Process Models of Medication Information

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Abstract
Medication information is an important component of the care process. Medication information is not always available in a correct content and format when and where needed. In various health information systems and electronic patient records medication information has different content and format. In this paper process models of medication information are presented in order to identify all information items and their relations and the sources and use contexts of medication information. The motivation for this study has been to find a harmonized approach for medication information. The resulting process models will be further used to build an information model of medication information. These process models demonstrate the complexity of the medication information management and how medication is related to the phases of care process. Through the modeling processes we are able to acquire an exact picture of medication processes and their interactions with care process.

1. Introduction

Medication is part of care and treatment processes. Medication is a concern of patients, of medical doctors and nurses, and of pharmacists, and even of patients’ families. It is extremely important that correct medication information is available and accessible for all stakeholders throughout the care processes [1,2]. Medication errors and malfunctions are common in health care and they may result in severe risks and consequences for health professionals and patients, and for care outcome [3,4].

Management of medication information can be supported in health care environment by various information systems that support the care process and collect information and data from various sources and make it accessible for health professionals. Medication information is required during various phases of the care process and it is important the information is valid, up to date, and is presented in an understandable manner and format.

Our ongoing research is focused on analysis and modeling of medication information. The research is divided into three phases: 1) Development of process models that describe the care processes where medication information is related to. Our viewpoint on the care processes is that of a medical professional, 2) Development of information models of medication information. The information models are presented as entity-relationship (ER) diagrams that present the entities of medication information, their attributes and the relations of entities with each other, 3) Development of an information architecture of medication information that enables implementation of the developed information model. The final medication information architecture will help to implement a harmonized approach for medication in health information systems because the information architecture can be implemented as a component in health information systems infrastructure, e.g. as a component in electronic patient record system, to support the management of medication information.

In this paper we present the results from our study phase 1 focused on process models of medication information.

The motivation for the development of these process models are the identified problems in accessibility and usability of all relevant medication information in medical decision making and treatment follow up. The problems in accessibility and usability of information are related to the coverage of medication information: information is missing, information has to be collected from various sources, in bits and pieces, and from the usability point of use medication information is not well presented, it is not available always when needed and it not easily accessed by the health professional.

This study has been carried out in Finland where the electronic patient record systems (EPR) have over 99% coverage in health care [5]. However, there are many different EPR’s in use and they have various contents and formats for medication information. In
many cases the content of medication information is not sufficient to meet the health professionals’ needs and they need to collect medication information from various sources during the patient’s visit to be able to make decisions and orders.

2. Medication information

Medication information is information on the patient’s medication covering the history of medication, the current situation and reasons and indications for medication. To be precise [6], medication information includes information on the generic names of the administered drugs, their commercial drug names, their dosage, their uptake, their interactions and on the care context of prescribing including diagnostic indications.

In the core data set documentation [7] medication is considered from four perspectives:
- Long-term medication, currently in use
- Long-term medication, taken when necessary
- Short-term medication, currently in use
- Ceased medication, both long-term and short-term medication that has been stopped now.

These perspectives for medication information have been considered useful from the decision making point of view and also from the patient’s point of view. The perspectives can be used as classification criteria for medication information in EPR’s and databases.

The current situation in access and use of medication information can be summarized [1, 2, 8]:
1. Medication information is managed and transmitted by and between many health information systems, e.g. electronic patient record systems, electronic prescription systems, order-entry systems, pharmacy systems.
2. Medication information is stored in various formats and contents in these systems, e.g. as prescriptions, as free text documentations, as medication lists and cards and presented by various classifications and nomenclatures.
3. The types of needed medication information are many: information on the history and current status, information on changes and modifications of medication, information on the relations to diagnoses and care indications, temporary and permanent medication information especially in the case of chronic diseases, and detailed information on selected drugs and their expected effects.
4. Legislation and other normative rules settle restrictions on the storage, use and access of the patient’s medication information.

Big problems in the management of medication information today are related to the varying contents of medication information in health information systems, and to various information representations, and to multiple documentation and storage of medication information, and to difficult accessibility and usability of medication information for health professionals in care situations [6, 8, 9, 10, 11, 12].

Health professionals’ needs for medication information are many. They need information on medical history, cumulative information on the progress of medication and its effects during care, information on drug side-effects and interactions, detailed information on current medication, information on the potential medication problems and risks, and information on medication in relation to the diagnoses and care outcome [1].

3. Normative rules and regulation for medication information

Legislation for data protection and security concerns also patient medication information as this information is health-related, private, confidential, sensitive, and needs to be protected from unauthorized access.

In Finland the data protection and security rules follow the EU directives and are very strict in protecting the security and safety of patient data [13]. Our national law on the management of the citizen’s personal data [14] and on the digital management of patient data in social security and health care [15] settle additional rules on the rights to access, use and manage patient data. These laws and directives build a framework for safe and secure data management where equal protection levels are used in all organizations where patient data is stored, accessed and managed.

