

Representing a Chemotherapy Guideline Using *openEHR* and Rules

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Abstract. Computerized guidelines can provide decision support and facilitate the use of clinical guidelines. Several computerized guideline representation models (GRMs) exist but the poor interoperability between the guideline systems and the Electronic Health Record (EHR) systems limits their clinical usefulness. In this study we analyzed the clinical use of a published lymphoma chemotherapy guideline. We found that existing GRMs have limitations that can make it difficult to meet the clinical requirements. We hypothesized that guidelines could be represented as data and logic using openEHR archetypes, templates and rules. The design was tested by implementing the lymphoma guideline. We conclude that using the openEHR models and rules to represent chemotherapy guidelines is feasible and confers several advantages both from a clinical and from an informatics perspective.

Keywords. computerized clinical guidelines, clinical decision support, electronic health records, openEHR, archetypes, templates, rules

1. Introduction

Clinical guidelines may improve care by reducing variability, reducing cost and safeguarding patient safety [1]. Several guideline representation models (GRM) have been developed, e.g., Arden Syntax, EON, GLIF, PRODIGY and PROforma. Integrating guideline engines with EHRs is well recognized as the bottleneck of implementing computerized guidelines [2].

This study is based on practical experience using written guidelines at the Regional Oncology Centre³ in Uppsala, Sweden. We have chosen a lymphoma guideline and created use cases based on how oncologists use the written guideline to administer the indicated treatment. We use the clinical requirements from these use cases to understand what is required to represent a guideline.

An analysis of current GRMs identified several weak points which made them less than optimal for use in our case. A central issue was the lack of integration with an EHR. In order to achieve optimal integration with an EHR, we hypothesized that a complete chemotherapy guideline can be built on a generic EHR model in combination

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³ Regional oncology centre. <http://www.roc.se>.

with external rules. More specifically, we chose to use openEHR⁴ archetypes [3] to model guideline data structures and use openEHR templates to specify data elements. We reused several existing archetypes and authored several new archetypes and templates to represent a lymphoma treatment guideline. Rules are used to represent the logic in the guideline and are implemented using the CLIPS⁵ rule engine.

2. Methods

In this study we use a lymphoma treatment guideline from the Regional Oncology Centre in Uppsala, Sweden. To investigate the clinical requirements of a guideline representation model we performed informal interviews with oncologists using the lymphoma treatment guidelines. From these interviews we created use cases modelling the oncologists using the lymphoma guideline to treat a patient with diffuse large B-cell lymphoma (DLBCL).

We also studied the literature on existing GRMs to see if they were suitable for representation of chemotherapy treatment guidelines. Based on our analysis of the lymphoma treatment guideline and our review of existing GRMs, we propose a novel way of representing guideline data and logic separately using openEHR models and rules respectively. We then represented the lymphoma guideline using this design. The design specification from the openEHR Foundation was used. In addition we used the editors from Ocean Informatics for archetype and template authoring. The archetypes we used came from the knowledge repositories at openEHR. The guideline logic was represented as rules in CLIPS syntax.

3. Results

3.1. Analysis of Clinical Use Cases

The guideline we used in this study is a guideline concerning the treatment of a common subtype of lymphoma, known as DLBCL. We considered a common situation where a patient has recently been diagnosed with DLBCL and is therefore referred to the oncology centre for treatment. The analysis of the clinical usage of the lymphoma guideline has led to the following findings.

- The medication orders are complicated and specific. And they need to be accessed by different actors.
- There are many clinical decisions to be made when using the guideline. We noted that the logic in the guideline is expressed as decision trees and as rules written in natural language.
- It is necessary to have tools for authoring and reviewing guideline definitions. These tools must be usable by the domain experts, the clinicians.
- It must be possible to check conformance of treatment to the guideline in a recorded EHR retrospectively, both for quality management and for new knowledge discovery purposes.

⁴ The openEHR Foundation. <http://www.openehr.org>.

⁵ Clips Rule Engine. <http://clipsrules.sourceforge.net/>.

3.2. Analysis of Existing Guideline Representation Models

Integrating an EHR system with a Guideline System is a well-known bottleneck that hinders implementation of guidelines in clinical settings. Data must be extracted from the EHR so that interventions can be suggested by the guideline engine at relevant patient states. The ability to query fine-grained EHR data has been seriously limited by the lack of a common EHR model and a reliable mechanism to point at specific data elements. This can be improved by using an EHR query language [4] that relies on a common EHR model using a path-like syntax.

Intervention suggestions from the guideline ideally should be interpretable by the EHR system and used to generate structured orders in EHR. This ability can also be seen as interoperability between the guideline engine and the EHR system. None of the existing GRMs seems to provide this level of interoperability. Furthermore, the details of the medication orders within the lymphoma guideline need to be maintained by oncologists with proper tools. The availability of authoring tools and runtime environments seem to pose another problem for adoption of these GRMs.

3.3. Representing Guideline Data Using the openEHR Models

Based on the analysis of the clinical usage of the lymphoma guideline and the issues with existing GRMs, we hypothesized that clinical guidelines can be better represented as EHR models and rules. We chose the openEHR archetypes to represent the clinical models in the guidelines to provide necessary structures facilitating data sharing and fine-grained EHR querying. Templates are used to compose larger logical structures, e.g., a treatment course, by grouping several archetypes, and to specify data elements forming detailed interventions.

