recognition technology with knowledge-based summarization of the care provider-to-patient interaction" (Maas et al., 2020). The aim of this solution is to automatically generate a medical report during a consultation. Afterward, the care provider can check and complete the report and upload it into the Electronic Health Record of the patient. Results of this solution were already found in the setting of a general practitioner's office. An elaboration on the findings of this study can be found in Section 3.3.2.

To expand the success of Automated Medical Reporting, a study into the implementation of Care2Report in the field of preoperative screening (POS) is initiated by the Utrecht University (UU) in conjunction with the anesthesiology department of the University Medical Center Utrecht (UMCU). Together with a team of researchers the implementation of an AMR system, Care2Report, is realized and the effectiveness of the system is studied. This case study focuses on the extensive preoperative screenings anesthesiologists often have to perform. In a preoperative screening, a preoperative patient is checked for any potential risks during surgery, because "a working understanding of the risks conveyed by surgery and anesthesia has great value" (Litaker,

1999). The medical evaluation is conducted by a member of the anesthesiology department according to a long checklist. Also, this member prepares the patient for the surgery from a medical and anesthetic perspective. The findings and decisions are captured in a report, which is important for the surgical and anesthetic team (Litaker, 1999). The last objective lies within the focus of this research. Anesthesiologists who perform a preoperative screening can benefit from the implementation of an Automated Medical Reporting system. An AMR system can be responsible for filling in the screening questions automatically and can generate a short conclusion of the consultation.

As research into the implementation of Care2Report for preoperative screening consultations is done with a team of researchers, several research areas are touched upon. In order to successfully implement the system as a whole, this thesis focuses on the User Interface (UI). As this is a new field of research, the usability criteria of AMR systems need to be investigated in order to provide guidance for optimal integration of such a system in the future.

1.1. Motivation

The rising demand for care in combination with the opportunities implementing information technologies have, is what drives this research the most. Administrative work should be minimized in order for the care professionals to be able to focus on the patient. The way healthcare is arranged can be improved by implementing administrative support systems, as long as it has a clear implementation process and an intuitive UI design. This research into the interface design of an Automated Medical Reporting system in healthcare will contribute to easing the adoption process of such innovative systems in the future.

The case study in which this research is set provides an excellent opportunity to investigate the interface of an AMR system since the system is developed from scratch. Through the UI, the anesthesiologists interact with the AMR system. Thus, this is an important aspect of the system. The goal of this research is to provide a generalized vision on the design of a UI of an AMR system. This generalized vision is derived from the findings in the field of preoperative screening and the vision on experts in the field of AI and health. Using this vision, the process of expansion to other fields and the process of adaptation to new software is eased. In the long term, this contributes to the efficiency of providing healthcare.

1.2. Problem Statement

Information technologies (IT) are more and more adopted in the healthcare sector (McCullough et al., 2010). By using technology, fewer medical errors are made and patient information is easily accessible. According to a study done by Hillestad et al. (2005), clinical IT also yield savings of 142

billion dollars annually. Although the implementation of information technologies in healthcare seems beneficial from a financial and patient safety aspect, it has downfalls too. The societal value of health IT may decrease due to design problems, incomplete data records and implementation issues (McCullough et al., 2010). A qualitative study done by researchers from different locations across the world showed an increase in medical errors due to the implementation of an information system. These errors occurred in entering information and the process of communication and coordination the system should support. Ash et al. (2004) also proposed some solutions for this such as optimizing the interface, educating care professionals in using a system and including them in the implementation process.

As the quality of and familiarity with information systems overall have improved over time, another downfall in the healthcare sector arises. The systems used up till now have a lot of specific reporting requirements which place a burden on clinicians (Heuer, 2022). Due to these requirements, the amount of administrative work for care providers increases. As Rao et al. (2017) state in their study: "administrative duties required substantial physician time and affected physicians' perceptions of being able to deliver high-quality care, career satisfaction, burnout, and likelihood to continue clinical practice". Another study done on administrative work in healthcare showed similar results. This study focused on registrations healthcare professionals need to do in order to improve the quality of care. The results of this study indicated that professionals spend almost an hour per working day on quality registrations. They perceived it as a burden and experienced these registrations as "diverting time from patient care and from actually improving quality" (Zegers et al., 2022). More elaboration on the administrative burden in healthcare can be found in Section 3.2.

A domain of healthcare in which a lot of administrative work needs to be done is the department of anesthesiology in hospitals. Before patients undergo a surgery, their current state of health need to be assessed (Jannink & Hobert, 2016). This is done during a preoperative screening (POS) in which a checklist is completed and an end-conclusion for colleagues is composed. In some cases, an additional physical examination is done too. This results in patient information that need to be entered into the IT system manually. As no mistakes can be made, a care provider often fills in this checklist during a consultation. However, this draws the attention away from the patient which can have a negative influence on how a consultation is perceived (Scott & Purves, 1996). As Caldwell, a clinician, states in his paper on the importance of clinical consultation, clinical consultations in hospital settings should be improved (Caldwell, 2019). During a consultation, care professionals are performing two high-level mental tasks simultaneously, attentive listening and clinical reasoning. However, the pressure of seeing more patients, following guidelines and using inefficient software take up a part of their cognitive capacity. This capacity could otherwise be used to better understand the patient and for clinical reasoning.

During a discussion at King's Fund, an English health charity for improving care, Caldwell proposed ten quality indicators that support improving clinical consultations (Launer, 2017). Ac-

cording to their experiences as a clinician in England, he listed these ten indicators. Three important indicators for this study are: 1) *the consultation should feel unhurried for the patient and clinician*, 2) *the clinician should be able to give undivided attention to the patient* and 3) *there should be a ready supply of information into the consultation*. Within the elaboration on the latter, Caldwell mentioned the difficulty of finding the right information. Different software applications combined with paper notes made the preparation of a consultation challenging. These indicators which are derived from experiences within the field of healthcare, can help with developing and integrating a system that should improve clinical consultations.

1.3. Research Questions

To ensure the usability and accessibility of the Automated Medical Reporting system for consultations, this research is initiated. A user-centered approach is chosen in order to establish a set of validated design principles for an interface for Automated Medical Reporting systems in healthcare. The research project on an AMR system for the preoperative screening procedure of the University Medical Center Utrecht was used as the research environment to answer the following main research question: *What are the key user-centered design principles that should be applied when designing an interface for an automated reporting system used in healthcare consultations?*

In order to answer the main research question, the social and knowledge context of the design is investigated. Elaboration on this can be found in Section 2.1. An overview of the research questions and their categories can be found in Figure 1.1. The knowledge context is investigated according to three research questions. In the scientific knowledge context, the research question *What are the important technological developments and user interface guidelines in healthcare?* is answered. The practical context of the research is investigated according to the research questions: *What is the workflow of a preoperative screening in the UMC Utrecht?* and *How is the Electronic Health Record system used during the preoperative screenings and what are its potential issues?*

The research question belonging to the social context of research is: *What are the stakeholders' expectations of the interface of an Automated Medical Reporting system?* According to the knowledge gained from answering the three research questions above, the research question: *How are the stakeholders' expectations translated into an interface design?* can be answered. Afterward, a prototype of an interface is developed and tested. To validate the design, another research question is added, *Which aspects of the User Interface of the Automated Medical Reporting system for preoperative screening contribute to a positive User Experience?* This research question generates results within the research context of the case study. How the research questions concretely guide this research towards an answer to the main question, can be found in Section 2.2.

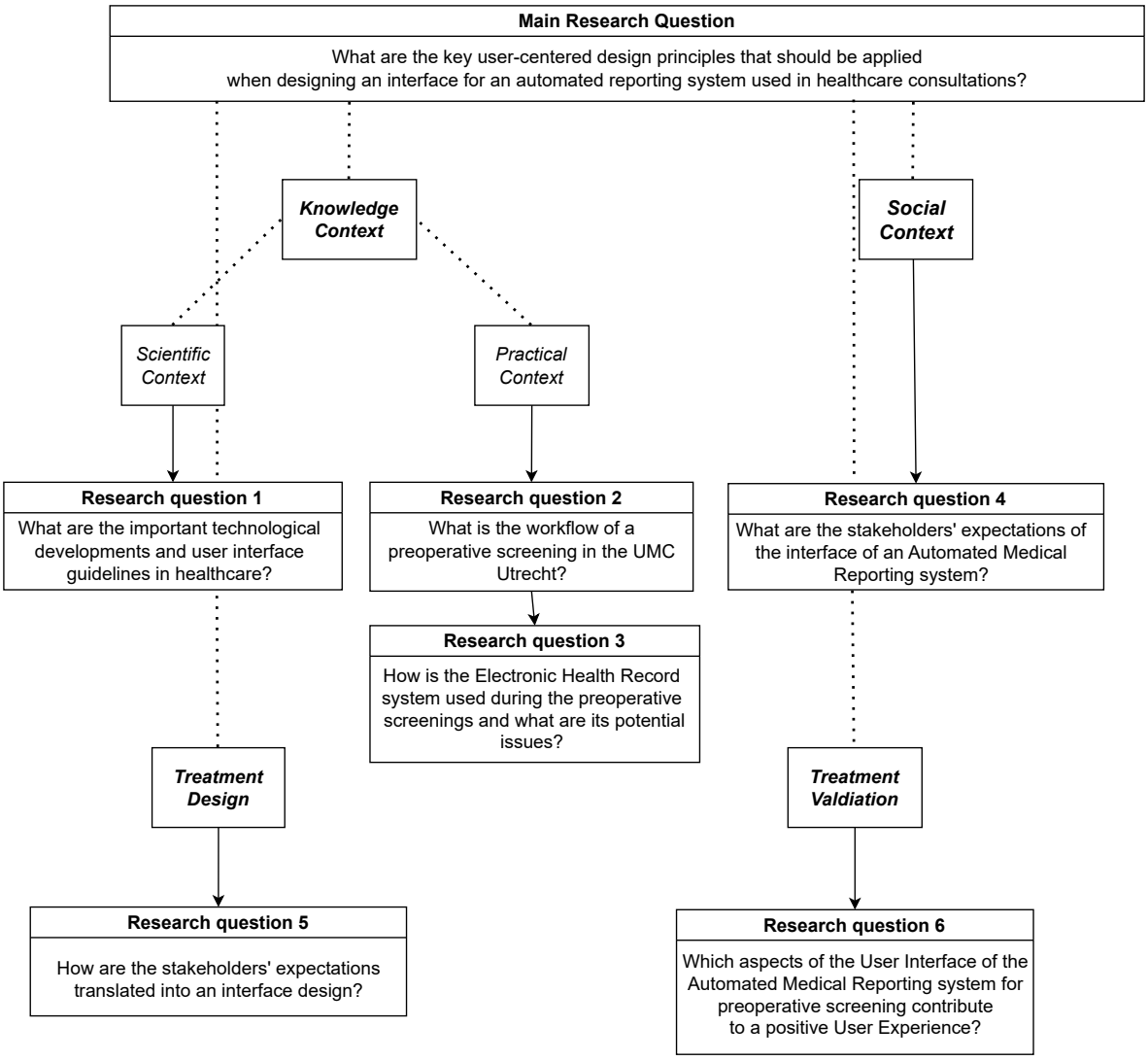


Figure 1.1: An Overview of the Research Questions and Their Relations

Chapter 2

RESEARCH METHOD

In this chapter, the research method used to give an answer to the main question stated in Section 1.3. is elaborated on. To provide a set of design principles for a User Interface design of an Automated Medical Reporting system, a specific design science is utilized. This design science is discussed in Section 2.1. Thereafter, the approach of the design science is specified for this case study, the design and evaluation of a UI in the field of preoperative screening, in Section 2.2.

2.1. The Design Science

For establishing a vision on a User Interface of an Automated Medical Reporting system, the design science of Wieringa was used as a theoretical framework. The *design cycle* which is part of the *Engineering Cycle* was used to specify the steps that needed to be taken within this research. By following the theory on the *Design Science Framework*, the context of the design was established (Wieringa, 2014). These theories were combined into a suitable framework for studying the key aspects of an interface in the context of the preoperative screening procedure.

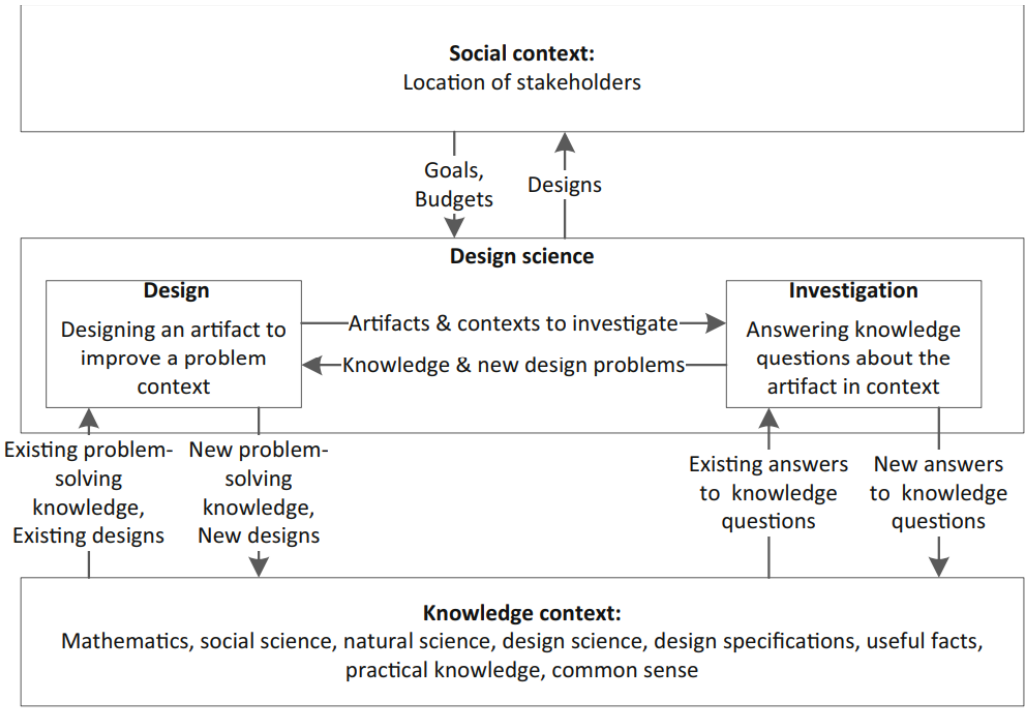


Figure 2.1: The Design Science Framework of Wieringa (Wieringa, 2014)

According to the design science framework, before starting a design process, relevant knowledge about the context of the design science needs to be collected. As the founders of this design framework state: "the problem context of an artifact can be extended with the stakeholders of the artifact and with the knowledge used to design the artifact" (Wieringa, 2014). In this design framework which can be found in Figure 2.1 the relation of the design science and the social and knowledge context is shown. Investigation and design processes both update the context of the design science regularly as a researcher answers research questions. The social context concerns the stakeholders, where the knowledge context contains amongst others: existing theories from science and specifications of currently known designs. The research questions of this study are categorized while carefully considering the design framework explained above. This way, every aspect of the context of the design science is reported.

As the Design Framework of Wieringa is utilized for the theoretical background of the context of the design science, the theoretical design guidance is retrieved from the Engineering Cycle of Wieringa. The Design Engineering Cycle is shown in Figure 2.2 in which five steps can be distinguished. The Engineering Cycle is established for the transfer of a validated treatment into the real world in which it is used and evaluated (Wieringa, 2014). Part of this Engineering Cycle can be identified as the design cycle, which focuses on only three of the five phases. These phases are the *problem investigation*, the *treatment design* and the *treatment validation*. The combination of these three phases represents the research approach without implementing a working artifact. Within the research into establishing a vision on the interface of a system for Automated Medical Reporting, a working artifact is not the goal.

For this reason, this research will adopt the design cycle of Wieringa. The problem investigation phase as explained in Figure 2.2 is the starting point to explore the problem context. Subsequently, the treatment design phase focuses on developing and refining the treatment design, followed by validation to ensure its effectiveness.

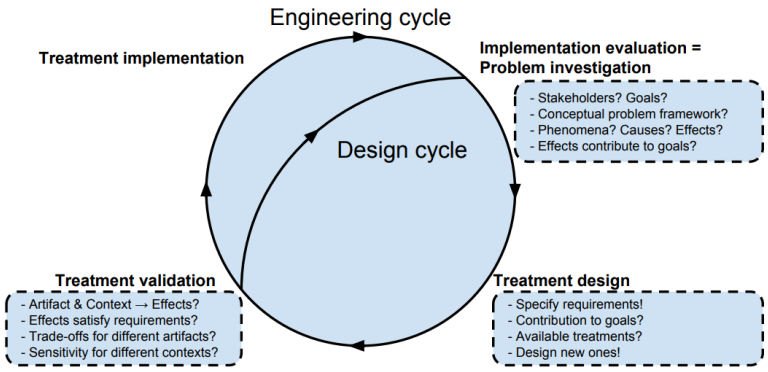


Figure 2.2: The Design Engineering Cycle of Wieringa (Martakis, 2015; Wieringa, 2014)

2.2. The Research Approach

The three phases all yield concrete steps for the case study of designing an interface of an AMR system in the field of preoperative screening. These qualitative research methods were combined into a research approach presented in Figure 2.3. In this Figure, each phase of the design cycle is applied to the case study. Every phase consists of one or more research questions. Elaboration on each phase and its corresponding research steps can be found in the following Sections.

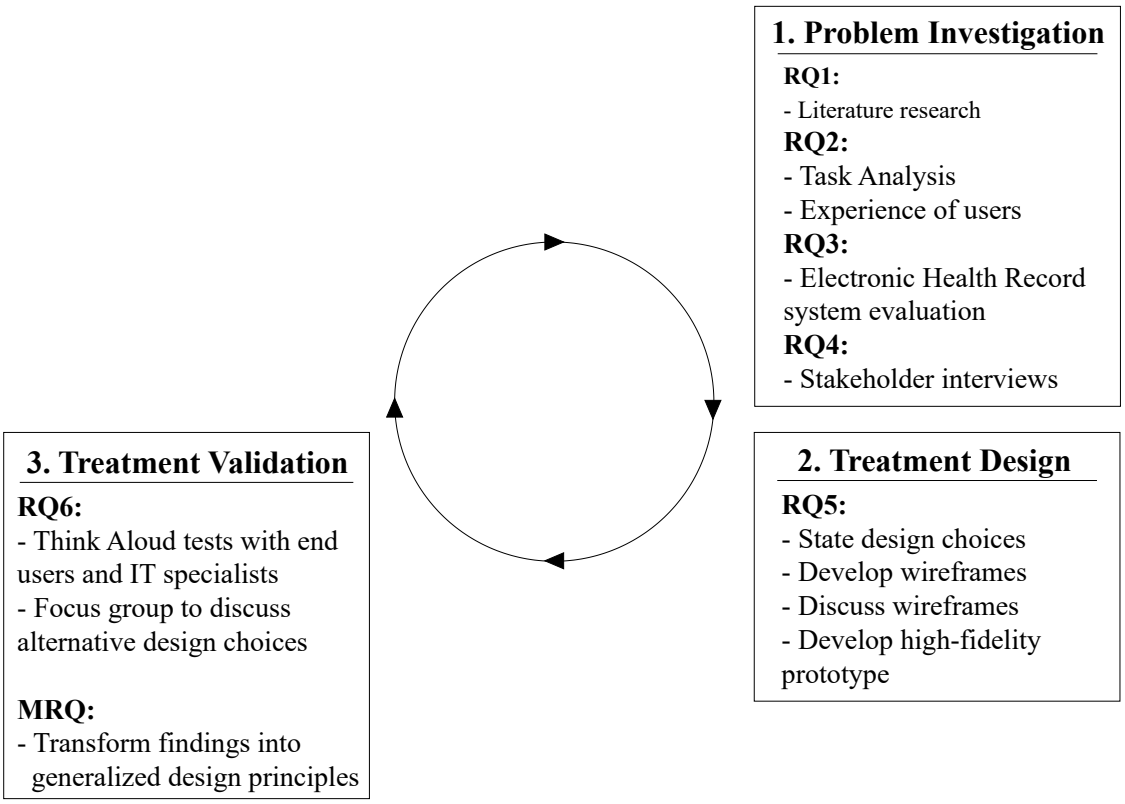


Figure 2.3: The Research Flow

2.3. Interpretation: Problem Investigation

In the first phase of the design cycle of Wieringa, the problem investigation, the research goal is to "investigate an improvement problem before an artifact is designed and when no requirements for an artifact have been identified yet" (Wieringa, 2014). The first task within this research goal is to identify, describe, explain and evaluate the problem. As Wieringa states, the problem investigation is focused on investigating the real world by visiting it, identifying stakeholder goals and

identifying real-world phenomena. The right upper box of Figure 2.3 contains the specific steps proposed to investigate the current situation and the context of the design science. The current situation yields the literature on specific topics related to Automated Medical Reporting and the operational processes of preoperative screeners. The methods used to anwer the questions stated in the right upper box of Figure 2.3 are explained in the subsections below.

2.3.1. The Literature Research

The first research step was to identify the gap in the scientific literature in order to answer the research question: *What are the important technological developments and user interface guidelines in healthcare?* The literature research was performed according to manual search starting at Google Scholar with terms such as *benefits "Electronic Health Records"*, *documentation in healthcare*, *administrative burden healthcare*, *medical assistants*, *Automated Medical Reporting*, *usability guidelines*, *"information system" healthcare usability*, *Nielsen heuristics*, *interface research healthcare system*, *speech recognition healthcare usability* and *interface speech recognition*. Apart from searching sufficient literature based on these search terms, backward snowballing was used. Reference lists of useful articles were checked on additional interesting studies (Wohlin, 2014). The members of the research team and the supervisors recommended some studies too. The details of the literature study can be found in Section 3.

2.3.2. The Task Analysis Procedure

The second research step within the problem investigation involves exploring the research environment. The focus is on understanding the workflow of a preoperative screening. This investigation aims to address the research question: *What is the workflow of a preoperative screening in the UMC Utrecht?* To answer this question, a task analysis is done. A task analysis is "the process of examining the way in which people perform their tasks" (Stone et al., 2005). The task analysis of a preoperative screening is performed by a team of researchers who shadowed preoperative screeners of the UMC Utrecht for one day. By observing the care professionals in their work and asking some additional questions, a task-analysis diagram is developed (Rosala, 2020; Stanton, 2006). The model of the task sequence of a preoperative screening is created with the goal to facilitate communication and understanding and to provide input for the design process (Wand & Weber, 2002).

2.3.3. The Heuristic Evaluation Method of the Electronic Health Record System

The part of the Electronic Health Record system utilized within the UMC Utrecht which is responsible for documenting preoperative screenings, underwent a heuristic evaluation based on

Nielsen's usability heuristics. These heuristics are elaborated on in Section 3.4.2. During a heuristic evaluation, "the evaluator goes through the interface several times and inspects the various dialogue elements and compares them with a list of recognized usability principles" (Nielsen, 1995). Normally when performing a heuristic evaluation, multiple evaluators assess the usability of the system for 1 or 2 hours. However, since the operation of the EHR system of UMC Utrecht is not the main focus, and the EHR system account used to perform this evaluation has limited rights, this evaluation will be limited in scope.

Additionally, the structure of a preoperative screening dossier is identified. This knowledge of the dossier and the EHR system currently utilized is essential for establishing requirements for a new system within the same environment and developing a realistic prototype.

According to this investigation, the research question *How is the Electronic Health Record system used during the preoperative screenings and what are its potential issues?* is answered.

2.3.4. The Stakeholder Interview Procedure

The research question, *What are the stakeholders' expectations of the interface of an AMR system?* reflects the part of the problem investigation phase focused on the stakeholder goals, the social context. In order to minimize the gap between IT and the medical field, a semi-structured interview setup that allows for unexpected follow-up questions was suited. A total of five semi-structured interviews were conducted. Three of the interviewees were preoperative screeners, one of them was the head of the anesthesiology department and the last interviewee was a research expert on Automated Medical Reporting. The guide for the semi-structured interview sessions that were used for the four care providers, can be found in Appendix A. As the interviewer, as well as the interviewees, were Dutch, this guide is in Dutch too.

As the guide for the interviews in Appendix A shows, the interview session started with an introduction to the research and retrieving consent. The participants provided their consent for their answers to be utilized for research purposes and for the interview to be recorded. After the introduction, several questions were asked. The interview questions are divided into three main subjects; the current situation, experiences with speech recognition, and expectations regarding the interface. The first five questions comment on the current situation and the Electronic Health Record system used. Within this first part of the interview, an important quantifying estimation is addressed by the question: *How many minutes do you spend on filling in the screening questionnaire and writing the conclusion on average?*

Secondly, the expectations of and experiences with speech recognition systems are addressed. In order to investigate to what degree the interviewees are open to speech recognition software questions on technical skills are addressed.

The third and last section of this interview is about interface design, the focus of this research. Again a short introduction is given to explain the goal and to state how important the participants' input is. Within the interface section, a distinction can be made between data processing, the integration with the EHR system, and the interviewees' thoughts about the future. Thoughts regarding the systems' interactions with the user during the consultation are gathered by asking questions on topics such as direct feedback and feedback about screening questions being missed by the screener or the system. Secondly, how the output of the AMR system should be integrated with the EHR system is addressed too.

Lastly, some questions were asked about the future of AMR systems, encouraging the interviewee to think beyond the possibilities offered now. As the system makes use of a microphone, and the automatically generated report always needs to be checked for errors, this can be done by dictating instead of typing.

Not only insights from a medical perspective were gained. As this research is part of a Care2Report project, the head of this research team was interviewed in order to obtain visions for interface design for an Automated Medical Reporting system. During this interview, existing design principles proposed by the Care2Report research team (Maas et al., 2020) were discussed.

The data obtained from the first four interviews were combined into a table. Subsequently, the table was subjected to thematic content analysis, a method employed for analyzing qualitative data. During this analysis, common themes in the texts are identified such that conclusions can be drawn (Anderson, 2007). The insights provided by the Automated Medical Reporting specialist regarding the existing design principles were documented and integrated with the themes that arose during the analysis of the interviews with the employees of the preoperative screening department.

2.4. Interpretation: Treatment Design

In the second phase in Figure 2.2 the treatment design and its properties are stated. In this phase, the requirements for the treatment identified in the previous phase, are listed.

Within the scope of this research, this phase consists of the steps in the right lower box shown in Figure 2.3. The requirements of the treatment were retrieved by analyzing the interviews conducted to gain insight into the expectations of future users. Besides, the design principles of Care2Report systems and interface design in healthcare were included in the list of requirements. These requirements were translated into design choices on which the interface prototypes were based.

2.4.1. Wireframe Sketching

The first step in designing the treatment was developing wireframes of a possible User Interface for a preoperative screening Automated Medical Reporting system. These wireframes are sketches on paper and provide "the basic blueprints that illustrate the core form and function of the screens of the application" (Hamm, 2014). Simultaneously, a set of digital wireframes were developed. Afterward, this blueprint was discussed with a set of ICT professionals, because wireframes are useful especially in the early stages of designing the user interface (UI) according to Molina et al. (Ramón et al., 2013). Having discussed these low-fidelity wireframes with ICT specialists, some adjustments were made.

2.4.2. High-Fidelity Prototyping

After having established the basic framework of the interface, an interactive high-fidelity prototype of the User Interface was created using Figma, an online interface design platform. Prototypes are used to gather detailed customer feedback on issues like for example aesthetics and the implementation (Christie et al., 2012).

2.4.3. The Creation of an Updated Task-Analysis Diagram

During the treatment design phase not only prototypes were developed. The task-analysis diagram of a preoperative screening was updated to a version including an Automated Medical Reporting system too. This diagram is validated according to a discussion with the research team as well as during the think-aloud sessions.

2.5. Interpretation: Treatment Validation

After having designed several wireframes for the interface of an Automated Medical Reporting system in the field of preoperative screening, the design choices of the interactive high-fidelity prototype were validated through different kinds of evaluation. First, the prototype was subjected to think-aloud sessions in a controlled setting. This part of the validation process is elaborated on in Section 2.5.1. Afterward, the design choices and additional design ideas were discussed in a focus group with members of the Care2Report research team. During the validation phase, questions about the treatment effect, trade-off, sensitivity, and satisfaction were asked to justify that the treatment would contribute to the stakeholder goals (Wieringa, 2014). These questions are derived from results during this study, thus elaboration on these subjects are elaborated on later in Section 7.1. and 7.2. According to the analysis of the results, an answer to the research question: *Which aspects of the User Interface of the AMR system for preoperative screening contribute to a positive User Experience?*, can be provided.

2.5.1. The Think-Aloud Test Procedure

To identify usability problems and discover alternative design options, guided think-aloud sessions were conducted. The basic principle of a think-aloud is "that potential users are asked to complete a set of tasks with the artifact tested and to constantly verbalize their thoughts while working on the tasks" (Van Den Haak et al., 2003).

Participants For the think-aloud sessions, a sample size of nine participants was established according to the literature on user tests. Usually, five participants are included in user tests according to Nielsen (Nielsen & Molich, 1990). However, with including a larger number of users, individual differences can be reported on, reliability increases, and more usability problems come to light (Alroobaea & Mayhew, 2014). Based on an analysis of 102 usability experiments, Hwang and Salvendy concluded that "an optimal sample size of '10±2' can be applied to a general or basic evaluation situation. For example, just basic training provided to evaluators and a limited evaluation time allowed" (Hwang & Salvendy, 2010). Within the sample for this research, the participants five medical professionals and IT specialists were selected. The participants were gathered using purposive sampling. This method is used to select respondents that are most likely to yield appropriate and useful information, to increase the depth of understanding (Campbell et al., 2020; Kelly et al., 2010; Miles & Huberman, 1994; Palinkas et al., 2015).

Observer During the think-aloud sessions, the observer will provide the participants with instructions and gives help when it is needed (Lewis, 1982).

Set-up To conduct the think-aloud sessions, it is essential to have a laptop or desktop computer equipped with the high-fidelity Figma prototype. To enhance the controlled environment, participants may choose to utilize a mouse instead of a touchpad. Furthermore, the sessions require a recording set to capture the audio, along with the think-aloud guide explained in Section 7.1.1.

Process The think-aloud sessions consisted of performing a set of tasks to guide the participant through the system. During the execution of these tasks, the participants were asked to express their thoughts. After having completed the tasks, a set of questions corresponding to the design choices were asked. The tasks and evaluation questions were based on findings during this study. Therefore the think-aloud guide including the tasks and questions is discussed in Section 7.1. Lastly, the task analysis which incorporates working with an AMR system is presented to the participants to elicit some feedback.

