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Requirements for Workflow-Based EHR Systems – Results of a Qualitative Study

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Abstract. Background: Today's high quality healthcare delivery strongly relies on efficient electronic health records (EHR). These EHR systems or in general healthcare IT-systems are usually developed in a static manner according to a given workflow. Hence, they are not flexible enough to enable access to EHR data and to execute individual actions within a consultation. Objectives: This paper reports on requirements pointed by experts in the domain of diabetes mellitus to design a system for supporting dynamic workflows to serve personalization within a medical activity. Methods: Requirements were collected by means of expert interviews. These interviews completed a conducted triangulation approach, aimed to gather requirements for workflow-based EHR interactions. The data from the interviews was analyzed through a qualitative approach resulting in a set of requirements enhancing EHR functionality from the user's perspective. Results: Requirements were classified according to four different categorizations: (1) process-related requirements, (2) information needs, (3) required functions, (4) non-functional requirements. Conclusion: Workflow related requirements were identified which should be considered when developing and deploying EHR systems.

Keywords. expert opinions, electronic health records, diabetes mellitus, semantics.

1. Introduction

The electronic health record (EHR) is seen as a major factor for reaching high structure-, process- and outcome quality in healthcare. One of its major advantages is given through the possibility of sharing a lifelong interoperable patient documentation across different institutions. Today, a major challenge of EHRs is related to data access: In order to avoid information overload, it is necessary to facilitate the retrieval of precise and particular required data. During a patient examination, the main goal of data retrieval for a physician is to get all the required information, displayed in an appropriate manner for creating a further treatment decision. Therefore, interfacing the EHR in a usable and functional manner is necessary. Available works in the literature have elaborated on how to offer the needed information [1,2]. However, none of them considered the further processing of the retrieved data as part of the physicians' duties.

In the context of a particular clinical situation, information logistics should go along with the intended workflow a physician, nurse or any other healthcare professional is following. Thus, any IT-system should adapt to the workflow and proactively support the physician without hindering medical work.

Available EHR systems or in general healthcare IT-systems offer user interfaces tailored to a static sequence of activities and thus are not flexible enough to fit individual,

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dynamic workflows. From a physician's perspective, functions for accessing the EHR are limited to basic query retrieve actions without any particular medical workflow relation. The project OntoHealth[2] tries to foster EHR utilization by executing functional flexible, individual workflows over a semantic service-based platform. As a first step within the design of such a system, we investigated on explicit requirements for IT-systems to fit healthcare professionals' workflows. To gather necessary functional and non-functional requirements we followed a triangulation approach that comprised a systematic literature review, observations in the clinical settings and expert interviews. The literature review resulted in a first classification of workflow building blocks [3] and the subsequent observations revealed process-related information about what tasks are executed considering EHRs for different situations [4]. This paper completes the above-mentioned requirement gathering tasks with expert interviews and reports on requirements pointed by physicians working with diabetes patients to design a system for supporting dynamic workflows for EHR activities.

Interviews with experts were planned in order to validate and enrich the already collected functional requirements for the design of a functional flexible, workflow-based and user-centered EHR utilization. We aimed also to gain insights regarding non-functional requirements (NFP) for the selection of services according to the user's needs. Based on these goals, we formulated the following research questions: (a) Do the results from the interviews correspond to the information we have identified in the literature review (information needs) and the observations (required functions, process-related requirements)?, (b) What additional information needs, required functions and process-related requirements are needed for valuable EHR utilization?, (c) What non-functional requirements do physicians consider mandatory when accessing proper services?

These research questions lead us to derive the following five topics, which we used as the core of our interview guideline:

- Examination process: What tasks are executed during routine consultation?
- Information needs: What Information is needed for different diabetes situations?
- Currently used clinical documentation system: What are the strengths and weaknesses of the person's currently utilized IT-system?
- Future changes: How to support clinical physicians' patient contacts with future challenges? What functions will be needed?
- Non-functional requirements: What non-functional requirements are necessary according to physicians for the service selection?