The lymphoma guideline is a treatment guideline and consists of detailed recommendations on medications (cytostatic or supportive), lab investigations and imaging requests. Since these are common clinical models, it was possible to reuse existing archetypes from public knowledge repositories. A new template (Figure 1) and several new archetypes were authored to organize all relevant instructions needed in one treatment course.

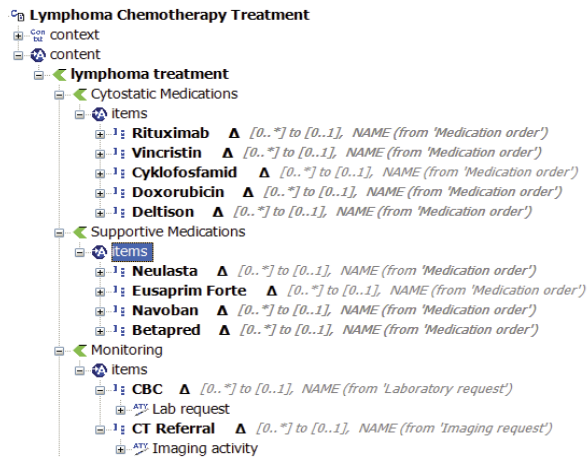


Figure 1. Lymphoma chemotherapy treatment template

3.4. Representation of Guideline Logic

The logic within the lymphoma guideline consists of: 1) logic for selection of a certain treatment regimen expressed as a decision tree; 2) algorithms for calculating medication doses; 3) logical relationships between different parts of the guideline, e.g., the dose reduction logic. Since the logic in the written guidelines is expressed as decision trees and rules in natural language we hypothesized that the logic in the computerized guideline could be expressed as formal rules using a standard forward-chaining rule engine.

An additional benefit of using rules is that they may be more easily written by domain experts with no knowledge of programming. To investigate the feasibility of using rules to represent guideline logic we represented the logic for the admission, the treatment planning, and for a part of the treatment course using the CLIPS Rule Engine. EHR data required for evaluation of the rules are expressed in EQL [4]. Each query is assigned a unique identifier, which is used in the decision rules instead of the query itself. This does not only improve readability but also make rules immune to the changes of EHR queries. We also used EHR paths to point at specific data elements in the action part of the rules, e.g., to make a dosage adjustment.

4. Discussion

Directly representing complex medication orders and other detailed data elements from chemotherapy guidelines using openEHR archetypes and templates has several advantages compared to using a separate GRM. The openEHR Reference Model (RM) and Archetype Model (AM) is a super-set of ISO/EN13606, a European and international standard for EHR communication. A guideline definition expressed using a standard EHR model is more likely to be supported by EHR systems than that using a separate GRM. Existing clinical content models in the form of archetypes can be reused as building blocks for new guideline definitions. The structure and terminology bindings in the archetypes can facilitate fine-grained EHR queries which together with rules allow guideline based decision support. Templates can be used to group different archetypes and pre-define specific data based on guideline recommendations. These templates can then be used by an EHR system to facilitate data entry on medication orders and lab investigations. Conformance to guidelines can also be checked by retrospective queries based on the archetype formalism. This functionality is necessary for auditing and research purposes and very difficult to provide using a separate GRM.

In recent years, openEHR tooling and software have proliferated thanks to a vibrant community consisting of clinicians, developers and health informatics researchers. Not only the design specifications and software tools are freely available and well maintained, high quality clinical content models in the form of archetypes and templates are becoming available. From a knowledge management perspective, it is advantageous to reuse clinical models in the form of archetypes and templates as building blocks of guidelines since it will simplify authoring and maintenance of the guidelines. The recently introduced openEHR Clinical Knowledge Management environment for distributed reviewing, indexing and releasing clinical content models can be useful also for the management of guidelines.

The use of an external rule language to represent guideline logic is due to the limited support for complex rules operating across different archetypes. However, our

design allows the use of any external rule language. The need for an external rule engine should be reviewed once the rule support within archetype formalism is improved. Our approach may also simplify authoring and maintenance of guidelines since the domain expert will not have to learn a whole new guideline language. Clinicians are already used to representing data in a format suitable for an EHR and in our case we noted that the logic was already stated as rules, although in natural language.

Process definitions necessary for modelling complex guidelines are supported by some GRMs. PROforma, Asbru and GLIF support many but not all process modelling concepts used by full-blown workflow languages [5]. This suggests that perhaps the process modelling can be done easier and better using a traditional workflow language. The lymphoma guideline has a simple linear structure which made process modelling superfluous. We recognize the need for process support to represent more complex guidelines. Due to the orthogonal nature of our design, it is possible to add process as the third component besides data and logic, into the design. The openEHR RM, which is the foundation of data representation of the guidelines in our design, can be used with an external process language. The details of how to incorporate process support will be investigated in future studies.

5. Conclusion

We conclude that it is feasible to represent chemotherapy guidelines using openEHR archetypes and templates in combination with rules. The main advantage of this approach compared with existing GRMs is that it facilitates integration with the EHR.

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