The Performance of the Finnish Diabetes Risk Score (FINDRISC) in Detecting Undiagnosed Type 2 Diabetes among Kenyan adults aged 18–69 years

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Abstract

Background: Diabetes mellitus is growing to epidemic proportions especially in LMICs. The disease is often undiagnosed until clinical manifestation of related complications. Africa, has the highest proportion of undiagnosed diabetes and in Kenya, is estimated at 53%. Studies have however demonstrated that early diagnosis & prevention delays its onset and related complications. Diagnosing & screening diabetes in Kenya, is however costly and not readily available. The alternative use of diabetes screening risk score tools advocated such as FINDRISC have not been validated for use in Kenya. We therefore aimed to measure the performance of the FINDRISC as a screening tool for undiagnosed type 2 diabetes among Kenya adults.

Methods: A secondary analysis of a Kenya STEPwise cross-sectional survey conducted between April and June 2015 was carried out. The modified FINDRISC and simplified FINDRISC versions were created based on available secondary data and regression analyses performed. Non-parametric analyses of the areas under the receiver operating characteristics curve (AUC), and statistics of the modified FINDRISC and simplified FINDRISC diagnostic tests were analyzed.

Results: A total of 4,027 data observations of individuals aged 18–69 years were analyzed. The prevalence of undiagnosed diabetes and prediabetes were estimated at 1.8% and 2.6% respectively. The AUC of the modified FINDRISC and simplified FINDRISC in detecting undiagnosed diabetes were 0.7481 and 0.7486 respectively, with no statistically significant difference ($p=0.9118$). With an optimal cut-off ≥ 7 , the simplified FINDRISC had a higher PPV (7.9%) and diagnostic odds (OR:6.65, CI: 4.43 – 9.96) of detecting undiagnosed T2D than the modified FINDRISC.

Conclusion: The simple and non-invasive modified FINDRISC and simplified FINDRISC tools performed well in detecting undiagnosed diabetes and may be useful in the Kenyan population and other similar population settings. Considering the context of the Kenyan population settings, the simplified FINDRISC is preferred.

1. Background

Globally, diabetes mellitus, which refers to a disease that affect how one's body uses blood glucose, is growing to epidemic proportions owing to rising levels of obesity, physical inactivity and inappropriate diet (1). In 2019, global estimates of diabetes among 20–79 year old adults was 463 million, and was projected to rise beyond 700 million by 2045. Type 2 diabetes (T2D) is the most common, accounting for almost 90% of all diabetes cases worldwide, and results mainly from a confluence of environmental, behavioral and/or genetic factors (2). T2D is often asymptomatic in its earliest stages, with many cases remaining undiagnosed until clinical manifestation of related complications, especially at the micro- and macro- vascular levels (2–4). Africa, has the highest proportion of undiagnosed diabetes at 59.7% compared to other regions in the world (2, 5). In Kenya, the proportion of undiagnosed T2D is estimated at about 53% (5, 6), almost the same as that of the continental average.

Undiagnosed T2D is a major risk factor for death and other severe health complications, such as: blindness, cardiovascular complications, peripheral artery disease, among others (7–9). The economic burden of treating diabetes and its related complications is likewise enormous and, affects household's income and savings, propagating the spiral of ill health and poverty. The loss of productivity and healthcare costs incurred also

threatens national economies (10, 11). However, studies have demonstrated that effective prevention and early detection delays the onset of diabetes and its complications, and prevents associated premature deaths (12, 13). Current diabetes diagnosis and/or targeted screening strategies such as: glycated hemoglobin, fasting plasma or 2-hourly random glucose measurement and point of care capillary blood glucose measurement recommended for use in low and middle income countries (LMICs) (14), are invasive, inconvenient and not feasible for population-wide screening (15, 16).

Additionally, health care systems in LMICs especially at primary care settings do not have sufficient human resource and diagnostic capacity to implement recommended diabetes diagnosis and/or screening strategies (17). The use of diabetes risk scores as active community diabetes screening tools have thus been advocated for, to identify high-risk asymptomatic individuals and prevent them from progressing to impaired glucose tolerance or overt diabetes. Among the many diabetes risk score tools developed from different populations to identify individuals at high-risk of developing T2D (18–23), is the Finnish Diabetes Risk Score (FINDRISC). It is the most widely used risk score owing to its validity and ease of applicability.