Currently, in Finland, we are in a process of building our national health IT infrastructure and architecture, which enable connection of all patient-centered health information systems into a national network and centralized storage of all health-related patient data [16]. This infrastructure makes it possible for all health care organizations and professionals to access patient data files from the
permanent digital archive, if there exists the patient’s consent for access.

This IT infrastructure puts special requirements on the content and format of digital patient documentation. The documentation has to be produced in a specified format and the content has to be structured following the given, national guideline for the minimum patient data set [7]. This kind of harmonization of the structure and format of the patient documentation is needed to make the documents in the centralized archive understandable and usable in various care contexts.

These harmonization requirements should be applied also on the patient’s medication information to be able to access medication history and use all relevant medication information of the patient in the care process.

Part of the national health IT infrastructure will be an electronic prescription system with a centralized prescription database. This database will be a storage for all prescriptions (about 40 million yearly in total) and can be accessed by health professionals and pharmacies, and in later stages also by patients.

In this national situation the information model describing the medication information is very important. The model would help to define all concepts, and term, and their relations in medication domain. Modeling is the only way to build a harmonized approach on medication information management [17].

In this paper the first phase of model building is presented, development of the process models of medication information. These process models present the phases and steps in the medication information management, and in detail identify what information items are managed, where are the information sources and the contents of information in these phases.

4. Process modeling approach

Process modeling is a method that helps to understand the actions, workflows and tasks of an organization, and how the tasks are executed. Process modeling captures the process flow and the actors in the process, and the tasks performed by these actors. The focus in process modeling is on the functional processes which are entities that start with a certain event and end with a certain result. A process has always an input and an output, input triggers the process and process results in an output [18, 19].

Each process consists normally of multiple steps and has a customer and an owner. Process model depicts the actions performed by the customers and owners and the relations between the actions, e.g. how the steps relate to each other and how information flows between them. In constructing the process model it is necessary to collect information on the composition of functions, processes and on the goals of the organization. Different approaches and abstraction levels may be used in modeling. The viewpoint may be that of a customer, employee, manager or information system [20].

Process model should define what resources or input (e.g. employees, services, machinery, information) the functions require, i.e. functional requirements. The process model also represents requirements for the information system, i.e. the information requirements: what information the information system must be able to make available for the functions [20, 21].

Information requirements of a function may be described in detail as follows [1, 10, 18, 21]:

- Information needs to be available from defined objectives, issues and cases (specificity, relevance),
- Information needs to be accurate (correctness, accuracy),
- Information needs to be represented in a predefined format (composition, structure, format),
- Information needs to be available at a certain situation and place (where and when needed: location, time, security),
- Information and its delivery, information service, must not be too costly (monetary or other resources).

The process models presented in the next sections have been developed following the presented general process modeling principles.

Process modeling has been selected as a modeling method for this study because it supports the analysis of workflows and how information is related to the various actions in workflows. We could have applied other methods, too, e.g. use case modeling would have been a good method to analyze and present the use of medication information from the health professional’s point of view. However, we wanted to focus on the processes instead of use cases to find out how medication information is related to the care processes, where are the information sources, and how medication information is used in these processes.

4.1 Process modeling applied with health information systems

In Germany [22] a hospital information system has been developed applying business process modeling
The approach taken was a two-level procedure: 1) A business process model was developed to capture the main features of hospital functions and their behavior, 2) Data models were developed for identified hospital processes.

Process-oriented approach has also been applied in a methodology [23, 24] developed in France in which health care processes are mapped by eliciting structured information of users’ needs and system requirements. The methodology has been used for e.g. analyzing and improving blood transfusion process. The process modeling approach was seen feasible in this study, because it helped to identify the required communication and information resources of a hospital information system. The process models especially enabled specification where and when information was produced and used in the hospital environment. In this study the resulting process models were reusable and extendable and thus they could be easily applied in an evolving situation.

5. Medication information process models

The medication process depicted in this article is from the viewpoint of
- medication information user,
- medication information producer,
- professionals in medicine,
- information systems.

The focus is on medication, and the model has been narrowed down so that mainly those process steps are included that are essentially related to retrieving, using or generating medication information by the professionals in medicine. Only the actions performed by the professionals in medicine are illustrated and e.g. actions performed by the patient such as obtaining drugs from pharmacy are not depicted. The model stays in a generalized level and many details and specialized areas of medication such as anesthetics have been left out. In this level of abstraction and detail the process model suits both for describing the medication process in primary and secondary health care and both inpatient and outpatient care.

The model follows the basic care process carried out in a Finnish health care organization in public sector. Disclosing the medication information out of the treatment process helps us to understand the many ways of usage during the treatment and the information dependencies with other organizations. This kind of analysis leads us eventually to answering such questions as what information about medication is needed, how to organize this information, what would be the information model and what kind of architecture would resolve current issues with retrieving and managing the medication information within and between organizations.

