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Building a Knowledge-Based Tool for Auto-Assessing the Cardiovascular Risk

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Abstract. The prevention of cardiovascular diseases needs first to quantify the cardiovascular risk. To estimate this risk, French national health authorities provided clinical practice guidelines extending the existing European SCORE, which doesn't include all the cardiovascular risk factors (e.g. diabetes). Hence, French national clinical practice guidelines to quantify the cardiovascular risk is able to deal with more clinical situations than the SCORE. The goal of this paper is to formalize knowledge extracted from these guidelines and implement the rules so that they can be used into an auto-assessing tool of cardiovascular risk. Formalization followed five steps and was conducted under the guidance of medical experts. It resulted into a decision tree fed by eight decision variables. Evaluation of the accuracy of the decision tree showed 80% of agreement with an expert in medical informatics in predicting the cardiovascular risk level for 15 different clinical situations. Discrepancies correspond to the knowledge gaps within Clinical Practice Guidelines. We intend to extend the implementation of the decision tree to a complete tool, for allowing patient to auto-assess their cardiovascular risk. This tool will be integrated into a platform providing recommendations adapted to the calculated level of cardiovascular risk.

Keywords. Cardiovascular risk, Clinical Practice Guidelines, Formalization

1. Introduction

Cardiovascular (CV) Diseases are the most common cause of death in Europe [1]. Many risk factors are associated with CV diseases and can be controlled by prevention actions. To trigger prevention, many scores exist to auto-evaluate CV risk, proposed by international, national or local groups. Framingham-D'Agostino CV risk scale [2] is used to assess the global CV morbidity and mortality risk. It was validated for United States population, and needs calibration to be transposed to other countries [2]. In Europe, the Systematic Coronary Risk Estimation (SCORE) [3], provided by the European Society of Cardiology, gives an estimation of ten-year risk of fatal CV disease given the patient profile. But this score is restricted to patients in a specific age range (40-65 y), and

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shouldn't be used for patients with risk factors such as blood pressure over 180/110 or diabetes. Discrepancies were also observed between the Framingham-D'Agostino and SCORE results on patient profiles associated to a high CV risk [4]. French national health authorities provided clinical practice guidelines (CPGs) to estimate the CV risk. In these guidelines, the cardiovascular risk is assessed by the SCORE, and when SCORE cannot not be applied (e.g. if diabetes), others parameters are used [3]. However, French CPGs are textual and complex documents dedicated to General Practitioners (GPs) [5]. Their use by patients within an computerized tool require their formalization [6]. The goal of our work was to build and implement an algorithm to auto-assess the CV risk by formalizing knowledge contained in CPGs.

2. Methods

2.1. Formalization of Clinical Practice Guidelines

To formalize the recommendations related to the assessment of the CV risk, we followed 5 steps [7]:

- Step 1: Identification of the decision variables.
  - From textual recommendations, we manually extracted all the terms related to the decision making and grouped them into categories of variables for which we associated a set of values. For each variable, the set of values was built from the values found in CPGs, and was completed with the help of medical experts. For example, we extracted "moderate renal failure", and "serious renal failure" and then grouped them into the variable "renal failure" for which we associated the following set of value {absent, moderate, serious}.
- Step 2: Definition of the hierarchy of decision variables in the decision tree.
  - The hierarchy of decision variables was first established according to the level of risk: the decision variables leading to a "very high CV risk" were put on the top, followed by those leading to a "high risk", then those leading to a "moderate risk" and then to a "low risk". The hierarchy was then validated by medical experts. They could decide to change the hierarchy according to the order in which the variables are usually tested in clinical practice.
- Step 3: Creation of a decision matrix.
  - A decision matrix including all the combinations of the values of the decision variables was built to check if all situations were well taken into account.
- Step 4: Creation of the decision tree.
  - The decision tree was created by ordering the decision variables resulting in a given output, as it was identified in previous steps.
- Step 5: Checking by medical experts.
  - Medical experts checked whether the decision tree was compliant with textual recommendations from CPGs.

2.2. Evaluation of the accuracy of the decision tree

We simulated a set of 15 clinical cases by attributing randomly some values for each decision variable, based on the prevalence of each risk factor in the population. For each clinical case, we compared the level of CV risk suggested by our tool to a gold standard. The gold standard was derived by a medical informatics expert – not involved in the building of the decision tree – from the reading of the guidelines in blind. For each clinical case, the expert was asked to give the clinical risk level associated by following faithfully the CPGs. For each clinical situation, the level of accuracy of the decision tree was considered as "exact" if it matched exactly to the gold standard. We determined the percentage of clinical situations for which the match was "exact".

3. Results

3.1. Decision variables taking part in the assessment of the cardiovascular risk

Eight decision variables were identified and ordered as taking part in the assessment of the CV risk (See Table 1). Some variables share the same rank in the evaluation order, to be in accordance with the decision of the medical experts.

Table 1. Sets of values of decision variables. Variables are described according to their type, universe of discus, and position in the hierarchy.

