ORIGINAL ARTICLE

Simple risk score to detect rural Asian Indian (Bangladeshi) adults at high risk for type 2 diabetes

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ABSTRACT

Aims/Introduction: To develop and evaluate a simple, non-invasive, diabetes risk score for detecting individuals at high risk for type 2 diabetes in rural Bangladesh.

Materials and Methods: Data from 2,293 randomly selected individuals aged $\geq$20 years from a cross-sectional study in a rural community of Bangladesh (2009 Chandra Rural Study) was used for model development. The validity of the model was assessed in another rural cross-sectional study (2009 Thakurgaon Rural Study). The logistic regression model used included age, sex, body mass index, waist-to-hip ratio and hypertension status to predict individuals who were at high risk for type 2 diabetes.

Results: On applying the developed model to both cohorts, the area under the receiver operating characteristic curve was 0.70 (95% confidence interval 0.68–0.72) for the Chandra cohort and 0.71 (95% confidence interval 0.68–0.74) for the Thakurgaon cohort. The risk score of >9 was shown to have the optimal cut-point to detect diabetes. This score had a sensitivity of 62.4 and 75.7%, and specificity of 67.4 and 61.6% in the two cohorts, respectively. This risk score was shown to have improved sensitivity and specificity to detect type 2 diabetes cases compared with the Thai, Indian, Omani, UK, Dutch, Portuguese and Pakistani diabetes risk scores.

Conclusions: This simple, non-invasive risk score can be used to detect individuals at high risk for type 2 diabetes in rural Bangladesh. Subjects with a score of 9 or above (out of 15) should undergo an oral glucose tolerance test for definitive diagnosis of diabetes.

INTRODUCTION

Type 2 Diabetes is a growing public health problem in both developed and developing countries. The International Diabetes Federation (IDF) estimated that 5.1 million people living in Bangladesh had diabetes in 2013[1], and approximately 40% of them were unaware of their diabetes status[1].

Type 2 diabetes is a complex metabolic disorder. Before diagnosis it normally passes through a prolonged dormant period and remains untreated. Studies have shown that approximately 30–50% of people with type 2 diabetes usually presented with one or more micro- or macrovascular complications at the time of diagnosis[2–4]. For these reasons, early identification of people with undiagnosed diabetes or those at an increased risk for developing type 2 diabetes has been recommended to improve outcomes[5]. Not only that, a number of randomized clinical trials have shown that both lifestyle and drug intervention strategies can prevent and delay the progression to type 2 diabetes among high-risk individuals, and this is likely to be cost-effective[6–8].

Evidence shows that current screening procedures using blood glucose, especially fasting venous plasma glucose, and the oral glucose tolerance test or glycated hemoglobin are regarded as invasive, relatively expensive and time-consuming, and thus not really suitable for the large population screening programs[9]. A simple, non-invasive tool, such as a risk scoring system based on a questionnaire and simple measurement of anthropometric

indices and blood pressure, would be practical for use by primary healthcare workers. Several risk scores have been developed worldwide[10–16], but validation studies have shown that the scores developed for a particular population often do not perform well for another population.

The vast majority of the Bangladeshi population lives in rural areas[17]. Like in urban areas, diabetes is also increasing rapidly in rural Bangladesh. One of the rural studies in Bangladesh found a significant rise in the prevalence of type 2 diabetes (2.3% in 1999 to 7.9% in 2009, $P < 0.001$) over 10 years[18]. The rising prevalence of type 2 diabetes will create a huge burden on the healthcare budget in a resource-constrained country like Bangladesh, where healthcare, especially diagnostic facilities, are still scarce. Therefore, the aim of the present study was to develop and to check the validity of a simple non-invasive diabetes risk score that can be carried out at a primary care level to detect individuals at high risk for type 2 diabetes in rural Bangladesh. Furthermore, we also tested the performance of the Thai[10], Indian[11], Omanis[12], UK[13], Dutch[14], Portuguese[15] and Pakistani[16] risk scores in our population.

