METHOD TO INTEGRATING CLINICAL GUIDELINES INTO ELECTRONIC HEALTH RECORD (EHR) BY APPLYING THE ARCHETYPES APPROACH

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Introduction

• Clinical Practice Guidelines – CPG
  • Natural language documents
  • Need to be integrated into Electronic Health Record (EHR)

• CPG and Decision Support Systems
  • Most of CPG are not fully integrated into EHR

• Requires an interface between the DSS and EHR
Context - Problem

- Transforming CPG – computable form
  - Representation formats
    - Arden Syntax, GLIF, PROforma
  - Isolated or restricted to a single specific EHR
    - GDL – new approach

- EHR standards - application
  - Two-level architecture as Archetypes approach
Context

- CPG describe
- Clinical data
- Relationships between data

1. Guideline for anemia treatment in Chronic Kidney Disease patients – Erythropoietin use (Brazilian Ministry of Health 2010);
   i. If hemoglobin rises > 0.5 g/dL/week or hemoglobin level is between 12-13 g/dL lower dose in 25-50% respecting the minimal dose of 50 UI/Kg/week

Relationship between hemoglobin level and dose alteration – Source: Brazilian Ministry of Health, 2010.
Introduction

- CPG data can be represented as archetypes
- CPG relationships can be represented as rules

Absolute iron deficiency diagnosis in Chronic Kidney Disease patients on hemodialysis is made when:

- Transferrin saturation < 20% and
- Serum ferritin < 200ng/dL

IF “transferrin saturation” < 20% AND “serum ferritin” < 200ng/dL
THEN “iron deficiency” = “absolute”
Introduction

- Wide adoption of archetypes
  - Australia, United Kingdom, Brazil, Europe

- Lack of studies specifying semantic relationships
  - Only relationships like hierarchy, cardinality ...

- More complex constraints can not be modeled
  - Conditional data entry
  - Relationship between different concepts
Objective

Present a method for integrating clinical guidelines to Electronic Health Record
Method

Phase I

Phase II

Phase III

Phase IV

Phase V

DSS Validation
Method

• Part I – Proposal of a way to identify guideline data and rules
  • Analyzing how this information is described in CPG text
  • Modeling of new archetypes

• Part II – Incorporation of rules into an archetype-enabled EHR
  • Analyzing how rules could be incorporated into archetypes
  • Need of an inference engine
    • JBoss Drools Expert
Results

- Method consisting in 5 phases

I – Identification of the data and the rules specified in the guideline

II – Archetypes elaboration

III – Definition and inclusion of rules in a rule-based inference engine and elaboration of the DSS

IV – DSS – EHR integration

V – DSS validation
Results – Phase I

- Identification of the data and the rules specified in the guideline
  - Summarization of the information
  - Revision of following points
    - Type of guideline
    - Diagnosis
    - Related signs and symptoms
    - Indicated treatments
    - Laboratory tests (values)
    - Involved epidemiological factors
Results – Phase I

• Examples

**RULE 1**
When “TSI < 20%” AND “serum ferritin < 200ng/dL”
Then “iron deficiency is absolute”

**RULE 2**
When “TSI < 20%” AND “serum ferritin >= 200ng/dL”
AND “serum ferritin < 800ng/dL”
Then “iron deficiency is relative”
Results – Phase II

- Archetypes elaboration
  - Lookup on available repositories
    - OpenEHR Foundation CKM, NeTHA
  - Reuse of existing archetypes
  - No archetypes were found

- Modeled the following archetypes
  - Hemoglobin, Hematocrit, Ferritin and Transferrin saturation index
Results – Phase III

- Definition and inclusion of rules in a rule-based inference engine and DSS elaboration
  - 4 rules for iron deficiency diagnosis
  - 14 rules for dose recommendation

<table>
<thead>
<tr>
<th>Iron Deficiency Rules</th>
<th>Transferrin Saturarion Index</th>
<th>Transferrin Saturarion Index</th>
<th>Ferritin intervals</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Deficiency</td>
<td>20</td>
<td>20</td>
<td>0.200</td>
<td>Iron Deficiency</td>
</tr>
<tr>
<td>Relative Deficiency</td>
<td>200,800</td>
<td>800</td>
<td></td>
<td>Absolute</td>
</tr>
<tr>
<td>Relative Deficiency (review)</td>
<td></td>
<td></td>
<td></td>
<td>Relative</td>
</tr>
<tr>
<td>No Deficiency</td>
<td></td>
<td></td>
<td></td>
<td>No deficiency</td>
</tr>
</tbody>
</table>

**Rule Table Iron Deficiency**
- CONDITION: transferrinSaturation < $1
- CONDITION: transferrinSaturation >= $1
- CONDITION: ferritin >= $1, ferritin < $2
- CONDITION: ferritin >= $1
- ACTION: setValue("ironDeficiency", "$param")
Results – Phase IV

- DSS-EHR integration
  - Prototype to simulate a web-based EHR
  - Data from an existing electronic medical record were imported into prototype database
  - Inference engine – JBoss Drools Expert (v. 5.3)
  - Decision table from Phase III
  - Execution of the rules
Results – Phase IV
Results – Phase V

• Phase V – DSS validation
  • Results generated by JBoss Drools Expert were compiled in a report
  • Two ways of validation
    • Previously validated database
    • Validation by a panel of experts
  • Validation by 3 experts
    • 205 patients
    • 617 orientations generated by JBoss Drools Expert
    • 100% agreement
Discussion

• CPG/EHR Incorporation needs representation

• Need to keep CPG  data structure and logic

• Suggested approach
  • Archetypes  -> data structure representation
  • Rules  -> logic representation
Discussion

• Existing studies do not describe how data and rules are extracted from CPG
• Other studies
  • Chen et al, use cases and interviews
  • Marcos and Martínez-Salvador, specific guideline

● Focus on describing a generic method
  • Systematic reproduction in any guideline
  • Modeling of identified data and/or rules according to its characteristics
Discussion

- Manual extraction of information
  - Employment of natural language processing
  - Use of tools to structure CPG information

- Method easy to be applied by clinicians with little knowledge in conditional statements
  - Specifically Phases I, II, and even III
Discussion

- Inference engine is the interface for CPG and EHR
  - Integration of new rules into EHR without changes in the software

- Archetypes facilitate generic extraction
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Acknowledgements

• Pontifícia Universidade Católica do Paraná
  • Research support
  • Financial support

• Archetypes research group at PUCPR

• Professor Claudia Moro
Pontifícia Universidade Católica do Paraná
Postgraduate Program in Health Technology
Polytechnic School

Thank you!
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