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User-Centered Design of a Speech-Based Application to Support Caregivers

Daniel REICHENPFADER[a,1] and Matthias GIRA[b]
[a] *Institute of Business Informatics and Data Science, FH JOANNEUM, Graz, Austria*
[b] *Solgenium OG, Linz, Austria*
ORCiD ID: Daniel Reichenpfader https://orcid.org/0000-0002-8052-3359

Abstract. The shortage of skilled nursing personnel is - among other reasons - due to the low attractiveness of the profession, comprising high workloads and atypical working hours. Studies show that speech-based documentation systems increase documentation efficiency and satisfaction of physicians. This paper describes the development process of a speech-based application to support nurses, according to the user-centered design approach. User requirements were collected based on interviews (n=6) as well as observations (n=6) in three institutions and were evaluated by means of qualitative content analysis. A prototype of the derived system architecture was implemented. Based on a usability test (n=3), further potentials for improvement were determined. The resulting application enables nurses to dictate personal notes, share them with colleagues and transmit notes to the existing documentation system. We conclude that the user-centered approach ensures the extensive consideration of the nursing staff's requirements and shall be continued for further development.

Keywords. eHealth, mobile applications, nursing documentation, User-Centered Design, speech recognition

1. Introduction

A study on the attractiveness of the nursing profession in Austria shows that 65 % of respondents consider it unlikely that they will continue in their profession until retirement. 15 % say they already have concrete intentions or plans to change jobs. The main reasons given for this low attractiveness is the high workload, time pressure and emotional stress [1]. For patients or residents of nursing homes, this shortage of caregivers in combination with the resulting overload is fatal:

According to the Ombudsman Board Austria, human rights were violated in nursing homes: Due to understaffing, beds were blocked as well as activities with residents and access to the outdoors restricted. These examples demonstrate that improvements in staffing resources are needed to ensure the quality of life of residents [2].

In addition to the shortage of personnel, the increasing amount of nursing documentation is also considered a burden: Regarding inpatient nursing, up to 35 % of total working time is spent on documentation tasks [3]. Increasing digitization in the healthcare sector is not providing any relief: electronic medical records lead to increased documentation quality, but also to greater documentation effort [4].

[1] Corresponding Author: Daniel Reichenpfader, E-mail: hello@danielreichenpfader.com.

One starting point for improving documentation by means of information and communications technology (ICT) could be the application of speech-based systems in nursing. Speech-based documentation (speaking into a microphone rather than typing out the text) is three or up to ten times faster than typing or writing by hand, respectively [5]. Vogel et al. show that speech-based documentation increases user satisfaction by 23 %, documentation speed by 26 % and the extent of documentation content by 82 % [6]. However, the last aspect can lead to increased effort for searching for information. Therefore, within the scope of this work, a speech-based system for supporting nursing documentation is developed. We focused on integrating caregivers into the entire development process according to the user-centered design (UCD) paradigm. This inclusion facilitates the ascertainment of the staff's requirements as comprehensively and correctly as possible.

2. Methods

As a first step, we conducted six guideline-based interviews and six structured observations with nurses in three Austrian healthcare institutions in order to identify user requirements. The interview transcripts and observation protocols served as input to a qualitative content analysis according to Mayring, which we performed using the software tool MAXQDA Plus 2022 [7]. For this analysis, we defined the following three research questions, providing guiding principles for the subsequent deduction of analysis categories:

- How is nursing documentation - regarding processes, procedures and contents - organized in the institution?
- What are the most severe problems experienced subjectively by the caregivers regarding nursing documentation?
- What is the attitude of nurses towards the use of speech-based mobile applications?

Utterances and observations were then classified into one of these categories. Paraphrases of these categorized elements in turn enabled the derivation of system requirements for the platform and the design of a system architecture. Next, we iteratively developed a prototype application of the system. iOS was chosen as target platform due to existing programming experience of the authors, as well as simple integration of built-in speech-recognition capabilities (Speech framework). After each iteration, a feedback interview was carried out with a nurse, in order to get direct feedback and to identify potentials for improvement. In order to transfer data from the mobile device to the legacy nursing documentation system, we developed a Java application to be installed on the hospital workstation. For the backend, we used a Software-as-a-Service platform (Google Firebase) to implement basic user management and a database to store documentation entries. Last, a concluding usability test was conducted with three different nurses, having three, ten and 30 years of professional experience respectively. Each person had to fulfil three tasks, comprising creation, sharing and transmission of documentation entries.

3. Results

The six conducted interviews lasted between 15 and 30 minutes and an average of 24 minutes. Interview transcripts and observation protocols formed the corpus for the subsequent qualitative content analysis. We identified and assigned 333 text passages to one of 15 deductively defined categories. The paraphrased passages served as the basis for defining 30 system requirements of the application to be developed.