Analysis A content analysis was performed in which the textual data of the think-aloud sessions were systematically categorized to draw conclusions (Miles & Huberman, 1994). Especially the comments on the design choices were reported.

2.5.2. The Focus Group Procedure

A focus group is conducted to discuss the findings of the think-aloud sessions. For this focus group, four students in the field of Automated Medical Reporting were included. A focus group can be defined as "a technique involving the use of in-depth group interviews in which participants are selected because they are purposive, although not necessarily representative, sampling of a specific population, this group being 'focused' on a given topic" (Thomas et al., 1995). A moderator leads the group discussion according to a guide, which functions as a road map. According to Vaughn et al., this guide should include an introduction; a warm-up; clarification of terms; easy and non-threatening questions; more difficult questions; a wrap-up; a member check (providing members with an opportunity to verify their feelings/ideas); and closing statements (Vaughn et al., 1996). Elaboration on the interpretation of the focus group for this research can be found in Section 7.2.1. since the interpretation is based on the findings of the think-aloud sessions.

2.5.3. The Evaluation Interview Procedure

Since the software developer of the Automated Medical Reporting system for preoperative screenings was unable to attend the focus group, an additional interview was conducted. This interview was focused on the interface and followed the same framework as the one used for the think-aloud sessions.

2.6. The Deliverables

During this research, deliverables are constantly translated, which eventually results in design principles for an interface for an Automated Medcial reporting system. How this translation process will proceed is illustrated in Figure 7.1. The upper row of boxes are research actions, the lower row are the deliverables.

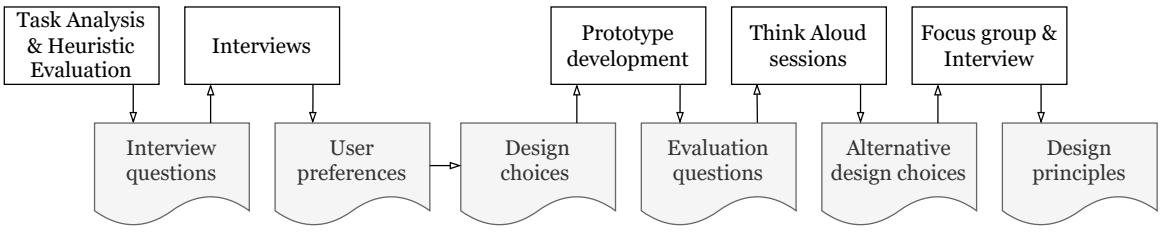


Figure 2.4: The Deliverables of This Study

2.7. The Validity Threats

2.7.1. Construct Validity

Construct validity refers to the extent to which the measures used in the research accurately capture the underlying constructs or concepts of interest (Bhandari, 2022). Within this study, the design choices are based on the input of potential end users, a task analysis and an analysis of the Electronic Health Record system. Testing the usability and satisfaction of these design choices might be threatening the construct validity since these themes are hard to objectify. To counter this threat, a combination of different evaluation methods is used.

2.7.2. Internal Validity

The internal validity of research concerns to which extent you can be confident about a cause-and-effect relationship (Runeson & Höst, 2009). In the context of this research, threats to this kind of validity are present within the development and testing of the prototype. Specifically, the translation of the outcomes of the problem investigation phase into certain aspects of the prototype may not directly reflect the intended cause-and-effect relationship.

For instance, one aspect of the prototype aimed to address the feeling of privacy by incorporating a deletion process. However, it is possible that the feeling of privacy may not be directly linked to the specific deletion process implemented in the prototype.

The internal validity is strengthened by gathering feedback from nine participants individually. However, the potential limitations need to be acknowledged.

2.7.3. External Validity

The external validity of research is the extent to which the findings can be generalized and applied to other situations (Runeson & Höst, 2009). Threats to this kind of validity are important since this research is a case study. The design choices are implemented and tested for an Automated Medical Reporting system for a preoperative screening procedure. The findings and conclusions drawn from this research may not be directly applicable to other healthcare settings or medical procedures.

Furthermore, the testing of design choices in a controlled lab setting without involving actual patients may limit the realism and generalizability of the findings. Including patients in the testing phase would provide a more authentic representation of the user experience and potential challenges encountered in real-world scenarios. However, this is not possible because of the complexity of preoperative screenings.

To enhance external validity, efforts were made to ask evaluation questions that are as generalized as possible. This involves formulating questions and assessing design choices in a way that allows for broader applicability beyond the specific preoperative screening setting.

2.7.4. Reliability

This aspect of validity is focused on the extent to which results can be reproduced (Runeson & Höst, 2009). Several threats to the reliability of this research exist, including the reliance on the current outline of the screening report within the prototype. Given that the outline is subjected to potential changes in the future, the reliability of the research findings may be affected since the prototype becomes outdated.

Furthermore, the unique circumstances surrounding the Care2Report project and its collaboration with the Anesthesiology department may not be easily replicated. It is unlikely that the exact same project will be conducted in the future, introducing variability and potential challenges in reproducing the research methods and outcomes.

To counter these threats, the method of this research is carefully documented and the guides used for qualitative data retrieval are included in the appendices.

Chapter 3

PROBLEM INVESTIGATION: TECHNOLOGICAL DEVELOPMENTS IN HEALTHCARE

In this Chapter, the scientific knowledge context of the research is reported. In the first Section, the technological changes in healthcare from the 90s until now are explained. These technological changes have a tendency to cause an administrative burden. How this is caused and what this burden is, is elaborated on in Section 3.2. Already proposed solutions to the administrative burden are discussed in Section 3.3.

Two other topics that are discussed in this Chapter are the existence of User Interface research and speech recognition systems in healthcare. Previously conducted UI research is reported on in Section 3.4. and 3.5. An overview of Speech Recognition systems in healthcare is provided in Section 3.6.

3.1. The Technological Changes in Healthcare

3.1.1. The Electronic Health Record

The documentation processes in healthcare are important for providing the care a patient requires. The documentation processes in healthcare consist of two parts: *information capturing* and *report generation*. Information capturing is the process of documenting the thoughts, perceptions, and actions of the patient and care provider. The input can vary in terms of source, for example, written or spoken text, and images. Report generation refers to structuring and analyzing the information such that it can be added to the patient's health record (Waegemann et al., 2002). To support the documentation processes in healthcare and improve its quality, an inter-organizational, patient-centered health record was introduced in the 1990s (Hoerbst & Ammenwerth, 2010), which is called an Electronic Health Record.

In an Electronic Health Record (EHR) of a patient, different reports of consultations of different care providers are stored in one place (Hoerbst & Ammenwerth, 2010). Besides, patient demographics, progress notes and vital signs are included. The record of a patient is stored in an EHR system such that the record can be adapted, managed, and consulted by authorized clinicians and staff of healthcare organizations. The storage of patient data is not the only thing an EHR system is used for. Electronic Health Record systems are designed to go beyond data collection to improve patient care ("What is an Electronic Health Record", 2019). These systems

provide several decision support features, prescribing tools and computerized physician order entry (CPOE), a system for directly entering medication orders (Baumann et al., 2018). A CPOE supports completing the health records and improving drug choice by doing drug allergy checking and basic dosing guidance (Pham et al., 2012).

3.1.2. The Effects of Using Information Technologies in Healthcare

The use of EHR systems has benefits such as the improvement of communication. Due to having patient records in online shared spaces, all patient-related information is accessible from almost anywhere on earth for authorized practitioners (Waegemann, 2003). Information is easily shared with other care providers and laboratory abnormalities can directly be communicated. Research in 1999 already showed that an automatic alerting system reduces the time until an appropriate treatment was ordered for patients who had critical laboratory results (Kuperman et al., 1999). Besides, during the same study, Kuperman stated that "information technologies that facilitate the transmission of important patient data can potentially improve the quality of care".

Lastly, by integrating Computerized Physician Order Entry systems in combination with clinical decision support systems, medication errors can be reduced (Pham et al., 2012). Devine et al. researched the difference in medical errors made between handwritten prescriptions and electronically written prescriptions. These electronically written prescriptions were given using a CPOE system. They found a significant reduction in medication errors after implementing a CPOE system (Devine et al., 2010). This is not the only study done on the impact of a CPOE system on medical errors. In a systematic review, in 8 of the 10 included studies on the effect of CPOE, evidence was found that a CPOE system was associated with a significant reduction in the medication error rate (Prgomet et al., 2017).

Overall, implementing an Electronic Health Record system and other information technologies show a reduction in medical errors which contributes to patient safety (Menachemi & Collum, 2011). Moreover, the benefits of implementing EHR systems do not only focus on patients and their care providers. Benefits focusing on societal outcomes include possibilities of research because of the amount of patient data that can be used to improve the population health (Menachemi & Collum, 2011). Data generated and stored can also be used to support research in the clinical area and in the area of system-specific quality. In the clinical area, data of several patients who suffer from the same illness can be used to improve self-service query tools (Horvath et al., 2014). For system-specific quality, data can be used for research into tasks and patterns within an EHR system and the effect of inclusion of task management tools for example (Glover et al., 2022).

Since the introduction of Electronic Health Records in the 90s, healthcare has improved due to the benefits stated above. However, Electronic Health Records and their systems have some disadvantages too. Menachemi and Collum (2011) have identified these potential disadvantages in their research into the benefits and costs of EHR systems. Costs they identified were for example

differences in workflow, financial shifts, and temporary loss of productivity due to the difficulty of getting familiar with a new system. Besides, these systems require a lot of specific information, which results in more administrative work for care providers.

3.2. The Administrative Burden in Healthcare

The scope and the number of administrative tasks of care providers are growing, which negatively affects the healthcare system as a whole (Erickson et al., 2017). This results in an administrative burden, which can be defined as 'the costs of administrative activities that organizations have to perform in order to comply with the information obligations' (Executive, 2006). Within these administrative tasks, two types can be distinguished: patient-related administration and non-patient-related administration (De Veer et al., 2017). Patient-related administration tasks are tasks such as creating a record or care plan. Non-patient-related administrative tasks are for example billing or keeping track of hours worked.

These administrative activities come with financial costs as can be deduced from the definition stated above. However, not only this financial perspective on the administrative burden in healthcare covers the costs made. The individual perception of a burden due to the administrative obligations healthcare professionals encounter is another perspective that needs to be taken into account (Burden et al., 2012). This perceived administrative burden focuses on the time spent by the care provider and the frustration that arises from the lack of usefulness of the administrative activities according to the research into the Dutch mental healthcare of Maris et al. (2021). Their research mostly focused on the increase of administrative burden as a result of a change in law.

Another research into the administrative burden in Dutch healthcare was done by De Veer et al. (2017). On behalf of Nivel, a public knowledge organization specializing in research into healthcare, and the Dutch government, De Veer et al. researched the number of administrative tasks performed by Dutch care providers. The answers to a survey showed that care providers in the Netherlands spend on average 10 hours per week on administrative tasks. In 7 of those 10 hours, the focus is on patient-related administration, and the other 3 hours were spent on non-patient-related administration. 64% of the 1500 care providers who filled in the survey state that they experience the pressure of the number of administrative tasks (De Veer et al., 2017). However, the results also indicated that care providers accept the negatives of administrative work, because it is important in health care to document noteworthy events.

3.3. The Proposed Solutions To the Administrative Burden in Healthcare

As research has been done into the administrative burden in healthcare, conclusions can be drawn. On average, a care provider spends 10 hours per week on administrative tasks in healthcare as stated above. Besides, the usefulness of these administrative tasks is often questioned too. However, the administrative tasks involved with patient-related documentation processes remain important. That is why eliminating administrative tasks to lower this burden cannot be done in most cases. As reducing the number of administrative tasks is often not an option, research into other solutions is done. Solutions proposed are for example hiring medical assistants and implementing a medical reporting system. These solutions are elaborated on in the following subsections.

3.3.1. A Secretary Transcriber

The number of administrative tasks in healthcare resulted in 2019 in France in the introduction of medical assistants (Guyonvarch et al., 2022). These medical assistants were trained to perform administrative and clinical tasks delegated by the physician. Assistants with medical backgrounds were able to take up more clinical tasks than the ones without a medical background. By lowering the workload of the physician, the introduction of medical assistants should contribute to the quality and productivity of the work of general practitioners (GP). Guyonvarch et al. studied these effects by doing a qualitative analysis of the inclusion of medical assistants. In their paper, they stated that "in general, a gain of efficiency in daily workload enabled general practitioners to slightly increase their productivity. However, for most GPs, it primarily helped them to maintain a high workload without burning out". In other words, the success of the inclusion of medical assistants can relieve the workload and stress of physicians. Because this study states that there is only a slight difference in productivity, the costs of including an assistant might weigh out this benefit.

3.3.2. Automated Medical Reporting Systems

Another possibility of decreasing administrative activities in healthcare is by implementing an Automated Medical Reporting system. Research into the advantages of these kinds of systems is done by several research teams. In 2023, a systematic review on automatic documentation of professional health interactions was conducted byFalcetta et al. (2023). Within their scope of the search, they included research on systems that could detect speech and transcribe it in a natural and structured fashion during doctor-patient consultations. None of the eight included studies had shown sufficient real-life experience or large-scale validated results. This can be partly declared by the challenges automated documentation yields. These challenges are identified by Quiroz et al. (2019). They proposed a basic digital scribe that needs to be able to: (1) record the

clinician–patient conversation, (2) convert the audio to text, and (3) extract salient information from the text and summarize the information. All Automated Medical Reporting initiatives that are out now, are based on this principle. This digital scribe is presented in Figure 3.1. The six challenges of automated documentation are: (1) recording high-quality audio, (2) converting audio to transcripts using speech recognition, (3) inducing topic structure from conversation data, (4) extracting medical concepts, (5) generating clinically meaningful summaries of conversations, and (6) obtaining clinical data for AI and ML algorithms.

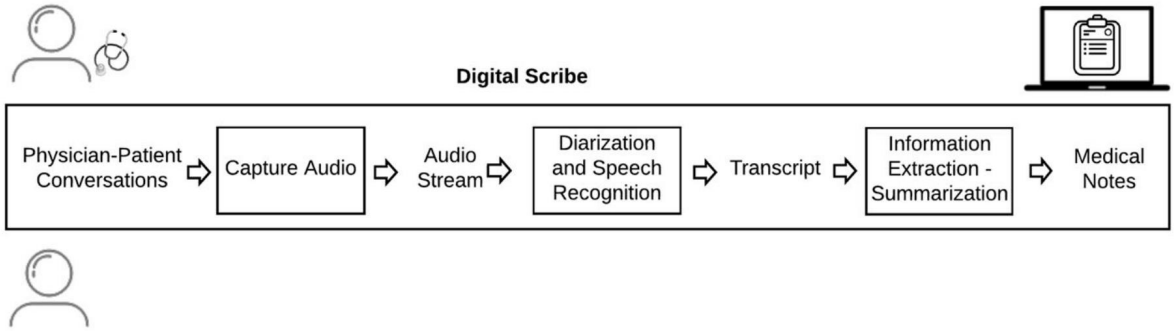


Figure 3.1: The Digital Scribe (Quiroz et al., 2019)

One of the eight studies that aim to support clinicians in medical documentation is the study of AutoScribe (Crampton, 2020; Khattak et al., 2019). A microphone attached to a physician's desktop computer records the consultation, Automatic Speech Recognition is used to automatically extract and parse medical and contextual information, and then Electronic Medical Record notes are generated by an optimized machine learning model. This process is similar to the basic digital scribe in Figure 3.1. The researchers believe with enough data, this can be a helpful assistant to clinicians.

In 2020 a research team at the University Utrecht proposed a vision on the automation of medical reporting for general practitioners (Maas et al., 2020). An integrated hardware and software platform is responsible for a process of three steps similar to the steps of a digital scribe. The first step is recording the medical consultation. This is done by using a microphone, camera, and sensor technology. Secondly, the transcriptions of the consultations need to be interpreted. Based on advanced semantic representation through knowledge graphs combined with medical guidelines and patient data, the consultations are interpreted. The last step is generating a medical report. These reports are automatically generated based on medical domain practices. Before uploading the report into the electronic medical record of the patient, it is checked for errors by the care provider.

The interpretation of the recorded consultation data is done according to the categorization

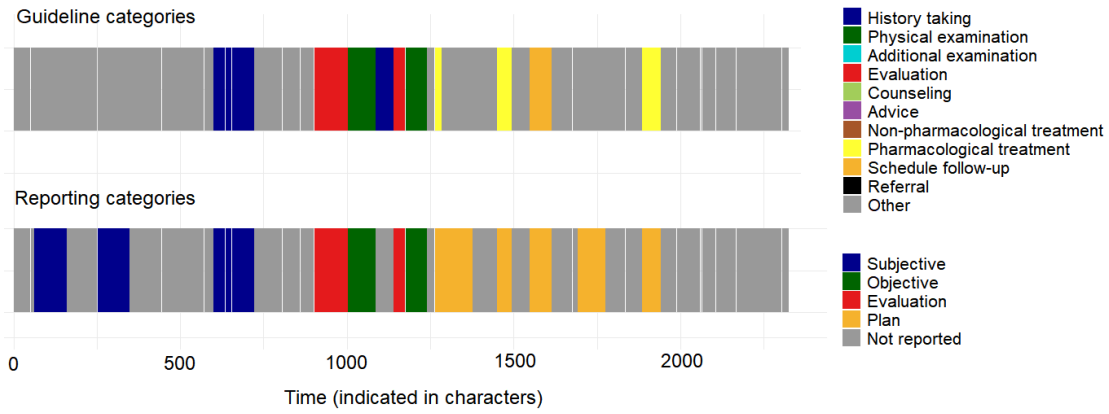


Figure 3.2: The Course of a General Practitioner Consultation (Maas et al., 2020)

of utterances. Utterances can vary from a single word to a sentence. All utterances were categorized twice, once based on the medical guideline suited for that specific consultation and once on the categories that will be reported. An example of the categorization of a medical consultation between a general practitioner and a patient is shown in Figure 3.2. The percentage of the consultation data that was relevant to generate a report was calculated by the researchers. Only around 15% to 40% of the dialogue contained relevant information. Advice and discussion about feelings often occur without directly influencing the report generation. In a further stage of this research, the Care2Report system needs to be able to filter out these utterances such that only relevant information remains. According to the reporting categories, a medical report of the consultation is automatically generated. These categories are Subjective, Objective, Evaluation, and Plan (SOEP), a convention that is often used by general practitioners to record medical input. An automatically generated report would look like the report in Figure 3.3 which is based on the SOEP convention. During the consultation, the general practitioner can fully focus on the patient in front of him, as the system keeps track of the findings. After the consultation, the report shown in Figure 3.3 can be checked and adjusted if necessary.

The results are as the researchers state, promising. They generated reports for eight transcripts of which two were summarized correctly. The other six reports showed mixed results. Matching the words of the transcript with the concepts of ontology, the starting point of the knowledge graph of the medical consultation, was shown to be difficult. Besides, limitations in natural language interpretation occurred too. Negative statements were frequently not picked up on as negative. This resulted in important facts missing from the report.

An initial vision exists for Care2Report in the medical field of General Practitioners. Current research into the implementation of Care2Report is done within the Department of Anesthesiology. The overarching study this research is part of.

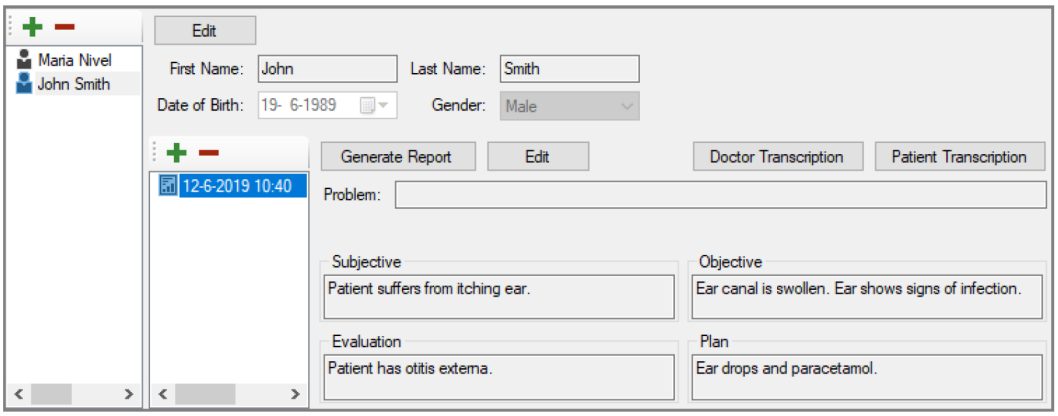


Figure 3.3: An Automated Medical Report (Maas et al., 2020)

3.4. The Interfaces of Information Systems in Healthcare

3.4.1. The User Interface

"The User Interface (UI) is that portion of an interactive computer system that communicates with the user", as stated by Jacob (2003). The UI is the visible part of the system and therefore a vital part of a computer system. Poor UI design has several consequences, such as increasing error rates, higher training costs, and reduced throughput of data (Stone et al., 2005). That is why adequate User Interface design contributes to the success of a system as a whole.

A high-quality interface is one that a user can use without being aware of using a computer (Stone et al., 2005). However, the quality of an interface is a subjective measurement. In order to objectify the quality of the interface, the usability of the interface can be identified. According to the International Organization for Standardization 9241, usability is defined as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO, 2018). Effectiveness indicates the accuracy and completeness of the interface for the specified users. Efficiency is defined as the resources expended, such as time, in relation to the effectiveness of the goals achieved. Satisfaction is the comfort and acceptability of the system to its users and other people affected by its use (Stone et al., 2005). During the design process of a User Interface, the specified users as well as the specified context is required to be taken into consideration according to Stone et al.

3.4.2. The Usability of Interfaces in Healthcare

In the field of Healthcare, the usability of new information systems is frequently overlooked (Shaw et al., 2015). Due to the ignorance of the usability concerns, user acceptance decreases. Poor UI's have been identified as the major obstacle to the acceptance and use of healthcare information systems. To overcome this issue, in 2011 the Agency for Healthcare Research and Quality of America presented a report in which it was stated that usability testing should be a core aspect in the development of Electronic Health Record systems (C. Johnson et al., 2011).

Usability issues of EHR systems did not only arise in America. In Finland in 2017, research on usability concerns of clinical professionals was conducted by Kaipio et al. (2017). In their study, they present the results of two surveys on the experiences with the EHR systems used. Results of these surveys suggest "the existence of serious problems and deficiencies which considerably hinder the efficiency of EHR use". Besides, changes over a period of four years have been studied and no significant improvements were shown. The bottom line of this research is that studying the experienced usability of EHR systems is essential in order for care workers to benefit from the implementation of such a system.

Recently in the Netherlands, where this research is situated, exploratory research was done by the Dutch National Institute for Health and Environment in conjunction with the University Medical Center of Amsterdam (Weda et al., 2020). This research focused on medication incidents as a result of user-unfriendly IT systems used by clinicians. This study resulted in a top 10 of the most frequently occurring usability issues. Insufficient synchronization of different systems within one system was mentioned the most. The usability issues of health IT systems that arose, were often solved by adjusting the workflow. Instead of approaching the software suppliers, paper notes have been hung up to guide the care provider through the system correctly. A key aspect derived from this research is that health IT system suppliers need to focus more on usability features, in the development process as well as the evaluation process.

Not just the usability of EHR systems needs to be studied more, the rise of Artificial Intelligence based algorithms in healthcare require interface research too. Increasing the trust and reliability of the users can be achieved by using explanation interfaces. Manresa-Yee et al. (2021) presented an overview of contexts in healthcare where explanation interfaces are used. An important research area for this case study, since the Care2Report system is an AI-based system and aims to produce real-time system feedback. Manresa-Yee et al. emphasized the challenges the HCI communities face in developing more explainable models. At this moment, no specific HCI design standards for AI solutions exist (Xu, 2019). Thus for this research, the design interface guidelines and principles available remain an important resource for the development of the interface prototype.

Including the end-users, the care professionals in this case, is shown to be an important aspect

in User Interface design (Kaipio et al., 2017; Stone et al., 2005). Furthermore, for ensuring the accessibility and usability of data generated by EHR systems, following UI design heuristics is essential according to Shaw et al. (2015). The well-known, revised set of usability heuristics Nielsen presented in 1994, was based on an analyzed, broader set of heuristics. The ten important heuristics UI designers often work with are: visibility of system status, match between system and the real world, user control and freedom, consistency, and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, and helping users recognize, diagnose, recover from errors and help and documentation (Nielsen, 1994a).

In 2023 a study on developing and extending usability heuristics evaluation for User Interface Design was published by Benaida (2023). Although Nielsen's heuristics are used the most, they are criticized based on the fact that it is a static analysis. Besides, according to a systematic review of usability heuristics, the generality of Nielsen's heuristics was indicated as the main disadvantage (Jimenez et al., 2016). In the past decade several improved sets of heuristics have been proposed, but all with weaknesses too. The lack of validation is one of the most important downsides. In his study, Benaida aimed at providing improved validated heuristics to guide evaluators toward heuristics that require more attention. This is done by combining Nielsen's heuristics and the USE (usefulness, satisfaction, and Ease) questionnaire, a questionnaire consisting of 19 usability questions (Lund, 2001). This combination resulted in 14 main heuristics, in which sub-heuristics are assigned priority rankings by Analytic Hierarchy Process (AHP). This process was initially developed to help researchers identify priorities in their multi-criteria and consistency ratios that help with the decision-making of experts in different fields (Saaty, 1987). With the use of five experts in Human-Computer Interaction, Software Engineering, and Information Systems, the new set of heuristics was validated. With this revised set, almost triple the amount of issues was identified compared to Nielsen's heuristics.

As research into Automated Medical Reporting systems is scarce, guidelines for or an example of an interface do not exist yet. As mentioned in Section 3.3.2. the Care2Report research team has provided a vision on an AMR system. A set of principles was included in this vision. As this research is part of the expansion of research into Care2Report implementations, several of those principles are considered in the interface design process. The three principles that affect the interface are: 1) report generation in real-time, 2) complete and concise summaries of consultations and 3) care provider must check and possibly edit reports (Maas et al., 2020). All eight Care2Rpeport design principles are shown in Figure 3.4.

3.5. The Design Choices in Healthcare Information Systems

Research into actual interface designs for Automated Medical Reporting systems is scarce. In order to obtain design recommendations for an interface of a system in healthcare, literature about similar systems was consulted. A kind of healthcare IT system that already exists and comes close

P_1	No interference with current working procedures.
P_2	Simple input control of all modalities.
P_3	Report generation in real time.
P_4	Complete and concise summaries of consultations.
P_5	Care provider must check and possibly edit reports.
P_6	System learns from corrections by care provider.
P_7	Applicable for multiple healthcare disciplines and languages.
P_8	Compliant with privacy regulations.

Figure 3.4: The Eight Initial Care2Report Design Principles (Maas et al., 2020)

to the objectives of report generation, is the Clinical Decision Support System (CDSS). At the simplest level, these are tools to help clinicians and patients make better informed decisions during the use of the Electronic Health Record system (Miller et al., 2018; Sim et al., 2001). Miller et al. conducted a narrative review to identify recommended design features for interfaces of CDSSs. In their review, 14 studies were included. Within these studies, the design features were measured according to improved significance, e. g. provider satisfaction and usability, and improved outcomes of care. A total of 42 design recommendations were identified, which were categorized in interface, information, and interaction recommendations. The 11 interface recommendations are shown in Figure 3.5.

Box 1. Interface features categorized as presentation, placement, positioning, and provision of multiple presentation layers

Interface (Presentation)

Presentation
- Make it simple
- Use appropriate font sizes
- Use meaningful colors
- Ensure acceptable contrast between text and background
- Keep presentation consistent
- Deploy space-filling techniques
- Make icons bold or bigger in size

Placement and positioning
- Display information in prominent positions to ensure that it is seen
- Allow for reading left to right
- Localize information

Provision of multiple presentation layers
- Avoid using only text

Figure 3.5: The Clinical Decision Support System Interface Recommendations (Miller et al., 2018)

For the interface, clean and simple designs are recommended. Besides, using only text needs to be avoided. Instead, tables, graphs, buttons, scroll bars, and iconic language can be used according to the narrative review. "Reducing text density makes the CDSS easier to interpret during busy clinician encounters and keeps the attention of the provider. Additionally, information-oriented, systematic graphic design helps providers understand complex information" (Miller et al., 2018).

Regarding the information features, incorporating content guidance was recommended. "A CDSS should provide a recommendation, not solely an assessment, and explain and justify the recommendations and their source by providing reasons and research evidence" (Miller et al., 2018). Besides, the cognitive workload of the users should be reduced by including information consistency. Recommendations of the CDSS should come from the same place and should have the same display.

The important aspects regarding interaction were amongst others; providing timely feedback and flexible design. A CDSS should provide timely feedback on what action has been done. Secondly, "CDSSs must be flexible and adaptable, able to explore multiple assumptions and incorporate new information as circumstances change" (Miller et al., 2018).

During this qualitative review, a list of recommendations was compiled, however not validated. Miller et al. state the limitations of their work to be the subjective basis since the review was based on their opinion. In further research, these design choices need to be validated by user tests.

3.6. Speech Recognition Systems in Healthcare

During a medical consultation, important aspects are discussed and documented. To ease this documentation process can be supported by Speech Recognition technology. Speech recognition (SR) systems compose of microphones, sound cards, and speech engine software (Al-Aynati & Chorneyko, 2003). Accurate Speech Recognition is an important aspect of the digital scribe in Figure 3.1. M. Johnson et al. (2014) conducted a systematic review of Speech Recognition technology in health care, in which substantial benefits of SR systems were found in terms of time reduction and the increase of quality patient care. However, some aspects that negatively affect the accuracy need to be considered, such as the length of the transcription task. Besides, it takes time before care providers are familiar with using an SR system, and frustration due to accuracy issues and poor interface design can result in disengagement. The accuracy of SP systems can be increased by integrating medical templates and dictionaries which eventually results in increased user acceptance.

Another systematic review on Speech Recognition for clinical documentation between 1990 and 2018 was conducted by Blackley et al. (2019). They selected a total of 122 articles in which amongst others, the research topics: productivity, error analysis, comparisons and impact on

workflow were studied. In these studies, productivity was often differently quantified and did not include exact numbers. In 18 studies, productivity was measured by time spent on documentation. 5 of these reported decreased documentation time due to the use of SR technology. 9 studies showed an increase of documentation time, and 4 reported no significant difference. In order to capture the expectations of clinicians, 5 studies included methods such as surveys and interviews. One of these studies was done in 2013. This study into the applicability of ASR for healthcare professionals was conducted byKeskinen et al. (2013). Experiences and expectations of real nurses were gathered during a small-scale Wizard-of-Oz evaluation. Instant dictating and note-taking were perceived as natural, easy to learn and useful. However, according to another study on the user experience of SR systems in healthcare, only half of the participants favored the SR technology over data entry methods (Derman et al., 2010). This was concluded over a 6-month implementation study. What could be concluded out of the 122 studies combined was that SR-assisted documentation in healthcare settings is common, but research into this topic remains largely heterogeneous.