MATERIALS AND METHODS

Study Population
Data were taken from two cross-sectional datasets; the 2009 Chandra Rural Study (model development data) and the 2009 Thakurgaon Rural Study (model validation data). The Chandra Rural Study was carried out in rural areas of the "Gazipur" district during March to December 2009. The area is approximately 40 km north of the capital, Dhaka city. Ten villages were randomly selected from 25 villages with a population of approximately 20,000 aged ≥20 years. For the present study, 3,000 individuals were randomly selected and among them 2,376 (79.2%) participated. The present analysis is based on these 2,293 participants (842 men and 1,451 women) for whom all the variables were available. The Thakurgaon Rural Study was carried out in 2009 in a north-western district, "Thakurgaon," 467 km from Dhaka. Participants were recruited from all five upazilas (subdistricts) of Thakurgaon. Ten villages were randomly selected from 20 villages of those five upazilas. A total of 1,000 individuals (both men and women) aged ≥25 years were invited to participate in this study by following a simple random procedure. Among them, 836 (83.6%) individuals were investigated. Exclusion criteria in both studies included pregnant women, and those with a diagnosed acute physical or mental illness. Descriptions of the recruitment process are described earlier in brief[19,20].

Measurements
In both surveys, once the selection procedure was completed, participants were requested to visit a nearby field center after an overnight fast of 8–12 h to obtain demographic and socioeconomic information, medical history, clinical examination and venous blood samples. On arrival at the field center, an 8-mL fasting venous blood sample was taken from each partici-

pant. All participants other than those with known diabetes were then given a 75-g oral glucose solution (75 g of oral glucose in 250 mL of water) to drink. Another 3 mL of venous blood was collected after 2 h to determine the 2-h post-oral glucose level. Glucose was measured by the glucose oxidase method using Dimalesion RxL Max (Siemens AG, Erlangen, Germany) in both studies. Both surveys obtained similar data including age, sex, socioeconomic condition, educational status, occupation, marital status and family history of diabetes. Anthropometric measurements, such as height, weight, and waist and hip circumferences, were taken with the participants wearing light clothes and without shoes. Body mass index (BMI) was calculated as the weight (kg) divided by square of the height (m^2). Waist circumference (WC) was measured by placing a tape horizontally midway between the lower margin of the last palpable rib and iliac crest on the midaxillary line. Hip circumference was measured at a level parallel to the floor, at the largest circumference of the buttocks. Waist-to-hip ratio (WHR) was calculated from the waist and hip circumference (cm). Blood pressure was measured in both the sitting and standing position by aneroid sphygmomanometer following standard procedures.

Definitions of Variables in Both Models
Diabetes was defined as plasma glucose ≥7.0 mmol/L and/or 2 h after 75-g oral glucose solution ≥11.1 mmol/L[21]. For this analysis, we only included newly diagnosed type 2 diabetes for model development. Hypertension (HTN) was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, or already on antihypertensive medication(s) or told to have high blood pressure by a physician[22]. Cut-off values for general obesity for both sexes was BMI of ≥25 kg/m^2; cut-off values for central obesity for men and women as defined by WC were ≥90 and ≥80 cm, WHR ≥0.90 and ≥0.80, respectively[23,24]. Family history of diabetes was classified as either present or absent of diabetes in first-degree relative(s) (parent, sibling, offspring).

Ethical Consideration
Both studies were carried out according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human participants were approved by the Ethical Committee of Diabetic Association of Bangladesh for Medical Research.

Statistical Analysis
Initially, factors that can be obtained in the primary care setting and that did not require any laboratory measurements were considered and entered into the model development. Age, sex, family history of diabetes, smoking, BMI, WHR and HTN status at the time of survey were assessed in the backward stepwise modeling. A P-value of 0.05 was considered significant for inclusion. After variables were considered for predicting type 2 diabetes in the final analysis: age (<30, 31–40 and ≥41 years), sex (female vs male), WHR (male <0.90 vs ≥0.90, female <0.80

vs ≥0.80), BMI (<25 vs ≥25 kg/m^2) and HTN (normal vs hypertensive).

