Implementing National Guidelines on Risk Prediction and Primary Prevention of Coronary Heart Disease in a Cardiology Information System

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Abstract

Recently the Dutch Institute for Healthcare Improvement (CBO) published a national consensus concerning both risk prediction and guidelines for primary prevention of coronary heart disease (CHD). The risk prediction algorithm used by the CBO was, after validating, taken as an input for an application, as part of the Cardiology Information System (CARIS) of the Leiden University Medical Center. By selecting the patient, the risk factors that are available in CARIS are filled in automatically. The remaining items are imported from the hospital information system. After that, the absolute risk on CHD is calculated and a treatment advice is presented. Since no manual input is necessary, the risk estimation tool is quick and easy to use. With this predictive tool for clinical decision support, the physician can opt for an intervention to minimize disease risk, or prevent risk factor development in the future.

1. Introduction

Knowledge of the risk on Coronary Heart Disease (CHD) has great importance for physicians, especially cardiologists, who see their patients for the first time at the outpatient clinic. Based on the CHD risk prediction, physicians can opt for minimizing the risk or prevent risk factor development in the future. Also, patients can be shown how changes in lifestyle may affect their risk profile. Discussing the CHD risk pattern with the patient can be both motivating and educational. Given the busy schedule in the outpatient clinic, it's necessary to predict the CHD risk in a simple and short way.

Risk models that are applicable to the Dutch population can be obtained from the results of the Framingham Heart Study. The objective of this American study was to identify the common factors or characteristics that contribute to CHD by following its development over a long period of time in a large group of participants who had not yet developed overt symptoms of CHD or suffered a heart attack or stroke. Comparable morbidity studies are also carried out in the Netherlands, but the risk models that have been developed based on these studies are not published yet.

The Dutch Institute for Healthcare Improvement (CBO) recently published a guideline concerning both risk prediction and recommendations on primary prevention of CHD. The guideline is based on a national consensus and advises the physician on whether or not to treat the patient's blood pressure or cholesterol, based on the estimated CHD risk. The treatment advice is presented in a risk prediction chart. However, this chart needs manual operation and its use during clinical routine is time-consuming, due to inaccurate reading and the need to interpolate treatment recommendations between different age categories.

Therefore, the goal of this project was to develop an application which, given the patient's major risk factors, automatically calculates the CHD risk and the accompanying CBO treatment advice. For the implementation we had to focus on some special issues. First of all we had to find out what Framingham risk function was used by the CBO and under what conditions the outcome was validated. For this purpose we investigated the validity of two Framingham functions that were published recently. Secondly, the user interface of the application needed to be able to support the physician during his consult with the patient. An important requirement here is a minimal number of actions needed to get an advise presented. Finally, as much of the data on risk factors that is already available in the information system(s) in the hospital should be used. Therefore we have chosen to develop the application as part of the Cardiology Information System (CARIS) of the Leiden University Medical Center.

2. Methods

The risk models published by Anderson et al. (1991) and by Wilson et al. (1998) predict multivariate 10-year CHD incidence in patients without overt CHD. Anderson estimates the risk by using a non-proportional hazards Weibull accelerated failure time model [3]. Wilson

presents a risk model based on a Cox proportional hazards model [4]. Both models are based on the same Framingham population and the same risk factors. The validity of the risk models and that of the CARIS risk application has been verified by studying the generalizability and the performance. The last section of this chapter goes into the design of the user interface of the risk application.

2.1. Generalizability

According to the Framingham Study the ability to provide accurate predictions in different samples of patients is a matter of concern. The study is based on a community sample of middle aged white subjects drawn from a suburb west of Boston. Because of this it overestimates the risk in young people [2]. The risk application will have to present a warning in this, when calculating the risk of patients less than 30 years of age. Also equations may not be directly applicable to populations with very low CHD incidence rates, since the CHD incidence level for the Framingham population is high. However, the major risk factors investigated in the Framingham cohort hold up as risk factors in other populations [3,4,5]. The CBO guideline states that the Framingham risk models are valid for the (white) Dutch population [1].