Although, the FINDRISC has been validated and used as a screening tool across European (24), and in some LMICs (25, 26), there is no evidence of its validation and use in Kenya. Population-based diabetes screening by measuring fasting blood glucose is not only a costly and invasive technique, but is also not practical and, not readily available in the community and primary care settings in some LMICs and Kenya in particular (27, 28). This study therefore aimed to measure the performance of the FINDRISC in detecting undiagnosed T2D among adults (18 – 69) years in Kenya.

2. Methods

2.1 Study Design

The study design, sampling, and implementation of the Kenya STEPwise survey has been described elsewhere (29). In brief, the 2015 Kenya STEPwise survey was a national cross-sectional household survey, designed with the aim of providing estimates for indicators on non-communicable diseases (NCDs) risk factors among adults in Kenya aged 18–69 years between April and June 2015.

2.2 Study population

A multi-stage stratified sampling design involving a selection of clusters, households and eligible Individuals was used to select a representative sample of the general adult population of Kenya. The sample size was estimated using a standard formula on the basis of a 50% prevalence of risk factors as no representative figures were available for the Kenya population at that time. A three stage cluster sample design was used; in the first stage, 200 clusters (100 urban and 100 rural) were selected. In the second stage, a uniform sample of 30 households were selected from the listed households in each cluster, while in the third stage, one individual was randomly selected from all eligible listed household members. With a target of 30 households from each cluster, a minimum sample size of 6,000 individuals was derived to allow for national estimates as per sex and residence (rural or urban). A total of 4500 subjects were successfully interviewed.

To produce unbiased estimates, sampling weights derived from the creation of a fifth National Sample Survey and Evaluation Programme (NASSEP V) master sampling frame from the Kenya National Bureau of Statistics,

developed using the enumeration areas generated from the 2009 Kenyan Population and Housing Census was used. Participant selection processes were calculated as the inverse of all selection probabilities. Eligible participants were selected using Kish sampling procedure. Inclusion criteria were all those subjects aged 18 to 69 years living in the household selected for more than six months. Exclusion criteria were pregnancy; inability to stand or communicate; or refusal to participate in the survey by not signing the informed consent.

The study protocol was designed in compliance with the Helsinki declaration and approved by the Kenya Medical Research Institute (KEMRI) Ethics Committee. All participants gave informed consent to study procedures prior to primary data collection. For this analysis, approval was obtained from the World Health Organization (WHO) NCD microdata repository (30), and access to data use provided by WHO STEPS team data repository administrator. The present report is presented according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (31)

2.3 Data Collection

The STEPwise data used in this study consisted of Step 1 to Step 3 data. All data collectors were trained on study protocol, human subject protection and supervised during actual data collection. The Step 1 data included: Socio-demographics and self-reports of NCD behavioral risk factors such as: tobacco use, past medical histories of raised blood pressure and diabetes mellitus, physical activity—assessed using Global Physical Activity Questionnaire developed by WHO (32) among others.

Step 2 data comprised of physical measurements: height, weight, blood pressure, waist and hip circumferences. Weight was measured (to the nearest 0.1 kgs) using a pre-calibrated digital weighing scale (SECA® 877), while participant stood barefoot with light clothing and standing height to the nearest 0.5 cm using a portable stadiometer (SECA® 877).

Waist circumference (to the nearest 0.5 cm) was measured using a constant tension standard tape measure and measurement was taken midway between the lowest rib and iliac crest. Blood pressure measurement was taken with participant in a sitting position using a validated digital blood pressure machine (OMRON M2 device). Three readings were taken 3–5 minutes apart for both systolic and diastolic pressure in accordance with WHO guidelines (33).

Step 3 data were biochemical measurements taken after overnight fasting, and included: total cholesterol, high density lipoprotein cholesterol (HDL-C) and fasting blood glucose (FBG). Finger-prick blood samples were collected and analyzed using a Point of Care CardioCheck® PA analyzer. A total of 4,178 observations of participants that completed Step 3 survey procedures were considered for this secondary analysis. Of those, 15 data observations with age records below 18 years and 136 data observations of records of pregnant participants were excluded leaving a final sample size of 4,027 data observations.

