Clinical Practice Guidelines Consistency for Patients with Multimorbidity: a Case-Study in the Management of Type 2 Diabetes and Hypertension

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Abstract. Decision support for the guideline-based management of patients with multimorbidity is a challenge since it relies on the combination of single-disease clinical practice guidelines (CPGs). The aim of this work is to present a framework to check, at the modelling level, whether two CPGs overlap and are potentially inconsistent, thus requiring further reconciliation. The method relies on an ontological comparison of the patient profiles covered by CPGs and the recommended actions attached. It was applied to check the consistency of CPGs for the management of arterial hypertension and for the management of type 2 diabetes. Results showed that the two CPGs had only one common patient profile, although more profiles were impacted through profile subsumption. In this specific case, recommended actions were not found inconsistent since antihypertensive and anti-diabetic drugs could be combined in an additive way.

Keywords. Practice guidelines as topic, Hypertension, Type 2 diabetes mellitus, Medication therapy management, Clinical decision support, Ontology

Introduction

Following the evidence-based paradigm, clinical practice guidelines (CPGs) are developed to provide a synthesis of state-of-the-art best practices for the management of patients. CPGs usually appear as textual documents describing a set of prototypical clinical situations for which treatments are recommended. However, if CPGs are usually focused on the management of single diseases, multimorbidity is common for patients. Most people with any chronic condition have indeed multiple conditions. This is true for elderly patients but also for younger patients [1]. These patients are engaged
in complex clinical pathways including multiple consultations with different practitioners. Most of them are medical specialists who prescribe disease-focused medications. Expected to have access to the whole picture of active diseases and current treatments, general practitioners are responsible of the global management of patients. However, they often lack guidance on how to approach clinical decision-making for such complex patients. Suboptimal treatments and drug-to-drug interactions are common, sometimes resulting in unnecessary hospitalizations or even death [2].

Computer-assisted medication reconciliation has already showed promise to avoid medication errors [3]. However, research on the provision of guideline-based decision support for patient with multimorbidity is only beginning. Some work is conducted to modify the process of clinical evidence creation and enlarge the review of the literature to develop CPGs for people with multiple comorbidities [4]. Another solution is to work on the combination of multiple single disease CPGs. Proposed solutions vary from a totally manual processing where physicians chose how to combine CPGs [5], to a totally automatic processing involving the identification of adverse interactions and the proposition of an appropriate clinical resolution [6].

In order to develop a guideline-based clinical decision support system for the global management of cardiovascular risk, the authors have implemented an ontological reasoning that has been already used to compare the consistency of multiple CPGs on the same topic and applied to the management of hypertension [7]. The aim of the new work presented in this paper is to present the use of an ontological reasoning to help in checking the consistency of the combination of several CPGs. The method is illustrated with a case study involving two CPGs in the field of the cardiovascular risk management, CPGs on the management of hypertension, and CPGs on the management of Type 2 Diabetes, chosen because of the high prevalence of the two diseases in the general population.

1. Material and Methods

Guideline reconciliation requires to combine the actions recommended by different CPGs for a given multiple conditions patient. The process is especially problematic when the recommended actions are in conflict. Conflicts may occur arbitrarily at run time depending on the data of the actual patient. In this case, they should be solved dynamically at the execution level. However, when studying the overlapping of CPGs and their consistency, some conflicts may be anticipated and pre-processed at the modeling level. We propose a framework for the different scenarios that occur when combining two single-disease guidelines. We denote $P_1$ and $P_2$ the sets of all the patient profiles covered by $CPGs_1$, resp. $CPGs_2$. In the same way, we denote $A_1$ and $A_2$ the set of the actions recommended by $CPGs_1$, resp. $CPGs_2$. The intersection of $P_1$ and $P_2$ may be empty (the two CPGs have no patient profile in common) or not (there is at least one patient profile covered by both CPGs). In the same way, the intersection of $A_1$ and $A_2$ may be empty or not. The four resulting theoretical scenarios are illustrated in Figure 1. When patient profiles are disjoint, recommended actions should be easily combined depending on the internal consistency of CPGs. On the contrary, when patient profiles are overlapping, recommended actions attached in $CPGs_1$, resp. $CPGs_2$ for a profile in $P_1 \cap P_2$ may need to be reconciliated (red links in Figure 1). This requires that interacting profiles issued from the two CPGs be first identified, then that the corresponding actions be checked for potential inconsistencies.
We considered CPGs on the management of arterial hypertension (AHT) and on the management of Type 2 Diabetes (T2D). Both CPGs have been developed as textual documents including flowcharts. They were edited and published by Vidal, a French company that markets the drug database namesake, among a collection of recommendations on numerous topics named “Vidal-Recos” available as a book and electronically [8]. The approach already applied to formalize AHT CPGs content [7] was used to formalize T2D CPGs content and build the T2D rule base:

1. Rule extraction. T2D CPGs were manually processed by three different persons (AG, JB, BS) working independently, which lead to three different sets of rules. The condition part of rules is made of a conjunction of criteria $C_i$ that describes a patient profile (e.g. "T2D\&Pregnancy\&AHT"). Then, a consolidation step was conducted to provide a unique consensual base of rules. Patient profile criteria and recommended actions were normalized to avoid variants.