2.2. Performance

Since both models are based on the same population and the same risk factors, the idea was to investigate to what extent the outcome of the models matched with each other. For this purpose the input range of all risk factors was varied (minimum, average and maximum) and each time the risk function's outcome was noted. This was done for both models, for men and women. Figure 1 shows a scatter plot in which the outcome is compared for men in three age groups. In this plot the model presented by Wilson seems to overestimate the risk for elderly men compared to the model of Anderson. The plot for women showed a similar result. Because there is no information on the outcome's precision one could not tell which model is more accurate. Both authors did not include a clinically usable method for calculating confidence intervals round the absolute risk estimation. However, physicians are normally aware of the fact that risk estimations might be inaccurate.

In spite of the uncertainty that remains about the absolute accuracy, there is an equal discriminatory ability of the prediction models. ROC curves from both models have been found in literature, indicating how well cases (true positives) are separated from non-cases (false negatives) by the risk function. The curves were nearly identical for the continuous and categorical formulations. This results also in a similar area under the curve, indicating an equal predictive capability (examined for members of Framingham cohort) [2].

Generally speaking, both risk models could be used for the risk application. In clinical practice both risk functions result in similar treatment recommendations. However, the choice has been made to implement the accelerated failure time model used by Anderson. This model has a possible advantage because in theory the parametric assumption on the underlying hazard leads to a greater precision of the estimated risk [3,6]. Also, the model can be extended for estimating cardiovascular disease. Knowledge of this risk is an additional clinical value for the physician.

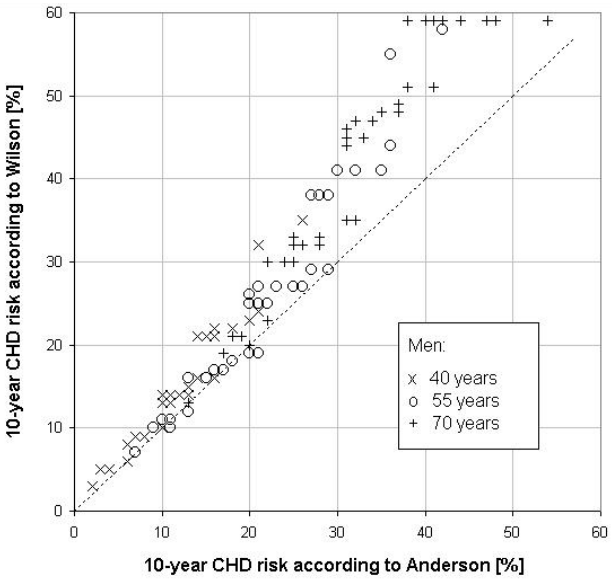

Figure 1. A scatter plot in which the outcome of two different Framingham risk models (Anderson et al.,1991; Wilson et al.,1998) is compared for men in three age groups. The diagonal dotted line indicates where both outcomes would be equal.

2.3. User interface

The IT group of the LUMC department of Cardiology has developed the risk prediction module. This group has longstanding experience from the Cardiology Information System (CARIS) that they developed. CARIS has been developed to store specific cardiology information, such as from the function lab and heart catheterization lab. The CARIS system is connected to the Hospital Information System (HIS) to obtain information such as patient demographics.

The CARIS system can be used to display various results such as ECG, angiographic and echocardiographic images and reports. The outpatient module in CARIS

appeared to be the most logical place to implement the risk prediction module. The risk model was implemented with a Delphi programming environment, just like all other CARIS modules. This way, the risk prediction module can be easily integrated with the necessary entry forms. Various checks have been built into the module to warn the user whenever a certain risk variable is out of range and would thus give an invalid or unreliable result.

Based on the indications for treatment as proposed by the CBO, a decision tree for treatment advice cholesterol and/or blood pressure has been developed. This decision tree was then used to develop the computer algorithm. All branches of the decision tree are based on if-then, else relations, without any undefined endpoints. The treatment recommendations for blood pressure and cholesterol are dependent on the CHD risk and based on age, blood pressure and diabetes.

3. Results

The implemented risk factors are gender, age, systolic blood pressure, ratio of total cholesterol and HDL cholesterol, smoking and diabetes. By selecting the patient, all known risk factors are filled in automatically. Gender, age, blood pressure, diabetes and smoking are referred from the CARIS database. A query on the HIS will give the cholesterol ratio. After that, the absolute 10-year CHD risk is calculated and a treatment advice is presented, according to the CBO guideline.

Still, risk factors can be altered or adjusted manually if necessary. In this way patients can be shown how changes in lifestyle (e.g. quit smoking) change their risk profile. Hints are given when the risk factor is not within the model's acceptance range: a warning will tell the user that the prediction will be extrapolated. Unlike the CBO risk prediction chart there's no need to interpolate between different age categories and there's no problem with inaccurate reading. Figure 2 shows a print screen of the risk application in CARIS.

