Screening Performance of Diabetes Risk Scores Among Asians and Whites in Rural Kerala, India

Thirunavukkarasu Sathish, MBBS, MPH; Srinivasan Kannan, PhD; Sankara P. Sarma, PhD; Kavumpurathu Raman Thankappan, MD, MPH

Suggested citation for this article: Sathish T, Kannan S, Sarma SP, Thankappan KR. Screening Performance of Diabetes Risk Scores Among Asians and Whites in Rural Kerala, India. Prev Chronic Dis 2012;10:120131. DOI: http://dx.doi.org/10.5888/pcd10.120131.

Abstract
We compared the screening performance of risk scores for Asians and whites for diabetes, dysglycemia, and metabolic syndrome. Our subjects were 451 people aged 15 to 64 years who participated in a cohort study from May 2003 through September 2010 in a rural area of the Thiruvananthapuram district of Kerala, India. All outcome measures showed overlap in the range of area under the receiver operating characteristic curves of Asian and white diabetes risk scores (DRSs). Asian and white DRSs performed similarly in rural India.

Objective
Although mass screening for diabetes is not practical or recommended, selective screening through risk scores is feasible, convenient, and cost effective. Most diabetes risk scores (DRSs) have been developed and validated among whites (1–7); evidence on their screening performance in Asians is limited (8,9). We compared the screening performance of Asian and white DRSs for diabetes, dysglycemia, and metabolic syndrome in rural India.

Methods
In 2003, a large-scale cross-sectional survey on risk factors for noncommunicable diseases was conducted among 7,449 people aged 15 to 64 years in urban, slum, and rural areas of the Thiruvananthapuram district of Kerala, India (10). From the rural sample of the survey (n = 2,510), 495 people were selected for biochemical analysis (fasting plasma glucose and serum lipids) through systematic random sampling. We followed these 495 people from May 2003 through September 2010. During the follow-up study in 2010, 452 people (91.3%) participated (11). We used the baseline data (2003 study data) of 451 people, excluding that of 1 pregnant woman, for the present analysis. We defined dysglycemia according to World Health Organization guidelines (12) as the presence of impaired fasting glucose (fasting plasma glucose 110–125 mg/dL and not on antidiabetes medication) or diabetes (fasting plasma glucose ≥126 mg/dL or on antidiabetes medication, or both). We defined metabolic syndrome according to International Diabetes Federation criteria (13) as the presence of 3 or more of the following: raised triglycerides (≥150 mg/dL or treatment of this lipid abnormality), reduced HDL cholesterol (<40 mg/dL in men and <50 mg/dL in women, or treatment of this lipid abnormality), raised blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or treatment of previously diagnosed hypertension), or raised fasting plasma glucose (≥100 mg/dL or previously diagnosed type 2 diabetes).

We chose 11 DRSs (1-7,14-17) that could be applied to our data set (Box). Variables in Asian DRSs were age, family history of diabetes, physical activity, body mass index, waist circumference, and blood pressure. Variables in white DRSs were age, sex, family history of diabetes, smoking history, history of elevated blood glucose (having been told by a health care professional that they had diabetes), history of hypertension, use of antihypertensive medication, daily consumption of fruits or vegetables, physical activity, body mass index, waist circumference, and blood pressure. We derived the area under the receiver operating characteristic curve (AROC) by plotting 1-specificity on the x-axis and sensitivity on the y-axis. We used the DeLong method (18) to compare the AROCs of DRSs. We used the range of
AROCs of Asian and white DRSs to compare their screening performance. We used univariate logistic regression analysis to examine the association of individual variables of Asian and white DRSs with outcome measures. For the optimal cutoff (score value with maximum sensitivity and specificity) of DRSs, we computed high risk (proportion of people requiring confirmatory biochemical testing), sensitivity (true positives/true positives + false negatives), specificity (true negatives/true negatives + false positives), positive predictive value (true positives/true positives + false positives), and negative predictive value (true negatives/true negatives + false negatives). We used SPSS version 17.0 (SPSS Inc, Chicago, Illinois) to perform data analyses. The study was approved by the Institutional Ethics Committee of the Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, India. We obtained written informed consent from all study participants.

Results

The mean age of the study sample was 39.4 (standard deviation [SD], 14.1) years. Table 1 provides details of screening performance of diabetes risk scores. We found no significant differences in the AROCs for diabetes, dysglycemia, or metabolic syndrome among Asian DRSs. However, the Rotterdam Prediction Model 1 (7) had significantly lower AROCs than other white DRSs for all outcome measures. We found overlap in the range of AROCs of Asian and white DRSs (excluding Rotterdam Prediction Model 1) for all outcome measures (Table 2). In Asian DRSs, 5 of 6 variables were associated with diabetes and dysglycemia and 5 with metabolic syndrome. Of the 12 variables in white DRSs, 8 were associated with diabetes and dysglycemia and 10 with metabolic syndrome. All 6 variables of Asian DRSs were present in white DRSs, although they had different cutoff values for age, body mass index, and waist circumference.