2.4 Definitions

For this study, impaired fasting glycaemia (IFG) was defined as fasting capillary whole blood ≥ 6.1 mmol/l but less than 7.0 mmol/l while diabetes mellitus was defined as fasting capillary whole blood ≥ 7.0 mmol/l (34–36). Hypertension was defined as systolic blood pressure ≥ 140 mmHg and diastolic blood pressure ≥ 90 mmHg or previous diagnosis of hypertension or taking medication for raised blood pressure (33). Body Mass Index (BMI) was computed by dividing the weight (kgs) by the height in meter squared (m^2), and used to develop

categories of underweight, normal weight, overweight and obesity (37). Abdominal obesity was measured as waist circumference ≥ 94 cm for men and ≥ 80 cm for women (38). Physical activity was expressed as self-reports of minutes of moderate or vigorous intensive physical activity per week and derived from the WHO Global Physical Activity Questionnaire (32). Dyslipidemia was defined as total cholesterol ≥ 5.0 mmol/l and/or HDL-C < 1.0 mmol/l in men and < 1.3 mmol/l in women (39).

2.5 Original Finnish (FINDRISK) diabetes risk score

The FINDRISC is a simple diabetes risk score tool original developed in Finland to predict incident diabetes among the Finnish population aged 35–64 years. (insert reference). It's based on eight simple diabetes risk factors including: age (years), BMI (kgs/m²), waist circumference (cm), history of high blood pressure, history of raised blood sugar, family history of diabetes, daily consumption of fruits or vegetables and daily physical activity(20). The tool does not require laboratory investigations, and has different weighted score according to the associated risk, with the final score ranging from 0 to 26(24).

2.6 Statistical Analyses

All statistical analyses were done using Stata version 14.0 (StataCorp LP, Texas, USA). All data for this analysis were weighted based on the primary data survey weights. Continuous variables were presented as median (IQR), and categorical variables as absolute and weighted frequencies. The prevalence and 95% confidence interval (95% CI) of IFG and undiagnosed T2D were calculated. Weighted logistic regression analyses were performed and because data were not normally distributed and contained outliers, non-parametric Receiver Operating Characteristic (ROC) curve of the modified and simplified FINDRISC scores were constructed to demonstrate the true positive and false positive relationships and AUC determined. Sensitivity, specificity, diagnostic accuracy, positive predictive values (PPV), negative predictive values (NPV), positive and negative likelihood ratios (LHRs), and diagnostic odds ratio (OR) of the risk score tools were also determined. The optimal cut-off points were determined as the points with the shortest distance in the ROC curve and, calculated as the square root of $[(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2]$ (40).

2.7 Creating a modified FINDRISC

Modifications to the original FINDRISC tool were made on the basis of available secondary analysis data. The primary study data collection instrument had no question on parental/family history of diabetes thus, data to that specific risk factor was not collected. However, data to the other FINDRISC tool question components: age, BMI, waist circumference, physical activity, fruit and/or vegetable consumption, personal histories of hypertension and diabetes were collected, and are what were considered in this analysis. The same original FINDRISC score for the different risk factor components were maintained. With this modification, the maximum score of the modified FINDRISC thus reduced from 26 of the original FINDRISC to 20.

2.8 Creating a simplified FINDRISC

The modified FINDRISC was further simplified based on logistic regression and ROC curve analyses. Fruit and/or vegetable consumption, and physical activity variables did not significantly influence the AUC in detecting undiagnosed T2D. With this analysis consideration, fruits and/or vegetable consumption and physical activity were excluded, to further simplify the FINDRISC tool. Only age, BMI, waist circumference and histories of diabetes and hypertension were retained, creating a simplified FINDRISC, with a maximum score 18.

3 Results

3.1 Descriptive analysis

From a total sample of 4500 data observations, a final sample size of 4,027 observations of non-pregnant individuals aged 18–69years (median: 35 [IQR:27 – 47]) were analyzed. Characteristics of participants in terms of FINDRISC risk factors are as shown in Table 1. The weighted prevalence of undiagnosed T2D was 1.8% and that of prediabetes was 2.6%. According to gender, women had a higher weighted prevalence of undiagnosed T2D (2.4% [CI: 1.7–3.3]) and prediabetes (2.8% [CI: 2.1–3.8]) than was noted among men (1.3% [CI: 0.7–2.3]) and (2.3% [CI: 1.5–3.4]) respectively. Summary of the descriptive analysis is as indicated in Table 1.

