

Observing health professionals' workflow patterns for diabetes care – First steps towards an ontology for EHR services

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Abstract. Increasing the flexibility from a user-perspective and enabling a workflow based interaction, facilitates an easy user-friendly utilization of EHRs for healthcare professionals' daily work. To offer such versatile EHR-functionality, our approach is based on the execution of clinical workflows by means of a composition of semantic web-services. The backbone of such architecture is an ontology which enables to represent clinical workflows and facilitates the selection of suitable services. In this paper we present the methods and results after running observations of diabetes routine consultations which were conducted in order to identify those workflows and the relation among the included tasks. Mentioned workflows were first modeled by BPMN and then generalized. As a following step in our study, interviews will be conducted with clinical personnel to validate modeled workflows.

Keywords. Electronic Health Records, Workflow, Diabetes Mellitus, Semantics

Introduction

Nowadays electronic health records (EHRs) play a crucial role in healthcare especially for interdisciplinary domains like chronic disease management. Cross-institutional exchange of clinical information in an interoperable manner is vital for the efficient management of such diseases. Different standards and best practices like e.g. IHE [1] or HL7 CDA [2] enable interoperable exchange of clinical information from a data perspective. However, additional efforts are required to enable - apart from an interoperable exchange of data - a more flexible interaction with EHR systems. Nevertheless, user-perceived functionality of current systems is often limited to basic query/retrieve functions on existing documents [3, 4].

The project *OntoHealth*² aims at closing the gap between available data and user-perceived functionality by offering a functionally versatile and flexible EHR-access based on semantic technologies. To achieve this goal, the system allows for the individual execution of clinical workflows (e.g. a routine consultation) by using different semantic web services. For this purpose atomic web services such as data retrieval or statistical services are selected and orchestrated based on functional and

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² *OntoHealth* website: www.ontohealth.org

non-functional requirements of clinical users. In order to provide a formal basis for the workflows, the description of requirements as well as the discovery/selection and automated orchestration, an ontology is to be developed. This ontology allows to model user-centered workflows in a generic way and to specify functional requirements (i.e. information needs) as well as additional non-functional requirements for tasks executed within the context of diabetes care. Although a number of existing works have already modeled workflows in the clinical domain [5, 6], to the best of our knowledge there is no approach so far that offers an ontology to represent generic clinical workflows or a specific model for the diabetes domain, targeted towards the interaction with EHRs (see also [7]).

As a first step towards the ontology, we conducted an initial systematic literature review of scientific literature in order to identify functional and non-functional requirements for workflow-enabled EHR-usage [7]. Based on those review results an initial structural workflow model was created and further extended by information from additional sources such as diabetes guidelines (e.g. [8]) and related past projects (see e.g. [9]). Currently this categorization/model contains 483 data elements, 42 actions and 44 contexts.

The goal of this paper is to introduce the results obtained from conducted direct observations in the clinical setting in order to identify links and sequences among different tasks within workflows. This constitutes the second step towards the ontology development. Based on our categorization/model we focused on answering in particular the following questions regarding the interaction with the IT-system and observed user needs: (1) Which information is accessed?, When?, How?, (2) Which functionality is used to access/generate information in the way needed?.

1. Methods

Direct observations in a clinical setting are an established method for collecting data about actual activities - in this case - performed by clinical personnel [10]. For the purpose of this study patient-related routine diabetes consultations were recorded including all common activities executed by clinical personnel with particular emphasis on IT-interactions.

Prior to the actual observations, the project was approved by the university ethics committee and all participating physicians confirmed a written consent. After the (1) data-gathering task (observations) two additional activities were conducted in our study: (2) data-digitalization and (3) workflow abstraction.

During the data-gathering task the observer stood in the background, annotated the observed workflows and if required asked open questions to the observed staff subsequently to clarify the observations. A predefined sheet for field notes facilitates the analysis task which contained information about the observation, the observed person and all included activities. The description of tasks was based on the schema of the categorization presented in [7]. After one observation day all conducted field notes were revised and completed by the observer. In order to digitalize the observations for further analysis, a small Java application was developed which stores data in a MySQL-database. The application supports to model each observation as an adapted Business Process Model and Notation 2.0 (BPMN)-model [11] using a graphical editor. BPMN is a graphical notation, developed from the Object Management Group (OMG) to facilitate and support business process management for all business stakeholders. Hence,

utilizing the application it is possible to create the particular process flow by adding and connecting *Tasks* and *BPMN-control-elements* (Start/End-Node, Parallel-Gateway³). BPMN was selected because it is a mature standard in business process modelling and offers enough expressivity to model all the identified workflows. Besides, the application permits to classify each recorded task according to the initial classification of actions, data elements and contexts extracted from the literature review as well as to extend this categorization when required. Finally, all observed workflow instances were used to (1) model a generic workflow that is able to cover all the individual observations (for each type of observed situation) and (2) to calculate statistical values. The workflows were abstracted by combining all workflows of a certain type in one BPMN-model adding exclusive gateways to match with all included instances.

2. Results

The observations were held in September 2014 in four different healthcare institutions in Austria, comprising three metabolism departments of hospitals and one private office of a general physician. A total of 70 observations with Physicians ($N_{per}=4$; $N_{obs}=35$)⁴, Nurses ($N_{per}=5$; $N_{obs}=34$) and Secretaries ($N_{obs}/N_{per}=1$) were recorded during their routine work in the diabetes domain.