There exist three common aspects in all three institutions, which became apparent during the qualitative content analysis. First, each institution maintains an ongoing report on the condition of a patient or resident. This is referred to as a nursing report. In some institutions, other professional groups also contribute entries in this report, which therefore serves as a main communication hub between professions, colleagues and shifts.

The second common aspect is the creation of personal notes by nursing staff: In order to avoid waiting times when starting up workstations and logging in and out, nurses usually jot down pending and completed tasks, important information about patients, and reminders. However, this information typically stays within the nurse's pocket on a piece of paper and is not shared.

The third common aspect is the documentation timing: In all three institutions, documentation is entered into a hospital information system or paper-based patient record for several patients or residents at once and only after the routine activities have been performed. Nurses state that these delayed and batchwise documentation practices are error prone.

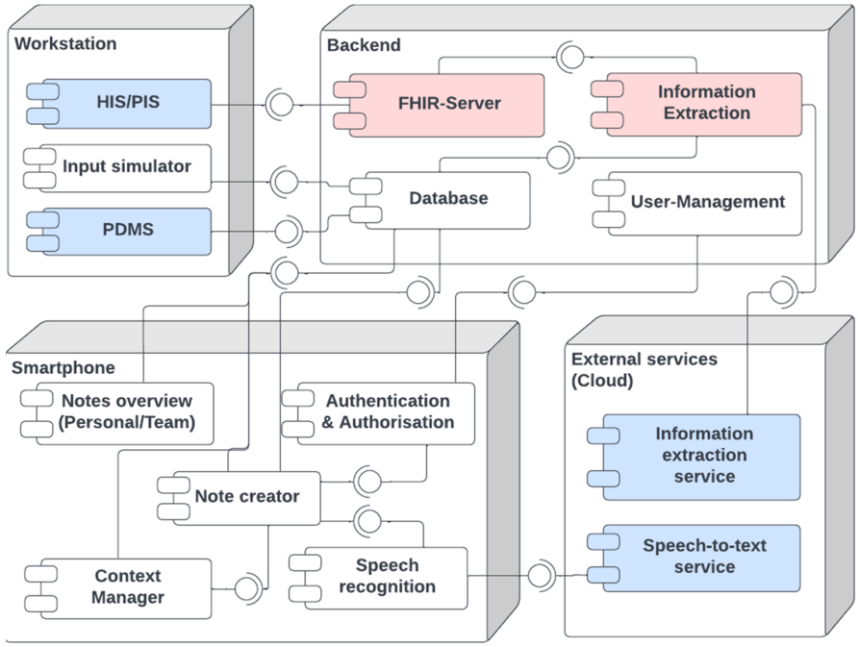

Figure 1. UML component diagram of the system architecture (blue = components provided by external systems, red = components not implemented as prototype).

Based on these three common aspects, the system architecture shown in Figure 1 was designed. The developed prototype provides the following functionalities: Nursing report entries as well as personal notes are created using speech-recognition with a single tap, shared with the team and marked as completed. A context manager component enables the quick and secure identification of the patient to be documented, e.g. by scanning a barcode or NFC tag. For speech recognition, the Speech framework provided by iOS was used. The developed Java application (Input simulator) enables immediate pasting of notes into the currently focused text field at the workstation upon a single tap on the mobile device. Implementation is based on the java.awt.datatransfer package.

During prototype development, two iterations were completed. The first feedback interview enabled us to identify 15 usability problems, of which nine were fixed. Respectively, we fixed three out of twelve usability problems after the second development iteration. Based on the concluding usability test, five additional potentials for improvement were identified.

4. Discussion and Conclusions

The proposed system architecture facilitates the creation of nursing report entries, replaces paper-based handwritten personal notes of nurses and allows for immediate documentation, one patient at a time. We chose these three aspects to be the core functionalities of the designed system as we assume that they might be generalizable to other Austrian healthcare institutions, therefore augmenting the target group of potential users.

As part of the prototype, the developed Java application enables the transmission and insertion of notes to the existing electronic documentation system on Windows-based systems via simulating input from the system clipboard. This low-level approach ensures vendor-independent interoperability. In future, structured information might as well be transmitted via standardized interfaces and exchange formats, handled by the *FHIR-Server* component. The proposed system is not intended to replace existing speech-recognition tools, but rather to provide an intuitive interface to use these services, regardless of the manufacturer. While for the prototype, on-device speech-recognition was used, integration of external speech-recognition services is already considered in the system architecture.