3.2 Modified FINDRISC

Overall, the modified FINDRISC scores ranged from 0 to 20, with a median of 3 (IQR:1–6). Participants with undiagnosed T2D had a score range of 0 to 18, with a median of 9 (IQR:3–12). The median score and IQR differed for both undiagnosed T2D and prediabetes across gender. The AUC of the modified FINDRISC in detecting undiagnosed T2D and prediabetes was 0.748 (CI: 0.692–0.804) and 0.631 (CI: 0.576–0.685) respectively (Table 2).

3.3 Simplified FINDRISC

With the simplified FINDRISC, scores ranged from 0 to 18, with a median of 2 (IQR:0–5). Participants with undiagnosed T2D and prediabetes identified by simplified FINDRISC had a median of 8 (IQR:3–11) and 5 (IQR:1–8) respectively. The AUC of the simplified FINDRISC in detecting undiagnosed T2D and prediabetes was 0.749 (CI: 0.692–0.805) and 0.636 (CI: 0.583–0.688) respectively. The median score and IQR differed for both undiagnosed T2D and prediabetes across gender (Table 2). However, there was no statistical difference ($P = 0.9118$) between the modified and simplified FINDRISC in detecting undiagnosed T2D as shown in Fig. 1.

Table 3 below shows the sensitivity, specificity, diagnostic accuracy, PPV, NPV, LHRs, and the diagnostic OR of six different cut-off points of the modified and simplified FINDRISC if used as tools for screening undiagnosed T2D. With a cut-off of ≥ 7 , the modified FINDRISC had a 2% higher sensitivity but with a 3.3% lower specificity level than the simplified FINDRISC. The diagnostic accuracy is the same (0.70) but the simplified FINDRISC had a higher PPV (7.9%) and diagnostic odds (OR:6.65, CI: 4.43–9.96) of detecting undiagnosed T2D than the modified FINDRISC.

4 Discussion

The FINDRISC tool has largely been validated in Caucasian populations and widely recommended as a simple T2D screening tool across Europe and in other various population settings (24, 41–43) but has to a less extent been validated in the African setting (44). Using data from a large national cross-sectional survey, the obtained AUC of the modified and simplified FINDRISC were 0.748 and 0.749 respectively. This performance was lower than the AUC of 0.87 obtained in the first validation study among the Finnish population (20) but better than some other validation studies conducted in: Finland with AUC of 0.727 (24); Bulgaria with AUC of 0.70 (42) and Greece with AUC of 0.724 (41). More so, the performance was again better than the findings from a large primary care study conducted in Spain with AUC of 0.69 (45). This study findings were generally similar to other several validation studies conducted in diverse settings, with AUC ranging between 0.65 and 0.88 (41, 44, 46). As such, the FINDRISC can be adopted and utilized in community screening of T2D in Kenya and other similar contexts.

Although, there are insufficient data on prior FINDRISC use in the African settings, a study from South Africa that used a simplified FINDRISC with only 6 risk factor (age, BMI, waist circumference, personal histories of hypertension and diabetes, and parental/family history of diabetes) in a diverse racial population of Cape Town, had comparable AUC findings of identifying T2D. Similarly, findings from another cross-sectional study conducted in Botswana had comparable but slightly lower AUC of 0.63 (47). Additionally, findings from a study conducted in Algeria to identify individuals with dysglycemia using FINDRISC was similarly lower, with AUC of 0.64 (48). Despite the low performance of the FINDRISC documented in a few studies conducted in some African countries, this study's overall findings of AUC of 0.748 is better than in other contexts, and thus useful in detecting people who might have undiagnosed T2D and should receive a diagnostic test (49).

The observed differences could be in part, attributable to diverse population characteristics and the genetic variants inherent in the African population, and the possible use of different diabetes diagnostic tests such as: glycated hemoglobin, FBG or Oral glucose tolerance test (OGTT) that have varying sensitivities and specificities in different settings (50, 51).