2. Methods

Physicians with different medical expertise relating to diabetes care were invited to participate in our study. The complete interview process comprised four steps: (1) interview preparation, (2) participant recruitment, (3) interview conduction and (4) qualitative analysis.

The mind-map depicted in Figure 1 contains all the topics and sub-topics derived from the research questions. This mind-map was used to guide the process of the qualitative part of the interview and its implementation was done by means of open questions.

[2] www.ontohealth.org

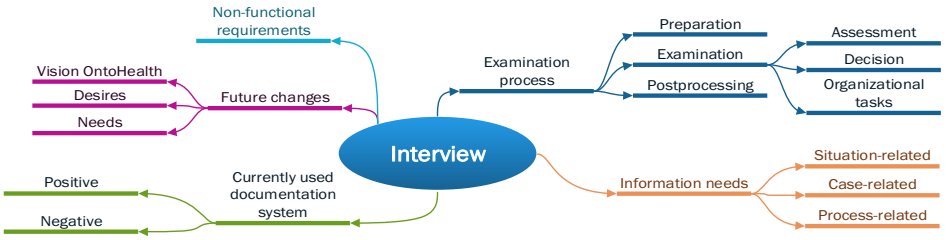

Figure 1. Mind-map showing the different topics for the interviews.

For each of the five topics within the guideline we formulated between two and eight questions. For example, for the topic "current used clinical documentation system" the following questions were asked: (1) What are important functions in the system? (2) What are the strengths of the system? (3) What weaknesses would you consider? (4) Are there any missing functions you would like to have? (5) Can you name any time-consuming tasks when using this software?

In addition, two quantitative questions with a five-point Likert scale were asked about how familiar the interviewed person was with IT in everyday usage and how familiar the person was with IT used in everyday work. Furthermore, information about the corresponding institution, gender, role and work experience after education end were surveyed.

Our interview study was divided in two stages. The first stage dealt with the evaluation of the design of the interview itself. For this pre-interview stage, we invited one physician with expertise in diabetes care. The goal of this initial task was to assure the correct design of the interview in terms of time, tasks and coverage of topics to answer the research questions of the study.

Theoretical sampling was used to select physicians, who got recruited through telephone or email. Telephone calls conveyed a very short introduction about the project and if the person indicated any interest, we switched to further email contact. Emails included an information document with a general description of the OntoHealth project and our intention regarding the need to gather physicians' requirements. Also, this document included the main topics of the interview in order to make the physicians familiar with the content of the conversation. The number of participants was determined by using the method of theoretical sampling according to the grounded theory approach [5]. All the interviews were held personally at the physicians' place, either in the hospital or office. The interviews were audio-recorded to facilitate further analysis.

After the talks, interview-recordings were manually transcribed to text documents. The content was transcribed literally without focusing on verbal expressions such as breaks or mood. Using the qualitative approach from Mayring et al. [6] we used MaxQDA[3], a software tool for qualitative analysis which facilitates to create and assign categories to the text content. Main attention was given to statements concerning information items, required functions, process-related requirements and non-function requirements according to EHR workflows. The initial selection and categorization was done deductively and in a very granular way. Once half of the content was annotated, all the topics were revised to inductively group the granular structure to a more generalized categorization before analyzing the remaining content.

[3] www.maxqda.de

3. Results

The evaluation of the initial test interview led to some modifications. For example, we had initially planned to use the resulting models from our literature review and observations as a starting point for the interviews. However, we found out during the test stage that the explanation of the general models was highly time consuming and that this approach could led to an influenced opinion on the interviewed person. Thus, it was decided to ask the questions independently of previous results and compare and combine the results afterwards. Furthermore, the test interview enabled us to verify the understandability of our questions as well as the correctness of the used vocabularies.