In terms of the usability of Speech Recognition systems, several other studies were conducted too. Dawson et al. (2014) studied speech-to-text (STT) technology for clinical handover management of nurses according to a usability framework. This study indicated the necessity of portable hardware with interface systems that are easy to learn, navigate and intuitive as possible. According to a quantitative study performed by Clarke et al, Speech Recognition Technology implementations in healthcare have critical issues. These issues such as inconsistency, unreliability, and dissatisfaction with the functionality and usability arose from the results of 71 surveys. The researchers concluded that "further attention to improve the functionality and usability of SRT for better adoption within varying healthcare settings is necessary" (Clarke et al., 2015).

This was also shown in a recent study on the word error rate of transcriptions in Automated Medical Reporting settings. Together with three researchers, I studied the effect of accent, voice frequency, and noise on the word error rate of the transcripts (Kwint et al., 2023). This is of great importance because accurate transcriptions are the basis of accurate medical reports in the Automated Medical Reporting setting. What was concluded was that the existence of noise showed a significant difference in word error rate. When studying the implementation of AMR systems in healthcare settings, noise should be minimized according to this study.

Chapter 4

PROBLEM INVESTIGATION: ANALYSIS OF THE PRESENT WORKFLOW

4.1. The Task Analysis

In order to develop a task-analysis diagram of the current workflow of a preoperative screening, a task analysis is done (Rosala, 2020; Stanton, 2006). A research team had the opportunity to report on real-time observations by shadowing three preoperative screeners of the University Medical Center Utrecht. Every researcher had 2-3 hours in which on average three patients were screened. Two types of screenings exist, 1) a consultation by phone or 2) a physical consultation in which the patient is physically present at the department. Whether a consultation is arranged by phone or is physical, depends on the complexity level of the case and the mobility of the patient. During the 2-3 hours of observation, the workflow processes were carefully reported on and occasionally some questions were asked. Based on the findings of this field study, the national preoperative screening procedure (Specialisten, 2020), and the preoperative screening protocol of the UMC Utrecht (Utrecht, 2012), a task-analysis diagram was created. To validate the task-analysis diagram, a discussion with the head of the anesthesiology department was initiated. This resulted in the task-analysis diagram presented in Figure 4.1 and a list of additional key findings.

4.1.1. The Stages of a Preoperative Screening

The task-analysis diagram consists of three stages, 1) the preparation stage, 2) the consultation, and 3) the summarization stage. These stages represent the different phases of a preoperative screening procedure. Within each stage, various tasks are depicted within boxes, indicating that these tasks can be performed in different sequences. While most tasks are common to every consultation, there are two tasks that may not be conducted during every session, denoted by the italicized font. Throughout the process, the screener has access to the HiX system, the Electronic Health Record system of the UMC Utrecht in which the anesthesiology dossier is displayed too. This dossier yields a questionnaire that consists of questions necessary for conducting a risk analysis based on the surgery proposal.

1. The preparation stage

Before the consultation involves the actual patient, the screener prepares the session by reading up on the patient's information in the patient's health record. On average, 15 minutes is spent on the preparation stage.

1. Read surgery proposal
   The treating physician of the patient has applied a surgery for the patient. This proposal is carefully read by the screener in order to understand the surgery plan.

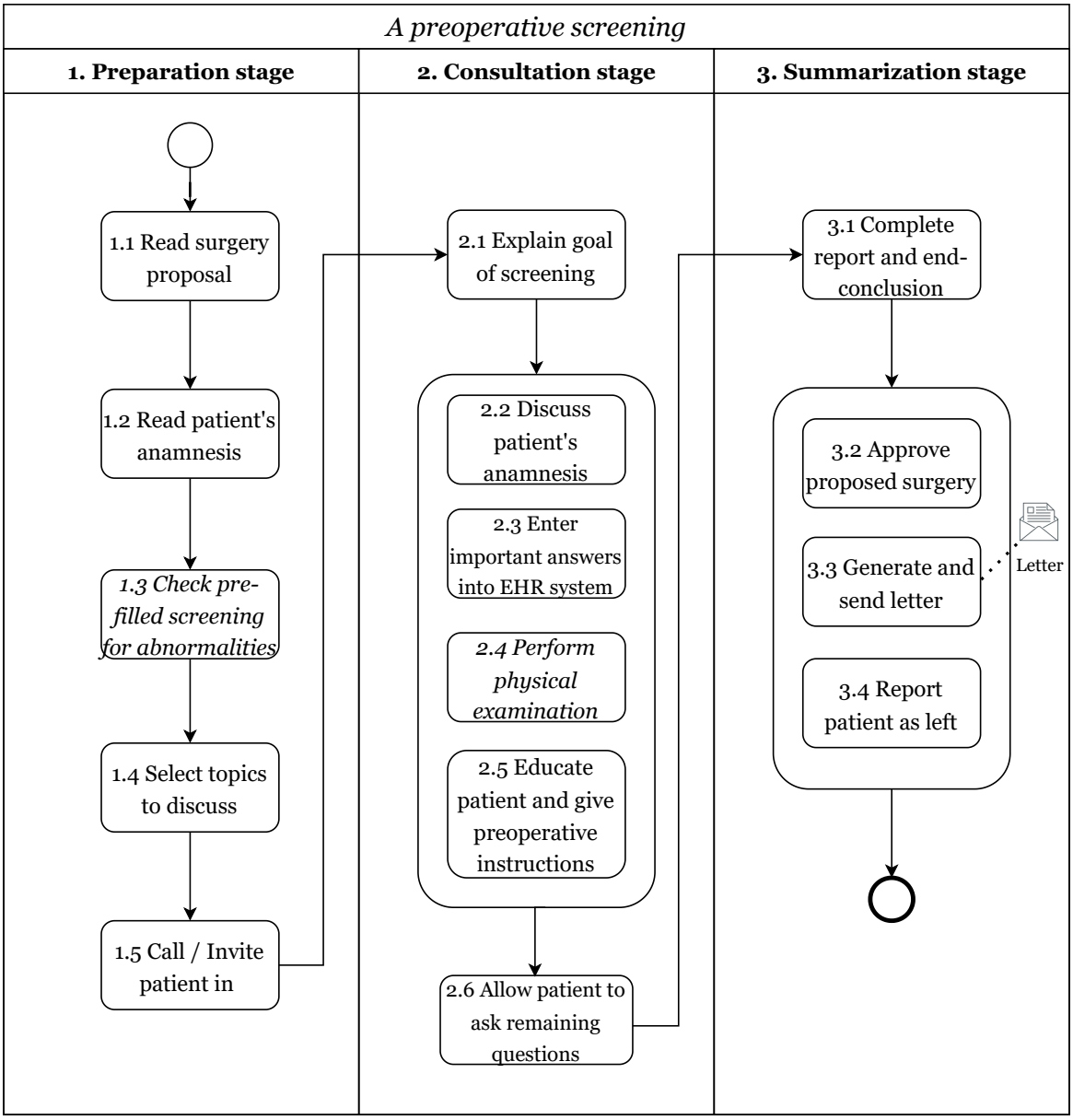


Figure 4.1: The Task-analysis Diagram of a Preoperative Screening

2. Read patient's anamnesis
   Then, the screener reads the medical history of the patient.
3. *Check pre-filled screening for abnormalities*
   Prior to the preoperative screening, a patient needs to fill in a health checklist, the 'gezondheidsvragenlijst' (GVL) in Dutch. Within these answers, a lot of information to assess the risk already can be found. However, sometimes the patient forgets to fill this in and this preparation task can not be performed.
4. Select topics to discuss
   Based on the answers of the GVL, a screener already selects important topics to discuss.
5. Call / Invite patient in
   If the screener has obtained enough information, the patient can be invited in or called.

2. Consultation stage

The second stage in the task-analysis diagram presented in Figure 4.1 is the consultation stage. The stage in which direct contact between the preoperative screener and the patient is facilitated. The focus is on carefully and attentively listening to the patient, regardless of the usefulness of the spoken words.

1. Explain goal of screening
   When the patient is invited in, the screener starts with explaining the goal of the preoperative screening: Assessing the risk and providing the patient with information about the anesthesia method that will be used during the surgery.
2. Discuss patient's anamnesis
   The risk is assessed by obtaining more information about the health history of the patient. The prepared topics will be discussed.
3. Enter important answers into EHR system
   Important findings that already arose during the consultation are directly entered in the preoperative screening report.
4. *Perform physical examination*
   Sometimes, a physical examination is performed. This can only be done in the case of a physical consultation.
5. Educate patient and give preoperative instructions
   Lastly, the patient is educated and is provided with preoperative instructions such as the sober policy.
6. Allow patient to ask remaining questions
   Afterward, additional room for questions about the procedure the patient is about to undergo, is always provided.

3. Summarization stage
When the patient has left or the phone has been hung up, the preoperative screening continues into the summarization stage.

1. Complete report and end-conclusion
   The preoperative screening report is completed and the end-conclusion is generated based on the consultation. From a medical perspective, the end-conclusion is the most valuable part of the report as this yields the instructions for anesthetic colleagues present at the surgery.

2. Approve surgery proposal
   Then, the surgery needs to be approved within the system, such that the surgery planners can decide on a date or can confirm the proposed surgery date. Within this model, the positive outcome of a preoperative screening is modeled. In the real world, the screener is also able to disapprove the surgery proposal.

3. Generate and send letter
   A letter is generated, partly automatic, in which some additional instructions for the patient are stated. This letter is in most cases send by email to the designated patient. When the patient requires a physical copy, it is directly printed out or sent to the patient's home address.

4. Report patient as left
   The only action left is reporting the patient as departed in the HiX system, the EHR system.

4.1.2. Additional Findings of the Task Analysis

During shadowing the screeners, questions were asked to investigate the willingness to integrate an Automated Medical Reporting system within the field of preoperative screening. A number of answers together with our observations resulted in the list of key findings below. It is important to consider that these findings, can vary for every individual screener.

1. Distribution of preparation data
   The patient's health history consists of dossiers generated by different care providers divided between different departments of the hospital. For every department, a different part of the Electronic Health Record system is used. Therefore information is spread over various parts of the EHR system which makes it harder to find relevant information.

2. Entering values
   The time spend on entering answers during a consultation in HiX,is limited. One might be more technically skilled, has more memory storage, or simply has more experience in performing a screening.

3. Conversation relevance
   During the consultation, a lot of time is spent on reassuring the patient and letting the patient

talk. This results in approximately 1/3 of the consultation being relevant for generating a preoperative screening report. The topics do not cover the questions of the preoperative screening checklist all the time.

4. Arbitrary order
   There is no concrete order of going through the questionnaire during a consultation. The order of going through the questions of the questionnaire also varies between the different screeners. One can be used to the order of the dossier and others may start in the middle of the checklist. Besides, it is important to consider the patient's anamnesis. A subject to be discussed which has the most impact for that specific patient, can be better discussed first.

5. Generate end-conclusion
   The main objective of a preoperative screening is to be able to safely perform a surgery. In order to do so, a risk analysis needs to be performed and an end-conclusion needs to be generated. However, from a patient care perspective, comforting the patient and giving preoperative instructions and advice, might be even more important.

6. Word count end-conclusion
   The end-conclusion of a preoperative screening differs from approximately 1-300 words. The conclusion which is created to inform colleagues consists of useful information that is accessed during a surgery. In the case that the patient is healthy and no complications were found during the screening, the screener only needs to write down 'healthy'. However, in some cases, a conclusion requires information about several subjects. That way the conclusion can consist of up to 300 words. The average word count of 142 end-conclusions collected for the training of the Care2Report software, is 87. However, some complex patients were excluded from this data-gathering project. The actual average may be higher.

4.2. The Analysis of the Electronic Health Record System in Use

As this case study is situated within the preoperative screening department of the UMC Utrecht as mentioned before, investigating the current Information Technology system used, is relevant. The Electronic Health Record system utilized in this hospital is HiX (Healthcare Information eXchange), the market leader in The Netherlands in the field of EHR systems. It is "a comprehensive, state-of-the-art, Microsoft-based, fully integrated, and innovative solution that is extremely flexible and configurable" according to Chipsoft, the company behind HiX ("Solutions Chipsoft", n.d.). HiX is the system that supports the documentation processes of every department of the hospital. The structure of the preoperative screening part of HiX is valuable for the further course of this study. That is why this structure is described in Section 4.2.1. This part of HiX is investigated according to the Nielsen heuristics, to be able to integrate the heuristic principle 'consistency and

standards' (Nielsen, 1994b) within the prototype design. The analysis of the system is done using a research account that allows for secretariat properties. Therefore some functionalities were excluded in this evaluation and only a basic overview is provided. The basic overview is elaborated on in Section 4.2.2.

4.2.1. The Preoperative Screening Dossier Setup

Every patient of UMC Utrecht has an Electronic Health Record including all data that is retrieved. This data is divided into dossiers of specific departments, personal information and measurements. Within a patient specific health record, pages that combine different recent consultation results can be found too.

By navigating through the patient navigation menu to the medical dossier, the preoperative screening checklist and patient's health questionnaire can be opened if this already exists. The preoperative screening checklist is the report the screener generates by filling in the questions during a preoperative screening. This report has six sections that need to be completed according to protocol. Most of these sections have a set of subsections and consist of multiple choice, yes/no and open questions. These six sections are:

1. Referral information and patient survey
   The first section consists of the referral data of the main practitioner of the patient and the preoperative survey the patient has filled in. Part of the information filled in by the patient is adopted in the next section, the anamnesis.
2. Anamnesis
   The anamnesis section includes amongst others the medical history of the patient, the cardiopulmonary information, and potential risks during a surgery.
3. Physical examination
   Within the physical examination section, already-known information about the physical state can be noted as well as newly obtained information.
4. Additional examinations
   The additional examinations can be described and requested in the fourth section.
5. Relevant information for the department
   Relevant information for the department in which the patient will be admitted is described in the fifth section.
6. Conclusion
   The last section is the conclusion, in which information for the anesthetist present at the surgery is provided. This section comprises numerous multiple-choice questions about the type of anesthesia, anti-coagulation, and a written end-conclusion.

While editing the report, every question for which an answer is provided is indicated with a filled bullet point. The questions that have not been answered yet are denoted with an open bullet point. When a section is completed, the font of the title turns bold. Not every question has to be answered and if the dossier is saved, only the completed answers are included in the final report.

4.2.2. A Heuristic Evaluation of the Electronic Health Record System

A low-level heuristic evaluation of the HiX preoperative screening system was performed to portray the usage of the present IT system. As mentioned in Section 2.3.2., the heuristic evaluation is used to state some basic observations of the interface currently used and to provide prior knowledge for the treatment design phase. These basic observations are categorized according to Nielsen's usability heuristics (Nielsen, 2005) and can be found in Table 4.1. Since only superficial statements were made, Nielsen's usability guidelines were used instead of the extended version of Benaida (2023).

The positive observations are stated in green, the negative statements are indicated in red. What is important to consider when developing a new system in this field, is the way the present system provides feedback about the questions answered. Bullet points and bold text are indicators for completion in the HiX system. The split screen and navigation options are positive aspects of this system too and therefore need to be incorporated in designs for a system such as an Automated Medical Reporting system.

Negative aspects which can be improved in new designs are amongst others, the icons which can be more realistic. The overload of text and the error prevention in terms of data getting lost can be improved too.

Table 4.1: The Heuristic Evaluation of the EHR system specified for preoperative screenings

Heuristic evaluation	
Heuristic	**Notes**
1. Visibility of the system status	• The system indicates when a question is answered and when a section is completed.
	• The system indicates which page is open and on which side of the screen it is displayed by using an icon.
2. Match between system and the real world	• Some icons used do not directly reflect their function. E. g. a binocular for searching the system.
3. User control and freedom	• The system provides the opportunity for the users to split their screen such that multiple parts of the system are shown.
	• The patient navigation menu and to do list cannot be folded.
4. Consistency and standards	• Toolbars are present at the top as well as at the bottom of the screen.
	• Some icons are different from icons used in other systems.
5. Error prevention	• When a dossier is opened too long without being saved, the content will be lost.
6. Recognition rather than recall	*None found*
7. Flexibility and efficiency of use	• There are multiple ways to navigate through the system, e.g. through the agenda and search for a patient.
	• A user can add certain pages to their favorites to make them for each patient easier accessible.
8. Aesthetic and minimalist design	• The interface consists of a lot of textual information.
9. Help users recognize, diagnose and recover from errors	*None found*
10. Help and documentation	• While hovering over icons, the description of that action is shown.
	• A questionmark indicates a navigation path to a help page.

Chapter 5

PROBLEM INVESTIGATION: STAKEHOLDER EXPECTATIONS

In order to gain insight into the expectations of the stakeholders regarding working with an Automated Medical Reporting system, a total of five semi-structured interviews were conducted. First, four interviews were conducted with employees of the preoperative screening department of the UMC Utrecht. These four interviewees were familiar with the idea of Automated Medical Reporting since the Care2Report research team was part of the department for two months in order to record consultations. These audio files were linked to the report screeners had generated and were used as input to train the Care2Report system that is currently in development. The interviewees participated in the process of collecting these audio files. Because of their participation in this research project already, the interviews became more valuable and interviews were easier to arrange. Each of the four semi-structured interviews with the employees of the preoperative screening department lasted approximately 30 minutes. Afterward, the interviews were transcribed in a summarized format. These summarized transcripts were combined into a table, shown in Appendix B. Interviewees 1-3 are preoperative screeners and interviewee 4 is the head of the anesthesiology department, responsible for overseeing preoperative screenings. Subsequently, the table was subjected to a thematic content analysis (Anderson, 2007). The themes that arose are elaborated on in the following subsections.

Thereafter, an interview with the head of Care2Report research team was initiated. The goal of this interview was to gain an in-depth understanding of the proposed design principles stated in Figure 3.4. This set of principles guided the interview questions. The findings are elaborated on in Section 5.2.

5.1. The Results of the Care Provider Interviews

5.1.1. The Current workflow

As was already shown in the task analysis diagram in Figure 4.1, the preparation of a consultation was identified as an important stage. All interviewees emphasized the importance of thoroughly reviewing the health checklist ('gezondheidsvragenlijst') completed by the patient prior to the consultation. The way the screeners document their findings varies. One screener interviewed does not use the computer at all during the consultation. The other screener can type without visual aid, the other one pauses the screening process to document during the consultation using the computer. The average time spent on typing, including completing the dossier, ranged between 2 and 15 minutes confirmed by all participants.

In the situation of an Automated Medical Reporting system in use, software and a microphone are added to the current workflow. The interviewees envisioned placing of the microphones as being in sight: 3 of the 4 preferred the microphone placed on the table. “That way you can see that it works and it is less intrusive”. In the past two months, they have worked with similar microphones to gather test data for the system. They all said to have no issue with having that visible.

5.1.2. The System in Use

When the interviewees were asked about the HiX system, the Electronic Health Record system currently utilized in the UMC Utrecht, they all expressed their frustration towards this system. Negative aspects concerning the preoperative screening part of HiX are 1) the excessive number of clicks necessary to document the screening; 2) the inadequacy of directly incorporating all important information into the screening report, such as details about the patient’s medication, which are located in a separate section of HiX and 3) the failure to transfer all responses of the ‘gezondheidsvragenlijst’ (GVL) into the anamnesis.

Interviewee 3 further mentioned an additional drawback of the screening form, namely the large number of questions with only approximately 15 necessitating an answer. The head of the department agreed with this observation.

On the positive side, all interviewees appreciated the existence of standardized text templates devised by the department head. During the documentation of the screening, certain fields require open-text responses. In several cases, such as the sober policy, standardized answers are readily available and easily accessible to the screeners. This positive attitude toward standardization can help by integrating an Automated Medical Reporting system since this system will report in a standardized way too.

Another aspect that was mentioned during the interviews, was the organized way the screening form is constructed. The way the tabs are divided, which is described in Section 4.2.1., makes it easier to navigate through.

5.1.3. The Future Interface

The last and most important section of the interview included questions about the interface design of a potential Automated Medical Reporting system for preoperative screenings. About the visibility of the AMR system, the interviewees mentioned that they want the status of the Automated Medical Reporting system to be displayed without being overly distracting. However, screeners need to be able to consult HiX during the consultation. The AMR system does not have to dominate the entire screen; as interviewee 2 mentioned, "I will not look at it if I trust the performance of the system".

The visibility of the system status is important, however the transcription process does not need to be shown directly. Additionally, the results of the interviews show that the generated transcript should be easily accessible if needed. Especially while checking and completing the generated report. Completing and correcting the report will be done together with the patient in the initial stages of use according to the interviewees.

During the interviews, the idea of indicating which questions were not answered yet was proposed. To the question of whether this is preferable, half of the participants positively reacted, but only if it is easy to overrule. The head of the department was skeptical. She stated "this depends, sometimes you consciously skip one subject, and showing that you missed it might frustrate users. On the other hand, we do forget crucial things sometimes. It depends on this balance."

Mixed reactions were elicited when the interviewees were asked about the possibility of using a dictation function for the correction process. While it may save time for minor transcription errors once the users become familiar with the system, there are limitations when it comes to formulating complex statements and conclusions. Besides, dictation is a skill that needs to be acquired according to the head of the anesthesiology department.

5.1.4. The Benefits Regarding Patient Time

Overall, implementing an automated reporting system would enhance the time spent directly engaging with patients, especially in complex cases according to the interviewees. "I feel more socially connected when I do not have to document constantly" is what interviewee 2 stated. The department head emphasized: "A consultation is partly medical and partly social. As a doctor, if you feel like you have more time, the social part is easier to do". Interviewee 3 already devotes all of the time during the consultation to patient interaction. However, he acknowledges the possible benefits too: "I do not document during the consultation but for me, the administration time would decrease and I can maybe see more patients".

5.2. The Results of the Design Principle Interview

In addition to conducting interviews at the preoperative screening department at the UMC Utrecht, an interview was conducted with the head of the Care2Report research team. This team has spent the last years formulating the initial stages of Automated Medical Reporting. During this interview, the design principles that are outlined again in Figure 5.1, were discussed (Maas et al., 2020).

As design principle 1 states, implementing an Automated Medical Reporting system cannot interfere with current working procedures. This means that such a system needs to integrate with HiX, the current EHR system in use. Aside from the importance of the integration of a new system in HiX, the interviewee stated that usability is important too. If the integration is too obstructive

P_1	No interference with current working procedures.
P_2	Simple input control of all modalities.
P_3	Report generation in real time.
P_4	Complete and concise summaries of consultations.
P_5	Care provider must check and possibly edit reports.
P_6	System learns from corrections by care provider.
P_7	Applicable for multiple healthcare disciplines and languages.
P_8	Compliant with privacy regulations.

Figure 5.1: *Reprinted:* The Eight Initial Care2Report Design Principles (Maas et al., 2020)

for the use of the system, this is not essential according to the head of Care2Report.

According to principle 2 in Figure 5.1 simple input control is important. It should provide direct feedback regarding the microphone and Bluetooth status to ensure the user's confidence in obtaining an accurate transcription of the consultation. This transcription does not have to be visible at real-time. However, according to the interviewee, an option to view the transcript needs to be integrated. Besides, as real-time report generation is such an important feature of an Automated Medical Reporting system, this process has to be directly visible.

Another important aspect of an Automated Medical Reporting system is the necessity of a care provider checking and editing the generated report. "The screener is required to check, complete and accord the report, such that the responsibility of the correctness remains with the screener".

As the transcript and the generated report include patient information, privacy is an important aspect and has to be taken into account while prototyping. After having completed and exported the report, this together with the transcript and audio need to be deleted. "A page with previous transcripts and reports can thus be excluded".

The interviewee indicated the following aspects as crucial for such a system to achieve the level of UX that is desirable: "Such a system needs to be generic, intuitive and the hardware cannot be intrusive".

5.3. The Key Findings of the Stakeholder Interviews

Eight general findings regarding an Automated Medical Reporting system arose during the stakeholder interviews. These findings are categorized in system status visibility, care provider control and patient privacy. System status visibility refers to the way the interface shows that the system is operating. Care provider control concerns the freedom users have to change things. Lastly, patient privacy refers to the way patient information is handled.

System status visibility

- F1. The status of the system needs to be visible.
- F2. An Automated Medical Reporting system does not have to dominate the whole screen.
- F3. An Automated Medical Reporting system has to work while being visible on screen as well as in the background.

Care provider control

- F4. A care provider needs to be able to edit and approve the report.
- F5. The transcript of the consultation needs to be accessible while checking and correcting the report.

Patient privacy

- F6. When a consultation is recorded, the microphone needs to be in sight.
- F7. The patients' information needs to be handled according to privacy regulations.
- F8. The possibility to upload the patient health questionnaire needs to be implemented.

Chapter 6

TREATMENT DESIGN: A PROTOTYPE OF AN AMR SYSTEM

In this chapter, the next phase of this research is elaborated on. Within this treatment design phase, the requirements that are stated in Section 5.3. are translated into an interface of an ICT system that can function as a treatment for the administrative burden in healthcare. The idea of implementing an Automated Medical Reporting system was already proposed by the Care2Report research team, but a User Interface which is built upon the users' expectations and current workflow has not been created yet. In the treatment design phase, wireframes as well as a high-fidelity prototype of an AMR system for preoperative screenings were developed. The research steps of in this phase are listed below.

1. Designing a set of five digital wireframes
2. Discuss these digital wireframes
3. Creating on-paper sketches of the wireframes of the whole system
4. Discuss the on-paper sketches
5. Developing a high-fidelity interactive prototype of an Automated Medical Reporting system for preoperative screenings

The wireframes that have been created for this treatment are elaborated on in Section 6.1. and 6.3. The design process of the high-fidelity prototype is described in Section 6.5.

To show the way an AMR system is integrated into the current preoperative screening workflow, the task-analysis diagram is adjusted to the situation in which an AMR system is used. The creation of this diagram is explained in Section 6.6.

With the wireframes, the high-fidelity prototype and the AMR task-analysis diagram, the idea of having an Automated Medical Reporting system is visualized. With the visualization, the treatment validation phase can be performed.

6.1. The Digital Wireframes

In the early stages of this research, prior to the interview sessions, five digital wireframes have been created using Canva. These frames illustrated only part of the system. The goal was to make it easier to visualize an Automated Medical Reporting System such as Care2Report. This visualization supported the opening of the conversation, which is an essential aspect of this research.

The digital wireframes were designed as if Care2Report works in full screen. These screens are split into two parts. Before the recording can be started, the status of the hardware is shown. In this first design, not only a microphone is included, but also the connection with a camera and the transcriber, the system itself, is displayed. When the connection with hardware is lost, instructions to solve the issue are given. When the system is ready, the recording can be started. During the recording, the screen is divided into all sections of the preoperative screening checklist on the left, apart from the end-conclusion section. This is separated from the rest since this conclusion is the most important part of the screening. Located at the top of the screen, are buttons for pausing and stopping the recording. The system provides feedback on its operation through a timer and a green notification stating "the system is recording". Furthermore, answers to the checklist are automatically entered by the system, and the end-conclusion is automatically generated too. The five digital wireframes are included in Appendix C.

6.2. The First Iteration Stage

During the task analysis, and discussions with the Care2Report research team and an IT specialist, several issues regarding the digital wireframes came to light. Screeners use the Electronic Health Record system to obtain relevant medical history while interacting with a patient. Therefore, the EHR system should be easily accessible while using an Automated Medical Reporting system. Besides, the IT specialist pointed out that the computer screens they use are larger and the amount of information shown in the digital wireframes is minimal. He suggested designing it in a smaller window.

In terms of the scope of the design, some adjustments were proposed too. In the digital wireframes not only the status of the microphone is shown, but also the statuses of the camera and the transcriber. A camera is not relevant regarding the AMR system specified for preoperative screenings. Besides, a member of the Care2Report research team mentioned the status of the transcriber as being irrelevant. The transcriber is the system as a whole and if this is not functioning, the whole system would not be functioning. Thus, system status visibility only needs to be integrated for the microphone in this case.

Regardless only five screens were created, another aspect was stressed. The screen is divided into the questionnaire and the end conclusion as this seemed to be the most important section of the report. However, the conclusion itself is not only plain text and can be seen as one of the sections of the dossier as explained in Section 4.2.1.

6.3. The Wireframe sketches

Based on the knowledge gained through the interviews and the first iteration stage, an elaborate paper-based version of an Automated Medical Reporting system for a preoperative screening was developed. In Figure 6.1 the computer screen of a care provider who uses Care2Report, an Automated Medical Reporting system, is shown.

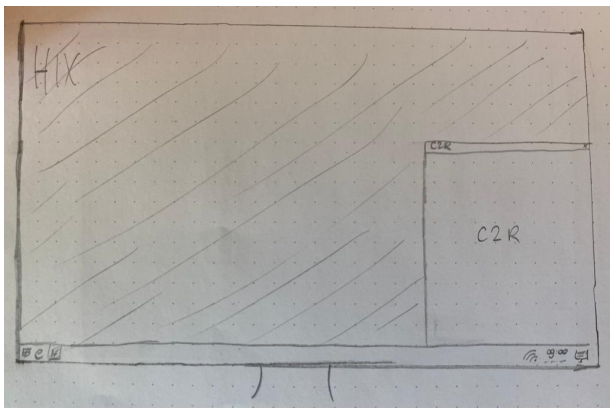
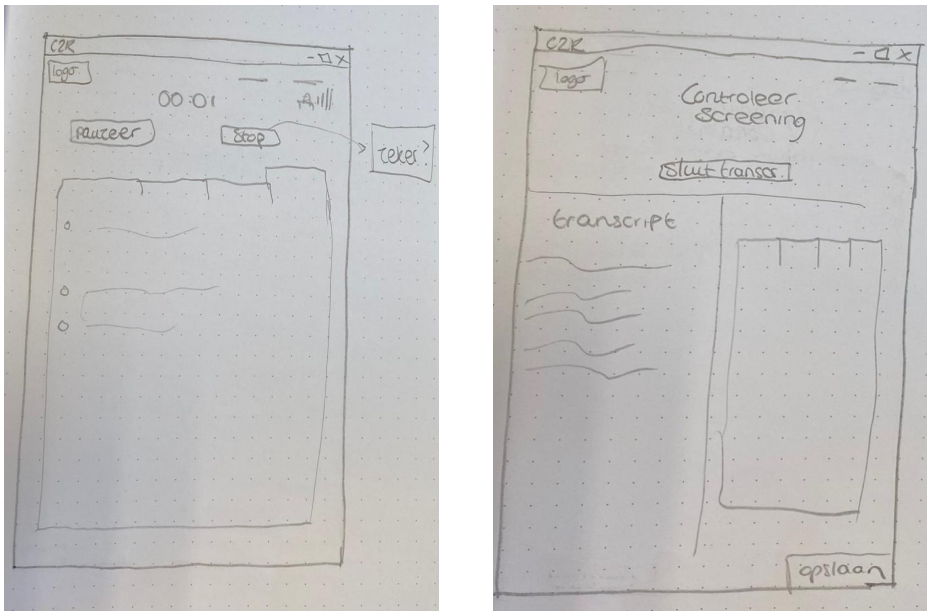


Figure 6.1: An Indication of How the EHR and the AMR System Are Divided on Screen

As the results of the interviews indicated, the Care2Report system did not have to dominate the whole screen. Besides, during the consultation information in the EHR system needs to be easily accessible according to the interviews. Thus, the Care2Report system is designed as a small window. All sketches are provided in Appendix D. Minimalistic design is chosen according to the heuristic principles, which results in a home screen with only one button. This button navigates the user to the start of the recording. If the connection with the microphone is lost, instructions for reconnecting are given. When the user has started the recording, the report is automatically filled in and is displayed as the wireframe in Figure 6.2a.