At univariate and multivariate analyses, physical activity and fruit or vegetable consumption variables were excluded because they were not associated with undiagnosed T2D. Additionally, a weighted proportion of 1.6 % of those who reported engaging in daily physical activity for at least 30 minutes had undiagnosed T2D and 0.8 % of those who reported daily consumption of fruits and/or vegetables too had undiagnosed T2D. With these adjustments, there was no statistically significant difference ($P = 0.9118$) between the simplified FINDRISC and the modified FINDRISC in detecting individuals with undiagnosed T2D.

To maximize true positive rates and minimize false negative rates, the optimal cut-off score of the FINDRISC was selected based on the trade-off between sensitivity and specificity, diagnostic accuracy, predictive values and the diagnostic odds. With a cut-off score of ≥ 7 the simplified FINDRISC had a fairly acceptable sensitivity and specificity and, attained reasonable predictive values and diagnostic odds of detecting more individuals with undiagnosed T2D than with the modified FINDRISC. However, with a cut-off of ≥ 8 , both the modified FINDRISC and simplified FINDRISC had similar diagnostic accuracy as with a cut-off of ≥ 7 but with lower sensitivity of 55.6% and 50.5% respectively. A cut-off score of ≥ 7 was therefore settled for, sacrificing a few PPV and diagnostic odds points but with a better sensitivity gain.

Using a **simplified FINDRISC** and the cut-off of 7 or more, 57.6% of those with a total score ≥ 7 will be true positive while 83.0% of those whose total scores ≤ 7 will be true negatives. On the other hand, using a **modified FINDRISC** and its optimal cut-off of 7 or more, 59.6% will be true positives while 79.7% will be true negatives. For this study, using a simplified FINDRISC than the modified FINDRISC, and taking the same risk cut-off of 7 or more, the number of people identified for a laboratory test narrowed from 858 (21%) to 723 (18.0%) and the prevalence of undiagnosed T2D increased from a pre-test probability of 1.8% to a post-test probability of 7.9% for simplified FINDRISC compared to 6.9% for modified FINDRISC.

Study strengths and limitations.

The main strength of this study is the use of a large national cross-sectional survey data. On the other hand, one of the limitations of this study is that it did not evaluate the detection of future incident diabetes because the STEPwise cross-sectional survey did not provide follow up data. However, FINDRISC was developed to detect undiagnosed diabetes and predict future incident diabetes (20). The other limitation is the use of self-reported

physical activity and fruit and/or vegetable consumption data among other forms of self-reported data that may have attenuated this study findings. There is also potential uncertainty surrounding the realization of participant fasting glucose state although study procedures required measurement of blood glucose after participant overnight fasting.

Conclusion

The performance of the modified and simplified FINDRISC in detecting undiagnosed T2D in Kenya was lower than the findings of the original FINDRISC but with an acceptable diagnostic AUC of 0.7486. With the modifications made to the FINDRISC, the tool can be usefully applied for community screening of diabetes in the Kenyan population and at cut-off score of ≥ 7 the simplified FINDRISC can reasonably discriminate individuals with diabetes from those without, making diabetes diagnosis more cost effective.

List Of Abbreviations

T2D: Type 2 diabetes

FINDRISC: Finnish Diabetes Risk Score

NCDs: Non Communicable Diseases

HDL-C: High density lipoprotein cholesterol

FBG: Fasting blood glucose

IFG: Impaired fasting glycaemia

ROC: Receiver operating characteristic curve

AUC: Area under curve

PPV: Positive predictive value

NPV: Negative predictive value

LHRs: Likelihood ratios

BMI: Body mass index

IQR: Interquartile range

WHO: World Health Organization

LMICs: Low middle income countries

NASSEP V: Fifth National Sample Survey and Evaluation Programme

Declarations

Ethics approval and consent to participants

Primary survey study approval was obtained from Kenya Medical Research Institute's Ethics Review Committee (SSC No. 2607). Written Informed consent from all subjects was obtained and filed prior to enrollment and collection of data in the primary study. For this secondary data analysis, approval was obtained from WHO STEPS team data repository administrator.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no known competing interests.

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Not applicable

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Authors' contributions

MBI conceived the study, conducted literature review, applied for data access, did the statistical analysis and drafted the manuscript. DTK and STW reviewed the draft manuscript, provided input and critical comments. JVO provided substantial contribution in reviewing the draft manuscript, provided input and critical comments. All authors read and approved the final manuscript.