Variable	Type	Universe of discourse	Hierarchical position
Heterozygote Familial Hypercholesterolemia	Boolean	{yes, no}	1
Cardiovascular disease documented	Boolean	{yes, no}	2
Chronic renal failure	Enumeration	{severe, moderate, absent}	3
Diabetes and related complications	(Boolean, Boolean)	{(yes, yes) ;(yes, no), (no, no)}	4
Age	Integer	<40 ; ≥40 and ≤65 ; >65	5
Blood Pressure (BP)	(Integer, Integer)	≥180 or ≥110 ; <180 and <110	5
At least one risk factor	Boolean	{yes, no}	6
SCORE	Integer	<1 ; ≥1 et<5 ; ≥5 et <10 ; ≥10	6

3.2. Decision matrix

All 1728 variables combinations were generated and associated to the devoted risk level according to the CPGs. This allowed us to identify the CPGs gaps. For instance, the CV risk level of a patient over 65 years old with no risk factor is not made explicit.

3.3. Decision tree

The decision tree is showed in Figure 1. Compliantly with the guidelines, it can lead to five levels of CV risk: "very high", "high", "moderate", "low" and "Unknown". "Unknown" corresponds to clinical situations for which there was a gap in CPGs. Nine gaps were found.

3.4. Accuracy of the decision tree

The accuracy of the decision tree was 80%. For three clinical cases, the level of CV risk calculated with the decision tree didn't fully match with the gold standard because of knowledge gap within CPGs. In these situations, the decision tree considered that the risk was "unknown" because it could only be assessed *at least* at the level given in the CPG, whereas the evaluator gave a specific value for these situations. For example, for one clinical situation, the CV risk was calculated at "at least high level" (gap "?*5") because it could be "high" or "very high" depending on the existence or not of risk factors which were not considered in CPGs, but taken into account by our panel of medical experts when building the decision tree (e.g. smoking or unbalanced food intake). By considering all outputs, without the "at least" mention, we obtain 100% of matching.

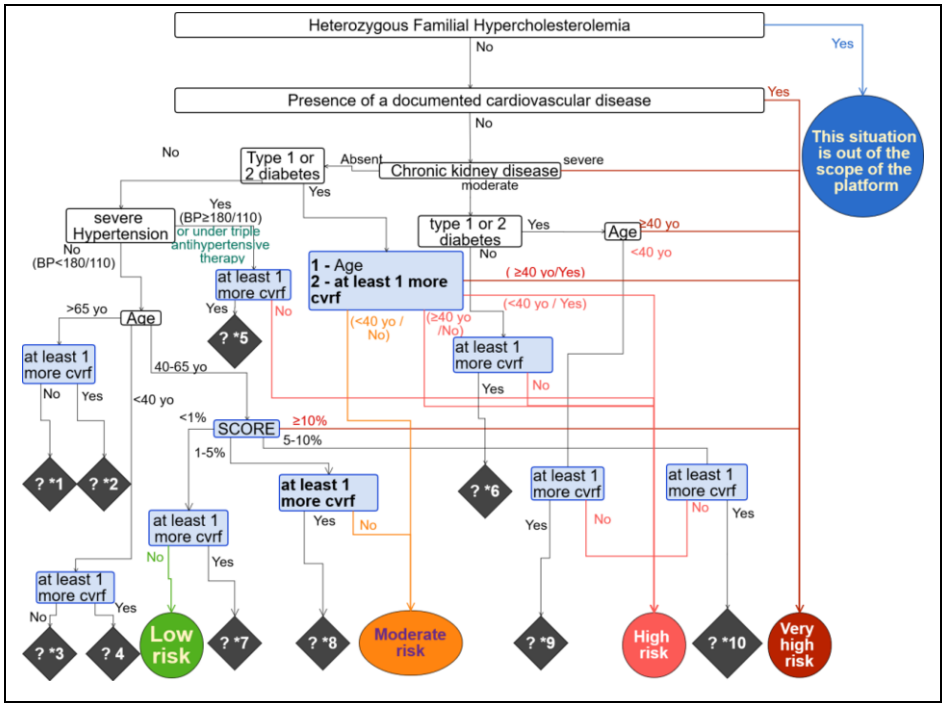

Figure 1. Decision tree of "Cardiovascular risk assessment". The decision tree shows levels of cardiovascular risk in circle, decision variables in rectangle and knowledge gaps in lozenge.

*cvrf stands for "cardiovascular risk factor"

4. Discussion

We formalized CPGs as a decision tree in order to build an algorithm for assessing the CV risk. The formalization considers the European SCORE, to which other risk factors were added among which diabetes, chronic renal failure, severe hypertension or age over

65 years old. Including more risk factors and their relationships in the algorithm is important for an overall appreciation of the CV risk [8].

Yet the formalization has still limitations. Some CV risk factors, like overweight and inactivity weren't considered, since CPGs ignore some of them. Thus, the estimation cannot be global; overall recommendations are still in discussion. But the formalization can follow evolution of knowledge because the method may update decision tree according to upgraded recommendations. Formalizing CPGs allowed to identify gaps [9]. Submitted to medical experts, a recommendation can be provided in all cases.

Our study has limitations. First, our formalization depends on a subjective interpretation of CPGs content. This was reduced by including six experts with different background: four general practitioners, two computer scientists. Second, the evaluation was limited by the number of clinical situations considered (n= 15) and the derivation of the gold standard by a single expert. However, the tree had been previously formally validated and, the expert had a good experience in reading CPGs and derived the gold standard blindly of the decision tree. A more robust evaluation should be conducted combining static and dynamic testing methods [10].

We intend to implement the algorithm in a tool, integrated into a platform, allowing people to get recommendations adapted to the calculated level of CV risk.

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