The microphone receiver as well as the timer indicates the working of the system. During the consultation, the user is able to pause and stop the recording. When the recording is stopped, a pop-up emerges to ask whether the user is sure to stop the recording. After the recording has been stopped, the report needs to be checked. During this checking phase, the user is able to open and close the transcript as can be seen in Figure 6.2b. Additionally, pages for help and saved recordings do exist. The navigation bar at the top of the screen is indicated with a logo and two lines. The lines and logo will be filled in with navigation options to a new recording, the help page, the home page and the saved recordings.



(a) The Recording has Started (b) Checking and Completing the Report

Figure 6.2: Two Wireframe Sketches of the Care2Report Interface

6.4. The Second Iteration Stage

The paper-based interface has been evaluated by a software developer that is employed at the UMC Utrecht, the hospital this research is situated. At the time of this evaluation, he is developing the real AMR system adapted to the preoperative screening as part of the overarching research. The evaluation session had two main goals; to ensure we had similar ideas about the front-end and to improve the paper-based design such that the enhanced version is translated into an interactive design.

The software developer mentioned that he will be working with a browser front-end. He visioned it as a smaller window too, and was planning on including a navigation menu too. However, during the evaluation session, we discussed the opportunity to enlarge the screen in which the report is being checked. A transcript and a report in a small window can cause information overload. Thus, within the interactive design, the page on which the generated report is checked will be full screen.

Another aspect that came to light during the interview with the Automated Medical Reporting specialist described in Section 5.2., was the privacy concerns. He stated that recordings cannot be saved within the AMR system. Regarding the paper-based sketches, the page including the saved recordings has to be eliminated in further design cycles.

6.5. The High-Fidelity Prototype

The design choices for the high-fidelity interactive prototype have been made based on the outcomes of the interviews and the low-fidelity wireframes. The key findings of the interviews which were categorized into system status visibility, care provider control and patient privacy, were translated into concrete design choices. These choices are documented in Table 6.1. These design choices were incorporated into the interactive design. This interactive design is developed using Figma, an online prototyping tool ("Figma", n.d.). During the design process, the usability heuristics of Nielsen are considered (Nielsen, 2005). For the timer feature and the switching between sections, the Figma community was used as inspiration ("Tabs prototype", n.d.; "Timer animation", n.d.). As the care providers work with desktops and Windows, the medical reporting system will be running on a desktop eventually too. To indicate that the Electronic Health Record system can be accessed at all times during the consultation, an image of HiX was included and used as background (Chipsoft, 2019). The patient data within this image is fictitious. An overview of the user interaction flow and the design choices are elaborated on in the following subsections. All images of the interactive prototype can be found in Appendix E. However, images of the dossier sections are excluded since screenshots of HiX were used, which are confidential.

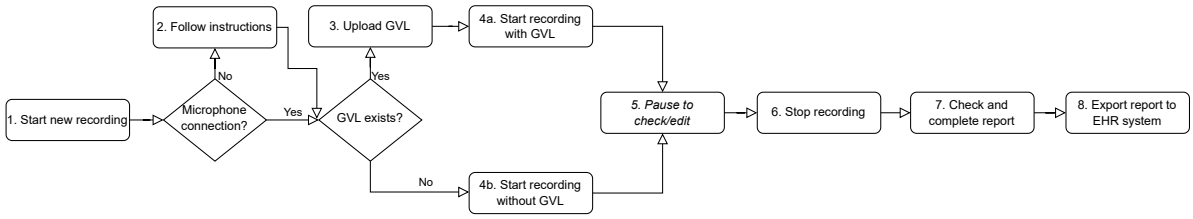


Figure 6.3: The User Interaction Flow

6.5.1. The User Interaction Flow

The user flow of the high-fidelity prototype is presented in Figure 6.3, illustrating the sequence from the home screen to exporting the generated report. When the Care2Report application is launched on the computer, a small window opens, as illustrated in Figure 6.4. From this point on, the user can initiate the recording process by clicking on the 'new recording' button. This causes the system to navigate to the microphone connection check screen. In case a connection with the microphone cannot be established, instructions to solve this are provided. Afterward, the opportunity to upload the GVL, the health checklist completed by the patient prior to the consultation, is provided. Then the recording can be started, either with or without the GVL. During the recording process, the user is able to pause and edit the report. The user can stop and

Table 6.1: The Translation of User Preferences into Design Choices

Finding	Interview result	Design choice
	System status visibility	
F1	The status of the system needs to be visible.	The connection to the microphone is shown and; if necessary, instructions to fix it.
		During the consultation, a timer and a microphone volume icon indicates that the system is recording.
		The system automatically switches between sections of the report, to indicate the system is generating a report in real time.
F2	An Automated Medical Reporting system does not have to dominate the whole screen.	The Care2Report system is visualized as a small window during the consultation.
F3	An Automated Medical Reporting system has to work while being visible on screen as well as in the background.	The user is able to minimize the system at all times. The system keeps recording and generating the report.
	Care provider control	
F4	A care provider needs to be able to edit and approve the report.	Both during and after the consultation, the care provider is able edit the report.
		When a care provider adds text to a textfield, this text will be in italics.
F5	The transcript of the consultation needs to be accessible while checking and correcting the report.	The transcript is shown directly after the recording has been stopped.
	Patient privacy	
F6	When a consultation is recorded, the microphone needs to be visible.	The microphone is placed next to the computer screen used during the consultation.
F7	The patients' information needs to be handled according to privacy regulations.	The audio, the transcript and the report are automatically deleted after the generated report is exported.
F8	The possibility to upload the patient health questionnaire needs to be implemented.	The opportunity to upload the pre consultation questionnaire that the patient has filled in is incorporated.

check the report using the generated transcript that is automatically displayed as shown in Figure 6.6. The only step left is exporting the complete report to the EHR system.

What is important to consider is the number of pop-ups to keep users from accidentally deleting the recording. Besides, a navigation menu at the top of the screen is included which eases the navigation back to the home page, a new recording and the help page. Navigating to a new recording page and the help page are disabled during the recording.

6.5.2. Design Choices: System Status Visibility

Microphone Connection Before the recording can be started, the connection to the microphone is checked. If the connection is lost, additional instructions are provided to solve this. Starting a recording is only enabled when the connection to the microphone is secured.

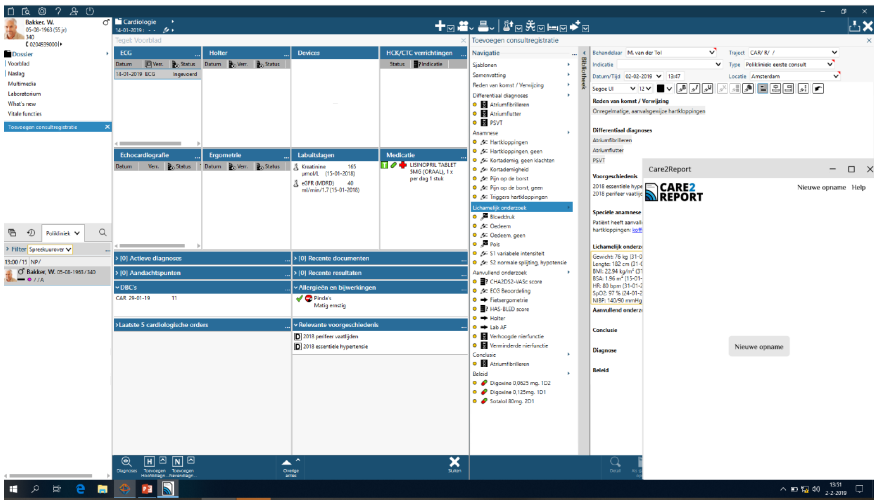


Figure 6.4: The Home Screen of Care2Report

Timer and Volume Icon During the consultation recording, the interface includes visual cues in the form of a timer and a volume icon to indicate its operational status. These visual cues are located at the top right of the Care2Report window. This is shown in Figure 6.5. When the recording has been started, this timer starts running.

Figure 6.5: The Timer and Volume Icon Indicating the System is Recording

Real-time Report Generation The report of the screening is generated automatically during the consultation. To give feedback about the status of this process, the system automatically switches between the sections of the report. When something important has been said, the system fills in an answer to the designated question. The sections between which the system switches, are illustrated in Figure 6.5. Unfortunately, the content of the sections cannot be shown since screenshots of the current dossier within the Electronic Health Record system were used.

Small Window The frame of the Care2Report system is designed as a small window in the bottom right of the screen. As can be seen in Figure 6.4. During the recording, the Car2Report interface is only used to get feedback about the status of the system, thus a smaller window is fitting. While editing the report, the system automatically switches to full screen.

Minimize the Window The ability to use the EHR system at all times was shown to be important. The use of the Automated Medical Reporting system must not interfere with this workflow, therefore the Care2Report system can be minimized. The recording as well as the report generation processes remain active.

6.5.3. Design Choices: Care Provider Control

Editing the Report The care provider can edit the generated report both during and after the consultation. After the consultation, the system automatically switches to full screen to ease this process.

Own Content Feedback The content the care providers add to open text fields is indicated in italics such that their own changes can easily be tracked. Changes that care providers make cannot be overwritten by the system.

Displayed Transcription The transcript of the consultation is automatically shown when the consultation has ended and the care provider wants to check the generated report. This is done according to a split screen, which is in line with the feature of the EHR system in use. This division is depicted in Figure 6.6. In which the transcript is displayed in the right box and the generated report in the left box. As was already mentioned, the report is not included since no permission was granted to include screenshots of the actual EHR system.

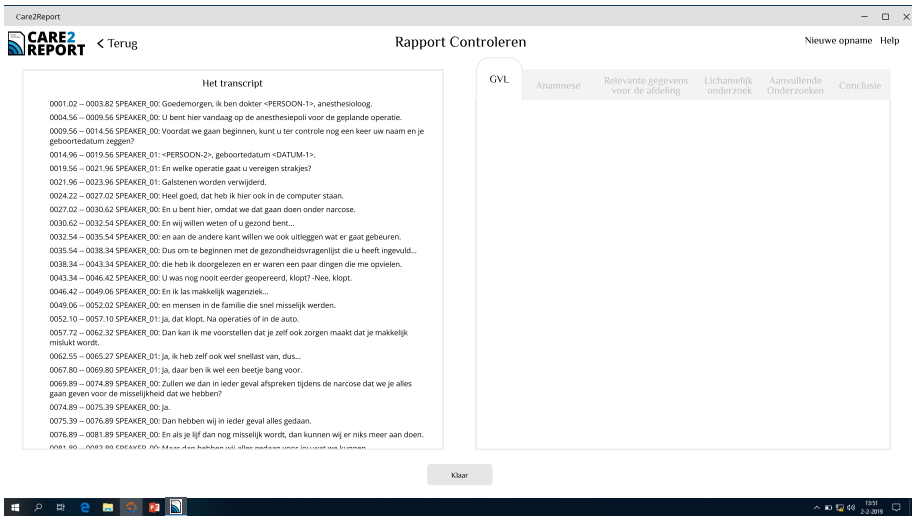


Figure 6.6: Checking the Generated Report in Care2Report

6.5.4. Design Choices: Patient Privacy

Microphone Placing When utilizing an external microphone setup, the components are positioned adjacent to the computer screen in use. This arrangement ensures minimizing intrusion and eases the fixing process of the connection when needed.

Deletion Process The audio file, the transcript and the generated report consist of sensitive information which needs to be handled with care. Within this interactive prototype, automatic deletion of this sensitive information is included. After the completion process, the report is exported to the EHR system in use. Simultaneously, the data generated during the consultation is deleted. Because of the integration of this automatic deletion process, before a user wants to exit the recording, pop-ups are incorporated into the prototype.

GVL Upload Process The patient health questionnaire (GVL in Dutch) which is filled in prior to the consultation can be uploaded to the AMR system. Since some patients have not completed the questionnaire, uploading the GVL is optional. For now, the process of uploading is designed as if the questionnaire is uploaded from the computer itself. Ideally, the questionnaire can be directly retrieved from the EHR system. The questions of the GVL that match the questions of the anamnesis are automatically filled in.

6.6. The AMR Task-Analysis Diagram

To indicate the aspects that change in the workflow of a preoperative screener when using an Automated Medical Reporting system, another task-analysis diagram was created. This proposed

new task-analysis diagram is depicted in Figure 6.7. The tasks that are different from the tasks in Figure 4.1 are indicated in blue. In the preparation stage, the AMR system has to be opened and optionally the patient health questionnaire needs to be uploaded.

Ideally, during the consultation, the task of editing the report can be excluded. Two additional tasks are included; starting and stopping the recording. Apart from the fact that two tasks are added and only one is excluded, the consultation will take up less of the care providers' time. Starting and stopping will take not more than 5 seconds while editing answers during the consultation take much longer.

In the summarization stage, the report is not only completed but also checked. In this stage, one task is added; uploading the report to the EHR system in use.

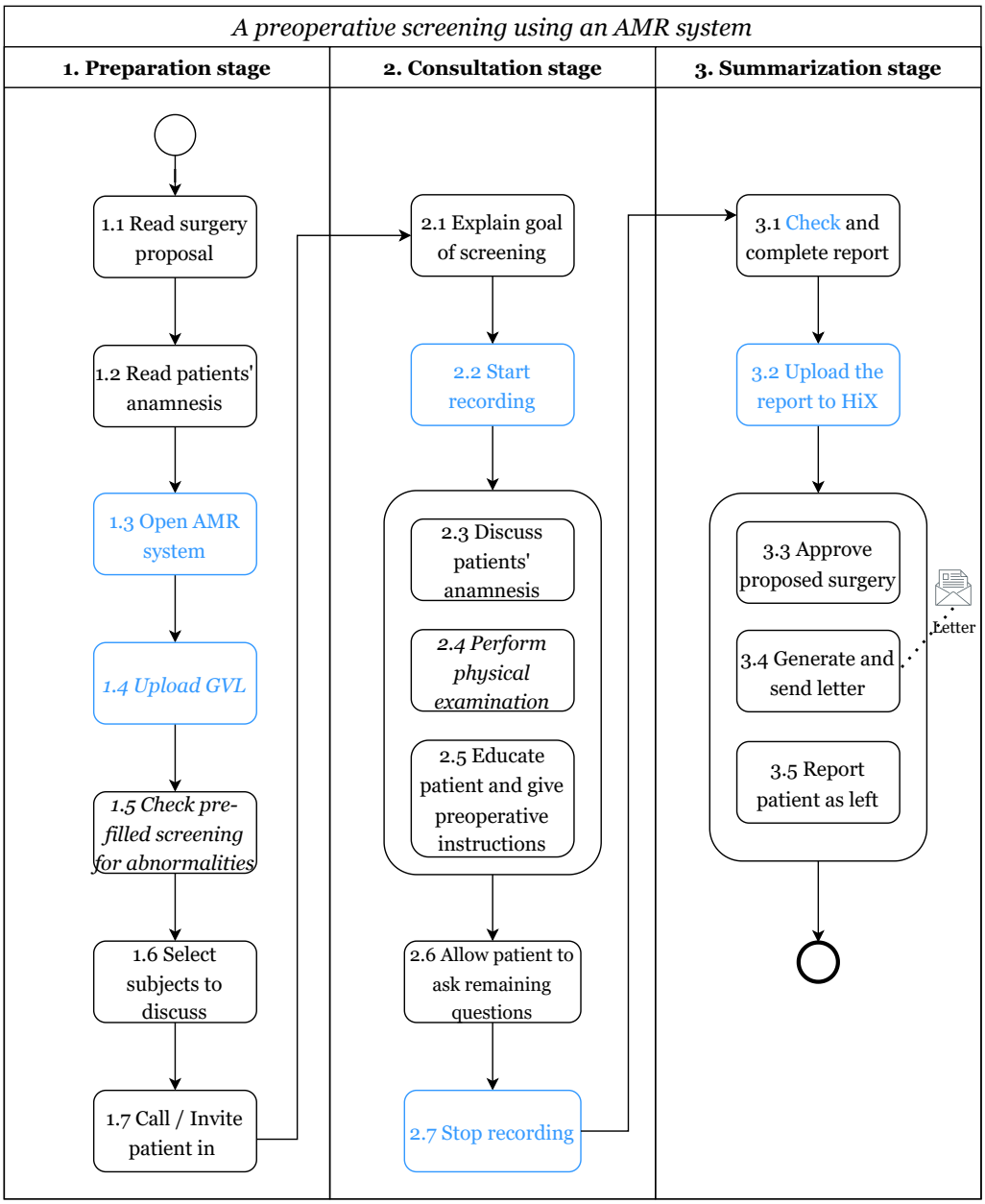


Figure 6.7: The Task-Analysis Diagram of a Preoperative Screening Using an Automated Medical Reporting System

Chapter 7

TREATMENT VALIDATION

The last phase of the design cycle of Wieringa is the treatment validation phase. Validation is done by showing the treatment satisfies its requirements (Wieringa, 2014). Within this research, the requirements are the user preferences specified according to the stakeholder interviews. These requirements were translated into design choices during the treatment design phase. To validate the design choices, qualitative research methods were used. The think-aloud sessions were mostly focused on gathering design alternatives and the focus group with Care2Report researchers together with the IT specialist interview were used to discuss these alternatives and to establish interface design principles.

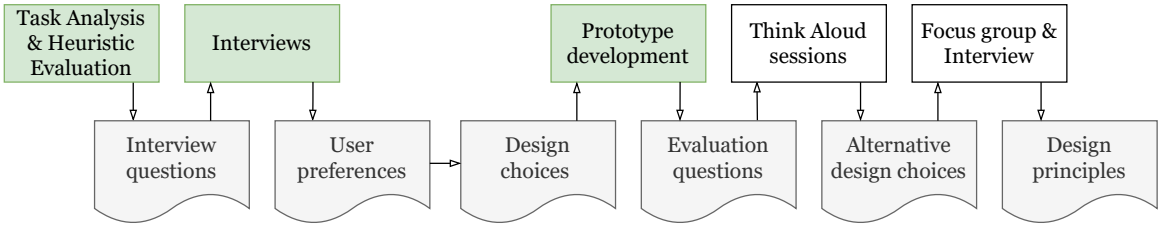


Figure 7.1: An Overview of the Obtainment of the Deliverables

7.1. The Think-Aloud Sessions

7.1.1. The Think-Aloud Guide

The think-aloud sessions started with a brief introduction, in which the participants were informed about the prototype's limitations and were instructed to vocalize their thoughts during the session. Thereafter, consent for recording the session is asked and the recording is started. Then, the participants had to perform a set of tasks and answer some questions. For this procedure, a guide was created which is included in Appendix F. This guide provides a road map which is described below point by point.

- Introduce the participant to the scene of a preoperative screening
- Ask the participant to perform the following tasks
  1. Repair the microphone connection and upload the GVL
  2. Start the recording
  3. Pause the recording to edit the answer to exercise tolerance
  4. Stop the recording and check the generated report

5. Export the complete report

- Ask the questions based on the design choices
- *If the participant is a screener*: ask the participant to validate the AMR task-analysis model

The evaluation questions are derived from the design choices and thus categorized into 1) system status visibility, 2) care provider control and 3) patient privacy. The questions were mostly phrased as 'how do you feel about -*design choice*-' and 'what can be different in order to achieve system status visibility' to obtain alternatives.

As was already explained in Section 2.5.1., nine think-aloud sessions were conducted which all lasted approximately 20 minutes. Since the background of the participants varied, the differences are shown in Table 7.1.

Table 7.1: The Background of the Think-Aloud Participants

Participant	**Role**	**Knowledge of Care2Report**
P1	Screener	Yes
P2	Health Data Science employee	Yes
P3	Health Data Science employee	Yes
P4	Screener	Yes
P5	Screener	Yes
P6	Head of Anesthesiology department	Yes
P7	HCI specialist	No
P8	Polyclinic secretary	No
P9	HCI specialist	No

7.1.2. The Results of the Think-Aloud Sessions

Performing the tasks All participants were able to complete the tasks with relative ease and minimal difficulties. During the think-aloud sessions, 5 of the participants came closer to the screen in order to read the text which indicated the font size is too small. P1 had issues with the third task, editing the report during the consultation. P1 could not find the anamnesis in which the exercise tolerance can be edited. This indicates the sections were hard to read. P1 liked the check phase to be in full screen. All participants used the buttons to navigate, the menu was not used.
During the think-aloud sessions, another main theme for the interface design arose. This resulted in the following four themes; system status visibility, care provider control, consultation traceability and patient privacy. The theme that has been added, consultation traceability, refers to the way the conversation can be linked to the transcript and the generated report.

System status visibility

Timer and Volume Icon The timer and volume icon which indicate the working state of the system, was experienced moderately positive. P4 mentioned the timer was not distracting or annoying. "If this kind of feedback is not provided, I would just keep checking". The timer could be smaller according to P6. P3 found the timer distracting, reasoning that "the idea is that the focus is on the patient instead of checking the computer screen".

Real-time Report Generation The automatic switching between sections of the dossier was experienced as distracting by most of the participants. Some sort of direct feedback on the report generation was desired, however in another design way. About this, P5 stated: "I think feedback is useful, maybe in the form of lightening up sections and questions answered. Switching between sections makes it confusing, I would like to be in control of switching between sections". P7 agreed; "It might switch when you are reading something, this is inconvenient. For the reason to give direct feedback about the status of the system I would not implement it this way".

Care provider control

Interface window During the think-aloud, the small window was shown to be inconvenient since half of the participants came closer to the screen in order to read what the interface stated. A lot of information needs to be displayed which makes the use of it frustrating by half of the participants. On the other side, P2 stated that a smaller window was pleasant especially to use while using another application too. Two participants mentioned the possibility to use a second screen in which Care2Report can be opened in full screen. As P6 said, "it depends on the goal with which Care2Report will be used. If you want to edit the report in Care2Report, the window can be larger". A lot of individual differences in preferences were noticed. This might ask for responsive design of which users have control. For this reason, the interface window aspect is transferred to the care provider control theme.

Minimize the window It is essential the Care2Report application can run together with the EHR system in use. As P1 mentions "I would switch between the EHR system and the Care2report system. Especially in the early phases of this application when trust needs to be built".

Editing the report The possibility to edit the generated report is important according to the participants. Every participant reviewed the pause button as useful. P1: "I would add something during the consultation too, especially if the patient is complex". However, 3 participants were somewhat hesitant toward editing during the consultation. P2 stated not to trust the system to save their own answers. Additionally, P6 stated the possibility to edit could cause some confusion about what is the real report. The application needs to export a version of the report in which

input fields remain.

Consultation traceability

Own content feedback Statements in italics indicate that additional text was provided by the screener. Feedback about their own content was perceived positively, however only during the review phase. P4 found it convenient that the system shows what was added by a screener. "Then I know what I have added and whether I need to specify that more". According to P8, it would contribute to time efficiency since it provides an overview more easily. Subsequently, alternatives to show screener additions such as indicating it with color or an icon were proposed too.

Displayed transcription The opinions regarding the presentation of transcription in the application were diverse. None of the participants wanted real-time visibility of the transcription being generated. Only half of the participants expressed their preference for displaying the transcript directly after the recording has been stopped. Conversely, P2, P3, P5 and P8 would like to have control over opening the transcript themselves. P8 states: "if it opens automatically, the amount of text is overwhelming".
P2 proposed an interesting feature that allows the user to link the answers of the screening to the transcript. P2 would like to see the part of the transcript the answer is based on lighten up when a generated answer is clicked. When this idea was presented to the other participants, their reactions were positive.
Three participants expressed a desire to retain the audio alongside the transcript. They cited the poor quality of the transcript as the primary reason for this preference. P3 mentioned wanting the questions to be linked to the transcript and the transcript to be linked to the audio file. Medical professionals, in particular, preferred excluding the audio. P6 stated that the transcript alone is sufficient as a resource, acknowledging its imperfections. P5 also expressed that the audio would not provide any additional value for her.

Patient privacy

Deletion process All participants expressed their preference for delaying the deletion process, rather than deleting the data immediately after the consultation. P1 mentioned the scenario of conducting multiple screenings before proceeding with administration tasks, highlighting the need to retain access to the transcripts and reports. Six participants suggested having a period of one day to access the data within the Care2Report application.
Two alternative ideas were proposed regarding the deletion of the data generated by Care2Report. One suggestion was to delete the data after the surgery is approved, while the other suggestion was to delete it after the actual surgery takes place. However, P6 expressed hesitation due to the increased risk of errors involving critical patient information. Instead, P6 advocated for uploading the report together with the transcript to the Electronic Health Record (EHR) system, where

necessary adjustments can be made at any time.

GVL upload process All participants designated uploading the health questionnaire filled in by the patients as useful. Especially if the application is able to copy the answers to the anamnesis, according to P1. However, P6 was worried about transferring patient information from and to the EHR system. In no circumstance, data can be interchanged between patients.

Safety in use Every participant would feel safe using the Care2Report application. P5 states: "I feel safe using such a system". Participant P4 mentioned feeling secure because the data would be deleted after a certain period. Participant P2 indicated that they would feel safe if the head of the department approved the system. Participant P3 mentioned feeling secure if the application was running on hospital computers, implying trust in the hospital's security measures.

The updated task-analysis diagram

The AMR incorporated task-analysis model The screeners who provided their feedback on the revised task-analysis diagram all expressed their agreement with the model. P1 "Seems logical to me, I cannot think of another way". Apart from the fact that no negative feedback was given, all screeners mentioned working with an AMR system as being hard to imagine.

Additional notes

During the think-aloud sessions, some additional statements were made by the participants. The preoperative checklist in the prototype was indicated by including screenshots from several parts of the checklist in HiX. According to P2, P3 and P4, this could give the impression of Care2Report as being part of the HiX system. Another choice for layout would be preferred. Several participants in the medical field mentioned that the workflow would change drastically when an Automated Medical Reporting system is used. Additionally, P4 addressed the processing time. P4 was worried about the exportation time since screeners have to request orders which are attached to the report they generate. Requesting orders is done in HiX.
The head of the Anesthesiology department had some additional thoughts too. She worries about the way of dealing with the report exportation. "How are you sure the report of a specific patient is being uploaded in the dossier of that specific patient?". To minimize this chance, automated deletion is preferable. And about the transcript, she stated the possibility to upload this transcript into the EHR system too. "For example, a colleague is on a holiday so we are not able to call her. However she forgot to write a critical part of the conclusion. A transcript would be ideal in this situation." Besides, patients sometimes ask if they could record the consultation themselves. If the transcript is provided in the EHR and is made available for the patient, the transcription is in a secure environment.

7.2. The Focus Group Session

After having discussed the prototype incorporating the design choices as they are now, a focus group was conducted to discuss the design choices and alternatives.

7.2.1. The Focus Group Guide

Before the focus group was conducted, the road map for this session was established in a guide, which can be found in Appendix F. This guide is based on the idea of effective focus groups according to Redmond and Curtis. They state: "To conduct effective focus group interviews, researchers should consider the questions they wish to ask. These questions depend on the research question, the purpose of the study and the type of data required" (Redmond & Curtis, 2009). The goal of this focus group was to discuss alternative design choices based on the three design themes and eventually to be able to draw conclusions. As can be seen in the guide, the questions were based on the themes of the interviews again (system status visibility, care provider control and patient privacy). However, not only the think-aloud questions reoccurred, the alternative design choices were included too. The guide was used by the moderator as a road map. Unfortunately, the moderator had to fulfill the role of note-taker too due to limited resources. The focus group as well as the guide were again in Dutch, since all participants were Dutch too.

The focus group took place in a dedicated room with a large screen on which the prototype could be displayed. The session had a duration of approximately one hour. The group consisted of four participants, one female and three males. To create a comfortable environment, the participants were seated in a circle arrangement and were offered snacks during the session. Then, an introduction was given in which the goal of the focus group was explained and consent for recording the session was asked. Besides, the participants were asked to react to each other if they had other ideas about the subject. After this brief introduction, the prototype was shown and elaborated on by the moderator. Then the discussion about the design choices and proposed alternatives was initiated by the moderator. Once all aspects were discussed, room for additional remarks was provided. The focus group concluded with expressions of gratitude for the participants' presence and contributions.

7.2.2. The Results of the Focus Group

System status visibility

Timer and section switching The participants agreed upon including a timer to indicate the system is recording. However, direct feedback about the system generating a report could be different than automatically switching between sections. "I would find it challenging to maintain focus when the sections automatically change". Feedback about report generation can be indi-

cated by small dots in front of the title of the sections.

Care provider control

Interface window The participants agreed with responsive design in order to accommodate individual differences. However, about the window of Care2Report being smaller, new design ideas were proposed. The group proposed an even smaller window that incorporates only the timer and a start/stop button. When the user maximizes it, the system automatically switches to full-screen mode, which facilitates easier editing. This is in line with the vision of Care2Report according to one of the participants. He explained: "The goal of Care2report is to support report generation. It will not be used as a reference system". Only editing and approving the generated report is done in the Automated Medical Reporting system. Since users need to edit the report in Care2report, switching to a bigger screen is a positive aspect. "Editing in Care2report has to be emphasized, to avoid potential overwriting of the user's input in the EHR system by the generated report". A different layout for Care2Report to indicate that it is a different system would contribute to this goal.