We considered diabetes as an event, and there were 181 diabetes patients and five candidate risk predictors in the Chandra cohort (model development). An average of 36 events per variable was given, which was above the general rule of thumb of 10–20 events per variable[25]; therefore, the sample size was adequate for this analysis.

The logistic regression analysis with diabetes as the dependent variable was carried out using the logit and logistic commands of Stata software (version 12; Stata Corporation, College Station, TX, USA). The diabetes risk score was developed using the β-coefficients of the model from the Chandra Rural Study. Each coefficient was multiplied by a factor of four, and the score number was rounded to the nearest digit. The lowest category for each score was defined as 0. The total score for each participant was calculated as the sum of individual scores, which thus varied from 0 to 15.

Sensitivity, specificity, the positive predictive value (PPV) and negative predictive value (NPV) with 95% confidence intervals (CIs) for each risk score were examined by plotting receiver operating characteristic (ROC) curves using a combination of the MedCalc (version 12.7.7; MedCalc Software bvba, Ostend, Belgium) and Stata 12 for windows. The area under the curve (AUC) was also calculated. Optimal cut-point for the risk score was illustrated by the ROC analysis. The more accurate discriminating the test, the steeper the upward portion of the ROC curve and the higher the AUC. The Stata roctab command with the option graph was used to draw ROC curves.

To observe the performance of Thai[10], Indian[11], Omanis[12], UK[13], Dutch[14], Portuguese[15] and Pakistani[16] risk models in the Bangladeshi population, the logistic regression equations from these models on which these risk scores were based were re-analysed using the Chandra Rural Study.

RESULTS

The characteristics of model development data (Chandra Rural Study) and model validation data (Thakurgaon Rural Study) are shown in Table 1. The prevalence of diabetes was 7.9 and 7.2% in the Chandra Rural Study and Thakurgaon Rural Study, respectively. In both surveys, the prevalence rate of diabetes was higher among men than women. Participants in the Thakurgaon Rural Study were found to be older and more hypertensive than those in the Chandra Rural Study. A family history of diabetes, and both general (defined by BMI) and central obesity (defined by WC) were observed to be higher among participants in the Chandra Rural Study.

The multivariate logistic regression model based on the Chandra Rural Survey is shown in Table 2. The probability of diabetes increased with age, male sex, BMI, WHR and the presence of hypertension at the time of the survey. Age and WHR were the strongest predictors of prevalence of diabetes, whereas sex, BMI and the current hypertension status had moderate effects.

Table 1 | Characteristics of model development data (Chandra Rural Study) and model validation data (Thakurgaon Rural Study)

