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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 design science study into the interface of an Automated Medical Reporting (AMR) system in order to establish user-centered design principles. AMR has been proposed as a solution to conquer the administrative burden in healthcare to improve patient-doctor contact. In order to expand this vision by including interface design principles without overlooking the usability aspects, a case study was performed within the preoperative screening department of an academic hospital. In this research, the current screening procedures were investigated by a task analysis, a heuristic evaluation of the current Electronic Health Record system, and stakeholder interviews. The preoperative screenings analysis 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 AMR system for preoperative screenings was developed. This treatment was evaluated by conducting think-aloud sessions and a focus group. Based on the evaluations, ten elementary design principles were formulated for the AMR system interface, which have been categorized into four themes: (1) system status visibility, (2) care provider control, (3) consultation traceability, and (4) patient privacy. We also experienced that medical specialists find it hard to envision the future of their workflow using an AMR system, and that many individual preferences exist.

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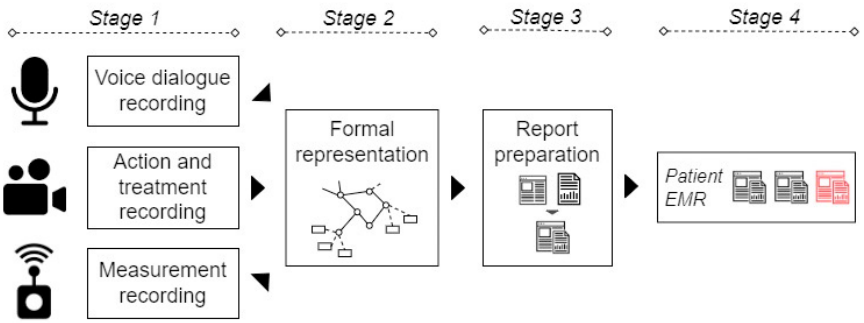

Fig. 1. The four stages of Automated Medical Reporting according to the vision of the Care2Report research program

1. Introduction – Automated Medical Reporting

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 [12]. 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 [10]. 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 [16].

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 in conjunction with the anesthesiology department of the University Medical Center Utrecht. 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 [17]. 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. Related literature

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 [15]. 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 [17]. For introducing a new information system, the behavioral intention to use a system needs to be high, which needs to be kept in mind. According to Venkatesh and Davis's Technology Acceptance Model (TAM), this intention is determined by two beliefs: perceived usefulness and perceived ease of use [8]. In a study done by Holden and Karsh, the application of TAM to health IT was reviewed. Although they proposed some adjustments to the model, the relationship between perceived usefulness and intention to use the system was shown to be significant in all 16 tests [19]. Inspired by these results, during this research perceived usefulness was focused on more. This was done by including the end-users, the care professionals in this case, which is also shown to be an important aspect of User Interface design [11, 18]. Furthermore, for ensuring accessibility and usability, following UI design heuristics is essential according to Shaw et al. [17]. For this study, Nielsen's ten usability heuristics [14] 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 [13, 18]. 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" [13]. 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 – Design Science

3.1 Problem investigation

For establishing design principles for a User Interface of an Automated Medical Reporting system, the Design Science Cycle of Wieringa was used to specify the research steps [20]. 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 sensitive 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
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	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
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
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

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 [12] and interface designs in healthcare [13], 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. These design choices were validated in the next stage of this research.

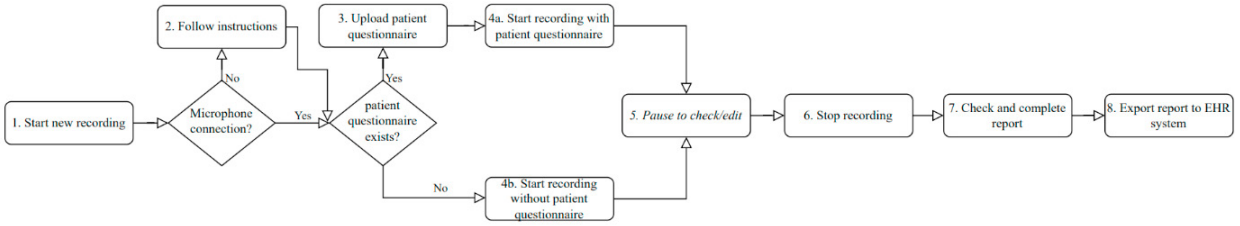

Fig. 2. Interaction flow of the prototype

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.

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" [9]. 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, see Box 1.

4.1 System status visibility

The timer and volume icon which indicates the working state of the system, was experienced moderately positive. MP2 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 MP4. ITP2 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 MP3 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*".

a. b.

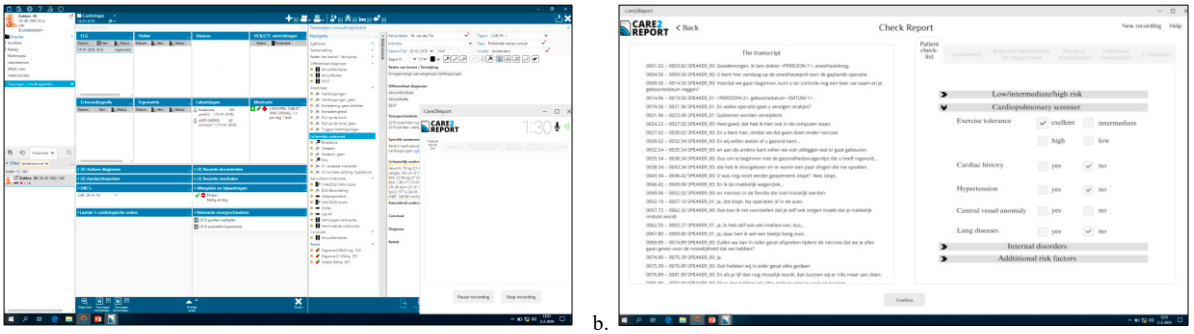

Fig. 3. (a) Screenshot: consultation is recording; (b) Screenshot: check the generated report.

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 MP4 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 the users, in this case the care providers, 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. ITP1 stated not to trust the system to save their own answers. Additionally, MP4 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 care providers 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, ITP1 proposed an interesting feature that allows the care provider to link the answers of the screening to the transcript. ITP1 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. MP4 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, MP4 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. MP4 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 care provider 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.

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

Care provider control – give care providers freedom in usage
- 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 – link the conversation to the generated report
- 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 – treat sensitive patient information with care
- The Automated Medical Reporting system needs to work according to privacy regulations

Box 1. Interface design principles for Automated Medical Reporting

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.

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