Report editing The participants all agreed with the user being able to edit the report. However, the design choice of pausing the recording to edit was perceived negatively. "You might forget to unpause the recording, I would implement the editing during the recording", states one of the participants. According to the participants of the focus group, the user should be in control of navigating and editing during the recording. You need to have a pause button, however only for discussing something off the record.

Note taking Another design idea that arose, was the possibility for the user to take notes within care2report. "The user can feel more in control when taking notes. Besides, most screeners already take notes on paper, integrating this feature in Care2Report might be beneficial for the user as well as the system". The system could use this as input for the report.

Consultation traceability

Transcript Integration For integrating the transcript, the participants agreed upon implementing care provider control. The split screens that are enabled in the EHR system, can be useful in the checking phase of Care2Report too. One of the participants proposed a screen division, with the transcript occupying one-third of the screen and the report taking up the remaining two-thirds.
Furthermore, specific remarks were made regarding the transcript. The participants suggested enhancing the clarity of speaker differentiation in the transcript and also recommended considering the exclusion of timestamps.

The suggestion to export the transcript to the EHR system received a positive response, particularly due to the potential benefits it offers to the patient. "In this scenario, the patient would no longer need to personally record the consultation if they want to refer to it later".

Saving audio recording When the possibility of saving the recording of the consultation was addressed, its usefulness was discussed. "Users might want to search for errors in the transcript according to the recording, which takes time". You need to trust the transcription process. Moreover, from a privacy perspective, the implementation of this feature would be challenging.

Own content feedback To indicate that the user has changed something, the participants suggested using colors. Besides, the system should provide feedback about the fact that the answers they give will not be changed again. If during the consultation, new information is provided about a specific question, the users have to change this themselves. This can be indicated with a lock or an answer being greyed out.

Patient privacy

Uploading GVL The possibility to upload the questionnaire the patient has filled in before the consultation was perceived positively.

Deletion process All participants agreed with the option to delete the transcript and the generated report after a designated period. One participant suggested that if this feature is implemented, a save button should be added. Regarding the current deletion process, it was noted that the export button should provide a clearer indication that the report will be deleted in Care2Report.

Additional design ideas

Patient-report validation Some additional suggestions were made by the participants of the focus group. They suggested that some sort of validation process within the EHR system needs to be initiated. This validation process prevents a report from being exported to the wrong patient.

Report Approval The participants agreed upon the design choice of having a final check before the report is exported. However, they emphasized the need for flexibility in this process. They proposed the inclusion of a lock icon that can be unlocked to facilitate easy editing. Additionally, they suggested that during this phase, incorporating a clear indication that the responsibility for the correctness of the report lies with the healthcare provider is necessary.

Progress notification Lastly, one participant suggested deviating from the current structure of the preoperative screening checklist and instead displaying notifications only when the system has

made changes. However, the feasibility of this approach was debated, considering the frequency of system updates. Additionally, another participant highlighted that the structure of the report is used during the preoperative screening. Such an approach may not be suitable for this case study.

7.3. The Evaluation Interview

A short interview about the interface was conducted with a software developer who currently develops the software for the Care2Report preoperative screening application. The interviewee was already familiar with the interface design since he was involved in the second iteration discussion described in Section 6.4. For this interview, the same questions as the ones in the think-aloud were used.

System status visibility

Regarding system status visibility, the interviewee stated the timer is useful to indicate the system is working. Switching between the sections could be replaced by dots according to him. Additionally, he suggested leaving the structure behind and including notifications. However, he doubted whether this would be desirable for users. He emphasized the goal of Care2Report again and stated that Care2Report is not intended to be a new Electronic Health Record system. He pointed out that the inability to integrate Care2Report into existing EHR systems is a fundamental issue.

Care provider control

While the interviewee favored responsive design, he emphasized the importance of starting with a single design initially, as having multiple designs could lead to confusion when learning to use the system.

Additionally, the interviewee highlighted the challenge of ensuring that users edit the report in Care2Report during consultation. Editing and indicating what has been added is important, however, according to the interviewee this needs to be integrated during the generating phase of the report. He did not find pausing the recording necessary for editing purposes, but suggested keeping a pause button for off-the-record comments.

For the checking phase, the interviewee suggested that only the report should be opened and a slide menu should enable opening the transcript and audio. He suggested saving the audio too, since it is ideal to use as evidence in some situations.

Patient privacy

In alignment with the head of the department, the interviewee was in favor of uploading the transcript in HiX and deleting the report and transcript in Care2Report immediately. However, he suggested the possibility to reopen a report and corresponding transcript in the Care2Report system, such that the user is able to edit it and export it again.

Chapter 8

DISCUSSION AND CONCLUSION

This qualitative research into the interface design of an Automated Medical Reporting system for preoperative screenings was initiated in order to answer the main research question: *What are the key user-centered design principles that should be applied when designing an interface for an Automated Reporting System used in healthcare consultations?* By performing a user study within the preoperative screening department of the University Medical Center Utrecht, insights into the expectations and preferences of the healthcare sector were gained.

8.1. Literature on Automated Medical Reporting Systems

As this is a new field of research, limited literature existed on this topic. According to the literature on Healthcare Information systems, medical reporting becomes easier through the use of Electronic Health Record systems. However, due to the implementation of information systems in the healthcare sector, the number of administrative tasks increase. Besides, usability issues in healthcare IT systems were often demonstrated, of which one of the consequences were documentation errors. For the development of new software in this sector, the inclusion of end-users in the design phase, basic usability heuristics, and intuitive design have been proven to be beneficial.

8.2. The Preoperative Screening Case Study

In order to identify the present situation of the case study environment, the present workflow and the Electronic Health Record system in use were investigated. A task-analysis diagram of preoperative screenings shows the workflow can be divided into a preparation stage, a consultation stage, and a summarization stage. In these stages, essential patient information is gathered in a preoperative checklist, a risk assessment is done and an end-conclusion is generated. The checklist is incorporated into the Electronic Health Record system and is divided into five sections. The EHR system provides feedback about the status of the checklist and enables the possibility to access other patient information by making use of the split screen functionality. However, the interface consists of a lot of textual information and the layout of the questions of the checklist is not congruent.

During the orientation interviews, eight stakeholder preferences regarding an interface for an Automated Medical Reporting system were established. The preferences were built around three main themes; system status visibility, care provider control, and patient privacy. Each of the eight user preferences was translated into a design choice and included in a high-fidelity prototype.

However, translating these expectations into design choices was shown to be difficult since the interface had to be created from scratch and a variety of choices could be applied. Therefore, in every design phase, qualitative feedback from users and IT experts was gathered using various prototypes based on the preoperative screening setting.

The most important finding during the evaluations with medical professionals was the fact that end users found it hard to imagine working with such a system. "Using an Automated Medical Reporting system requires a whole other way of working". This made it hard to evaluate design choices. Therefore, IT specialists were included in the validation phase to obtain more radical statements too.

8.3. The Interface Design Principles for Automated Medical Reporting Systems

Since this is the initial phase of designing an interface for such a system, participants proposed diverse design alternatives. Therefore, specifying interface design principles was challenging. However, four important themes arose during the evaluation phase: system status visibility, care provider control, consultation traceability and patient privacy. System status visibility refers to the way the interface shows that the system is operating. Care provider control concerns the freedom users have to change things. Consultation traceability, refers to the way the conversation can be linked to the transcript and the generated report. Lastly, patient privacy refers to the way patient information is handled. Within these themes, the ten interface design principles for an Automated Reporting system in healthcare shown in Figure 8.1 can be concluded.

System status visibility
The recording status of the system needs to be indicated according to a timer such that the user can conduct the consultation without having to worry about this. This is presented directly to the user, which is in line with the usability heuristics of Nielsen (1994b). However, report generation feedback cannot be too distracting, since the focus should be on the patient during the consultation.

Care provider control
Future users all had different preferences about the window size. This was mainly due to the goal of the AMR system being unclear. Reading the checklist to form questions and completing the checklist cannot be done in the smaller window. Responsive design would be ideal, however responsive design represents significant challenges for developers because it depends on shuffling elements around (Bernacki et al., 2016). This was also stated in the last interview with the developer who is currently developing the Automated Medical Reporting system for preoperative

screenings.

System status visibility
- A timer needs to indicate the system is recording
- Report generation needs to be indicated by small update dots

Care provider control
- The interface window needs to be responsive
- The Automated Medical Reporting system needs to operate without interfering with the functionalities of the Electronic Health Record system
- Editing during the recording needs to be enabled

Consultation traceability
- Each part of the report needs to be linked to the corresponding part of the transcript
- Additions made by users need to be indicated with color
- The layout of the Automated Medical Reporting system needs to be different from the layout of the Electronic Health Record system
- The possibility of editing the report according to the transcript at a later time needs to be integrated

Patient privacy
- The Automated Medical Reporting system needs to work according to privacy regulations

Figure 8.1: The Ten Interface Design Principles for Automated Medical Reporting

Consultation traceability

The results indicated that future users liked to have the possibility to access generated reports and corresponding transcripts for a longer period after the consultation has ended. This is in line with the present working procedure. In the initial stage of the Care2Report business, saving the transcript and generated reports including the adjustments made by the care provider might be beneficial to train the system. However, because of the associated privacy issues and the increasing chance of mixing patient data, implementing this feature might not be desirable. When performing a preoperative screening with the use of an Automated Medical Reporting system, the working procedure is likely to be changed. Why not change this part of the workflow too? The resistance to these changes might be declared by the fact that people do not like to change what they think they know (Duffy, 2003). After the consultation has ended, the screener can upload the generated report to the Electronic Health Record system including the transcript. If the screener wants to add something later on, this can be done within the EHR system. This way, direct deletion can be facilitated. What even can be incorporated in the Automated Medical Reporting system, is the opportunity to re-upload the transcript and the report again, such that easy editing can be facilitated. Further exploration research into these alternatives needs to be done.

According to the results of the Think Aloud sessions and the focus group, adjustments made

by the screener within the Automated Medical Reporting system can be indicated with more than only an italic font. Using different colors to indicate changes was proposed numerous times. One can argue that colorful interfaces might be more distracting, however appropriate color use can aid user memory and facilitate the formation of effective mental models according to Taylor and Murch (Taylor & Murch, 1986; Wright et al., 1997). Further research into colorful interfaces should be done to establish the best practice on this topic.

Patient privacy
Since future users are already accustomed to handling patient data within the Electronic Health Record system, privacy concerns about the usage of AMR systems were not mentioned. Users expressed no resistance as long as the system operates on hospital computers.

8.4. The Comparison of Care2Report Design Principles Over Time

In the Matrix in Table 8.1 the Care2Report design principles which were proposed in 2020 by Maas et al., are compared to the interface design principles according to this research. Apart from the interface design principles regarding the layout and responsiveness, all new principles correspond to the ones that have been proposed in 2020. The principles on system status visibility contribute to already proposed Care2Report design principles. The Care2Report design principle of 'Care provider must check and possibly edit reports', is expanded with the new principle, since the possibility of editing has to be enabled during the consultation. Consultation traceability is a new theme that arose. However almost all principles expand ones that already exist. The design principle on privacy remains the same. Two principles proposed in 2020 by the Care2Report team do not match the interface design principles stated according to this research. However, these guidelines are focused on the operability and generalizability instead of the interface design. Therefore, this difference is easily explained. These two columns are indicated in grey.

Table 8.1: The Matrix Comparing the Care2Report Design Principles with the Conclusions of this Research

		The Care2Report Design Principles (2020)							
		No interference with current working procedures	Simple input control of all modalities	Report generation in real time	Complete and concise summaries of consultations	Care provider must check and possibly edit reports	*System learns from corrections by care provider*	*Applicable for multiple healthcare discipines*	Compliant with privacy regulations
New interface design principles	**System status visibility**								
	A timer needs to indicate the system is recording		Contributes to						
	Report generation needs to be indicated by small update dots			Contributes to					
	Care provider control								
	The interface window needs to be responsive								
	The Automated Medical Reporting system needs to operate without interfering with the functionalities of the Electronic Health Record system	Contributes to							
	Editing during the recording needs to be enabled					Expands			
	Consultation traceability								
	Each part of the report needs to be linked to the corresponding part of the transcript				Expands				
	The layout of the Automated Medical Reporting system needs to be different from the layout of the Electronic Health Record system								
	Additions made by users need to be indicated with color					Expands			
	The possibility of editing the report according to the transcript at a later time needs to be integrated					Expands			
	Patient privacy								
	The Automated Medical Reporting system needs to work according to privacy regulations								Is similar to

8.5. Additional Remarks

The data of end users were gathered during Think Aloud sessions. This method provides good qualitative data from a small number of test users, but the laboratory environment may influence test users' behaviors (Hwang & Salvendy, 2010). Since the evaluation is done with a prototype in a controlled setting, patients were excluded. The participants were able to fully focus on the interface without having a conversation with a patient. In further research, it would be interesting to investigate how the user would interact with the system during a consultation.

Another limitation of the data obtained during the focus group can be the homogeneity of the background of the participants. All participants were working on a Care2Report project at the time of participation. The discussions might have been more valuable if a medical specialist and/or an Automated Medical Reporting skeptical would have been included. Unfortunately, medical specialists, were as mentioned before, occupied.

Not only testing the interface during a more realistic setting can be a valuable topic for future research. The inclusion of hardware can be investigated too. This was already addressed during

the interviews, however mixed reactions were acquired. Some interviewees stated they would like to see the microphone on the table. Another interviewee liked it to be integrated into the computer. How this would affect the intrusiveness of the system might be interesting.

Another interesting aspect of interface design for Automated Medical Reporting systems would be its design for healthcare departments that require more physical examination or portability. Whether a mobile application for this situation would be fitting, can be investigated in further research.

Concluding, medical specialists find it hard to vision their workflow including the usage of an Automated Medical Reporting system and a lot of individual preferences exist. However, what could be established is that the interface design of an Interface for Automated Medical Reporting system should be built around system status visibility, care provider control, consultation traceability and patient privacy.

Bibliography

Ajami, S. (2016). Use of speech-to-text technology for documentation by healthcare providers. *The National medical journal of India*, *29*(3), 148.

Al-Aynati, M. M., & Chorneyko, K. A. (2003). Comparison of voice-automated transcription and human transcription in generating pathology reports. *Archives of pathology & laboratory medicine*, *127*(6), 721–725.

Alroobaea, R., & Mayhew, P. J. (2014). How many participants are really enough for usability studies? *2014 Science and Information Conference*, 48–56.

Anderson, R. (2007). Thematic content analysis (tca). *Descriptive presentation of qualitative data*, 1–4.

Ash, J. S., Berg, M., & Coiera, E. (2004). Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *Journal of the American Medical Informatics Association*, *11*(2), 104–112.

Baumann, L. A., Baker, J., & Elshaug, A. G. (2018). The impact of electronic health record systems on clinical documentation times: A systematic review. *Health policy*, *122*(8), 827–836.

Benaida, M. (2023). Developing and extending usability heuristics evaluation for user interface design via ahp. *Soft Computing*, 1–15.

Bernacki, J., Błażejczyk, I., Indyka-Piasecka, A., Kopel, M., Kukla, E., & Trawiński, B. (2016). Responsive web design: Testing usability of mobile web applications. *Intelligent Information and Database Systems: 8th Asian Conference, ACIIDS 2016, Da Nang, Vietnam, March 14–16, 2016, Proceedings, Part I 8*, 257–269.

Bhandari, P. (2022). Construct Validity | Definition, Types, 038; Examples. *Scribbr*. https://www.scribbr.com/methodology/construct-validity/

Blackley, S. V., Huynh, J., Wang, L., Korach, Z., & Zhou, L. (2019). Speech recognition for clinical documentation from 1990 to 2018: A systematic review. *Journal of the american medical informatics association*, *26*(4), 324–338.

Bremmers, S. (2019). Hogere werkdruk, toch aandacht. *Zorgvisie*, *49*(1), 56–59.

Burden, B. C., Canon, D. T., Mayer, K. R., & Moynihan, D. P. (2012). The effect of administrative burden on bureaucratic perception of policies: Evidence from election administration. *Public Administration Review*, *72*(5), 741–751.

Caldwell, G. (2019). The process of clinical consultation is crucial to patient outcomes and safety: 10 quality indicators. *Clinical Medicine*, *19*(6), 503.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: Complex or simple? research case examples. *Journal of research in Nursing*, *25*(8), 652–661.

Chipsoft. (2019). https://www.chipsoft.nl/oplossingen/478/HiX-update-Doorontwikkeling-consult-2-0

Christie, E. J., Jensen, D. D., Buckley, R. T., Menefee, D. A., Ziegler, K. K., Wood, K. L., & Crawford, R. H. (2012). Prototyping strategies: Literature review and identification of critical variables. *2012 ASEE Annual Conference & Exposition*, 25–1091.

Clarke, M. A., King, J. L., & Kim, M. S. (2015). Toward successful implementation of speech recognition technology: A survey of srt utilization issues in healthcare settings. *Southern Medical Journal*, *108*(7), 445–451.

Crampton, N. H. (2020). Ambient virtual scribes: Mutuo health's autoscribe as a case study of artificial intelligence-based technology. *Healthcare Management Forum*, *33*(1), 34–38.

Dawson, L., Johnson, M., Suominen, H., Basilakis, J., Sanchez, P., Estival, D., Kelly, B., & Hanlen, L. (2014). A usability framework for speech recognition technologies in clinical handover: A pre-implementation study. *Journal of medical systems*, *38*, 1–9.

De Veer, A., Groot, K. d., Brinkman, M., & Francke, A. (2017). Administratieve druk: Méér dan kwestie van tijd.

Derman, Y. D., Arenovich, T., & Strauss, J. (2010). Speech recognition software and electronic psychiatric progress notes: Physicians' ratings and preferences. *BMC medical informatics and decision making*, *10*(1), 1–7.

Devine, E. B., Hansen, R. N., Wilson-Norton, J. L., Lawless, N. M., Fisk, A. W., Blough, D. K., Martin, D. P., & Sullivan, S. D. (2010). The impact of computerized provider order entry on medication errors in a multispecialty group practice. *Journal of the American Medical Informatics Association*, *17*(1), 78–84.

Duffy, F. M. (2003). I think, therefore i am resistant to change. *The Learning Professional*, *24*(1), 30.

Erickson, S. M., Rockwern, B., Koltov, M., McLean, R. M., Practice, M., & of the American College of Physicians*, Q. C. (2017). Putting patients first by reducing administrative tasks in health care: A position paper of the american college of physicians. *Annals of internal medicine*, *166*(9), 659–661.

Executive, B. R. (2006). Administrative burdens-routes to reduction. *United Kingdom*.

Falcetta, F. S., de Almeida, F. K., Lemos, J. C. S., Goldim, J. R., & da Costa, C. A. (2023). Automatic documentation of professional health interactions: A systematic review. *Artificial Intelligence in Medicine*, 102487.

Figma [Accessed: 2023-04-24]. (n.d.). https://www.figma.com

Glover, W. J., Li, Z., & Pachamanova, D. (2022). The ai-enhanced future of health care administrative task management. *NEJM Catalyst Innovations in Care Delivery*, *3*(2).

Guyonvarch, O., Bourgueil, Y., & Dugué, F. (2022). Introduction of medical assistants in france: An innovative approach to healthcare access? ophelie guyonvarch. *European Journal of Public Health*, *32*(Supplement_3), ckac131–306.

Hamm, M. J. (2014). *Wireframing essentials*. Packt Publishing Ltd.

Heuer, A. J. (2022). More evidence that the healthcare administrative burden is real, widespread and has serious consequences; comment on "perceived burden due to registrations for quality monitoring and improvement in hospitals: A mixed methods study". *International Journal of Health Policy and Management*, *11*(4), 536–538.

Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., & Taylor, R. (2005). Can electronic medical record systems transform health care? potential health benefits, savings, and costs. *Health affairs*, *24*(5), 1103–1117.

Hoerbst, A., & Ammenwerth, E. (2010). Electronic health records. *Methods of information in medicine*, *49*(04), 320–336.

Horvath, M. M., Rusincovitch, S. A., Brinson, S., Shang, H. C., Evans, S., & Ferranti, J. M. (2014). Modular design, application architecture, and usage of a self-service model for enterprise data delivery: The duke enterprise data unified content explorer (deduce). *Journal of biomedical informatics*, *52*, 231–242.

Hwang, W., & Salvendy, G. (2010). Number of people required for usability evaluation: The 10±2 rule. *Communications of the ACM*, *53*(5), 130–133.

ISO. (2018). Ergonomics of human-system interaction — part 11: Usability: Definitions and concepts. https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en

Jacob, R. J. (2003). User interface. In *Encyclopedia of computer science* (pp. 1821–1826).

Jannink, W., & Hobert, E. (2016). *Predictiemodel tijdsduur preoperatieve screening* (B.S. thesis). University of Twente.

Jimenez, C., Lozada, P., & Rosas, P. (2016). Usability heuristics: A systematic review. *2016 IEEE 11th Colombian Computing Conference (CCC)*, 1–8.

Johnson, C., Johnston, D., Crowle, P., et al. (2011). Ehr usability toolkit: A background report on usability and electronic health records. *Rockville, MD: Agency for Healthcare Research and Quality*.

Johnson, M., Lapkin, S., Long, V., Sanchez, P., Suominen, H., Basilakis, J., & Dawson, L. (2014). A systematic review of speech recognition technology in health care. *BMC medical informatics and decision making*, *14*(1), 1–14.

Kaipio, J., Lääveri, T., Hyppönen, H., Vainiomäki, S., Reponen, J., Kushniruk, A., Borycki, E., & Vänskä, J. (2017). Usability problems do not heal by themselves: National survey on physicians' experiences with ehrs in finland. *International Journal of Medical Informatics*, *97*, 266–281.

Kelly, S. E., Bourgeault, I., & Dingwall, R. (2010). Qualitative interviewing techniques and styles. *The SAGE handbook of qualitative methods in health research*, 307–326.

Keskinen, T., Melto, A., Hakulinen, J., Turunen, M., Saarinen, S., Pallos, T., Kallioniemi, P., Danielsson-Ojala, R., & Salanterä, S. (2013). Mobile dictation for healthcare professionals. *proceedings of the 12th International Conference on Mobile and Ubiquitous Multimedia*, 1–4.

Khattak, F. K., Jeblee, S., Crampton, N., Mamdani, M., & Rudzicz, F. (2019). Autoscribe: Extracting clinically pertinent information from patient-clinician dialogues. In *Medinfo 2019: Health and wellbeing e-networks for all* (pp. 1512–1513). IOS Press.

Kuperman, G. J., Teich, J. M., Tanasijevic, M. J., Ma'Luf, N., Rittenberg, E., Jha, A., Fiskio, J., Winkelman, J., & Bates, D. W. (1999). Improving response to critical laboratory results with automation: Results of a randomized controlled trial. *Journal of the American Medical Informatics Association*, *6*(6), 512–522.

Kwint, E., Zoet, A., Labunets, K., & Brinkkemper, S. (2023). How different elements of audio affect the word error rate of transcripts in automated medical reporting.

Launer, J. (2017). Is there a crisis in clinical consultations? *Postgraduate Medical Journal*, *93*(1095), 58–58.

Lewis, C. (1982). *Using the" thinking-aloud" method in cognitive interface design*. IBM TJ Watson Research Center Yorktown Heights, NY.

Litaker, D. (1999). Preoperative screening. *Medical Clinics of North America*, *83*(6), 1565–1581.

Lund, A. M. (2001). Measuring usability with the use questionnaire12. *Usability interface*, *8*(2), 3–6.

Maas, L., Geurtsen, M., Nouwt, F., Schouten, S. F., Van De Water, R., Van Dulmen, S., Dalpiaz, F., Van Deemter, K., & Brinkkemper, S. (2020). The care2report system: Automated medical reporting as an integrated solution to reduce administrative burden in healthcare. In *Information technology in healthcare: It architectures and implementations in healthcare environments*. Hawaii International Conference on System Sciences (HICSS).

Manresa-Yee, C., Roig-Maimó, M. F., Ramis, S., & Mas-Sansó, R. (2021). Advances in xai: Explanation interfaces in healthcare. In *Handbook of artificial intelligence in healthcare: Vol 2: Practicalities and prospects* (pp. 357–369). Springer.

Maris, A., Buwalda, V., Leermakers, J., & Bouwman, R. (2021). The impact of a legislative amendment on administration burden in dutch mental healthcare. *ECMLG 2021 17th European Conference on Management, Leadership and Governance*, 285.

Martakis, A. (2015). *Framework for enterprise uncertainty-driven decision-making: Feud* (Master's thesis). University of Twente.

McCullough, J. S., Casey, M., Moscovice, I., & Prasad, S. (2010). The effect of health information technology on quality in us hospitals. *Health affairs*, *29*(4), 647–654.

Menachemi, N., & Collum, T. H. (2011). Benefits and drawbacks of electronic health record systems. *Risk management and healthcare policy*, *4*, 47.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. sage.

Miller, K., Mosby, D., Capan, M., Kowalski, R., Ratwani, R., Noaiseh, Y., Kraft, R., Schwartz, S., Weintraub, W. S., & Arnold, R. (2018). Interface, information, interaction: A narrative review of design and functional requirements for clinical decision support. *Journal of the American Medical Informatics Association*, *25*(5), 585–592.

Nielsen, J. (1994a). Enhancing the explanatory power of usability heuristics. *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, 152–158.

Nielsen, J. (1994b). *Usability engineering*. Morgan Kaufmann.

Nielsen, J. (1995). How to conduct a heuristic evaluation. *Nielsen Norman Group*, *1*(1), 8.

Nielsen, J. (2005). Ten usability heuristics.

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 249–256.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research*, *42*, 533–544.

Pham, J. C., Aswani, M. S., Rosen, M., Lee, H., Huddle, M., Weeks, K., & Pronovost, P. J. (2012). Reducing medical errors and adverse events. *Annual review of medicine*, *63*(1), 447–463.

Planbureau, S. C. (2018). Trends in de ouderenzorg 2018-2030. *SCP*. Retrieved December 13, 2022, from https://digitaal.scp.nl/ouderenzorg/

Prgomet, M., Li, L., Niazkhani, Z., Georgiou, A., & Westbrook, J. I. (2017). Impact of commercial computerized provider order entry (cpoe) and clinical decision support systems (cdsss) on medication errors, length of stay, and mortality in intensive care units: A systematic review and meta-analysis. *Journal of the American Medical Informatics Association*, *24*(2), 413–422.

Quiroz, J. C., Laranjo, L., Kocaballi, A. B., Berkovsky, S., Rezazadegan, D., & Coiera, E. (2019). Challenges of developing a digital scribe to reduce clinical documentation burden. *NPJ digital medicine*, *2*(1), 114.

Ramón, O. S., Molina, J. G., Cuadrado, J. S., Vanderdonckt, J., et al. (2013). Gui generation from wireframes. *14th Int. Conference on Human-Computer Interaction Interaccion'2013*.

Rao, S. K., Kimball, A. B., Lehrhoff, S. R., Hidrue, M. K., Colton, D. G., Ferris, T. G., & Torchiana, D. F. (2017). The impact of administrative burden on academic physicians: Results of a hospital-wide physician survey. *Academic Medicine*, *92*(2), 237–243.

Redmond, R. A., & Curtis, E. A. (2009). Focus groups: Principles and process. *Nurse researcher*, *16*(3).

Rosala, M. (2020). Task analysis: Support users in achieving their goals. https://www.nngroup.com/articles/task-analysis/

Runeson, P., & Höst, M. (2009). Guidelines for conducting and reporting case study research in software engineering. *Empirical software engineering*, *14*, 131–164.

Saaty, R. W. (1987). The analytic hierarchy process—what it is and how it is used. *Mathematical modelling*, *9*(3-5), 161–176.

Scott, D., & Purves, I. N. (1996). Triadic relationship between doctor, computer and patient. *Interacting with Computers*, *8*(4), 347–363.

Shaw, R. J., Horvath, M. M., Leonard, D., Ferranti, J. M., & Johnson, C. M. (2015). Developing a user-friendly interface for a self-service healthcare research portal: Cost-effective usability testing. *Health Systems*, *4*(2), 151–158.

Sim, I., Gorman, P., Greenes, R. A., Haynes, R. B., Kaplan, B., Lehmann, H., & Tang, P. C. (2001). Clinical decision support systems for the practice of evidence-based medicine. *Journal of the American Medical Informatics Association*, *8*(6), 527–534.

Solutions chipsoft [Accessed: 2023-06-06]. (n.d.). https://www.chipsoft.com/solutions

Specialisten, F. M. (2020). Startpagina - perioperatief traject - richtlijn - richtlijnendatabase. https://richtlijnendatabase.nl/richtlijn/perioperatief_traject/startpagina_-_perioperatief_traject.html

Stanton, N. A. (2006). Hierarchical task analysis: Developments, applications, and extensions. *Applied ergonomics*, *37*(1), 55–79.

Stone, D., Jarrett, C., Woodroffe, M., & Minocha, S. (2005). *User interface design and evaluation*. Elsevier.

Tabs prototype [Accessed: 2023-05-22]. (n.d.). https://www.figma.com/community/file/1220299367682445811

Taylor, J. M., & Murch, G. M. (1986). The effective use of color in visual-displays-text and graphics applications. *Color research and application*, *11*, S3–S10.

Thomas, L., MacMillan, J., McColl, E., Hale, C., & Bond, S. (1995). Comparison of focus group and individual interview methodology in examining patient satisfaction with nursing care. *Social Sciences in Health*, *1*(4), 206–220.

Timer animation [Accessed: 2023-05-22]. (n.d.). https://www.figma.com/community/file/1005527611597019254

Utrecht, U. (2012). Wet inzake de geneeskundige behandelingsovereenkomst pos.

Van Den Haak, M., De Jong, M., & Jan Schellens, P. (2003). Retrospective vs. concurrent think-aloud protocols: Testing the usability of an online library catalogue. *Behaviour & information technology*, *22*(5), 339–351.

Vaughn, S., Schumm, J. S., & Sinagub, J. M. (1996). *Focus group interviews in education and psychology*. Sage.

Waegemann, C. P. (2003). Ehr vs. cpr vs. emr. *Healthcare Informatics online*, *1*.

Waegemann, C. P., Tessier, C., Barbash, A., Blumenfeld, B. H., Borden, J., Brinson Jr, R. M., Cooper, T., Elkin, P. L., Fitzmaurice, J. M., Helbig, S., et al. (2002). Healthcare documentation: A report on information capture and report generation. *Newton, MA: Medical Records Institute*.

Wand, Y., & Weber, R. (2002). Research commentary: Information systems and conceptual modeling—a research agenda. *Information systems research*, *13*(4), 363–376.