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Tables

Table 1
Characteristics of study participants, according to normal fasting glucose, impaired fasting glucose and diabetes.

	Missing (%)	Gender (M/F)	All, n = 4,027	Normoglycemia, n (weighted %) 3,805 (95.6)	Elevated fasting blood glucose	
					Prediabetes n (weighted %) 123 (2.6)	Diabetes n (weighted %) 99 (1.8)
Proportion/Prevalence [95% CI]				95.6% [94.4–96.5]	2.6% [1.9–3.4]	1.8% [1.3–2.6]
Gender distribution, Proportion/Prevalence [95% CI]		M	50.6% [47.8–53.4]	96.4% [95.0–97.4]	2.3% [1.5–3.4]	1.3% [0.7–2.3]
		F	49.4% [46.6–52.2]	94.7% [93.3–95.9]	2.8% [2.1–3.8]	2.4% [1.7–3.3]
Age (years)		M	36 (27 – 47)	35 (27 – 46)	40 (30 – 56)	44 (35 – 55)
		F	35 (27 – 47)	35 (27 – 46)	37 (29 – 58)	51 (40 – 60)
BMI (kgs/m ²)	14 (0.35)	M	21.6 (19.5 – 24.0)	21.6 (19.5 – 23.9)	21.1 (19.1 – 26.2)	23.0 (18.5 – 26.8)
		F	23.5 (20.4 – 27.5)	23.3 (20.3 – 27.2)	24.2 (21.4 – 29.4)	27.9 (23.7 – 30.5)
Waist circumference (cm)	8 (0.2)	M	78.0 (72.0 – 85.0)	78.0 (72.0 – 85.0)	81.3 (74.0 – 91.0)	81.0 (71.5 – 95.0)
		F	79.5 (72.0 – 89.0)	79.0 (71.5 – 88.0)	85.0 (76.0 – 94.0)	90.0 (75.0 – 99.0)

Data are presented as median (IQR), IQR: Inter Quartile Range; and n (weighted %) unless otherwise specified; BMI: Body Mass Index; BP: Blood Pressure; FBG: Fasting Blood Glucose; n: count number; CI: Confidence Interval.

	Missing (%)	Gender (M/F)	All, n = 4,027	Normoglycemia, n (weighted %) 3,805 (95.6)	Elevated fasting blood glucose	
					Prediabetes n (weighted %) 123 (2.6)	Diabetes n (weighted %) 99 (1.8)
Systolic BP (mmHg)	2 (0.05)	M	125.0 (116.5 – 135.5)	125.0 (116.5 – 135.0)	129.5 (120.0 – 151.5)	129.0 (112.5 – 150.0)
			120.5 (111.5 – 132.0)	120.0 (111.5 – 131.5)	121.6 (109.5 – 138.5)	132.5 (118.5 – 152.0)
		F				
Diastolic BP (mmHg)	2 (0.05)	M	81.0 (73.5 – 88.5)	81.0 (73.5 – 88.0)	82.0 (73.0 – 93.5)	84.8 (73.0 – 100.0)
		F	81.5 (74.5 – 89.0)	81.5 (74.0 – 88.5)	82.0 (74.6 – 90.0)	88.0 (79.0 – 95.5)
Physical inactivity (< 30 minutes/day)		M	55 (1.9)	53 (3. 5)	0 (0)	2 (0.3)
		F	114 (1.6)	100 (2.8)	8 (0.2)	6 (0.1)
Daily Fruit & vegetable consumption (No)		M	891 (1.9)	851 (5.6)	23 (1.1)	17 (0.8)
		F	1,358 (1.6)	1,280 (5.5)	49 (1.8)	29 (1.3)
High BP history (mmHg) or on medication		M	109 (2.8)	97 (4.8)	6 (0.3)	6 (0.4)
		F	335 (5.9)	295 (10.8)	13 (0.3)	27 (0.9)
High blood glucose history		M	21 (2.8)	14 (0.7)	2 (0.2)	5 (0.1)
		F	48 (5.9)	24 (0.6)	4 (0.1)	20 (0.8)
Data are presented as median (IQR), IQR: Inter Quartile Range; and n (weighted %) unless otherwise specified; BMI: Body Mass Index; BP: Blood Pressure; FBG: Fasting Blood Glucose; n: count number; CI: Confidence Interval.						