Once the interview design was validated, we sent the recruitment call to 15 physicians from Tyrol, Austria, of whom five male and two female physicians agreed to participate in the interviews. Participants were diabetes specialists, working in ambulatory metabolism wards in public hospitals (n=4) and physicians from private offices (n=3). The latter group comprised two diabetes specialists and one general physicians. All the selected physicians are engaged in the domain of diabetes mellitus. Mean work experience after education end of all participants was 19,7 years (ranging from 10 to 32 years). Four participants indicated that they are familiar[4] with IT in everyday usage and in everyday work.

All the interviews were conducted in mid-2015 by one researcher. The mean duration of an interview was 44 minutes. All the talks were held in German. Although transcripts were written in German, the code-system was directly created in English. Analyzed results lead to a total of 442 assigned codes categorized through four main categories: (1) process-related requirements (N[5]=146), (2) information needs during diabetes examination (N=157), (3) required functions (N=113) and (4) non-functional requirements (N=26). As shown in Figure 2, the discussed topics in the interview led to extract different results.

After a short introduction about the OntoHealth project and the interview process, we asked the physicians about typical workflows for diabetes consultations and the comprising tasks they were executing.

Three different situations for diabetes treatment were identified: (1) first consultation (NP[6]=6), (2) routine follow up consultation (NP=7) and (3) emergency (NP=3). The tasks followed in a diabetes routine consultation as well as in a follow up

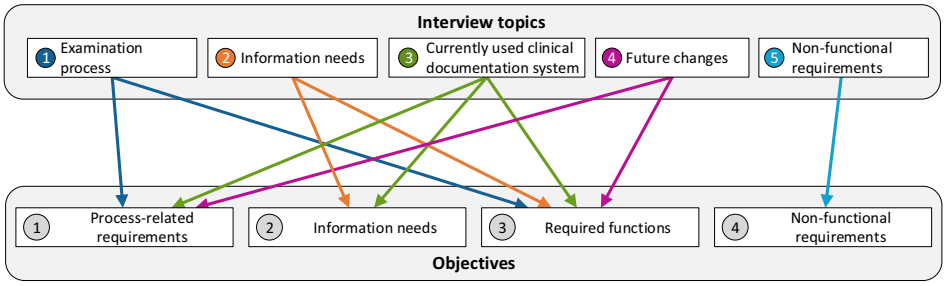

Figure 2. Arrows show relation between discussed topics and results topics. E.g. the interview topic "examination process" led to results for "process-related requirements" and "required functions".

[4] Equals a rating of 2 on the 5-point Likert scale

[5] Number of assigned Codes within that category – multiple assignments possible

[6] Number of interviewed persons giving that answer

consultation correspond from a process-related perspective. The main difference between these two workflows relates to the different information needs. One Physician claimed (Dr. B): *"If it's the first time for a patient at my office, I'm doing a more detailed informative conversation, create a comprehensive laboratory checkup and read and scan documents the patients brought."*

According to the analysis of the different interviews, a physician-patient consultation can be grouped in the following parts: (1) Patient evaluation: inquiry (assessment talk, measuring vital signs, laboratory checkup, physical examination) and documentation (patient history, documents, self-documentation); (2) Therapy decision: discussion/decision for therapy, prescription; (3) Organizational management: referral, appointment planning.

Nowadays, the information that can be requested is highly dependent on each specific IT-system and physicians often need to adhere to those rigid structures. Physicians claimed to miss a seamless patient documentation. Due to the lack of clinical information from other institutions, some tests are done several times (NP=3). On the other side, sometimes too much information is present in the patient chart: Two physicians stated that they are missing filtering functions for laboratory results, as they get displayed too much information not needed for diabetes treatment.