Weda, M., Brummelhuis, W., Wattel, A., Cornet, R., & Peute, L. (2020). Medicatie-incidenten als gevolg van gebruiksonvriendelijke it-systemen.

What is an electronic health record. (2019). https://www.healthit.gov/faq/what-electronic-health-record-ehr

Wieringa, R. J. (2014). *Design science methodology for information systems and software engineering*. Springer.

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. *Proceedings of the 18th international conference on evaluation and assessment in software engineering*, 1–10.

Wright, P., Mosser-Wooley, D., & Wooley, B. (1997). Techniques & tools for using color in computer interface design. *XRDS: Crossroads, The ACM Magazine for Students*, *3*(3), 3–6.

Xu, W. (2019). Toward human-centered ai: A perspective from human-computer interaction. *interactions*, *26*(4), 42–46.

Zegers, M., Veenstra, G. L., Gerritsen, G., Verhage, R., Hoeven, H., & Welker, G. A. (2022). Perceived burden due to registrations for quality monitoring and improvement in hospitals: A mixed methods study.

Appendix A

The Orientation Interview Guide

Framework Oriëntatie interviews POS

17/04/2023
Versie 2

Bedankt dat u mij de mogelijkheid biedt om kort wat vragen te stellen. Allereerst, ik wil graag dit gesprek opnemen om het later in rust terug te kunnen luisteren. De informatie verkregen uit dit interview wordt anoniem verwerkt in mijn onderzoek. Als u hiermee akkoord gaat, zet ik nu de opname aan. Ter verificatie: mag ik uw naam en een bevestiging dat u akkoord gaat met het opnemen van dit interview?

Het onderzoek:
Zoals u waarschijnlijk al heeft meegekregen ben ik met een aantal studenten van de Universiteit Utrecht aan het onderzoeken of we een systeem kunnen ontwikkelen die screenings automatisch opneemt en samenvat. Jullie werkwijze zou hierdoor uiteindelijk veranderen, en ik wil graag in kaart brengen wat jullie verwachtingen zijn en hoe zo'n systeem zo optimaal mogelijk zou werken binnen jullie poli.

1. **Werkwijze nu**

1.1 Zou u kort de **stappen** van een gemiddeld fysiek consult kunnen beschrijven?
A. Gebruik je HiX tijdens het consult of alleen ter voorbereiding? Zo ja, welk onderdeel van het systeem gebruik je dan?

1.2 Hoeveel **minuten** bent u tijdens en na een gemiddeld consult kwijt aan het invullen van de vragenlijst en het schrijven van een conclusie?

1.3 Zijn er dingen binnen **HiX** tijdens een **screening** die beter kunnen?

1.4 Zijn er dingen binnen HiX tijdens een screening die u goed vindt?

1.5 Wat vindt u verder van de **look** van HiX?

2. **Verwachtingen**

2.1 In hoeverre staat u **open** voor het gebruik van **nieuwe systemen** op werk?

2.2 Heeft u op werk of thuis weleens gebruik gemaakt van dicteren, **spraakherkenning** of dergelijke? Zo ja, wat zijn uw ervaringen?

2.3 Op een schaal van 1-10, hoe **technisch vaardig** zou u uzelf schatten?

2.4 En hoe **technisch vaardig** schat u het gemiddelde van alle **collega's** op de poli?

2.5 Als het consult zou worden opgenomen met camera en **microfoon**, hoe zou de **setting** er dan volgens u uitzien? Staat er een microfoon op tafel, hangt het aan de muur, zit de microfoon aan uw kleding, is het duidelijk zichtbaar of juist onzichtbaar etc

2.6 En hoe ziet het op de computer eruit?

3. Interface Care2Report

Het systeem wat nu ontwikkeld wordt, zou bestaan uit software apart van HiX en opnameapparatuur die is aangesloten aan de werkcomputer. In het stadium waar we nu zijn zal dit enkel een microfoon zijn. Later kan er ook een camera aan toegevoegd worden. Op het moment dat het consult start en de patiënt consent heeft gegeven, kan u de opname starten. Vanaf dat moment is het systeem gelijk bezig met het verwerken van de gesproken woorden en het filteren van de relevante informatie.

Verwerking

3.1 Voordat het gesprek gestart kan worden, moet de microfoon, eventueel de camera en het systeem werken. Het kan zijn dat de instellingen nog niet goed staan. Zou u bereid zijn om, aan de hand van **instructies** die af te lezen zijn van uw scherm, bijvoorbeeld de microfoon te resetten?

3.2 Automatisch wordt het consult opgenomen, wordt de vragenlijst ingevuld en de conclusie gegenereerd. Dit gebeurt **tijdens** het gesprek. Op het scherm kan worden **bijgehouden** wat er al is ingevuld. Zou u dit prettig vinden om te zien, of denkt u dat dit afleidt?

3.3 Wat zou u ervan vinden als het systeem aangeeft welke **onderwerpen** van de vragenlijst nog **niet besproken** zijn?

3.4 Het kan natuurlijk zijn dat het systeem sommige belangrijke delen van het gesprek niet goed heeft **verwerkt**. Zou u dit voor het einde van het gesprek willen zien, zodat er nog een mogelijkheid is om de patiënt om extra informatie te vragen? Of heeft u het liever als de patiënt is beëindigd?

3.5 Als het consult is afgelopen, zullen de automatisch gegenereerde antwoorden en conclusie **gecontroleerd** moeten worden. Hoe ziet u dit voor zich?

Integratie met HiX

Het Care2Report systeem staat los van HiX, maar samenwerking tussen die systemen is natuurlijk essentieel. De komende vragen gaan in op deze samenwerking.

3.6 Jullie starten met het inlezen van het medisch dossier van de patiënt. In veel gevallen heeft de patiënt ook de **gezondheidsvragenlijst** ingevuld. Is het voor jullie handig als deze gezondheidsvragenlijst door het Care2Report systeem overgenomen kan worden?

3.7 Zou u bereid zijn de ingevulde vragenlijst en conclusie **in HiX te laden** als dit vanuit het Care2Report systeem gemakkelijk te doen is?

Toekomst

3.8 Denkt u dat u meer **aandacht** voor de patiënt kunt hebben als het systeem automatisch noteert?

3.9 Voordat de ingevulde vragenlijst en de conclusie ingeladen kan worden, moet u de automatisch gegenereerde antwoorden **nakijken** en eventueel verbeteren. Hoe ziet u dit voor zich?

A. Aangezien het systeem gebruik maakt van **microfoons** zou het checken van de gegenereerde antwoorden ook door middel van spraak kunnen. Ziet u het voor zich om de eindconclusie **dicterend** te verbeteren?
B. Ziet u het dan voor zich om al **typend** de antwoorden te verbeteren, mocht dit nog nodig zijn?

Appendix B

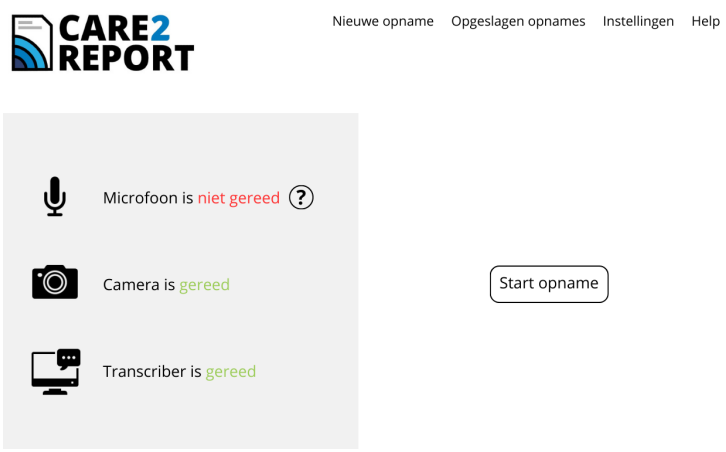
The Summarized Interview transcripts

vraag nr	Onderwerp	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
1	*Werkwijze*				
1.1	Consult flow	**structuur**: voorbereiden - patient ophalen - introductie van jezelf - ingevulde vragenlijst doornemen - javragen uitvragen - cardiopulmonaal - lichamelijk onderzoek -	Voorbereiding - van tevoren vul ik al heel veel in - begin met vragen of patient al vragen heeft	Voorbereiding - aandachtspunten op een rij zetten - vragnelijst openen en doorlopen met de patient - lichamelijk onderzoek	Sommige belangrijke dingen typ ik gelijk
1.2	Minuten typen	Ik kan niet blind typen. Copy paste van EPD. Tijdens het consult 10% van de tijd aan het typen. Na het consult 5-15 min bezig voor de afronding	Tijdens het gesprek typ ik heel weinig, als het kan helemaal niet. Wel kort op papier. Ook omdat ik een ouderwetste typer ben.	ik typ en praat tegelijk, denk 50%	Moeilijk om te zeggen, hangt ook af van de complexiteit van de patient. Bij een gezonde patient 2-3 min tot max 15 min
1.3	Hix negatieve punten	Veel klikken tijdens zo'n consult, medicatie wordt niet direct overgenomen, bij drugs grote uitklapvraag	Informatie opvragen bij cardiologen, dat zou misschien anders kunnen	Alle vragen van de vragenlijst komen erin te staan, terwijl ik maar 15 vragen echt belangrijk vindt. niet alle vragen van de patientvragenlijst	Alles wat je niet hoeft te klikken scheelt tijd en frustratie, fijner om zo te werken met IT
1.4	HiX positieve punten	Standaardteksten (mag nog uitgebreider), verwijzing voor de operatie staat bij het rapport van het consult	Standaardteksten (nuchterbeleid), dat scheelt. Tabbladen zijn overzichtelijk.	tabbladen is goed voor navigeren, overzichtelijk van verschillende afdelingen	Daar waar we vaak hetzelfde noteren hebben we standaardteksten: kan men ook lui maken. Sommige informatie gaat gestandaardiseerd over, daar hoef je as anesthesist niks mee maar
1.5	HiX look				HiX open tijdens het consult
2	*Verwachtingen*				
2.1	Nieuwe systemen op werk	Alleen HiX, wat natuurlijk al wel veranderd is. Niet iets externs.Orders zijn wel verbeterd binnen HiX. Niet iets met spraakherkenning.	Asis, 4 kleuren pen: overzicht van de OK. Verder alleen met HiX	Meta vision op de IC ergens anders, kan je niet vergelijken	Op OK en hiervoor met mirador, men gunt zich geen tijd om een systeem goed te leren kennen. Moet intuitief zijn (geen tijd hebben of willen
2.2	Spraakherkenning ervaring	Geen ervaring met spraakherkenning	Ik niet. Mijn schoonzoon heeft het	Geen Apple, vrij weinig eigenlijk, zit thuis eigenijk sowieso weinig achter de computer	
2.3	Technisch vaardig jezelf	6	6. Maar het gaat vrij snel. Het deel van HiX waar ik mee werk, daar kom ik wel uit.	Ja, onze generatie is er meer mee opgegroeid	
2.4	Technisch vaardig de poli	Assistenten en artsen zijn allemaal jonger. Screeners zijn wat ouder. Wisselend dus.	Ik denk van wel.	De rest is wel wat moeizamer. Toen HiX kwam moest ik als coassistent ook helpen	Zou ik graag willen generaliseren naar leeftijd, jongere mensen zijn wel flexibeler omdat ze gewend zijn aan verandering. En luiheid: als het even niet werkt, niet op zoek naar zelf een
2.5	Setting met microfoon	Uiteindelijk hoeft het niet in het zicht, in de computer verwerkt. Juist wel fijn als het niet in het zicht is. Met de opnames heeft nu niemand er	Ik heb niet zoveel last van de microfoons op tafel. Ik heb het geprobeerd zo natuurlijk mogelijk te laten verlopen.	Op tafel is het makkelijkste, hoef ik geen uitleg te geven waar het dan wel is	Denk dat je eraan moet wennen, eerste keer is misschien gek maar daarna gaat het vanzelf
2.6	C2R op het beeldscherm	Het is wel handig als HiX ook nog zichtbaar is, misschien ook met een tweede scherm. Wel zien dat er wat gebeurt	Hoeft niet beeldvullend te zijn, zichtbaar dat het microfoontje werkt, in een hoekje.	Het moet op de achtergrond draaien en samen kunnen met HiX	HiX nodig om informatie op te halen. Wel fijn om te zien dat hij het doet. Kan me voorstellen dat het afleidend is maar ook dat kan gewenning zijn. Ja

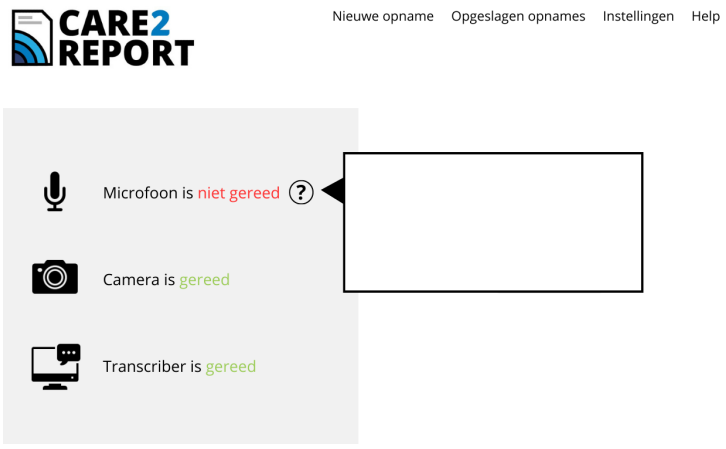
vraag nr	Onderwerp	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
3	*Interface Care2Report*				
	Verwerking				
3.1	Instructies	Ja, microfoon resetten kan ik als er wordt aangegeven hoe dat moet. Of toch een backup die je kan bellen	Ja dat moet lukken. Bij de computer zelf check ik ook wel eens zelf als het het even niet doet.	Ja prima, waarschijnlijk zal ik zelf ook de basics proberen (aan en uit zetten)	Dat is fijn! Dat de computer zegt wat je moet doen
3.2	Automatisch invullen op het scherm	Lastig, aan de ene kant graag feedback dat het bezig is. Je hoeft er ook niet de hele tijd naar te kijken. Ja feedback maar niet te groot	Ik denk dat ik daar niet naar kijk als het goed werkt. Achteraf zou ik het pas checken. Ik wil wel zien dat ie uberhaupt wat invult. Voor mijn werkwijze verandert het wel aan de voorbereiding	Alleen miscrofoon feedback, niet teveel wisselen tussen tabbaden	Het is wel fijn om te zien wat transcript is en wat van jou is
3.3	Aangeven welke onderwerpen niet besproken zijn	Ja, voor jezelf wel handig. Wegklikken als je er bewust iets hebt overgeslagen.	Er zijn ook bewust vragen die je openlaat.	Ja met bolletjes bijv aangeven en dat je dat makkelijk kan overrulen. Je moet het toch controleren	Soms hoef je dingen niet te bespreken en dan is het niet fijn, aan de andere kant vergeten we ook wel eens. Het hangt af van de balans
3.4	Aangeven welke onderwerpen niet verwerkt zijn		Ja ik denk dat dat sowieso wel goed is, je moet altijd even kijken of het wel klopt.		Simpel wegklikken gaat mensen al irriteren. Slim ermee omgaan: belangrijke onderwerpen wel hierin includeren. Alleen nuchterbeleid, verder zijn er heel veel dingen waar een variabele tussenzit
3.5	Antwoorden controleren	Vooral in de beginfase, vertrouwen in het systeem krijgen. Waar de patient nog bijzit. Je wint ook tijd doordat je tussendoor niet hoeft te typen.	In eerste instantie zou ik de patient nog wel even laten wachten met de patient naar huis sturen. Eerst samen het rapport checken	Ja, met de patient erbij	Alles wat er aan tekst staat waar je eigenlijk niet naar hoeft te kijken leidt af van dingen die wel belangrijk zijn. Weglaten dus. Mensen irriteren zich echt aan dingen die er niet toe doen
	Intergratie met HiX				
3.6	Gezondheidsvragenlijst	De vragenlijst inladen, geeft al een beeld. Wordt nu natuurlijk ook gedaan.	Ik denk dat dat wel helpt. Ook voor jullie, dan is er al heel veel bekend. Ook daarin verander je ook nog wel eens wat door middel van een toelichting	Ik denk dat dat wel handig is, ben je toch weer dubbel informatie aan het inwinnen. Misschien vraag je het niet omdat het al bekend is	Denk dat dat vooral voor het systeem handig is. Voor het rapport wat eruit komt maakt dat het ook overzichtelijker
3.7	HiX inladen	Met een knop terugladen.	Dat zou wel ideaal zijn	Ja accodeert en naar HiX sturen. Daarna moet je nog een brief genereren in HiX dus dat is dan wel extra werk	Exporteer knop ja. Anders moet je kopiëren plakken. En waar ga je data opzetten. Denk aan AVG, maar je bent ook aan het transcriberen natuurlijk
	Toekomst				
3.8	Aandacht voor de patient	Het scheelt natuurlijk wel. Zeker bij de complexere patienten. Qua communicatie wel prettiger. Asociaal als je zoveel op de computer zit	Nu doe ik dat ook al wel, het moment voor de patient probeer ik ook zo kwalitatief mogelijk te zijn. Voor mij is de winst meer in het administratieve deel. Dan kan ik sneller de nieuwe patient ophalen	Er zijn ook dingen die meer tijd gaan kosten, maar je wint natuurlijk ook tijd. Ik denk dat je dan wat rustiger gaat zitten, maar heb wel het gevoel dat ik dat nu ook al doe. Het enige stukje wat dan wegvalt is wat ik dan doe: momentje ik moet heel even wat typen	Het scheelt, meer registratietijd, dus dan heb je ook meer tijd over. Consult bestaat uit een medisch en sociaal deel. Als je meer tijd hebt doe je makkelijker dat sociale deel
3.9	Controleren dmv dicteren	Eerst even vertrouwen in krijgen, als het goed werkt dan om iets toe te voegen.	Op zich is dat wel snel en makkelijk, zeker met het ouderwetse getyp van mij.	Ligt eraan hoe makkelijk het is, als je er gewend mee bent dat je dat inderdaad gaat doen	Dicteren is wel iets wat je moet leren, is best moeilijk. Ik weet niet of dat handiger is of niet. Dat de mogelijkheid er is zou wel fijn zijn. Efficient als er kleine transcriptie fouten uitgehaald kunnen worden. Niet als je eerst wil nadenken hoe je het wilt formuleren. En ligt aan hoe je zelf bent ingesteld als persoon.

Appendix C

The Digital Wireframes



1. Microphone connection is lost



2. Instructions for solving microphone issues are shown

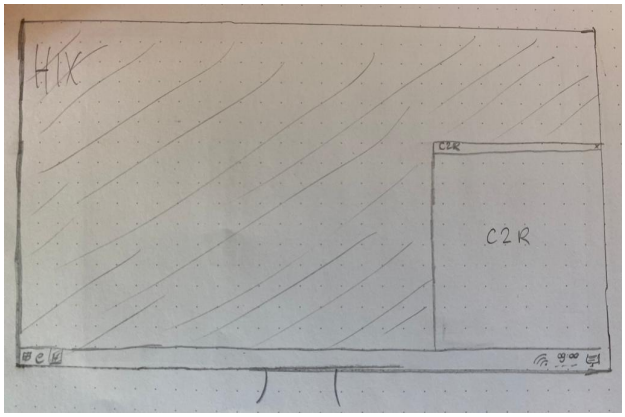
3. Microphone connection is solved

4. The recording has started

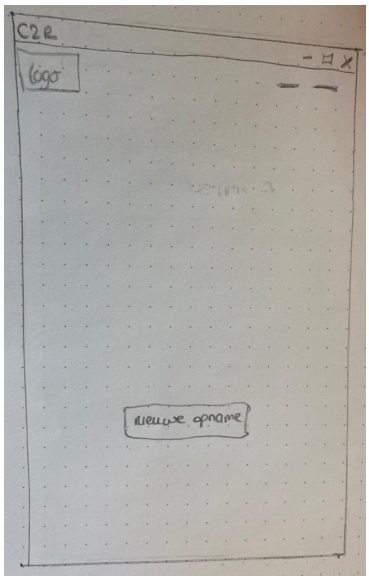
5. The system is recording and generates a report automatically