2. Ontology alignment and enhancement. We used the ontology we previously built from the extraction of the subpart dedicated to the management of cardiovascular risk in OntoUrgences [9], enriched to account for AHT concepts, in order to align patient profile criteria used in T2D CPGs with a unique concept. Again, concepts from T2D CPGs modeling that were missing in the ontology were added.

At the end of this manual process, we got two rule bases, formalized according to the same conceptual framework, which preconditions and actions are aligned with the concepts of the ontology. We could then process the automatic ontological classification of patient profiles [7] of the two rule bases using an OWL reasoner. This allows the identification of rules, linked by a subsumption relationship in the subsumption graph of profiles, that would be concurrently triggered. The analysis of linked rules enables the checking of potential inconsistencies between rules within a same rule base/CPGs or between distinct rule bases/CPGs.

2. Results

The modelling process was conducted on T2D CPGs. AHT and T2D CPGs were thus formalized as two rule bases with two sets of patient profiles and two sets of recommended actions. Table 1 provides the comparison of the sets of patient profiles and the sets of recommended actions.
Table 1. Comparisons of the sets of patient profiles and recommended actions for AHT and T2D CPGs.

<table>
<thead>
<tr>
<th></th>
<th>AHT</th>
<th>T2D</th>
<th>AHT (\land) T2D</th>
</tr>
</thead>
<tbody>
<tr>
<td># Patient profiles</td>
<td>152</td>
<td>84</td>
<td>1</td>
</tr>
<tr>
<td># Recommended actions</td>
<td>92</td>
<td>97</td>
<td>12</td>
</tr>
</tbody>
</table>

Only one profile is shared by the two sets of patient profiles: “T2D\(\land\)AHT” which belongs to three rules in AHT CPGs and two rules in T2D CPGs. However, the subsumption graph of profiles in Figure 2 shows that more rules interact. Indeed, six profiles (in purple) are subsumed by “T2D\(\land\)AHT”. All inherit logically from profiles from AHT CPGs (in blue) or T2D CPGs (in orange). The two CPGs overlap and the consistency can be checked.

![Subsumption graph of patient profiles](image)

Figure 2. Subsumption graph of patient profiles that account for the overlapping of AHT and T2D CPGs.

For each profile impacted by the two CPGs, all inherited actions from both guidelines were collected. Table 2 reports recommended actions for the common profile. With overlapping patient profiles and overlapping recommended actions, we are in the fourth cell of the matrix provided in Figure 1 with potential problems of guideline reconciliation. The consistency of actions was manually checked: all actions were either identical or non-conflicting. Common actions correspond to the fact that T2D CPGs recommend the use of antihypertensive drug classes for patients with hypertension, and that these classes are consistent with what AHT CPGs recommend. On the side of AHT CPGs, no specific action is recommended for T2D management.

Table 2. Recommended actions for the “AHT\(\land\)T2D” profile from AHT and T2D CPGs.

<table>
<thead>
<tr>
<th>CPGs</th>
<th>Patient Profiles (Rule conditions)</th>
<th>Recommended actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHT</td>
<td>AHT (\land) T2D</td>
<td>- Target_PAS_130, Target_PAD_80;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ACEi, ARBs, BBs, CCBs eligible;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ACEi recommended.</td>
</tr>
<tr>
<td>T2D</td>
<td>T2D (\land) AHT</td>
<td>- Target_PAS_130, Target_PAD_80;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Thiazides, BBs, ARBs, CCBs recommended.</td>
</tr>
</tbody>
</table>
3. Discussion and conclusion

We proposed a framework based on an ontological modelling of CPG content to check at the modelling level whether two guidelines overlap and would require reconciliation. Similar approaches to merging clinical pathways using ontologies have been proposed [10]. This is a top-down approach to consistency checking, that departs from the patient profiles modelled in CPGs to common recommended actions that may be potentially conflicting. A bottom-up approach could be applied in the same framework, departing from pairs of conflicting actions, or “discrepancies”, to identify corresponding profiles in the CPG rule base and their compatibility using the ontology.

In the case of Vidal CPGs on AHT and T2D, we found that CPGs overlap but not that much, and are globally consistent in their recommendations, although they share common actions. This can be explained by the fact that the two diseases require independent drugs (antihypertensive and anti-diabetic drugs) that can be combined in an additive way. Moreover, these two CPGs have been written by the same editing company, which suggests care for consistency during the writing process.

The presented framework will be used to integrate additional CPGs and build a consistent knowledge base of a decision support system applied to the global management of cardiovascular risk.

References