Variable	Chandra Rural Study			Thakurgaon Rural Study		
	Total (95% CI)	Male (95% CI)	Female (95% CI)	Total (95% CI)	Male (95% CI)	Female (95% CI)
n	2,293	842	1,451	836	438	368
Age (years)	41.8 (41.2–42.4)	44.3 (43.3–45.2)	40.4 (39.7–41.1)*	45.5 (44.7–46.3)	46.6 (45.5–47.6)	44.3 (43.2–45.5)*
Family history of diabetes (%)	17.6 (16.1–19.2)	17.7 (15.1–20.3)	17.6 (15.6–19.5)	16.7 (15.0–18.4)	17.1 (14.3–19.9)	16.5 (14.4–18.6)
BMI (kg/m^2)	22.6 (22.5–22.8)	22.6 (22.3–22.8)	22.7 (22.5–22.9)	22.0 (21.8–22.2)	22.2 (22.0–22.5)	21.7 (21.4–22.1)
BMI, ≥25 kg/m^2 (%)	26.2 (24.4–28.0)	25.2 (22.3–28.2)	26.8 (24.5–29.0)	17.3 (14.8–19.9)	18.9 (15.3–22.4)	15.4 (11.7–19.1)
WC (cm)	80.7 (80.3–81.1)	81.7 (81.0–82.4)	79.7 (79.2–80.3)*	76.2 (75.5–77.0)	78.8 (77.7–79.8)	73.7 (72.6–74.9)*
WC, m ≥ 90 cm; f ≥ 80 cm (%)	39.8 (37.9–41.8)	24.4 (21.5–27.3)	48.7 (46.2–51.3)*	23.6 (20.7–26.4)	18.8 (15.3–22.4)	29.6 (24.9–34.3)*
WHR	0.88 (0.87–0.89)	0.90 (0.89–0.91)	0.86 (0.85–0.87)*	0.90 (0.89–0.91)	0.92 (0.91–0.93)	0.89 (0.88–0.90)*
WHR, m ≥ 0.90; f ≥ 0.80 (%)	71.6 (69.8–73.4)	58.6 (55.2–61.9)	79.1 (77.0–81.1)*	68.5 (65.7–71.4)	51.2 (46.7–55.7)	89.9 (87.0–93.0)*
SBP (mmHg)	116.2 (115.6–116.9)	117.2 (116.2–118.3)	115.2 (114.4–116.1)*	118.6 (117.4–119.8)	119.4 (117.8–121.0)	117.9 (116.1–119.7)
DBP (mmHg)	77.1 (76.6–77.5)	77.6 (76.9–78.2)	76.5 (76.0–77.1)	77.9 (77.0–78.8)	78.0 (76.9–79.2)	77.7 (76.4–79.0)
Hypertension (%)	15.5 (14.1–17.0)	17.5 (15.1–20.0)	14.3 (12.5–16.1)	24.6 (21.8–27.5)	23.9 (20.1–27.7)	25.6 (21.1–30.0)
FPG (mmol/L)	5.2 (5.1–5.3)	5.3 (5.2–5.5)	5.1 (5.0–5.2)	5.2 (5.1–5.3)	5.2 (5.1–5.4)	5.2 (4.9–5.4)
2hPG (mmol/L)	6.3 (6.2–6.4)	6.3 (6.1–6.5)	6.2 (6.1–6.4)	6.3 (6.1–6.5)	6.2 (5.9–6.5)	6.3 (6.0–6.6)
DM, (%)	7.9 (6.8–9.0)	9.1 (7.2–11.0)	7.2 (5.8–8.5)	7.2 (5.4–8.9)	8.2 (5.7–10.7)	5.8 (3.4–8.2)

*P < 0.05 between male and female within same group. 2hPG, 2-h plasma glucose; BMI, body mass index; DBP, diastolic blood pressure; DM, diabetes mellitus; f, female; FPG, fasting plasma glucose; m, male; SBP, systolic blood pressure; WC, waist circumference; WHR, waist-to-hip ratio.

Table 2 | Logistic regression model to develop the diabetes risk score with diabetes as a dependent variables, Chandra Rural Study

Risk factors	Univariate model		Multivariate model		Score
	β-Coefficient	OR (95% CI)	β-Coefficient	OR (95% CI)	
Age (years)					
≤30	–	1	–	1	0
31–40	0.79	2.2 (1.3–3.7)	0.69	1.9 (1.1–3.2)	3
≥41	1.10	3.0 (1.9–4.9)	0.91	2.5 (1.5–4.1)	4
Sex					
Female	–	1	–	1	0
Male	0.34	1.4 (1.1–1.9)	0.42	1.5 (1.1–2.1)	2
BMI (kg/m^2)					
<25 kg/m^2	–	1	–	1	0
≥25 kg/m^2	0.68	2.0 (1.4–2.7)	0.41	1.5 (1.2–2.1)	2
WHR					
m < 0.90; f < 0.80	–	1	–	1	0
m ≥ 0.90; f ≥ 0.80	1.29	3.6 (2.2–5.9)	1.21	3.3 (2.0–5.4)	5
HTN status (mmHg)					
SBP < 140; DBP < 90	–	1	–	1	0
SBP ≥ 140; DBP ≥ 90	0.81	2.3 (1.6–3.2)	0.51	1.7 (1.2–2.4)	2