Main processes

The medication process consists of four steps (Figure 1) in the highest abstraction level. Each of the steps and the relations between them are depicted in more detail in Figure 2.

Process begins when the patient arrives to the reception of a doctor or a nurse. It ends when the patient is discharged. This may occur straight after reception or the patient may move to ward and stay in the process for even a long period. While discharged, patient may be referred to another health care unit for continued treatment or sent home with a possible follow-up plan.

The actor of the processes is a doctor unless mentioned otherwise. A sole actor cannot be always named, because in some cases an action might be completely or partially performed by either a doctor or a nurse.

Step 1: Arrival / First assessment of the patient

The purpose is to assess whether the patient needs care and if so, to decide what the goals of the care to be given are. The goal may be e.g. preventive, palliative, or simply of healing a common infection with antibiotics. To do these decisions, a comprehensive understanding of the patient’s current and previous medication is needed. The doctor looks through the information to see if the previous or current medication has been suitable and whether there have been any side-effects, interactions or allergic reactions. The decision maker will also need to see patient’s short-term and long-term diagnoses and previously given treatments and nursing periods.
Commonly a nurse will make the first assessment collecting basic data about the patient and then hand over the case to the doctor if treatment seems to be needed. A preliminary list for inpatient medication is sometimes made by the nurse and later on confirmed by a doctor. The final decisions about treatment and medication are always of doctor’s responsibility.

Step 2: Planning the care

The doctor creates a treatment plan for the patient based on the goals defined in the previous step. The plan is either for outpatient or inpatient care.

For outpatient treatment the doctor produces a medication list, prescriptions for drugs and medication instructions for the patient.

In inpatient care nurses will be responsible for the treatment and the doctor creates them a list of medication, treatment plan and other instructions necessary for the treatment.

In inpatient care the outpatient medication is put on hold and inpatient medication is taken in use. Inpatient medication has a basis on the outpatient medication, previous inpatient medications, and on the medication needed for the planned treatment. In many cases it might not be long since the patient has been inpatient in the same place for the same reason, and especially in that case the previous inpatient medication list plays a big role, because it can be taken in use often without any changes, thus avoiding the tedious analysis of the patient’s medication history.

Step 3: Treatment and evaluation

In inpatient care nurses are responsible for managing and disposing of the drugs. Patient is medicated according to the inpatient medication list and the impact of medication and other treatment is followed. Impact of the treatment and disposal of the drugs to patients is recorded to the electronic patient record. Some drugs are given only if needed and nurses are responsible for the decision-making. Some minor changes to the medication may be done by nurses and approved later on by the doctor.

Periodically a doctor will assess the results. If the medication or treatment has to be changed, Step 2 is repeated and the treatment plan modified accordingly.

Any operative treatments executed within the organization such as surgery happen on this step. The decision of such operation is made on step 2 as part of the treatment plan and executed on step 3.

In outpatient care the patient, relative or a home nurse is responsible for the treatment process and of evaluating the impacts. In case the treatment is not working or a follow-up reception has been agreed on, a doctor will assess the situation and change the treatment plan as needed.

The process of evaluating the impact of treatment (Step 3) and changing the plan (Step 2) is repeated.
until either the goal defined in the first step is met or the patient is referred to another health care unit.

**Step 4: Discharge, referral or follow-up**

Process ends when the patient does not need the present kind of treatment anymore. The patient is either sent home or to a continued care to somewhere else. However, patient may be discharged and still stay in follow-up and occasionally drop in to the process. From the point-of-view of the medication process the follow-up is not much different from the whole process from Step 1 to 4 and therefore not shown in the diagram separately.

When inpatient is discharged the outpatient medication list is taken back to use and it is updated according to the current needs of the patient. Patient will receive the outpatient medication list, prescriptions for drugs, medication instructions and possibly a referral letter.

Inpatient medication is transferred to outpatient medication and prescriptions are made regardless of whether the patient goes home or heads straightway to another health care facility, where the medication list would be again transferred to inpatient medication list.

### 6. Summary and conclusions

The process models of medication information have been presented in this paper. They present the first results of our study. These process models describe the care process divided into four phases: First assessment, planning of the care, treatment and evaluation, discharge / referral / follow up. At each phase of the care process the sources, contents, types and use of medication information has been analyzed and the items of medication information have been identified.

The development of these process models has been iterative and has been carried out with medical professionals. The development process has been very fruitful with walkthrough sessions where the models have been tested and evaluated. The resulting models are satisfactory and form the basis for further work, development of medication information models and information architecture that enables implementation of the developed models.

The next phase of the study is the development of medication information models to present explicitly the information entities, attributes and relations of medication information. Finally, based on the process and information models we develop a medication information architecture to support implementation of a harmonized approach for medication information management in health information systems and EPR’s.

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### 7. References


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