Appendix D

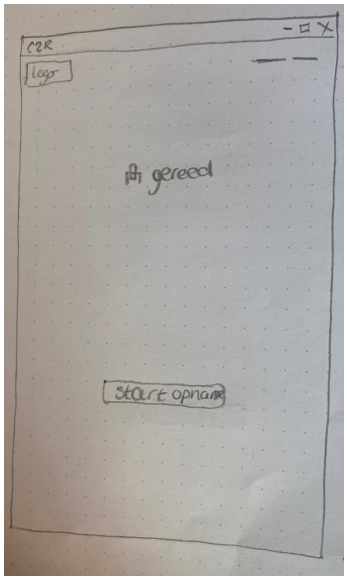
The Wireframe Sketches



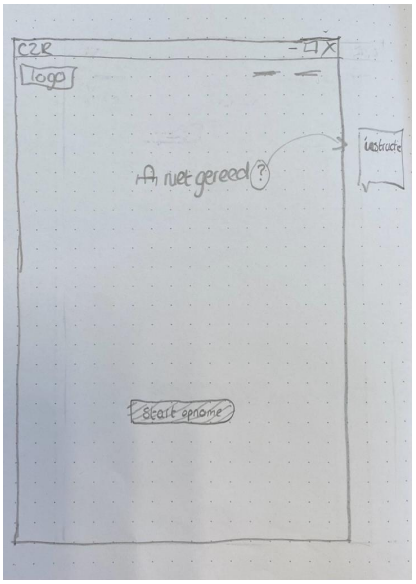
Integration



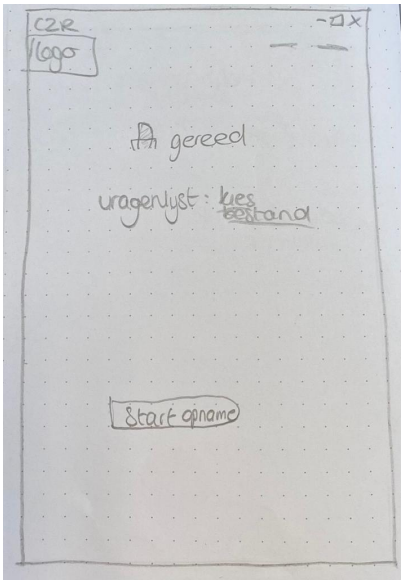
Home screen



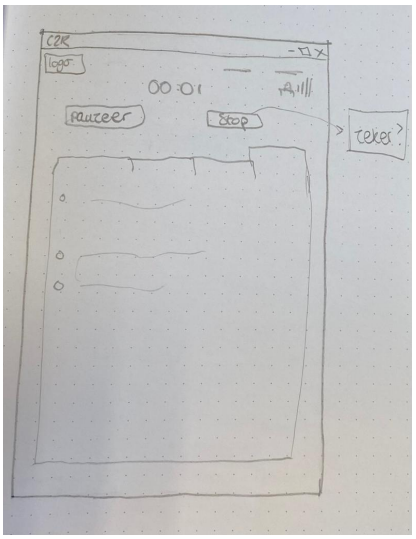
Start new recording



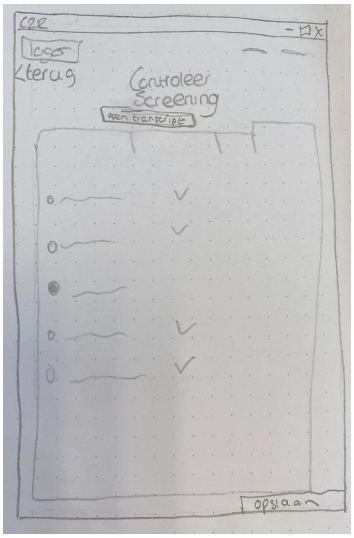
Microphone is not connected



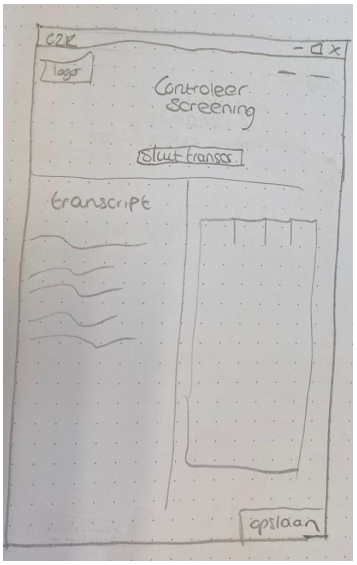
Upload patient survey



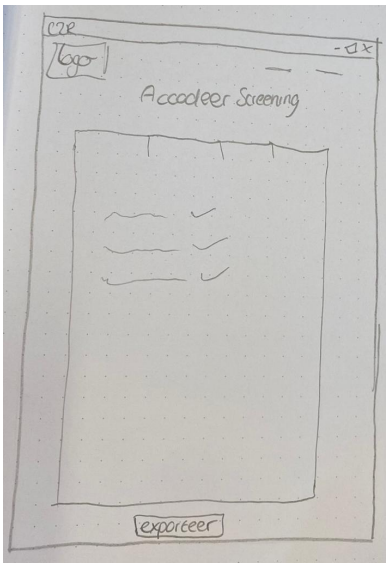
System is recording



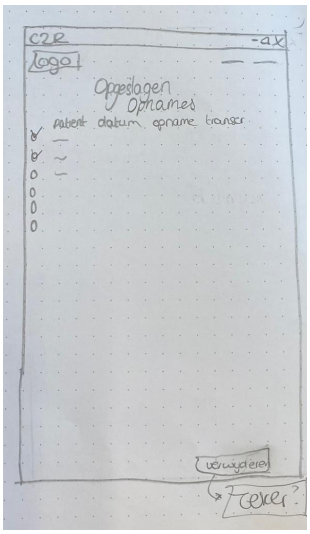
Check report



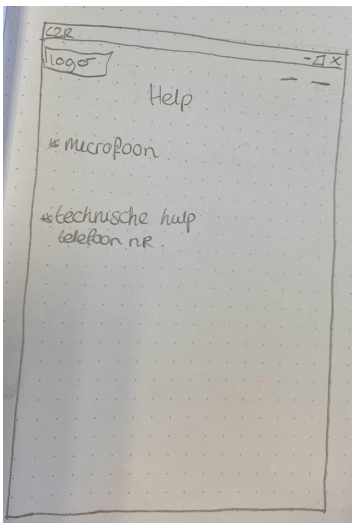
Check report including transcript



Approve report



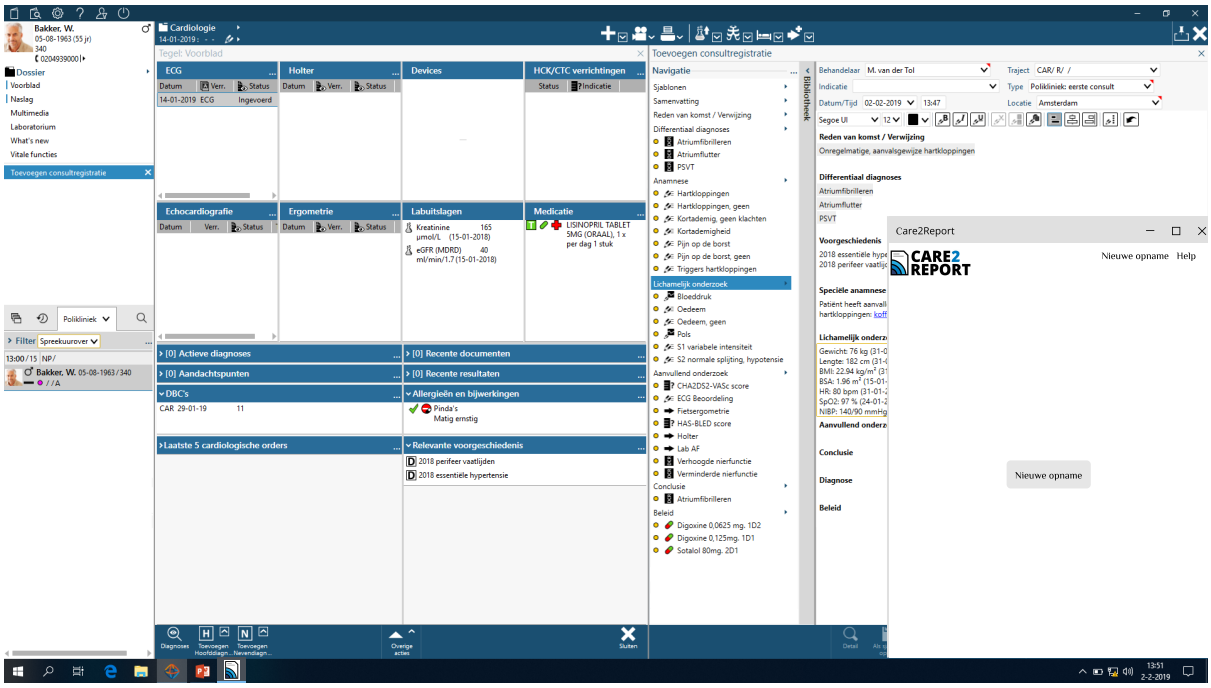
Saved recordings

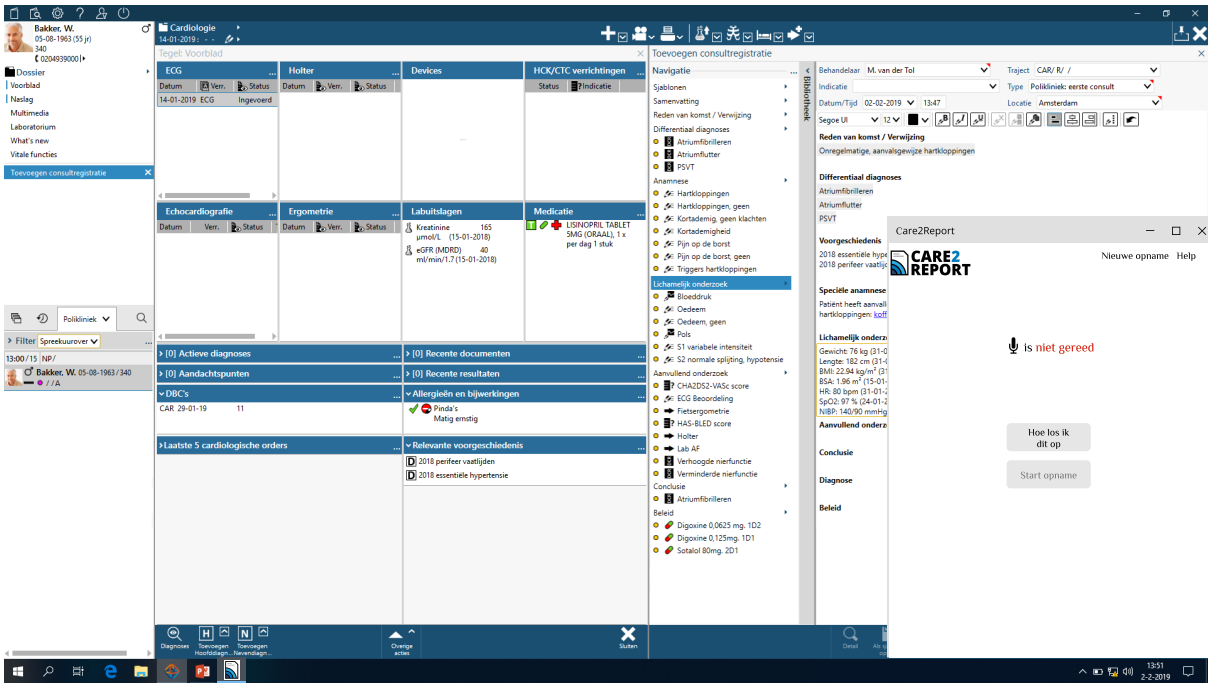


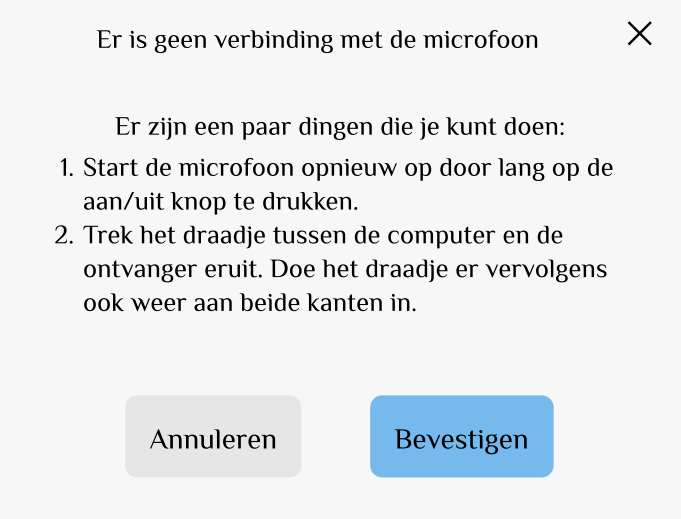
Help

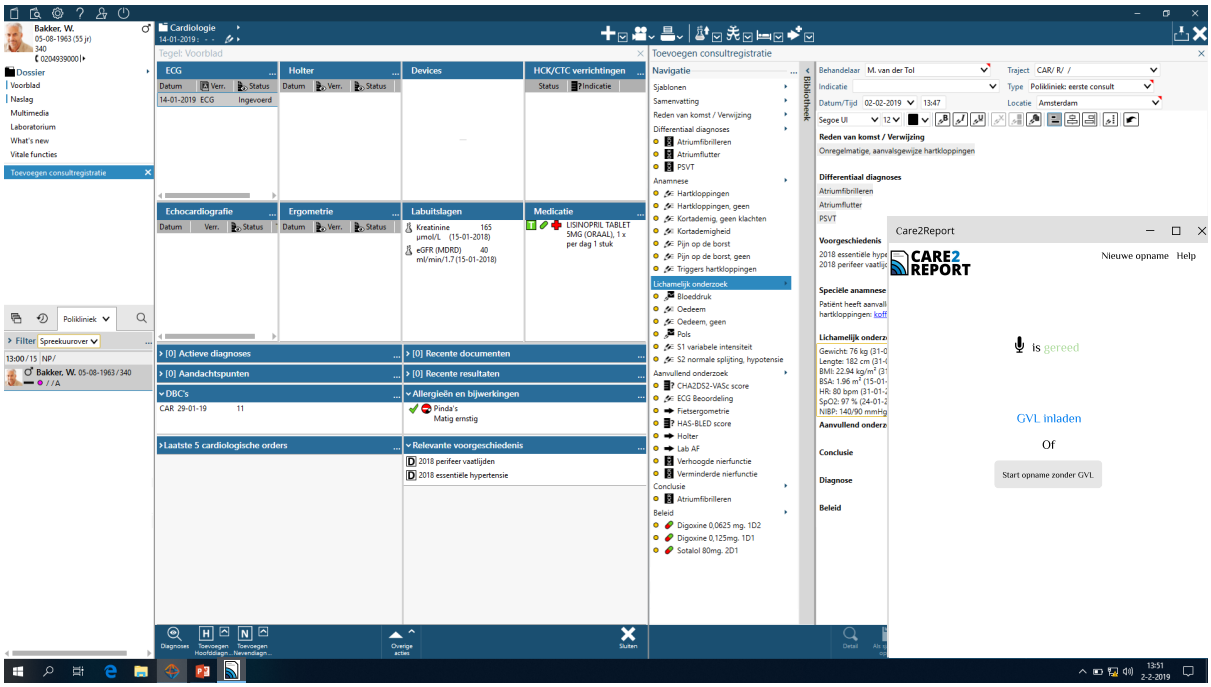
Appendix E

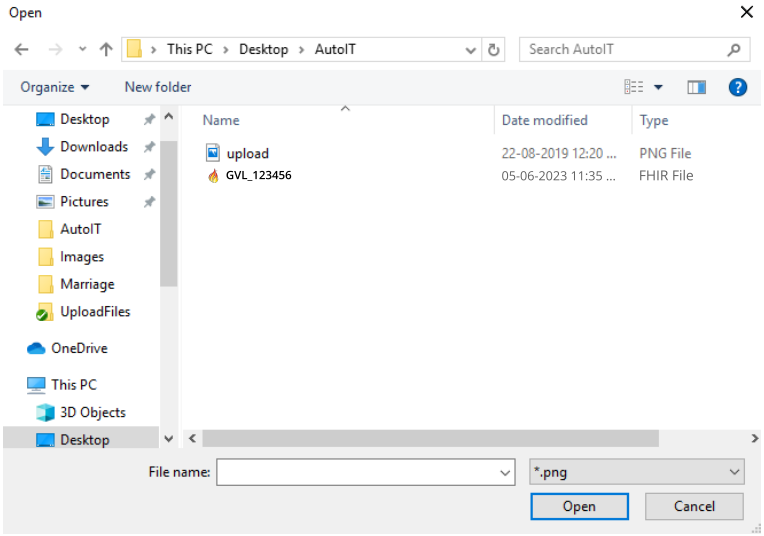
The Interactive Prototype

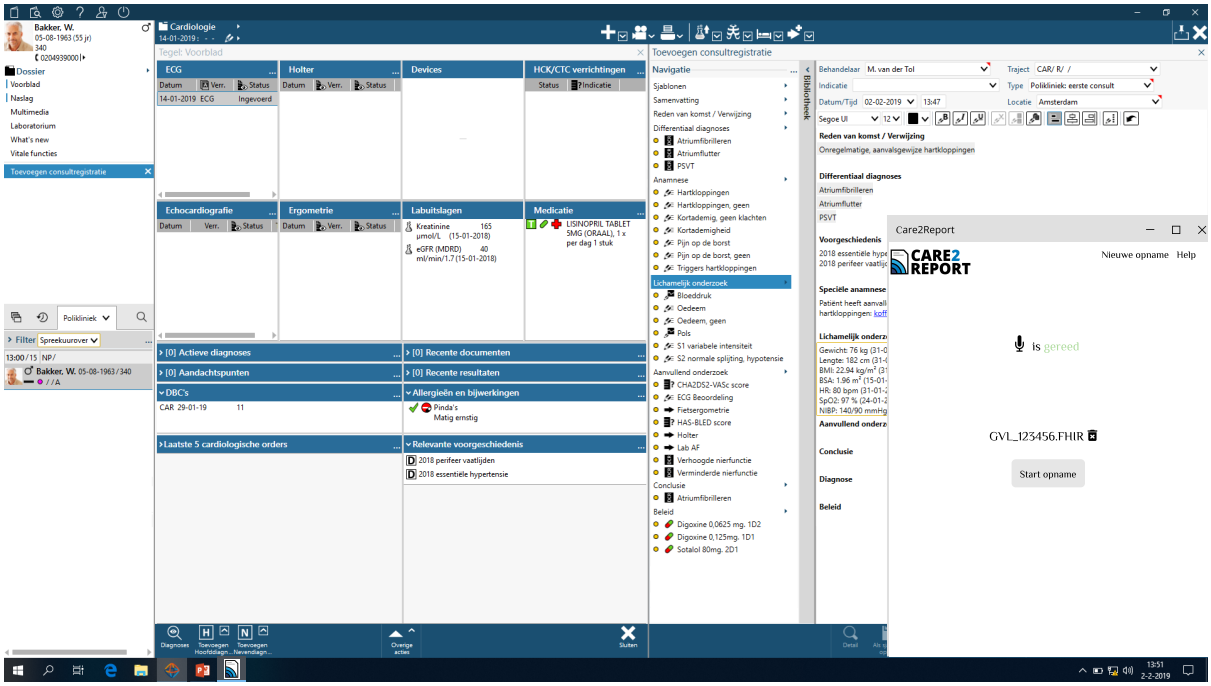


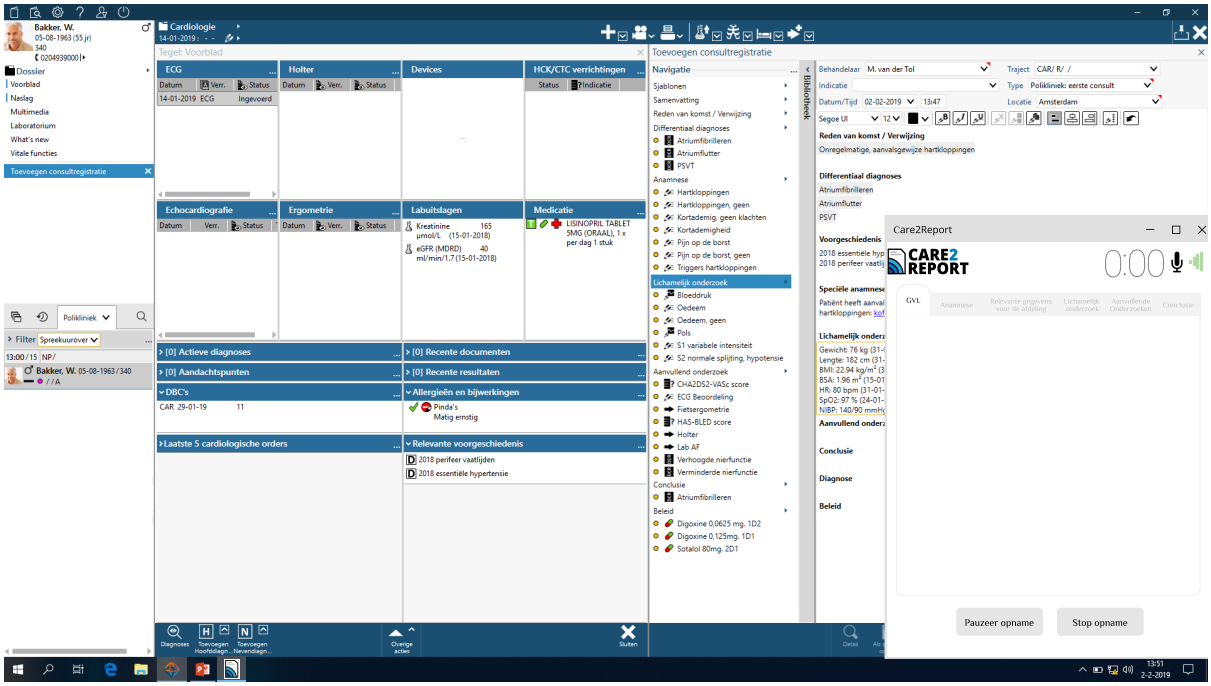

Cardiologie
ECG
Holter
Devices
HCK/CTC verrichtingen
Echocardiografie
Ergometrie
Labuitslagen
Medicatie
Toevoegen consultregistratie
Navigatie
Bibliotheek
Care2Report
CARE2 REPORT
Nieuwe opname
Help
is niet gereed
Hoe los ik dit op
Start opname

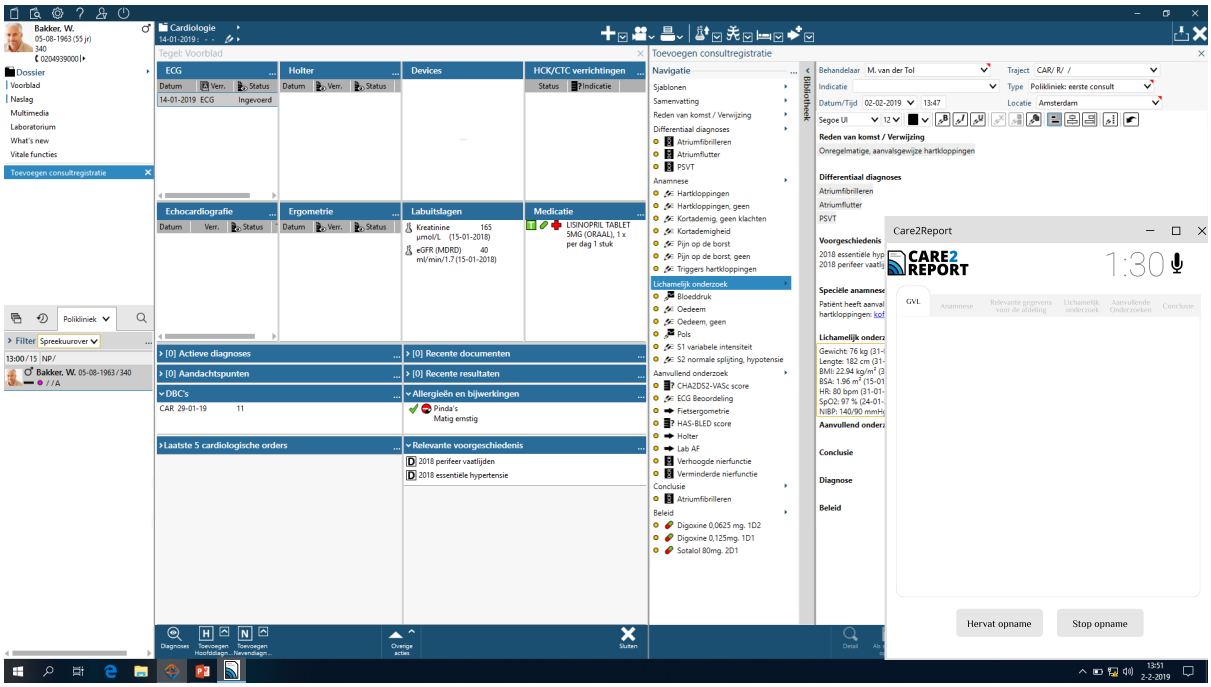

Er is geen verbinding met de microfoon
Er zijn een paar dingen die je kunt doen:
1. Start de microfoon opnieuw op door lang op de aan/uit knop te drukken.
2. Trek het draadje tussen de computer en de ontvanger eruit. Doe het draadje er vervolgens ook weer aan beide kanten in.
Annuleren
Bevestigen

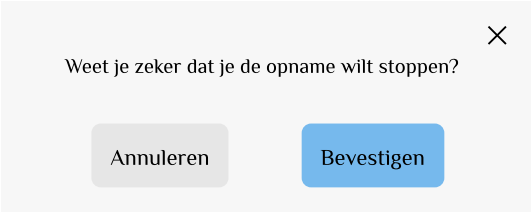

Cardiologie
Toevoegen consultregistratie
ECG
Holter
Devices
HCK/CTC verrichtingen
Echocardiografie
Ergometrie
Labuitslagen
Medicatie
Navigatie
Bibliotheek
Care2Report
CARE2 REPORT
Nieuwe opname
Help
is gereed
GVL inladen
Of
Start opname zonder GVL

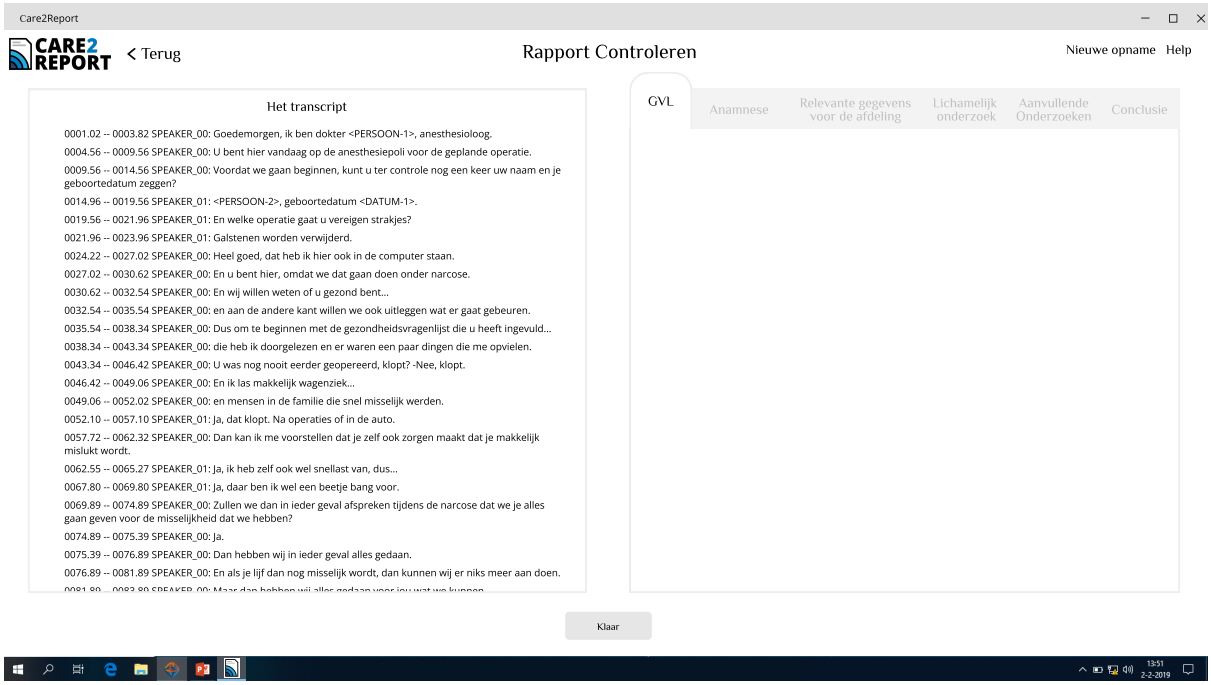

Open
This PC › Desktop › AutoIT
Search AutoIT
Organize
New folder
Desktop
Downloads
Documents
Pictures
AutoIT
Images
Marriage
UploadFiles
OneDrive
This PC
3D Objects
Desktop
Name
Date modified
Type
upload
22-08-2019 12:20 ...
PNG File
GVL_123456
05-06-2023 11:35 ...
FHIR File
File name:
*.png
Open
Cancel

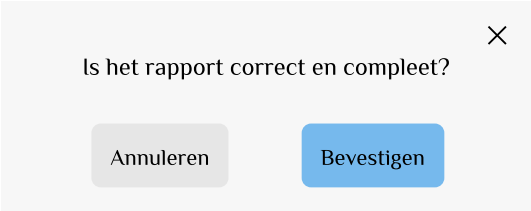

Care2Report
CARE2 REPORT
Nieuwe opname
Help
is gereed
GVL_123456.FHIR
Start opname

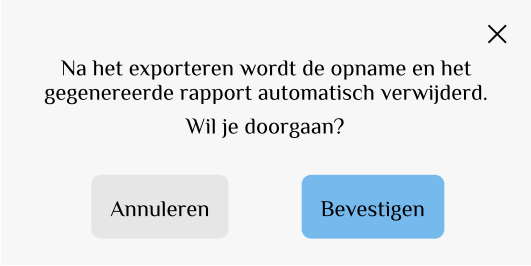

Care2Report
CARE2 REPORT
0:00
Pauzeer opname
Stop opname

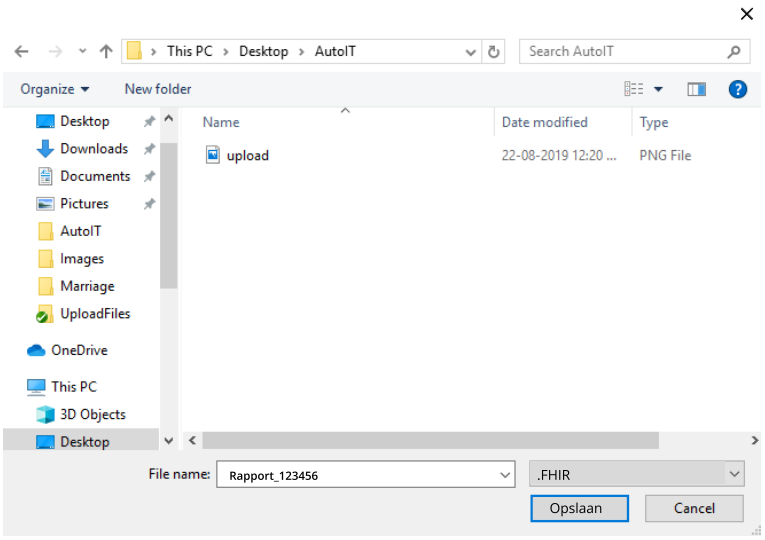

Cardiologie
Toevoegen consultregistratie
Care2Report
CARE2 REPORT
1:30
Hervat opname
Stop opname

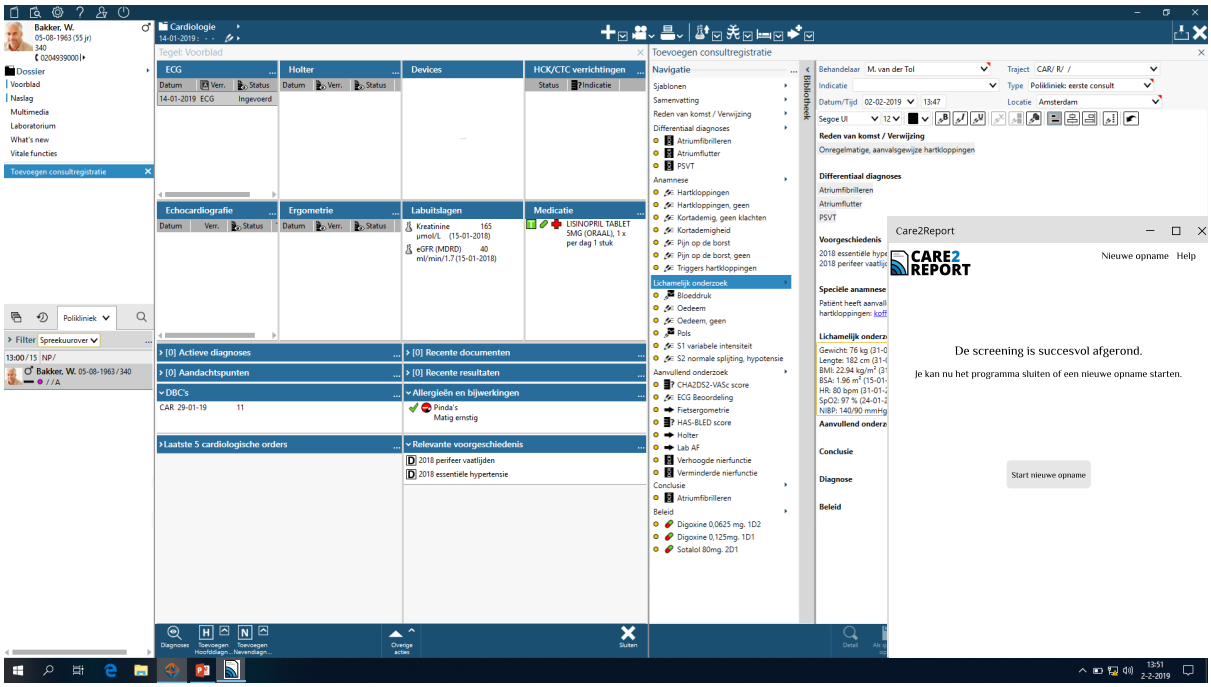

Weet je zeker dat je de opname wilt stoppen?
Annuleren
Bevestigen

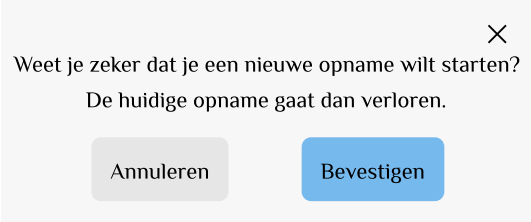

Care2Report
CARE2 REPORT
< Terug
Rapport Controleren
Nieuwe opname
Help
Het transcript
0001.02 -- 0003.82 SPEAKER_00: Goedemorgen, ik ben dokter <PERSOON-1>, anesthesioloog.
0004.56 -- 0009.56 SPEAKER_00: U bent hier vandaag op de anesthesiepoli voor de geplande operatie.
0009.56 -- 0014.56 SPEAKER_00: Voordat we gaan beginnen, kunt u ter controle nog een keer uw naam en je geboortedatum zeggen?
0014.96 -- 0019.56 SPEAKER_01: <PERSOON-2>, geboortedatum <DATUM-1>.
0019.56 -- 0021.96 SPEAKER_01: En welke operatie gaat u vereigen strakjes?
0021.96 -- 0023.96 SPEAKER_01: Galstenen worden verwijderd.
0024.22 -- 0027.02 SPEAKER_00: Heel goed, dat heb ik hier ook in de computer staan.
0027.02 -- 0030.62 SPEAKER_00: En u bent hier, omdat we dat gaan doen onder narcose.
0030.62 -- 0032.54 SPEAKER_00: En wij willen weten of u gezond bent...
0032.54 -- 0035.54 SPEAKER_00: en aan de andere kant willen we ook uitleggen wat er gaat gebeuren.
0035.54 -- 0038.34 SPEAKER_00: Dus om te beginnen met de gezondheidsvragenlijst die u heeft ingevuld...
0038.34 -- 0043.34 SPEAKER_00: die heb ik doorgelezen en er waren een paar dingen die me opvielen.
0043.34 -- 0046.42 SPEAKER_00: U was nog nooit eerder geopereerd, klopt? -Nee, klopt.
0046.42 -- 0049.06 SPEAKER_00: En ik las makkelijk wagenziek...
0049.06 -- 0052.02 SPEAKER_00: en mensen in de familie die snel misselijk werden.
0052.10 -- 0057.10 SPEAKER_01: Ja, dat klopt. Na operaties of in de auto.
0057.72 -- 0062.32 SPEAKER_00: Dan kan ik me voorstellen dat je zelf ook zorgen maakt dat je makkelijk mislukt wordt.
0062.55 -- 0065.27 SPEAKER_01: Ja, ik heb zelf ook wel snellast van, dus...
0067.80 -- 0069.80 SPEAKER_01: Ja, daar ben ik wel een beetje bang voor.
0069.89 -- 0074.89 SPEAKER_00: Zullen we dan in ieder geval afspreken tijdens de narcose dat we je alles gaan geven voor de misselijkheid dat we hebben?
0074.89 -- 0075.39 SPEAKER_00: Ja.
0075.39 -- 0076.89 SPEAKER_00: Dan hebben wij in ieder geval alles gedaan.
0076.89 -- 0081.89 SPEAKER_00: En als je lijf dan nog misselijk wordt, dan kunnen wij er niks meer aan doen.
GVL
Anamnese
Relevante gegevens voor de afdeling
Lichamelijk onderzoek
Aanvullende Onderzoeken
Conclusie
Klaar

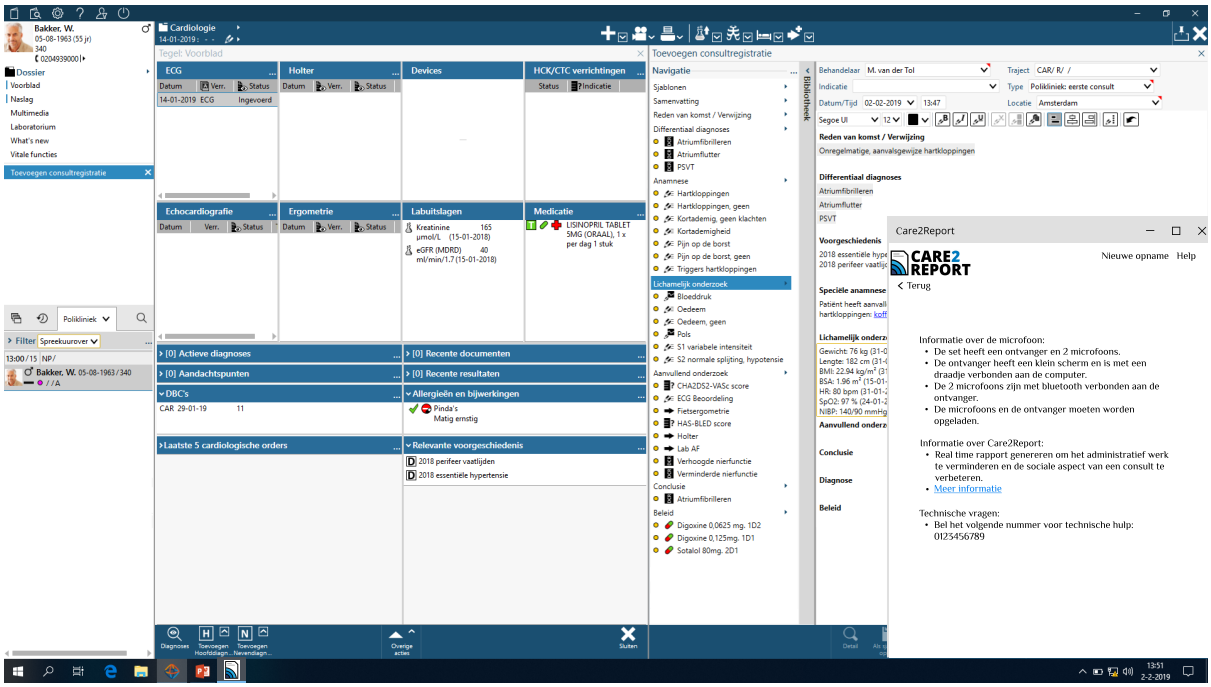

Is het rapport correct en compleet?
Annuleren
Bevestigen


Na het exporteren wordt de opname en het gegenereerde rapport automatisch verwijderd.
Wil je doorgaan?
Annuleren
Bevestigen


This PC › Desktop › AutoIT
Search AutoIT
Organize
New folder
Desktop
Downloads
Documents
Pictures
AutoIT
Images
Marriage
UploadFiles
OneDrive
This PC
3D Objects
Desktop
Name
Date modified
Type
upload
22-08-2019 12:20 ...
PNG File
File name:
Rapport_123456
.FHIR
Opslaan
Cancel


Cardiologie
ECG
Holter
Devices
HCK/CTC verrichtingen
Echocardiografie
Ergometrie
Labuitslagen
Medicatie
Toevoegen consultregistratie
Care2Report
CARE2 REPORT
Nieuwe opname
Help
De screening is succesvol afgerond.
Je kan nu het programma sluiten of een nieuwe opname starten.
Start nieuwe opname


Weet je zeker dat je een nieuwe opname wilt starten?
De huidige opname gaat dan verloren.
Annuleren
Bevestigen


Cardiologie
Toevoegen consultregistratie
ECG
Holter
Devices
HCK/CTC verrichtingen
Echocardiografie
Ergometrie
Labuitslagen
Medicatie
Navigatie
Bibliotheek
Care2Report
CARE2 REPORT
Nieuwe opname
Help
Terug
Informatie over de microfoon:
De set heeft een ontvanger en 2 microfoons.
De ontvanger heeft een klein scherm en is met een draadje verbonden aan de computer.
De 2 microfoons zijn met bluetooth verbonden aan de ontvanger.
De microfoons en de ontvanger moeten worden opgeladen.
Informatie over Care2Report:
Real time rapport genereren om het administratief werk te verminderen en de sociale aspect van een consult te verbeteren.
Meer informatie
Technische vragen:
Bel het volgende nummer voor technische hulp: 0123456789

Appendix F

The Think Aloud Guide

Framework Think Aloud

31/05/2023
Versie 1

Bedankt dat u mij de mogelijkheid biedt om het prototype te evalueren. Allereerst, ik wil graag deze evaluatie opnemen om het later in rust terug te kunnen luisteren. De informatie verkregen uit deze evaluatie wordt anoniem verwerkt in mijn onderzoek. Als u hiermee akkoord gaat, zet ik nu de opname aan. Ter verificatie: mag ik uw naam en een bevestiging dat u akkoord gaat met het opnemen van dit interview?