CI, confidence interval; DBP, diastolic blood pressure; f, female; HTN, hypertension; m, male; OR, odd ratio; SBP, systolic blood pressure; WC, waist circumference; WHR, waist-to-hip ratio.

ROC curves were obtained for this risk assessment tool and tested for newly diagnosed diabetes using the World Health Organization criteria. The AUC 0.70 (95% CI 0.68–0.72) for the Chandra Rural data and 0.71 (95% CI 0.68–0.74) for the Thakurgaon Rural data (Figure 1).

Table 3 provides the diagnostic performances (sensitivity, specificity, PPV, NPV) of different risk scores in study cohorts for diagnosis of diabetes using World Health Organization criteria. A value >9 had the optimum sensitivity and specificity for determining diabetes. This cut-point gave the sensitivity of 62.4% (95% CI 54.9–69.5%) and the specificity of 67.4% (95% CI 65.3–69.4%) in the Chandra Rural Cohort, and the sensitivity of 75.7% (95% CI 62.1–85.5%) and the specificity of 61.6% (95% CI 58.1–65.0%) in the Thakurgaon Rural cohort. The PPV for this cut-point was 14.1% (95% CI 11.8–16.7%) for the Chandra cohort, and 13.1% (95% CI 9.7–17.2%) for the Thakurgaon cohort. The NPV was 95.4% (95% CI 94.3–96.4%) and 97.0% (95% CI 95.0–98.3%), respectively.

In Table 4, both the surveys were classified into three diabetes risk score categories. The prevalence of diabetes was elevated with increasing risk score value in both populations (χ^2 for linear trend, $P < 0.001$ in both populations). In the Chandra and Thakurgaon survey, 62.4% and 75.7% of diabetes cases were in the group of score >9, respectively. In both surveys, a diabetes risk score of >9 had shown a fivefold greater risk of diabetes than the risk score of 0–4 (reference value).

Table 5 shows the performance of the Thai, Indian, Omanis, UK, Dutch, Portugal and Pakistan risk score models to predict diabetes among the Chandra Rural cohort. From the external models, the Thai model showed the highest sensitivity (57%), yet it had the lowest specificity (69.4%). The Indian and the

Omani models showed similar performance with very similar sensitivity (48.1 and 42%) and specificity (75.1 and 76.9%). The UK, Dutch, Portugal and Pakistan models performed poorly, with low sensitivity (37, 26.4, 25.4 and 14.9%) and high specificity (80.2, 88.7, 89.7 and 93.6%) in individuals from the Chandra Rural cohort.

DISCUSSION

This current study is among the few in South Asia that develops and evaluates a simple non-invasive diabetes risk score to diagnosed individuals of having type 2 diabetes in Bangladesh. This score was developed using data from a randomly selected rural population who all undertook both fasting and a 75-g oral glucose test. Besides the model development data, we also used other rural data for the validation of our risk score. Diabetes was diagnosed using the 1999 World Health Organization criteria[21] in both surveys. It should be noted that 72% of the Bangladeshi population live in rural areas[17], and the demographic of which is similar to the rest of the country. The entire population (other than the 2% tribal population) belong to the same ethnic group and speak the same language. Therefore it could be applicable to the Bangladeshi population.