Integration of other reports often leads to interpretation limitations, as one physician (Dr. F) said: *"It's sometimes a problem to interpret the results of other institution's reports without further efforts. For example, if a patient brings a report, important values, like HbA1c, could have a percentage unit while my system uses mmol/mol. I first would need to convert the values in order to compare them with my results. Further it's often hard to find the interesting facts, like pathologic results, as all reports use a different style."*

One part of a consultation is the patient elucidation, i.e. to give information for the patient about his/her test results and explain the further therapy. For a diabetes routine checkup this information comprises: change of therapy with receipt and/or diabetes pump adjustments, present laboratory results, and organizational information, e.g. the next routine checkup or a planned referral to a specialist. All interviewed physicians told that the patient gets this information through printouts of the test results (e.g. laboratory) and/or a general report of the consultation.

In total the interviews led to the identification of 64 information items (including parent categorizations), of which 12 new items were added to the existing categorization of data elements. All the results were properly included in the existing categorization of information needs from previous literature analysis and observations. The main categories of identified information items were administrative data (demographic data, recent medical activities) and medical data (vital parameter, self-documentation, clinical documents, clinical problems and general patient information). A full list of all results can be obtained from the authors.

Documentation handling differs between hospitals and offices as well as among offices. While all the selected physicians document electronically, some physicians document at the time of the patient contact (NP=4), others take paper-based notes during the consultation and transfer to IT later (NP=3), which is usual in private offices. Asking more about this documentation behavior revealed complicated and non-intuitive use of the software, missing knowledge of necessary functions or non-adherence to the workflow. One (Dr. E) said: "*Even though I could document immediately in the system, it's too complicated and I like to do the assessment in the conventional way, using a preprinted sheet of paper. My secretary is then adding this information in the electronic*

record system. […] During the patient contact I take my general notes on a sheet of paper as well. At the end of the day I add all those notes in the IT-system for each patient".

The required data needs to be processed through functions. The interviews revealed 15 main functions and 14 sub functions, physicians need to use when accessing diabetes related information. All functions were successfully aligned with the previous gathering results about functions. The most stated functions in the interviews comprised: (1) Filter functions: Extract information of interest in an individual, case-specific manner (N=11, NP=5); (2) Use of templates: predefined set of all necessary items/functions for a situation/patient (N=10, NP=5); (3) Flexible workflow management (N=9, NP=6); (4) Data integration: avoid multiple documentation (N=7, NP=3); (5) Shared workflow exchange: physicians/organizations know planned and executed tasks according to a complete disease workflow. (N=5, NP=4); (6) Asynchronous documentation: document time-independently (N=2, NP=2); (7) User groups for workflow rights: e.g. hospitals don't want to give the right for allowing the physicians to fully design their own workflows. (N=2, NP=2); (8) Offline access to information (N=1, NP=1).

We asked the physicians to imagine our planned OntoHealth system, where components could be flexible selected according to the users' needs with restriction to quality parameters. We asked them, if they would embrace the feature of selecting a proper component, needed for the fulfilling of a defined goal, by specifying its functional and quality needs. Whenever needed, the interviewer gave an example of such quality parameters like "costs" or "performance": So if the physician wants to retrieve prescribed medication from the EHR, there could be several services available for fulfilling that goal. The main difference between those services would relate to quality parameters, e.g. one service is really fast in executing, but is tied to higher costs, the other one is slower but cheaper.

Answers of physicians were mixed. Some physicians (NP=3, all related hospital doctors) claimed that they would not admit to choose quality parameters for their needed components, e.g. Dr. B: *"I just want to use the system. I don't have time to define any quality parameters for the proper use of the system. Of course in common it makes sense to allow the flexibility in the system, but selection of quality parameters should be part of a higher entity, e.g. the management"*. For physicians working in a hospital, selecting functions and/or related quality parameters should not be part of their responsibility. However, all of the physicians owning their own practices/offices stated, that creating own workflows would be valuable and the proper selection of suitable services through non-functional parameters would lead to an efficient way of getting the needed functionality for accessing the right data.

Mentioned non-functional parameters from the interviewed physicians were: Usability (NP=5), Efficiency (NP=4), Security/privacy (NP=4), Performance (NP=3) and Availability (NP=3). Note that some of the requirements such as usability relates to a criterion related to the interface design rather than the service requirements.