Discussion

Our study compared the screening performance of Asian and white DRSs for diabetes, dysglycemia, and metabolic syndrome in rural India and found them similar. They were similar because most variables in Asian and white DRSs were associated with all outcome measures and because white DRSs shared all variables of Asian DRSs. This finding is in agreement with a study from Taiwan that showed that DRSs developed in different populations could perform well in detecting diabetes, metabolic syndrome, and chronic kidney disease (8). Conversely, a risk score developed in whites did not perform well in other populations of diverse racial/ethnic origins because of variation in distribution of risk factors and their effect on diabetes in racial/ethnic groups (9). Future research is required to examine whether modifying white DRSs according to the characteristics of Asian populations could enhance their screening performance.

Our study has limitations. For the American Diabetes Association questionnaire we did not have data on macrosomic infant to include in scoring. For the Finnish Diabetes Risk Score (FINDRISC), we did not have data on ever having used antihypertensive medication, and we replaced these with data on current use for scoring. We used the FINDRISC definition of physical inactivity in DRSs that had physical activity as a component, which may have resulted in misclassification.

In conclusion, Asian and white DRSs performed similarly in detecting diabetes, dysglycemia, and metabolic syndrome in rural India.

### Box. Asian and White Diabetes Risk Scores (DRSs) Applied to Data Set

| Asian DRSs            | White DRSs            |
|-----------------------|-----------------------|
| Mohan et al (IDRS) (14) | Herman et al (ADA questionnaire) (1) |
| Ramachandran et al (15) | Bang et al (2) |
| Chaturvedi et al (16) | Chen et al (AUSDRISK) (3) |
| Aekplakorn et al (17) | Lindström et al (FINDRISC) (4) |
|                       | Glümer et al (Danish Risk Score) (5) |
|                       | Balkau et al (DESIR) (6) |
|                       | Baan et al (Rotterdam Prediction Model 1) (7) |

**Abbreviations:** IDRS, Indian Diabetes Risk Score; ADA, American Diabetes Association; AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; FINDRISC, Finnish Diabetes Risk Score; DESIR, Data from the Epidemiological Study on the Insulin Resistance Syndrome.
Acknowledgments

The research had no external funding. We thank all the study participants. This article was presented as a poster display in the World Diabetes Congress organized by the International Diabetes Federation December 4–8, 2011, in Dubai, United Arab Emirates.

Author Information

Corresponding Author: Thirunavukkarasu Sathish, MBBS, MPH, Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram 695011, Kerala, India, and Faculty of Medicine, Nursing and Health Sciences, Monash University, VIC 3004, Australia. Telephone: 011-61-470221638. E-mail: speaktosat@gmail.com.

Author Affiliations: Srinivasan Kannan, Sankara P. Sarma, Kavumpurathu Raman Thankappan, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Kerala, India.

References

1. Herman WH, Smith PJ, Thompson TJ, Engelgau MM, Aubert RE. A new and simple questionnaire to identify people at increased risk for undiagnosed diabetes. Diabetes Care 1995;18(3):382–7. CrossRef PubMed
2. Bang H, Edwards AM, Bombacq AS, Ballantyne CM, Brillon D, Callahan MA, et al. Development and validation of a patient self-assessment score for diabetes risk. Ann Intern Med 2009;151(11):775–83. PubMed
3. Chen L, Magliano DJ, Balkau B, Colagiuri S, Zimmet PZ, Tonkin AM, et al. AUSDRISK: an Australian Type 2 diabetes risk assessment tool based on demographic, lifestyle and simple anthropometric measures. Med J Aust 2010;192(4):197–202. PubMed
4. Lindström J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. Diabetes Care 2003;26(3):725–31. CrossRef PubMed
5. Glümer C, Carstensen B, Sandbaek A, Lauritzen T, Jørgensen T, Borch-Johnsen K; Inter99 study. A Danish diabetes risk score for targeted screening: the Inter99 study. Diabetes Care 2004;27(3):727–33. CrossRef PubMed
6. Balkau B, Lange C, Fezeu L, Tichet J, de Lauzon-Guillain B, Czernichow S, et al. Predicting diabetes: clinical, biological, and genetic approaches: Data from the Epidemiological Study on the Insulin Resistance Syndrome (DESIR). Diabetes Care 2008;31(10):2056–61. CrossRef PubMed
7. Baan CA, Ruige JB, Stolk RP, Witteman JC, Dekker JM, Heine RJ, et al. Performance of a predictive model to identify undiagnosed diabetes in a health care setting. Diabetes Care 1999;22(2):213–9. CrossRef PubMed
8. Lin JW, Chang YC, Li HY, Chien YF, Wu MY, Tsai RY, et al. Cross-sectional validation of diabetes risk scores for predicting diabetes, metabolic syndrome, and chronic kidney disease in Taiwanese. Diabetes Care 2009;32 (12):2294–6. CrossRef PubMed
9. Glümer C, Vistisen D, Borch-Johnsen K, Colagiuri S, DETECT-2 Collaboration. Risk scores for type 2 diabetes can be applied in some populations but not all. Diabetes Care 2006;29(2):410–4. CrossRef PubMed
10. Thankappan KR, Shah B, Mathur P, Sarma PS, Srinivas G, Mini GK, et al. Risk factor profile for chronic non-communicable diseases: results of a community-based study in Kerala, India. Indian J Med Res 2010;131:53–63. PubMed
11. Sathish T, Kannan S, Sarma PS, Razum O, Thankappan KR. Incidence of hypertension and its risk factors in rural Kerala, India: a community-based cohort study. Public Health 2012;126(1):25–32. CrossRef PubMed
12. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia: report of a WHO/IDF consultation. http://www.who.int/diabetes/publications/Definition%20and%20diagnosis%20of%20diabetes_new.pdf. Accessed April 9, 2011.
13. International Diabetes Federation. Worldwide definition of the metabolic syndrome. http://www.idf.org/webdata/docs/IDF_Metasyndrome_definition.pdf. Accessed August 24, 2011.
14. Mohan V, Deepa R, Deepa M, Somannavar S, Datta M. A simplified Indian Diabetes Risk Score for screening for undiagnosed diabetic subjects. J Assoc Physicians India 2005;53:759–63. PubMed
15. Ramachandran A, Snehalatha C, Vijay V, Wareham NJ, Colagiuri S. Derivation and validation of diabetes risk score for urban Asian Indians. Diabetes Res Clin Pract 2005;70(1):63–70. CrossRef PubMed
16. Chaturvedi V, Reddy KS, Prabhakaran D, Jeemon P, Ramakrishnan L, Shah P, et al. Development of a clinical risk score in predicting undiagnosed diabetes in urban Asian Indian adults: a population-based study. Global Heart 2008;3(3):141–51. CrossRef