This risk score only includes five non-invasive variables (age, sex, BMI, WHR and presence of HTN) and therefore, it does not require any laboratory assistance. Furthermore, the variables used in our risk score have also been found to be common for the Asian population[26–28]. There might be a concern about including both BMI and WHR in the same model, whereas WC is more easily measurable than WHR. First of all, in the present study, both BMI and WC were strongly correlated
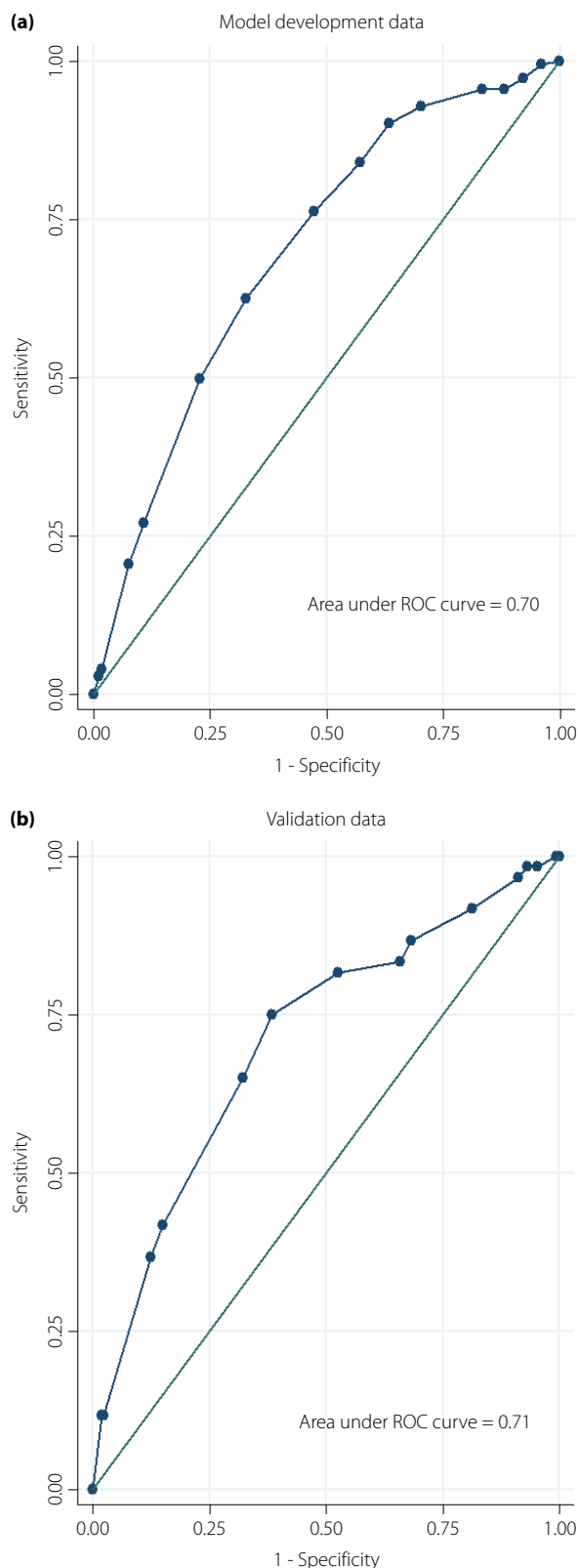
(a)

Model development data

(b)

Validation data

Figure 1 | Receiver operating characteristic (ROC) curves for (a) model development data (Chandra Rural Study) and (b) validation data (Thakurgaon Rural Study).

(r = 0.85). Second, previous prospective and cross-sectional studies have found WHR to be a better predictor of undiagnosed diabetes in the Bangladeshi population[20,29–31].