Latif et al. show that the application of speech-based documentation has high potential to improve different healthcare settings [8]. The authors point out that one challenge is to ensure interoperability between systems, which we considered in our system architecture. Within the nursing domain, speech-based documentation has recently gained momentum with similar software systems being currently developed [9, 10]. In contrast to existing systems however, our proposed solution provides vendor-independent interoperability on two levels: Documentation entries can either be pasted into an arbitrary text field (low-level) or transmitted as standardized and structured FHIR resources. While the low-level approach does not require any changes to existing documentation systems, the support of FHIR ensures future interoperability as the adoption of this standard is continuously advancing among information system vendors. Furthermore, we intentionally followed the UCD approach to acquire a deep understanding of nurses' challenges regarding documentation in day-to-day operations. This methodology enabled us to design a system fitted to the needs of the profession, generalized to three – and possibly more – Austrian healthcare institutions.

Although this study yielded valuable insights, there are limitations that must be acknowledged: Due to the relatively small sample size of six interviewees and six observation participants, transferability to other institutions can only be hypothesized. Moreover, due to time and resource constraints, we decided to omit implementation of the system components regarding automatic information extraction; these components however are essential to enable the fully automated extraction of speech-based documentation entries, omitting the need to transfer entries to the documentation system at the workstation. Furthermore, we developed the application prototype for the iOS platform only, which some test persons might not have been familiar with. Nevertheless, we put focus on the development of a simple and easily understandable mobile user interface for this platform. Usability testing was facilitated by implementing the remaining system components based on a Minimum Viable Product (MVP) approach.

Additional functionalities such as support for care documentation in the native language of a caregiver and automatic translation could be similarly investigated for their acceptance based on the described UCD approach. Conducting quantitative research methods based on the fully implemented system, e.g. by introducing and testing the system at a hospital ward, could provide statistical evidence of the system's impact on nurse productivity and satisfaction as well as efficiency and safety of nursing documentation. In the future, our system can contribute to the improvement of working conditions in nursing as well as to increasing the attractiveness of nursing professions and thus counteract the acute shortage of nursing staff.

References

[1] Federal Ministry of Social Affairs, Health, Long-Term Care and Consumer Protection Austria (BMSGPK). Arbeitsbedingungen in Pflegeberufen. Sonderauswertung des Österreichischen Arbeitsklima Index [Working Conditions in Nursing Professions. Special Evaluation of the Austrian Work Climate Index]. 2021.

[2] Austrian Ombudsman Board. Bericht der Volksanwaltschaft an den Nationalrat und an den Bundesrat 2021 [Report of the Ombudsman Board to the National Council and the Federal Council 2021]. 2022. German.

[3] Collins S, Couture B, Kang MJ, Dykes P, Schnock K, Knaplund C, Chang F, Cato K. Quantifying and Visualizing Nursing Flowsheet Documentation Burden in Acute and Critical Care. AMIA Annu Symp Proc. 2018 Dec;2018:348-357. PMID: 30815074; PMCID: PMC6371331.

[4] Baumann LA, Baker J, Elshaug AG. The impact of electronic health record systems on clinical documentation times: A systematic review. Health Policy. 2018 Aug;122(8):827–36. doi: 10.1016/j.healthpol.2018.05.014

[5] Kumah-Crystal Y, Pirtle C, Whyte H, Goode E, Anders S, Lehmann C. Electronic Health Record Interactions through Voice: A Review. Appl Clin Inform. 2018 Jul;09(03):541–52. doi: 10.1055/s-0038-1666844

[6] Vogel M, Kaisers W, Wassmuth R, Mayatepek E. Analysis of Documentation Speed Using Web-Base Medical Speech Recognition Technology: Randomized Controlled Trial. J Med Internet Res. 2015 Nov 3;17(11):e247. doi: 10.2196/jmir.5072

[7] Mayring P. Qualitative Inhaltsanalyse: Grundlagen und Techniken [Qualitative content analysis: Foundations and methods]. Weinheim Basel: Beltz; 2015. German.

[8] Latif S, Qadir J, Qayyum A, Usama M, Younis S. Speech Technology for Healthcare: Opportunities, Challenges, and State of the Art. IEEE Rev Biomed Eng. 2021;14:342–56. doi: 10.1109/RBME.2020.3006860

[9] Schmidberger M. Voize [Internet]. Potsdam: Voize GmbH; c2022 [cited 2023 Mar 2]. Available from: https://www.voize.de

[10] Nuance Communications, Inc. AI Powered Clinical Documentation Solutions for Nurses [Internet]. [cited 2023 Mar 2]. Available from: https://www.nuance.com/en-gb/healthcare/care-settings-specialties/nursing.html