Het onderzoek:
Zoals u waarschijnlijk al heeft meegekregen ben ik met een aantal studenten van de Universiteit Utrecht aan het onderzoeken of we een systeem kunnen ontwikkelen dat screenings automatisch opneemt en samenvat. Na het houden van interviews, heb ik een voorstel gemaakt voor een systeem. Graag wil ik uw mening meenemen om een rapport hierover te kunnen opstellen.

Nu:
Ik ga zo het prototype openen en zal u een paar opdrachten geven om zo door het systeem te gaan. TIjdens deze opdrachten wil ik u vragen om zo veel mogelijk te zeggen wat u denkt. Waarom je kiest om ergens op te klikken en waarom niet bijvoorbeeld. Hierna stel ik graag nog een paar vragen. Bedenk wel dat dit een prototype is, en dus niet als een compleet werkend systeem dient.

1. **Opdrachten**

Voordat je de patiënt gaat ophalen of gaat bellen, bereid je het systeem voor.

- Zorg dat de microfoon werkt en dat de gezondheidsvragenlijst is ingeladen.
- Start de opname.
- Pauzeer de opname om de inspanningstolerantie aan te passen en iets toe te voegen bij de opmerkingen voor de relevante gegevens voor de afdeling.
- Stop de opname, check het transcript en voeg nog wat toe aan de conclusie.
- Accordeer en exporteer het rapport.

Ga nu nog even rustig door het systeem.

2. **Vragen**

<u>Status visibility</u>

- Aan de hand van de timer, de feedback dat de microfoon werkt en dat de tabbladen vanzelf wisselen, ziet u dat het systeem werkt. Wat vindt u hiervan?

- Het systeem is geïmplementeerd alsof het een kleiner scherm is tijdens het consult. Bij de controle verandert dit naar schermgrootte. Wat vindt u hiervan?
- Het systeem werkt op de achtergrond zodat u tussendoor wat in het dossier kan opzoeken. Wat vindt u hiervan?

User control

- Tijdens en na het consult is er de mogelijkheid om het rapport aan te passen. Hoe vindt u dat dat is verwerkt?
- Hoe zou u het anders zien?

- Het transcript is alleen zichtbaar bij het controleren van het rapport. Wat vindt u hiervan?
- U kunt het transcript zelf niet verbeteren, zou u dit willen?

Privacy and patient safety

- De mogelijkheid van het inladen van de gvl is nu verwerkt. Wat vind je hiervan?

- Het systeem werkt met patientgevoelige informatie. Is het systeem volgens u veilig genoeg op de manier dat het nu is voorgesteld?

- Zitten er genoeg of juist te veel waarschuwingsmeldingen en controle stappen in het prototype?

Al met al:

- Is dit een beetje wat je had verwacht naar aanleiding van de interviews?

3. Task analysis

Een screening zou iets anders verlopen als er een systeem zoals Care2Report zou worden gebruikt. Graag laat ik u zien hoe jullie proces dan zou veranderen. Wat vindt u van deze werkflow?

Appendix G

The Focus Group Guide

Framework Focus Group

10/06/2023
Versie 1

Welkom en bedankt dat jullie allemaal de tijd heben genomen om hier te zijn. Allereerst, ik wil graag deze focus groep opnemen om het later in rust terug te kunnen luisteren. De informatie verkregen uit deze evaluatie wordt anoniem verwerkt in mijn onderzoek. Als jullie hiermee akkoord gaan, zet ik nu de opname aan. Ter verificatie: mag ik jullie naam en een bevestiging dat jullie akkoord gaan met het opnemen van dit interview?

1. **Het doel van de focus groep**

Het doel van de focusgroep is om de design keuzes te analyseren aan de hand van voorgestelde alternatieven. Probeer zo open mogelijk te zijn en op elkaar te reageren als je dat wilt.

2. **Het prototype**

Ik laat nog een keer rustig de interface zien.

3. **De design keuzes**

Status visibility

- Microfoon **instructies**
- Timer, microfoon **feedback**
    - Alternatieven: kleinere timer, geen timer
- Wisselende **tabbladen**
    - **afleidend**
    - Zelf de controle houden
- De **window** wordt nu alleen tijdens de controle fase groter
    - Echter tijdens de evaluaties bleken er veel individuele voorkeuren hierin te zijn. Is **responsive** een optie?

User control

- Tijdens het consult kan je pauzeren en **bewerken**. Is dit handig? soms loopt het systeem misschien achter.
- **Aangevulde tekst** is nu als schuingedrukt aangegeven, check antwoorden hebben geen indicatie van verandering. Wat vinden jullie hiervan?
    - Icoontjes en kleuren zijn als opties voorbij gekomen.

- Het **transcript** is gelijk zichtbaar bij het controleren van het rapport.
    - Zelf de controle over het openen van het transcript
    - Gegenereerde antwoorden koppelen aan het stuk van het transcript
- **Transcript** mee naar **HiX**

- **Audio** van het consult is niet meegenomen in het design
    - De helft vind dit prima, transcript als naslag

    - Maar het transcript is lang niet altijd van goede kwaliteit

Privacy and patient safety
- Het uploaden van de GVL
    - Direct uit HiX

- Gelijk verwijderen nadat het rapport geexporteerd is.
- Bang voor het verwisselen van patienten. Hebben jullie een idee?

WVTTK

Dank jullie wel!

Appendix H

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Design Principles for the Interface of an Automated Medical Reporting System: a User Study in Preoperative Screening

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Abstract

This paper presents a qualitative study into the interface design of an Automated Medical Reporting system in order to establish user-centered design principles. Automated Medical Reporting was already proposed as a solution to the administrative burden in healthcare think-aloud to increase patient-doctor contact. In order to expand this vision by including interface design principles without overlooking the usability aspects, a case study within the preoperative screening was performed. In this research, the current situation of this case study was first investigated according to a Task Analysis, a heuristic evaluation of the Electronic Health Record system in use, and stakeholder interviews. Then the knowledge gained on preoperative screenings and the findings of the interviews were translated into design choices. Based on these design choices and IT expert feedback, a treatment design in the form of a high-fidelity prototype of an Automated Medical Reporting system for preoperative screenings was developed. This treatment was evaluated by conducting think aloud sessions and a focus group. According to the evaluations, the following can be concluded. Medical specialists find it hard to envision their workflow using an Automated Medical Reporting system, and many individual preferences exist. However, the design of an Interface for an Automated Medical Reporting system should be built around system status visibility, care provider control, consultation traceability and patient privacy according to the future users.

Keywords: Automated Medical Reporting, Interface Design, User Study, Preoperative Screening

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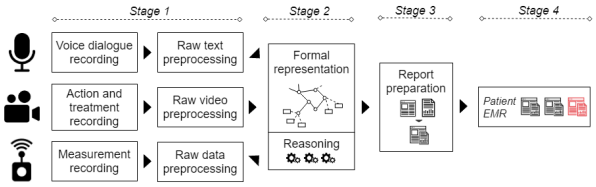


Fig. 1. The phases of the vision of Care2Report

1. Introduction

In healthcare, the focus should be on providing the care the patient requires [3]. To do so, care providers need to document their observations and findings during consultations, which takes time. De Veer et al. researched the time spend on administrative tasks by Dutch care providers. The answers to their survey showed that care providers in the Netherlands spend on average 10 hours per week on administrative tasks [4]. These tasks result in an administrative burden, which is defined as 'the costs of administrative activities that organizations have to perform in order to comply with the information obligations' [5,7].

Improving the efficiency of administrative task to lower the workload of care professionals can contribute to a solution to this burden. A solution that is proposed by the Care2Report team of Utrecht University, is an Automated Medical Reporting (AMR) system. The aim of this solution is to automatically generate a medical report during a consultation by using speech and action technology. Based on advanced semantic representation through knowledge graphs combined with medical guidelines and patient data, the consultations are interpreted [11]. The stages of this process are depicted in Fig. 1. A medical report is generated which the care provider can check and complete.

A domain of healthcare in which a lot of administrative work needs to be done is the department of anesthesiology in hospitals. Before patients undergo a surgery, their current state of health needs to be assessed [9]. This is done during a preoperative screening (POS) in which a checklist is completed and an end-conclusion for colleagues is composed. In some cases, an additional physical examination is done too. This results in patient information that needs to be entered into the hospital information system manually. As no mistakes can be made, a care provider often fills in this checklist during a consultation. However, this draws the attention away from the patient which can have a negative influence on how a consultation is perceived [15].

To investigate the impact Automated Medical Reporting could have on the preoperative screening process, a case study was initiated by the Care2Report research team of Utrecht University (UU) in conjunction with the anesthesiology department of the University Medical Center Utrecht (UMCU). Within this case study, several research areas were investigated, of which this study focuses on the User Interface (UI). A user-centered approach to establish usability criteria of AMR systems was employed since interfaces were shown to be an important aspect of system integration processes. In the field of Healthcare, the usability of new information systems is frequently overlooked [16]. Due to the ignorance of the usability concerns, user acceptance decreases. Besides, poor UI's have been identified as the major obstacle to the acceptance and use of healthcare information systems.

To fill this gap, a qualitative study into the interface design principles for an Automated Medical Reporting system according to future users is presented. This is done by answering the following research question: *What are the key user-centered design principles that should be applied when designing an interface for an Automated Reporting System used in healthcare consultations?*

2. Literature Research

2.1 Automated medical reporting

Not only Care2Report proposed a solution in the form of Automated Medical Reporting. In 2023, a systematic review of automatic documentation of professional health interactions was also conducted by Falcetta and colleagues [6]. Within their scope of the search, research on systems that could detect speech and transcribe it in a natural and structured fashion during doctor-patient consultations was included. None of the eight included studies had shown

sufficient real-life experience or large-scale validated results. This can be partly declared by the challenges automated documentation yields. These challenges were identified by Quiroz et al. in 2019 [14]. The six challenges of automated documentation are: (1) recording high-quality audio, (2) converting audio to transcripts using speech recognition, (3) inducing topic structure from conversation data, (4) extracting medical concepts, (5) generating clinically meaningful summaries of conversations, and (6) obtaining clinical data for AI and ML algorithms.

2.2 Interface design principles in healthcare

A challenge one might add is the design of the user interface for an Automated Medical Reporting system. In the field of Healthcare, the usability of new information systems is frequently overlooked. The poor usability of Electronic Health Record systems, in which different reports of consultations of patients are stored, causes resistance among care providers towards using new technologies [16]. Including the end-users, the care professionals in this case, is shown to be an important aspect of User Interface design [10, 18]. Furthermore, for ensuring accessibility and usability, following UI design heuristics is essential according to Shaw et al. [16]. For this study, Nielsen's ten usability heuristics [13] were taken into account during the design process.

A kind of healthcare IT system that already exists and aligns the objectives of report generation, is the Clinical Decision Support System (CDSS). At the simplest level, these are tools to help clinicians and patients make better-informed decisions during the use of the Electronic Health Record system [12, 17]. A narrative review to identify recommended design features for interfaces of CDSSs was conducted by Miller et al. in 2018. According to the results of 14 studies, 42 design recommendations were identified. The recommendations were categorized into interface, information, and interaction. For the interface, Miller et al. stated: "Reducing text density makes the CDSS easier to interpret during busy clinician encounters and keeps the attention of the provider. Additionally, information-oriented, systematic graphic design helps providers understand complex information" [12]. Regarding the information features, incorporating content guidance was recommended. The important aspects regarding interaction were amongst others; providing timely feedback and flexible design.

3. Research Method

3.1 Problem investigation

For establishing design principles for a User Interface of an Automated Medical Reporting system, the Design Cycle of Wieringa was used to specify the research steps [19]. The first research phase, the Problem Investigation, is focused on investigating the real world by visiting it, identifying stakeholder goals and identifying real-world phenomena. A Task Analysis on a preoperative screening was done and a heuristic evaluation based on Nielsen's heuristics was performed. According to this investigation, a preoperative screening checklist appeared to be divided into different sections of which the end-conclusion was the most important. Screeners use the checklist to formulate questions and enter values already during a consultation. No specific order is followed regarding the formulations of these questions. The Electronic Health Record of a patient is consulted during the consultation to look up existing information. Frustration about the usability of this system was observed. During the heuristic evaluation, issues such as the amount of textual information, poor error prevention and poor icon use were identified.

Subsequently, five semi-structured stakeholder interviews were conducted to obtain qualitative data about the present workflow, experiences with speech recognition, and expectations regarding the interface. Three participants were preoperative screeners, one was the head of the Anesthesiology department and the last stakeholder interview was conducted with an Automated Medical Reporting expert. According to a thematic content analysis, in which common themes in texts are identified such that conclusions can be drawn [2], insights into the expectations of care providers were gained.

According to the stakeholder interviews, three main themes for the interface design of an Automated Medical Reporting system arose: system status visibility, care provider control and patient privacy. System status visibility refers to the way the interface shows that the system is operating. Care provider control concerns the freedom users have to change things. Lastly, patient privacy refers to the way patient information is handled. The preferences within these categories are shown in the left column of Table 1.

Table 1. The translation of user preferences into design choices.

Finding	Interview result	Design choice
	System status visibility	
F1	The status of the system needs to be visible.	The connection to the microphone is shown and; if necessary, instructions to fix it. During the consultation, a timer and a microphone volume icon indicates that the system is recording. The system automatically switches between sections of the report, to indicate the system is generating a report in real time.
F2	An Automated Medical Reporting system does not have to dominate the whole screen.	The Care2Report system is visualized as a small window during the consultation.
F3	An Automated Medical Reporting system has to work while being visible on screen as well as in the background.	The user is able to minimize the system at all times. The system keeps recording and generating the report.
	Care provider control	
F4	A care provider needs to be able to edit and approve the report.	Both during and after the consultation, the care provider is able edit the report. When a care provider adds text to a textfield, this text will be in italics.
F5	The transcript of the consultation needs to be accessible while checking and correcting the report.	The transcript is shown directly after the recording has been stopped.
	Patient privacy	
F6	When a consultation is recorded, the microphone needs to be visible.	The microphone is placed next to the computer screen used during the consultation.
F7	The patients' information needs to be handled according to privacy regulations.	The audio, the transcript and the report are automatically deleted after the generated report is exported.
F8	The possibility to upload the patient health questionnaire needs to be implemented.	The opportunity to upload the pre consultation questionnaire that the patient has filled in is incorporated.

3.2 Treatment design

In the second research phase, a treatment is designed for the identified problem situation. Based on the findings of the problem investigation, the design principles of Care2Report systems [11] and interface designs in healthcare [12], an interactive, high-fidelity interface prototype of an Automated Medical Reporting system for preoperative screenings was developed. The requirements identified during the analysis of the interview data were translated into design choices for this prototype. This translation is shown in Table 1. The design choices are not validated in this stage of the research.

First, wireframe sketches were created on paper followed by an iteration phase in which the sketches were discussed with an Automated Medical Reporting software developer. Adjustments were made and adopted in the high-fidelity prototype for preoperative screenings. This prototype followed the interaction flow depicted in Fig. 2.

When the Care2Report preoperative screening application is launched, the user can initiate the recording process by clicking on the 'new recording' button. This causes the system to navigate to the microphone connection check screen. In case a connection with the microphone cannot be established, instructions to solve this are provided. Afterward, the opportunity to upload the health checklist completed by the patient prior to the consultation is provided. Then the recording can be started, either with or without the questionnaire filled in by the patient. This is shown in Fig. 2a. During the recording process, the user is able to pause and edit the report. The user can stop and check the report using the generated transcript that is automatically displayed as shown in Fig. 2b. The only step left is exporting the complete report to the Electronic Health Record system.

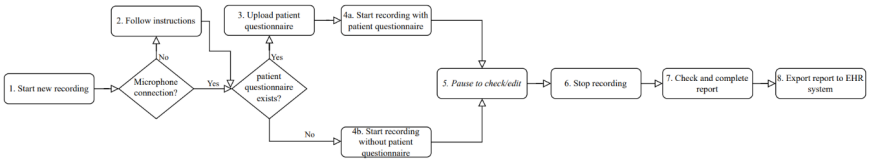
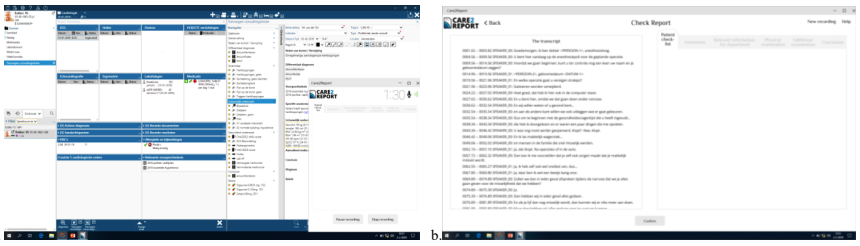


Fig. 2. Interaction flow of the prototype



a. b.

Fig. 3. (a) Screenshot: consultation is recording; (b) Screenshot: check the generated report.

3.3 Treatment validation

The design choices that have been implemented according to the preferences of the users and the existing interface design principles were evaluated according to think-aloud sessions and a focus group. For the think-aloud sessions, a sample size of nine participants was established since "An optimal sample size of '10±2' can be applied to a general or basic evaluation situation" [8]. Including a larger number of users, individual differences can be reported on, reliability increases and more usability problems come to light [1]. The participants were gathered using purposive sampling. Five participants were medical professionals, indicated with MP and four had an IT background, indicated with ITP. The think-aloud sessions started with performing a set of tasks to guide the participant through the system. During the execution of these tasks, the participants were asked to express their thoughts. After having completed the tasks, a set of questions corresponding to the design choices were asked.

A focus group was initiated to discuss the findings of the think-aloud sessions. For this focus group, four specialists in the field of Automated Medical Reporting were included. The session had a duration of approximately one hour. To create a comfortable environment, the participants were seated in a circle arrangement and were offered snacks during the session. An introduction was given in which the goal of the focus group was explained and consent for recording the session was asked. Besides, the participants were asked to react to each other if they had other ideas about the subject. After this brief introduction, the prototype was shown and elaborated on by the moderator. Then the discussion about the design choices and proposed alternatives was initiated by the moderator. The guide the moderator used consisted of the same questions asked in the think-aloud sessions, however, the alternative design choices were included too.

4. Results

During the think-aloud sessions, another main theme for the interface design arose. This resulted in the following four themes; system status visibility, care provider control, consultation traceability and patient privacy. The theme that has been added, consultation traceability, refers to the way the conversation can be linked to the transcript and the generated report. The results of both the think-aloud sessions and the focus group are combined and categorized into these four themes.

4.1 System status visibility

The timer and volume icon which indicates the working state of the system, was experienced moderately positive. MP 4 mentioned the timer was not distracting or annoying. "If this kind of feedback is not provided, I would just keep checking". The timer could be smaller according to MP6. ITP3 found the timer distracting, reasoning that "the idea is that the focus is on the patient instead of checking the computer screen". The participants of the focus group agreed upon including a timer to indicate the system is recording.

However, direct feedback about the system generating a report could be different than automatically switching between sections. "I would find it challenging to maintain focus when the sections automatically change" was mentioned during the focus group. Feedback about report generation can be indicated by small dots in front of

the title of the sections. think aloud MP5 agreed: "I think feedback is useful, maybe in the form of lightening up sections and questions answered. Switching between sections makes it confusing, I would like to be in control of switching between sections".

4.2 Care provider control

During the think-aloud sessions, the small window was shown to be inconvenient since half of the participants came closer to the screen in order to read what the interface stated. think aloud MP6 said, "It depends on the goal with which Care2Report will be used. If you want to edit the report in Care2Report, the window can be larger". A lot of individual differences in preferences were noticed. This might ask for a responsive design in which users have control. For this reason, the interface window aspect is transferred to the user control theme. During the focus group, the group proposed an even smaller window that incorporates only the timer and a start/stop button. When the user maximizes it, the system automatically switches to full-screen mode, which facilitates easier editing. This is in line with the vision of Care2Report according to one of the focus group participants. He explained: "The goal of Care2report is to support report generation. It will not be used as a reference system".

The focus group and think-aloud participants all agreed with the user being able to edit the report. However, three think-aloud participants were somewhat hesitant toward editing during the consultation. ITP2 stated not to trust the system to save their own answers. Additionally, MP6 stated the possibility to edit could cause some confusion about what is the real report. Besides, the design choice of pausing the recording to edit was perceived negatively during the focus group. "You might forget to un-pause the recording, I would implement the editing during the recording", states one of the participants. According to the participants of the focus group, the user should be in control of navigating and editing during the recording. You need to have a pause button, however only for discussing a topic off the record.

4.3 Consultation traceability

Statements in italics indicate that additional text was provided by the screener. Feedback about their own content was perceived positively by the think-aloud participants, however only during the review phase. During the focus group, some alternatives were proposed. To indicate that the user has changed something, the participants suggested using colors. Besides, the system should provide feedback about the fact that the answers they give will not be changed again. If during the consultation, new information is provided about a specific question, the users have to change this themselves. This can be indicated by a lock or an answer being greyed out.

Regarding the displayed transcription in the report checking phase, feedback showed the interface needs to enable opening the transcript by a button or navigation menu. Split screen functionality can be integrated to enhance the completion process. During the think-aloud sessions, ITP2 proposed an interesting feature that allows the user to link the answers of the screening to the transcript. ITP2 would like to see the part of the transcript the answer is based on lighten up when a generated answer is clicked. When this idea was presented to the other participants and during the focus group, their reactions were positive. MP6 would like to import the transcript together with the generated report into the Electronic Health Record system. Patients as well as colleagues can consult this transcript when confusion exists about a preoperative screening report. Especially because in present situations, patients ask to record the consultation themselves since often important risks are discussed. When exporting the transcript, the patient has access to everything that has been said too, however it is stored in a safe space.

4.4 Patient privacy

Almost all participants preferred the option to save the transcript and the generated report for a designated period in order to be able to edit the report at a later time. However, MP6 expressed hesitation due to the increased risk of errors involving critical patient information. When saving reports are enabled within the Care2Report system, exporting them to the right Electronic Health Record can be a challenge. MP6 advocated uploading the report together with the transcript to the Electronic Health Record system, where necessary adjustments can be made at any time. The focus group proposed a solution in the form of an additional validation step within the EHR system.

5. Discussion and Conclusion

This qualitative research into the interface design of an Automated Medical Reporting system for preoperative screenings was initiated in order to answer the main research question: *What are the key user-centered design principles that should be applied when designing an interface for an Automated Reporting System used in healthcare consultations?* By performing a user study within the preoperative screening department of the University Medical Center Utrecht, insights into the expectations and preferences of the healthcare sector could be gained.

During the orientation interviews, eight stakeholder preferences regarding an interface for an Automated Medical Reporting system were established. The preferences were built around three main themes; status visibility, user control, and privacy. Each of the eight user preferences was translated into a design choice and included in a high-fidelity prototype. However, translating these expectations into design choices was shown to be difficult since the interface had to be created from scratch and a variety of choices could be applied. Therefore, in every design phase, qualitative feedback from users and IT experts was gathered using various prototypes based on the preoperative screening setting. The most important finding during the evaluations with medical professionals was the fact that end users found it hard to imagine working with such a system. "Using an Automated Medical Reporting system requires a whole other way of working". This made it hard to evaluate design choices. Therefore, IT specialists were included in the validation phase to obtain more radical statements too.

Since this is the initial phase of designing an interface for such a system, participants proposed diverse design alternatives. Therefore, specifying interface design principles was challenging. However, four important themes arose during the evaluation phase: system status visibility, care provider control, consultation traceability and patient privacy. Within these themes, the ten interface design principles for an Automated Medical Reporting system in healthcare shown in Box 1 can be concluded.

What has to be considered while interpreting the interface design principles, is the laboratory environment which may influence test users' behaviors [8]. Since the evaluation is done with a prototype in a controlled setting, patients were excluded. The participants were able to fully focus on the interface without having a conversation with a patient. In further research, it would be interesting to investigate how the user would interact with the system during a consultation. Besides, implementation in other departments that require more physical examination or portability can be interesting too. Another limitation of the data obtained during the focus group can be the homogeneity of the background of the participants. All participants were working on a Care2Report project at the time of participation.

Concluding, medical specialists find it hard to vision their workflow including the usage of an Automated Medical Reporting system and a lot of individual preferences exist. However, what could be established is that the interface design of an Interface for Automated Medical Reporting system should be built around system status visibility, care provider control, consultation traceability and patient privacy.

System status visibility
- A timer needs to indicate the system is recording
- Report generation needs to be indicated by small update dots

Care provider control
- The interface window needs to be responsive
- The Automated Medical Reporting system needs to operate without interfering with the functionalities of the Electronic Health Record system
- Editing during the recording needs to be enabled

Consultation traceability
- Each part of the report needs to be linked to the corresponding part of the transcript
- Additions made by users need to be indicated with color
- The layout of the Automated Medical Reporting system needs to be different from the layout of the Electronic Health Record system
- The possibility of editing the report according to the transcript at a later time needs to be integrated

Patient privacy
- The Automated Medical Reporting system needs to work according to privacy regulations

Box 1. Interface design principles for Automated Medical Reporting

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References

[1] Alroobaea, R., & Mayhew, P. J. (2014). How many participants are really enough for usability studies? In 2014 science and information conference (pp. 48–56). IEEE.

[2] Anderson, R. (2007). Thematic content analysis (tca). Descriptive presentation of qualitative data, 1–4.

[3] Bremmers, S. (2019). Hogere werkdruk, toch aandacht. Zorgvisie, 49 (1), 56–59.

[4] De Veer, A., Groot, K. d., Brinkman, M., & Francke, A. (2017). Administratieve druk: M´e´er dan kwestie van tijd.

[5] Executive, B. R. (2006). Administrative burdens-routes to reduction. United Kingdom.

[6] Falcetta, F. S., de Almeida, F. K., Lemos, J. C. S., Goldim, J. R., & da Costa, C. A. (2023). Automatic documentation of professional health interactions: A systematic review. Artificial Intelligence in Medicine, 102487.

[7] Hampton, P. (2005). Reducing administrative burdens. London [Hampton Report].

[8] Hwang, W., & Salvendy, G. (2010). Number of people required for usability evaluation: The 10±2 rule. Communications of the ACM, 53 (5), 130–133.

[9] Jannink, W., & Hobert, E. (2016). Predictiemodel tijdsduur preoperatieve screening (B.S. thesis, University of Twente).

[10] Kaipio, J., L¨a¨averi, T., Hypp¨onen, H., Vainiom¨aki, S., Reponen, J., Kushniruk, A., . . . V¨ansk¨a, J. (2017). Usability problems do not heal by themselves: National survey on physicians' experiences with ehrs in finland. International Journal of Medical Informatics, 97, 266–281.

[11] Maas, L., Geurtsen, M., Nouwt, F., Schouten, S. F., Van De Water, R., Van Dulmen, S., . . . Brinkkemper, S. (2020). The care2report system: Automated medical reporting as an integrated solution to reduce administrative burden in healthcare. In Information technology in healthcare: It architectures and implementations in healthcare environments. Hawaii International Conference on System Sciences (HICSS).

[12] Miller, K., Mosby, D., Capan, M., Kowalski, R., Ratwani, R., Noaiseh, Y., . . . Arnold, R. (2018). Interface, information, interaction: A narrative review of design and functional requirements for clinical decision support. Journal of the American Medical Informatics Association, 25 (5), 585–592.

[13] Nielsen, J. (1994). Usability engineering. Morgan Kaufmann.

[14] Quiroz, J. C., Laranjo, L., Kocaballi, A. B., Berkovsky, S., Rezazadegan, D., & Coiera, E. (2019). Challenges of developing a digital scribe to reduce clinical documentation burden. NPJ digital medicine, 2 (1), 114.

[15] Scott, D., & Purves, I. N. (1996). Triadic relationship between doctor, computer and patient. Interacting with Computers, 8 (4), 347–363.

[16] Shaw, R. J., Horvath, M. M., Leonard, D., Ferranti, J. M., & Johnson, C. M. (2015). Developing a user-friendly interface for a self-service healthcare research portal: Cost-effective usability testing. Health Systems, 4 (2), 151– 158. 8

[17] Sim, I., Gorman, P., Greenes, R. A., Haynes, R. B., Kaplan, B., Lehmann, H., & Tang, P. C. (2001). Clinical decision support systems for the practice of evidence-based medicine. Journal of the American Medical Informatics Association, 8 (6), 527–534.

[18] Wieringa, R. J. (2014). Design science methodology for information systems and software engineering. Springer.