TakeDecision support for clinical cardiovascular risk assessment

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# 1 Introduction

In this paper we describe a clinical decision support tool which uses BNs as the underlying reasoning engine. This tool, TakeHeartII, supports clinical assessment of risk for coronary heart disease (CHD). CHD comprises acute coronary events including myocardial infarction (heart attack) but excluding stroke. Improved predictions of cardiovascular deaths would allow for better allocation of health care resources and improved outcomes. Amid burgeoning healthcare costs (A$1 billion per year is currently spent on anti-lipid and anti-hypertensive medication in Australia), cost effectiveness has become a dominating consideration for determining which preventive strategies are most appropriate. Improved assessment and better explanation and visualisation of risk in a clinical setting may also help persuade the patient to adopt preventive lifestyle changes.

We have designed TakeHeartII for clinicians who know nothing about BNs. The clinical GUI is generated automatically from the underlying BN structure. Therefore it is simple to update the GUI when the BN is changed (for example, by adding a new node, or changing states). This separation also helps adapt the BN to a new dataset, or to new priors that reflect the population seen in a particular clinical environment.

## 1.1 The Original Take Heart

Monash University's Epidemiological Modelling Unit developed the original Take Heart program [**?** ] in conjunction with BP Australia's Occupation Health Services Department. Take Heart estimated CHD10 risk for approximately 900 BP Australia employees, starting from 1997 and extending for over two and a half years. Take Heart's epidemiological model used equations from the Multiple Risk Factor Intervention Trial (MRFIT) study [**?** ], adjusted so that the background risk factor probabilities fit the Australian population. It used a Microsoft Access database to store cases, and Access macros for the calculations.

## 1.2 TakeHeartII Architecture

Figure 1 shows the architecture for TakeHeartII, divided into the BN construction phase (on the left) and its use in a clinical setting (right). The construction phase depicts the general process described earlier in this chapter, with the BN built using a combination of models from the epidemiological literature, expert knowledge and data. It also includes an adaptation phase, where a BN (built using any method) can be adapted for a different population (such as re-parameterising the PROCAM model from the Busselton dataset, described in Section **??**).

Figure 1: TakeHeartII Architecture: Construction and Adaptation (left) provide BNs used for risk assessment in a clinical setting (right).

## 1.3 TakeHeartII Implementation

We wrote the scripting language *Modular Bayesian Network* (ModBayes) to implement TakeHeartII. ModBayes links a Bayesian network to graphical controls such as drop-down menus, buttons and check-boxes; as well as visualisations such as the chart and risk displays of Figure 2. It also manages a case file associated with the BN. ModBayes allows speedy organisation of the controls and displays on screen: someone knowledgeable in the scripting language could redesign the layout in minutes. In addition, it automatically integrates with the powerful Bayesian Network viewer, *Causal Reckoner* [**? ?** ]. Causal Reckoner inputs BNs in the Netica `.dne` format, and uses Netica as the the BN reasoning engine. It also provides additional functionality for network layout, causal manipulation and causal power. When evidence is entered in the Causal Reckoner, it appears on ModBayes's controls, and vice-versa, which enables the BN display to change according to the needs of the user.

The scripting language itself is a dialect of Lisp, and thus is a full-featured programming language in its own right. This means that the scripting language can be extended (by an advanced user) to create arbitrary Bayesian network interfaces.

## 1.4 TakeHeartII Interface

TakeHeartII's main interface, shown in Figure 2 is divided into two sections. The top section is for case information about the patient being assessed, provided in a survey form style. The clinician inputs information about

the patient where known, which is then entered as evidence in BN by the reasoning engine.

Figure 2: The main GUI for TakeHeartII.

The case title ("Cassy" in the figure) is an editable text field. This title becomes the case label on the risk assessment displays and on the case viewer (described below). In the survey form, answers to multiple choice questions are entered with drop-down boxes and yes-no answers are simple button clicks.

At any stage, the clinician can ask TakeHeartII to make a risk assessment of a CHD in the next 10 years, by clicking the "Enter case" button. If the clinician has entered age information, then TakeHeart displays the extrapolated 10 year risk for the current "case", shown with label Cassy. The case is also saved (with its label) in the case database. The clinician can then modify the current case, for example to show the effect of a life-style change such as quitting smoking. The risk assessment then shows the risk for *both* cases (see Figure 3). The higher curve is her current projected risk, and the lower curve is her projected risk should she quit smoking; clearly, smoking has increased her risk of heart attack substantially. There is no formal limit to the number of cases that can be displayed together, however in practice the size of the screen will dictate a limit of 6-8 cases. At any time, the clinician can clear the charts (to re-start) or show only risk given the current survey case information.

Figure 3: Extrapolated 10 year for (above) 2 Cases and (below) 6 Cases

TakeHeart also provides risk assessment by *age*. Figure 4 shows a category plot of heart attack risk by age, again comparing smokers with non-smokers (the form was filled out the same as for Cassy, but with age left blank). Again, this provides a clear visualisation of the impact of smoking, almost doubling the risk for each age group.

How are the risk assessment values calculated? The category display is simple: the risk for each age group, given the other risk factors, is simply calculated in turn. The extrapolated risk chart is more complex. An exponential curve ($y = e^{mx+c}$), is fitted to two points: the current risk and the risk for someone five years older (or five years younger if the person is in the oldest age range). The exponential distribution is chosen because it matches observed data in how risk increases with age (e.g., [**?** ]).

Figure 4: Heart attack risk by age for a smoker and and a non-smoker.

There are two additional displays provided with TakeHeartII. The first is Causal Reckoner's BN viewer, which is fully integrated into TakeHeartII: when the clinician enters evidence using the survey form, the BN display is also updated, and conversely, if the clinician chooses to enter evidence directly into the viewer (by clicking a value), the survey is updated. The BN viewer may also display non-input (i.e. "intermediate") nodes, whose values are not included in the main survey form, such as the Score nodes in the full PROCAM BN (see Figure **??**). Finally, the Case Viewer allows the clinician to look at the history of cases entered into TakeHeart.

Here we have only sketched TakeHeartII's main features. Full details, including the extrapolation algorithm/method, are provided in [**?** ]. A prototype version of TakeHeartII is currently being evaluated by our medical research collaborators and a clinical evaluation is being planned.

## References


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