4. Discussion

The interviews about the process workflow were limited to direct physician patient contacts (e.g. nursing consultation or administrative workflows were not discussed). The reason for this is that EHRs are used most frequently in this situation [7] and the results could be aligned with our previous results from the observations and literature analysis. The current number of participants reduced generalizability, however, the interviews

delivered enough details on the needed requirements to generalize and validate the complete results from the triangulation approach. The fact that only one researcher performed the qualitative content analysis could entail a limitation of the study.

The results from this study provide evidence for the demand and need of experts (in this case in diabetes) for more flexible case-specific IT-Systems. Future systems should provide individual and case-specific selection of required information as well as functions for processing this information, e.g. at the beginning of a diabetes routine consultation a physician usually needs a compact but complete patient overview comprising, among others, a list of currently prescribed medication with information about the related drug, regime, prescribing physician and reason for the prescription. Several steps for processing the data could lead to the desired goal: e.g. retrieve patient's documents, find medications, present result. Containers and templates are needed, because same sub-processes could be re-used, e.g. "medication overview" as part of the general patient assessment and when the physician is editing medication later in the workflow.

The interviews also revealed the differences in workflows between physicians: Whenever needed, the physician should have the choice for defining the precise information content (precise lab parameters, etc.) within the task definition of a certain workflow. A structure of granular building blocks representing the processing of information items is needed to compose user-centered workflows. The main physician's need during a consultation is to get the exact required information without unwanted details and the proper presentation of this information on the screen [8].

According to the interviews, physicians found that it is a good idea to move from a static data-driven approach to workflow-based EHR processing. However, some physicians, in particular those working in hospitals, were not satisfied to define the workflows themselves, as they find, IT-systems should act the same way for all physicians within the same hospital or at least within the same ward. On the other hand, physicians from private offices would embrace the feature of choosing functions themselves, as they do not need to adhere to common structures.

Our interviews did not reveal significant additional information needs to our prior results [3,4] but revealed more information about needed functions and workflow-related requirements which had not been identified through literature analysis and observations. Process-related information about how to access clinical data (information needs) for different situations could be obtained, for which two perspectives can be differentiated: (1) Disease-specific information needs, i.e. information is defined according to the disease known factors of having an influence on diagnosis and therapy. In our case, the information depends on diabetes related factors. And (2) Case-specific information needs, i.e. all patients are different. There are secondary disorders, allergies and other factors that have influence on the diagnosis and therapy. According to these two cases, a workflow-based EHR system should cover disease- and case-specific structures. Stated functions in the interviews relate to results from literature [1,9], enhancing the granularity structure of needed functions.

Non-functional requirements for EHRs can be found in the literature [9], as well as information about the generic selection of generic Web Services [10]. Our work augmented the state of the art with combined NFPs for the selection of services for the particular case of improving user-related EHR workflows. Results show, that hospital physicians do not want to deal much with individual, flexible service selection through defining proper NFPs, as higher authorities should take those decisions (e.g. management). Physicians of private offices show higher interest, as they prefer high

flexibility to foster their EHR usage. The reason for this could be different responsibility: While physicians in hospitals merely act as the consumer of health IT, physicians practicing in their own offices are responsible for the complete healthcare system they utilize. According to the analysis of the persons' experience with used IT, we could not find any relation between gender, role, years in business and IT-experience. IT-experience in work tend to be slightly worse than compared to everyday IT-experience (all results had same rating or worse in contrast to the related everyday experience).

Current IT-systems in healthcare do not exploit the potential of structure data. This leads to some drawbacks such as information overload when interfacing the EHR. There is an urgent need of managing healthcare data with syntactical, semantical and process interoperability. Static software is too inflexible to manage different users' needs and the different and often changing medical situations. This leads to unstructured data, information gaps and unsupported workflows. Service oriented architectures such as the one designed in the OntoHealth project [3] can offer a good solution to enable access to EHR data fulfilling individual user goals.

Acknowledgments

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