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Design of stepwise screening for prediabetes and type 2 diabetes based on costs and cases detected

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Abstract

Objectives: To provide insight into the trade-off between cost per case detected (CPCD) and the detection rate in questionnaire-based stepwise screening for impaired fasting glucose and undiagnosed type 2 diabetes.

Study Design and Setting: We considered a stepwise screening in which individuals whose risk score exceeds a predetermined cutoff value are invited for further blood glucose testing. Using individual patient data to determine questionnaire sensitivity and specificity and external sources to determine screening costs and patient response rates, we rolled back a decision tree to estimate the CPCD and the detection rate for all possible cutoffs on the questionnaire.

Results: We found a *U*-shaped relation between CPCD and detection rate, with high costs per case detected at very low and very high detection rates. Changes in patient response rates had a large impact on both the detection rate and the CPCD, whereas screening costs and questionnaire accuracy mainly impacted the CPCD.

Conclusion: Our applied method makes it possible to identify a range of efficient cutoffs where higher detection rates can be achieved at an additional cost per detected patient. This enables decision makers to choose an optimal cutoff based on their willingness to pay for additional detected patients.

Keywords: Screening; Decision analysis; Primary prevention; Technology assessment; Health services research; Diabetes mellitus; Type 2; Prediabetic state

1. Introduction

Type 2 diabetes mellitus (DM2) is a disease associated with a large burden at both patient and societal level. In Europe, an estimated 56.3 million people aged 20−79 years have diabetes, of which 90% have DM2. The associated direct health care costs amounted to €111 billion in 2013 [1]. DM2 is therefore widely considered to be a major public health problem. There are two main strategies to address this issue [2]. First is the reduction in the incidence of DM2-related complications through the early detection and treatment of asymptomatic DM2 patients (secondary prevention). Second is the provision of interventions aimed at slowing down the progression to DM2 in patients considered to be at high risk of developing DM2 (primary prevention), which is usually defined in terms of the presence or absence of prediabetes [i.e., impaired glucose tolerance or impaired fasting glucose (IFG)]. As both strategies rely on blood glucose testing to either diagnose DM2 (secondary prevention) or to diagnose prediabetes and rule-out undiagnosed DM2 (primary prevention), a practical implementation of the second strategy results in finding undiagnosed DM2 patients as well. As a result, the combined screening for prediabetes and previously undiagnosed DM2 is more efficient and has gained widespread interest in the past years [3−5].

The target population for prediabetes and DM2 screening includes a large part of the entire population, but prevalences are low. Consequently, economic and logistic aspects of screening tools are an important consideration. To that end, blood glucose testing is generally considered too burdensome and costly to be applied in all individuals eligible for

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What is new?

Key findings

- This study demonstrates a practical method to gain insight into the trade-off between feasibility (costs) and detection rate in stepwise screening and applies this method to the case of stepwise screening for (pre)diabetes.

What this adds to what was known?

- We found that only a small range of cutoffs on the first test in a stepwise screening for (pre)diabetes is efficient.

What is the implication and what should change now?

- When a stepwise screening program for (pre)diabetes or otherwise is initiated, the implications of the choice of cutoff on the costs and detection rate can and should be evaluated to prevent wasteful spending of resources.

screening [6−9]. Instead, consensus has been reached that screening should proceed in a stepwise manner by first making a preselection of high-risk individuals and then inviting those exceeding a predetermined threshold for further blood glucose testing. Risk questionnaires based on a small set of biocharacteristics have shown to be accurate predictors of DM2 risk, while being a relatively inexpensive form of testing [10,11]. Stepwise screening using a risk questionnaire has therefore found its way into several guidelines [12−14].

Although the strategy of stepwise screening is more feasible and practical, it inevitably also leads to a number of undiagnosed DM2 and prediabetes patients remaining undetected. Stepwise screening thus presents a trade-off between feasibility, often measured in terms of the cost per case detected (CPCD) [15−17], and the detection rate (percentage of patients with disease in the target population that are detected through screening [18]). In current guidelines, the selection of the cutoffs was based on an arbitrary value of absolute risk [12,13] or was not supported at all [14]. It therefore seems that the economic aspects were not explicitly considered during the formation of these guidelines, which may have been caused by the lack of insight into the trade-off between the CPCD and the detection rate.

In this article, we seek to provide insight into the trade-off between CPCD and detection rate that comes with choosing a cutoff on a risk questionnaire. Furthermore, we want to estimate the effects of changes in patient response rates, screening costs, and questionnaire accuracy within the strategy of questionnaire-based stepwise screening on this trade-off.

2. Methods

2.1. Structure of the stepwise screening program

The stepwise screening program evaluated in this study was based on the Dutch guideline "Preventieconsult" [13]. This guideline was developed to identify individuals at an increased risk for developing cardiovascular diseases, DM2, and kidney damage. We adapted this strategy to focus solely on IFG and DM2 by assuming the use of a dedicated DM2 questionnaire based on a version of the Finnish Diabetes Risk Score (FINDRISC) validated in the Dutch population [19].

The protocol for the screening program is as follows. Screening is initiated through the general practitioner (GP) office by sending a questionnaire to all registered individuals of between the ages of 40 and 75 years who have not been diagnosed with DM2 before. This questionnaire is returned to the GP office and assessed by the GP or a nurse. All individuals with a score equal to or above a predetermined cutoff value are invited for a consult and instructed to follow an 8-hour fasting protocol. At the consult, the answers of the questionnaire are verified and discussed and a fasting plasma glucose test is performed using a plasma calibrated capillary blood glucose meter. All patients with fasting plasma glucose levels of 6.1 mmol/L or higher are invited for a second consult and instructed to follow the fasting protocol again. During the second consult, another fasting plasma glucose test is performed. The final diagnosis is based on the lower of the two test results. Thus, patients are diagnosed with DM2 if their fasting plasma glucose levels on both tests are 7.0 mmol/L or higher, with IFG if their fasting glucose level for the second test is between 6.1 mmol/L and 7.0 mmol/L, and with normal fasting glucose if their fasting plasma glucose level on the second test is below 6.1 mmol/L.

2.2. Risk questionnaire

The Dutch version of the FINDRISC questionnaire used in our screening design calculates a risk score based on five patient characteristics. These characteristics and the maximum number of points that can be acquired for each are age (four points), body mass index (BMI) (three points), waist circumference (four points), the use of antihypertensives (two points), and the occurrence of parental diabetes (five points). This means that a patient can score between 0 points (lowest risk) and 18 points (highest risk) [19]. The original version of the Dutch FINDRISC questionnaire includes an item on previously diagnosed DM2. As this was an exclusion criterion for the screening protocol as defined in the guideline, we removed this item from the questionnaire in our study.

2.3. Study population

The assessment of the stepwise screening program was performed using data from the PREVEND Groningen