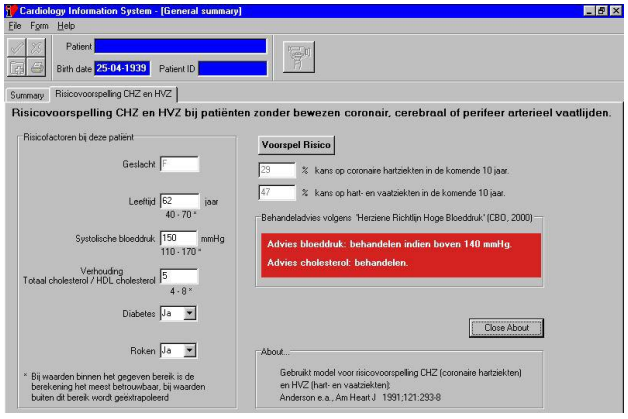

Figure 2. A screenshot of the risk application in CARIS. The left side of the screen shows the risk factors and on the right side the 10-year CHD risk and the treatment advice is given.

After the first period of testing in the outpatient clinic an extra feature was needed. With the CBO risk prediction chart physicians were able to determine graphically whether a treatment advice was close to a "treat/don't treat" threshold. In order to implement this in the risk application the application not only needs to estimate the treatment advice related to the patient's risk factors, but also for a number of surrounding points. The margin between the initial point and surrounding points is chosen from the inaccuracy of +/- 10 mmHg on measuring the patient's blood pressure and a 5% inaccuracy on cholesterol estimating techniques. These clinical relevant margins now determine the surrounding points. The risk application gives a warning when the treatment advice of one of the surrounding points differs from the initial treatment advice. In this way the physician is alerted for treatment thresholds. With his own professional knowledge the physician is able to determine whether which side of the threshold he should choose.

4. Discussion

The CBO treatment recommendation as well as Anderson's risk prediction model is only applicable to people without cardiovascular disease. The present risk prediction module should therefore be regarded as an instrument for primary prevention. However, it would be easy to extend the CARIS risk prediction module with treatment recommendations for secondary prevention. Especially for cardiologists this would have great additional benefit, because many patients come to the cardiologist with known cardiovascular diseases. When, in the future, risk prediction models will be published in which the patient's cardiovascular history can be used as an additional risk factor, this can be added to the present computer application.

Although a lot of research is being done to estimate new risk factors, Anderson's risk function is limited to the factors mentioned in the previous chapter. Adding new risk factors to the risk application is useful when its predictive value is significant and the value can be obtained from CARIS or the HIS.

The effect of the prediction tool is subject of further study. We have discussed our experiences with the development of the risk prediction module with investigators from the Julius Center for Health Sciences and Primary Care. The Julius Center wants to implement a comparable risk prediction module in the information system that is in use with general practitioners. A

research project will be started to determine the effect of automated risk prediction and treatment recommendations on the CHD risk management of the general practitioner.

The present risk prediction tool can also be made available (as a stand-alone application) on the LUMC Cardiology website. This way, the patient can look at the effect of his CHD risk factors at home. However, the treatment advice is something the physician must decide on for each patient individually whether it is suitable or not. Therefore this feature will not be shown on the website.

5. Conclusions

The risk prediction models of the Framingham Heart Study are valid enough to describe the relation between risk variables and the chances for CHD on the Dutch population. The applicability and predictive capability of both the Weibull and the Cox models are equal. Although there seems to be some difference in absolute accuracy, both models result in similar treatment recommendations in clinical practice. We have chosen to use the accelerated failure time model as a basis for a risk prediction module that we have implemented in the Cardiology Information System (CARIS) of the LUMC. Based on the risk variables of a patient, this module gives the chance of suffering from CHD over the next ten years, and is meant as a recommendation for possible treatment (primary prevention).

Since no manual input is necessary, the risk estimation tool is quick and easy to use. With this predictive tool for clinical decision support, the physician can opt for an intervention to minimize disease risk, or prevent risk factor development in the future. Furthermore, patients can be shown how changes in lifestyle may affect their risk profile. Updating the tool with new risk functions or new treatment decision rules is possible. At this moment the effect of using the prediction tool is subject of further study.

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