2.1. Identified Workflows: Statistics

Table 1 shows the different types (and most relevant) of observed workflows ($N=61$) with descriptive values about executed tasks, duration of tasks, and IT-based tasks. These workflows comprise: (1) initial consultation outpatient, (2) routine follow-up examination outpatient, (3) routine follow-up examination inpatient. All other non-relevant types of workflows ($N=9$) were excluded (e.g. secretary report writing). The categorization was extended during the assignment of data element, action and context to each analyzed task ($N=996$) in the application. At the end 45 new data elements, 30 new actions and 11 new contexts were added. Most of the new categories pertain to non-IT-based actions like “review documents”, “ask patient” or “explain/educate” and more general data elements like “current documentation/results/reports”, “currently prescribed medication” or “patient chart”.

Table 1. Descriptive values filtered for type of observation.

Type of workflow	N_{obs}	Mean tasks per workflow	Mean workflow duration ⁵ [s]	Ratio of IT-tasks	Ratio of IT-task duration
Initial Examination Physician	1	26	1085.0	NaN ⁶	NaN
Initial Examination Nurse	2	21.5	285.0	0.512	0.266
Routine Examination Physician	32	15.4	305.2	0.352	0.198
Routine Examination Nurse	24	14.1	285.1	0.513	0.227
Routine Examination Physician (inpatient)	1	13	200	0.308	0.207
Routine Examination Nurse (inpatient)	1	17	865	0.412	0.125

³ as all of the observations are workflow-instances there is no need for exclusive gateways;

⁴ abbreviations: N_{per} = number of observed persons; N_{obs} = number of observed patient contacts;

⁵ got calculated according to the process information; duration in seconds

⁶ no IT-interaction observed

2.2. Identified Workflows: Abstraction

All observations were modeled as workflow-instances using BPMN and the Java application. Using these instances the patient-centered abstract workflow model could be derived which describes the workflow of a diabetes consultation within four parts: (1) Admission, (2) Assessment, (3) Tests and (4) Physician Encounter. After patient admission, the nurse does the initial assessment containing the measurement of different values (e.g. blood pressure, blood glucose) and the preparation for the physician encounter later. Then different tests are ordered/performed if necessary (e.g. laboratory test, foot examination). When all test results are available the physician conducts the patient checkup, where all results (nurse examination results, lab results and other examination results) as well as the therapy plan (e.g. prescription changes) are discussed and continuing care is organized. Focusing on the details of the physician encounter, figure 1 shows the generalized tasks a physician needs to execute.

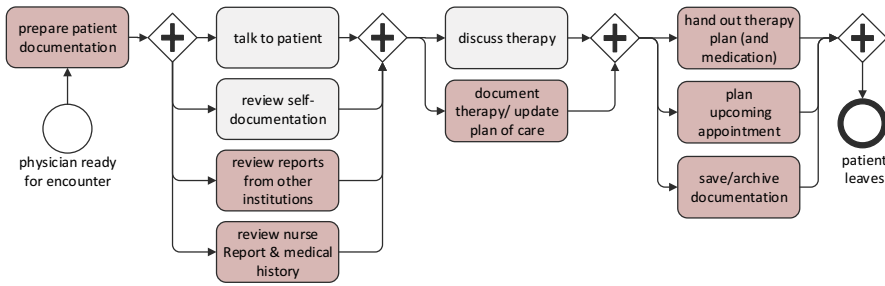


Figure 1. Generic physician workflow for diabetes examination. Red tasks are related to IT-interactions.

3. Discussion and Outlook

The observations allowed for the identification of different sequences of tasks and relations among the workflow elements. In addition, the most common tasks could be identified. A formalized sheet for documentation permitted to register tasks in a timely and comparable manner. However, it cannot be guaranteed that every executed task could be identified and documented. The Java application and the use of BPMN enabled an easy update of the initial classification and enhanced flexibility in data-processing and abstraction. This approach allowed to model parallel tasks in a specified manner (data-element, action, and context) as opposed to other observation approaches like [4] which analyzed activities during consultation using the classification of [12]. Future yet unknown workflows may be easily added in a formal manner by combining related tasks, which are described as a set of data-element, action and context.

From a patient-centered perspective, the different types of observed examinations basically followed the same approach though single tasks differed. While e.g. in one hospital almost no IT-interactions were observed during consultation (paper-based ambulance card), all others were using electronic documentation. Final clinical results were documented electronically in all hospitals as electronic documentation, transcribed notes or scanned reports. A small number of observed initial ($N=3$) and inpatient consultations ($N=2$) leads to a reduced significance but comparing all types of different observations, IT-based tasks did not differ according to the way of execution.

The observations emphasize the crucial role of IT during routine consultation though IT did not fully support emerging workflows. While all observed nurses documented electronically, physicians from one hospital ($N_{Obs}=18$) used printouts and took paper-based notes although there was a possibility to document electronically. While physicians use IT mostly for “retrieving information” ($N=73$), the most assigned IT-action for nurses is “document data” ($N=102$). The most time-consuming IT-related action for physicians is “document changes” ($t_{med}=44s^7$) while for nurses it is “order/request” ($t_{med}=30s$). Similar results are obtained from other studies [4, 13], though they focus on a high-level process description. In general our classification describes the tasks which build a formalization of patterns for workflow activities.

As a next step interviews with clinical personnel will be conducted in order to (1) validate and refine the observation results according to the opinion of health professionals and (2) to gather information about non-functional requirements which should be considered when executing an IT-related task. Those requirements will later be used to formalize the ontology for the service description in order to enable (semi-) automated service orchestration.

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⁷ Abbreviation: t_{med} = median execution duration [s];