Table 2

Modified and simplified Finnish Risk Score according to normal fasting glucose, impaired fasting glucose and diabetes.

		All, n = 4,027	Normoglycemia, n (weighted %) 3,805 (95.6)	Elevated fasting blood glucose	
				Prediabetes n (weighted %) 123 (2.6)	Diabetes n (weighted %) 99 (1.8)
Modified Finnish Diabetes Risk Score, by gender	Median score [IQR]	3 [1– 6]	3 [1–6]	5 [1–8]	9 [3–12]
	Male	2 [1– 4]	2 [1–4]	3 [1–7]	5.5 [2–8]
	Female	4 [1– 7]	4 [1–7]	7 [3–9]	10 [5–13]
	Range	0–20	0–19	0–18	0–18
	ROC-AUC [95% CI]			0.631 [0.576– 0.685]	0.748 [0.692– 0.804]
Simplified Finnish Diabetes Risk Score, by gender	Median score [IQR]	2 [0– 5]	2 [0–5]	5 [1–8]	8 [3–11]
	Male	1 [0– 3]	1 [0–3]	2 [0–6]	4.5 [1–8]
	Female	3 [0– 7]	3 [0–6]	6 [3–8]	9 [5–12]
	Range	0–18	0–18	0–17	0–18
	ROC-AUC [95% CI]			0.636 [0.583– 0.688]	0.749 [0.692– 0.805]
95% CI: Confidence Interval; n: counts; ROC-AUC: area under the receiver operating characteristics curve.					

Table 3

Sensitivity, specificity, AUC, predictive values likelihood ratios and diagnostic odds ratios of different cut-off points of the modFINDRISC and simpFINDRISC in the diagnosis of undiagnosed diabetes.

Cut-off	N, Population Identified (% tot pop)	Sensitivity (%)	Specificity (%)	Diagnostic accuracy	PPV (%)	NPV (%)	(+) LR	(-) LR	Diagnostic Odds	
									OR	95% CI
Modified FINDRISC										
≥ 4	1,764 (43.8)	72.7	56.9	0.65	4.1	98.8	1.69	0.35	3.52	2.26–5.49
≥ 5	1,417 (35.2)	69.7	65.7	0.68	4.9	98.9	2.03	0.46	4.40	2.86–6.77
≥ 6	1,110 (27.6)	64.6	73.4	0.69	5.8	98.8	2.43	0.48	5.04	3.33–7.63
≥ 7	858 (21.3)	59.6	79.7	0.70	6.9	98.7	2.93	0.51	5.78	3.85–8.67
≥ 8	638 (15.8)	55.6	85.2	0.70	8.6	98.7	3.74	0.52	7.17	4.79–10.74
≥ 9	472 (11.7)	49.5	89.2	0.69	10.9	98.6	4.60	0.57	8.12	5.42–12.17
Simplified FINDRISC										
≥ 4	1,531 (38.0)	72.7	62.9	0.68	4.7	98.9	1.96	0.43	4.51	2.90–7.03
≥ 5	1,219 (30.3)	67.7	70.7	0.69	5.5	98.9	2.31	0.46	5.05	3.30–7.71
≥ 6	920 (22.8)	58.6	78.1	0.68	6.3	98.7	2.67	0.53	5.03	3.36–7.54
≥ 7	723 (18.0)	57.6	83.0	0.70	7.9	98.7	3.40	0.51	6.65	4.43–9.96
≥ 8	484 (12.0)	50.5	88.0	0.70	10.4	98.6	4.57	0.56	8.21	5.48–12.31
≥ 9	396 (9.8)	43.4	91.0	0.67	10.9	98.5	4.83	0.62	7.78	5.16–11.72
PPV: positive predictive value; NPV: negative predictive value; (+)LR: positive likelihood ratio; (-) LR: negative likelihood ratio; OR: odds ratio; 95% CI: 95% confidence interval										

Figures

Figure 1

ROC comparison between modified FINDRISC and simplified FINDRISC

Supplementary Files

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- [AppendixA.pdf](#)