The usefulness of risk-prediction tools is generally assessed based on their sensitivity, specificity, and ROC curves. Both the risk and validation models in the present study showed a moderate sensitivity (62.4 and 75.7% in the Chandra and Thakurgaon cohorts, respectively) and specificity (67.4 and 61.6% in the Chandra and Thakurgaon cohorts, respectively), but a very high NPV (95.4 and 97% in the Chandra and Thakurgaon cohorts, respectively) for predicting individuals at high risk for type 2 diabetes with a cut-off of risk score >9. Both prospective and cross-sectional studies reported PPV for prevalent undiagnosed diabetes between 10 and 12%[32]. We have found similar findings in the present study (14.1 and 13.1% in Chandra and Thakurgaon cohorts, respectively). We have also found a reasonable performance in predicting type 2 diabetes, with an AUC of 0.70, which is consistent with the Leicester risk score in the UK (0.72)[13], and the Indian risk score developed by Mohon *et al.* (0.70)[33] and Chaturvedi *et al.* (0.68)[34].

We have found that individuals with a risk score 0–9 have a low probability of type 2 diabetes and need not be investigated further. This way of selecting people will help to reduce 30–40% of overall laboratory tests and thereby it could be a cost-effective method for identifying high-risk individuals in a budget-constrained setting, like Bangladesh. Mohon *et al.* have reported the cost-effectiveness of their risk model to identify high-risk Indian individuals[33].

Several risk prediction tools have been developed to identify individuals with increased risk of developing type 2 diabetes[13–15,31,34,35]. Most of them have been directed at largely Western populations and thus are not necessarily applicable to Asian populations. For example, cut-points for general obesity (defined by BMI) and central obesity (define by WC and WHR) are lower in Asian populations[36]. Despite lower WC and BMI, there is a disproportionate rise in cardiometabolic risk factors, especially type 2 diabetes and heart disease across Asia. Considering both Asian and global cut-offs for BMI and WC, both general and central obesity with associated cardiovascular risk factors are more highly prevalent in South Asian populations than East and South East Asian populations[36]. This shows the differences among the Asian population that cannot simply be due to ethnicity, but probably involve a range of genetic, socioeconomic and cultural factors. Most importantly, these differences are usually not taken into account in Western studies.

Some of the studies also included biochemical and lifestyle parameters, such as diet (fruits and vegetables consumption) and physical activity, for developing their risk scores[13,31,37,38]. Like the Pakistani study[16], we also could not include dietary and physical activity variables in our regression model because of a lack of proper standardization of food portions and also a lack of correct categorization of physical activity level in our country.

Table 3 | Diagnostic performances of different risk score in study cohorts (two points above and two points below the optimal cut-off score only shown)

Risk score	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)
Chandra Study				
>7	83.9 (77.8–89.0)	42.9 (40.7–45.0)	11.2 (9.6–13.0)	96.9 (95.6–97.9)
>8	76.2 (69.4–82.2)	52.8 (50.6–54.9)	12.1 (10.3–14.2)	96.3 (95.0–97.3)
>9	62.4 (54.9–69.5)	67.4 (65.3–69.4)	14.1 (11.8–16.7)	95.4 (94.3–96.4)
>10	49.7 (42.2–57.2)	77.1 (75.3–78.9)	15.7 (12.8–19.0)	94.7 (93.5–95.7)
>11	27.1 (20.7–34.2)	89.1 (87.7–90.4)	17.5 (13.2–22.5)	93.4 (92.3–94.5)
Thakurgaon Study				
>7	83.3 (71.5–91.7)	34.2 (30.8–37.6)	8.9 (6.7–11.6)	96.4 (93.4–98.2)
>8	81.7 (69.6–90.5)	47.4 (43.9–51.0)	10.7 (8.0–13.9)	97.1 (94.9–98.5)
>9	75.7 (62.1–85.5)	61.6 (58.1–65.0)	13.1 (9.7–17.2)	97.0 (95.0–98.3)
>10	65.0 (51.6–76.9)	67.9 (64.5–71.2)	13.5 (9.8–18.0)	96.2 (94.2–97.6)
>11	41.7 (29.1–55.1)	85.1 (82.3–87.5)	17.7 (11.8–25.1)	95.0 (93.1–96.5)

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

Table 4 | Prevalence and risk association of having diabetes by diabetes risk score in the Chandra and Thakurgaon Rural Study

Score	Chandra Rural Study			Thakurgaon Rural Study		
	n	% (95% CI)	OR (95% CI)	n	% (95% CI)	OR (95% CI)
0–4	361	4.4 (2.3–6.5)	Ref	70	3.3 (−0.9–7.5)	Ref
5–9	1,130	33.1 (30.4–35.6)	1.95 (0.89–4.26)	423	21.7 (17.8–25.6)	1.08 (0.23–5.01)
>9	802	62.4 (59.0–65.8)	5.50 (2.62–11.53)	343	75.0 (70.4–79.6)	5.04 (1.11–22.79)
P for trend		<0.001			<0.001	

CI, confidence interval; OR, odd ratio.

Table 5 | Performances of different diabetes risk score models to predict diabetes among the Chandra Rural Study participants

Model	Chandra Rural Study			
	Optimal cut-point	Sensitivity (%)	Specificity (%)	AUC (95% CI)
Current study	>9	62.4	67.4	0.70 (0.68–0.72)
Thai[10]	≥6	57.5	69.4	0.51 (0.45–0.56)
Indian[11]	>21	48.1	75.1	0.53 (0.48–0.59)
Omani[12]	>10	42.0	76.9	0.55 (0.49–0.61)
UK[13]	≥16	37.6	80.2	0.54 (0.48–0.61)
Dutch[14]	≥11	26.4	88.7	0.50 (0.37–0.62)
Portuguese[15]	>23	25.4	89.7	0.53 (0.44–0.61)
Pakistan[16]	≥4	14.9	93.6	0.48 (0.41–0.56)

AUC, area under the curve; CI, confidence interval.

We tested the performance of the Thai[10], Indian[11], Omanis[12], UK[13], Dutch[14], Portuguese[15] and Pakistani[16] risk scores in our population (Chandra rural population). Risk variables including age, sex, family history of diabetes, BMI, WC, presence of hypertension, physical activity, monthly income and smoking were used in the aforementioned risk scores for model development. We could not test the performance of the aforementioned risk scores in the Thakurgaon cohort (validation model)

because of an unavailability of some risk variables. None of the tested models performed well in the present study population. Al-Lawati and Tuomilehto.[12] and Rathmann et al.[39] have also found similar findings in their studies. It means that the risk score should be developed specifically for the population in which they will be used.

The present study had some limitations. First, the data used for model development were cross-sectional; therefore, we

could only associate prevalent cases of type 2 diabetes, rather than identify incident cases. More prospective or longitudinal datasets are required to determine its validity in predicting future risk of type 2 diabetes. However, many studies have shown good validity of similar diabetes risk scores even in cross-sectional settings[12,16,33]. Second, all the participants of the two cohorts had high risks for type 2 diabetes, thus the selection bias could lead to an underestimation of association. Third, there were differences in age and obesity indices in the model development and validation population, but overall the risk profile was similar. Finally, the predictive score of type 2 diabetes can be divided between men and women, because many confounding factors exist between them, such as sex hormones, physical activity and different jobs, which could influence the risk variables in our model. To reduce the over-fitting caused by a smaller number of diabetes subjects over candidate risk predictors in the Thakurgaon cohort and also to keep the statistical power, we could not carry out the sex-specific predictive score.

In conclusion, a simple risk score based on age, sex, obesity (BMI and WHR) and the presence of HTN resulted in moderate validity in identifying individuals at high risk of having type 2 diabetes in Bangladesh. Further work is required to assess its value in prospective studies, and in urban populations and also immigrant Bangladeshis in other countries. Finally, individuals with a score of 9 or above (out of 15) should visit physicians for definitive diagnosis of diabetes, and also for appropriate clinical and preventive management.

DISCLOSURE

The authors declare no conflict of interest.

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