17. Aekplakorn W, Bunnag P, Woodward M, Sritara P, Cheepudomwit S, Yamwong S, et al. A risk score for predicting incident diabetes in the Thai population. Diabetes Care 2006;29(8):1872–7. CrossRef PubMed

18. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics 1988;44(3):837–45. CrossRef PubMed

Tables

Table 1. Screening Performance of Diabetes Risk Scores for Diabetes, Dysglycemia, and Metabolic Syndrome Among 451 Participants in Rural Kerala, India

| Diabetes Risk Score         | Optimal Cutoff<sup>a</sup> | High Risk<sup>b</sup>, % | Sensitivity<sup>c</sup>, % | Specificity<sup>d</sup>, % | PPV<sup>e</sup>, % | NPV<sup>f</sup>, % | AROC<sup>g</sup> (95% CI) |
|-----------------------------|-----------------------------|--------------------------|---------------------------|--------------------------|------------------|------------------|--------------------------|
| **Diabetes<sup>h</sup>**    |                             |                          |                           |                          |                  |                  |                          |
| IDRS (14)                   | ≥60                         | 49.0                     | 85.7                      | 59.4                     | 32.6             | 94.8             | 0.80 (0.76–0.85)        |
| Ramachandran et al (15)     | ≥24                         | 35.3                     | 71.4                      | 73.0                     | 37.7             | 91.8             | 0.79 (0.75–0.84)        |
| Chaturvedi et al (16)       | ≥22                         | 29.9                     | 65.5                      | 78.2                     | 40.7             | 90.8             | 0.78 (0.73–0.83)        |
| Aekplakorn et al (17)       | ≥7                          | 45.5                     | 79.8                      | 62.4                     | 32.7             | 93.1             | 0.78 (0.72–0.83)        |
| ADA questionnaire (1)       | ≥6                          | 37.3                     | 70.2                      | 70.3                     | 35.1             | 91.2             | 0.74 (0.69–0.80)        |
| Bang et al (2)              | ≥3                          | 25.5                     | 59.5                      | 82.3                     | 43.5             | 89.9             | 0.76 (0.70–0.82)        |
| AUSDRISK (3)                | ≥15                         | 27.3                     | 67.9                      | 82.0                     | 46.3             | 91.8             | 0.83 (0.78–0.88)        |
| FINDRISC (4)                | ≥6                          | 37.7                     | 73.8                      | 70.6                     | 36.5             | 92.2             | 0.81 (0.75–0.86)        |
| Danish Risk Score (5)       | ≥18                         | 39.7                     | 73.8                      | 68.1                     | 34.6             | 91.9             | 0.76 (0.71–0.82)        |
| DESIR<sup>i</sup> (6)       | ≥3                          | 41.7                     | 66.7                      | 64.0                     | 29.8             | 89.4             | 0.72 (0.66–0.78)        |
| Rotterdam Prediction Model 1 (7) | ≥6                      | 12.2                     | 28.6                      | 91.6                     | 43.6             | 84.8             | 0.58 (0.50–0.65)        |
| **Dysglycemia<sup>j</sup>** |                             |                          |                           |                          |                  |                  |                          |
| IDRS (14)                   | ≥60                         | 49.0                     | 83.1                      | 63.1                     | 44.3             | 91.3             | 0.80 (0.76–0.84)        |
| Ramachandran et al (15)     | ≥23                         | 40.4                     | 74.6                      | 71.8                     | 48.4             | 88.8             | 0.80 (0.75–0.84)        |
| Chaturvedi et al (16)       | ≥15                         | 58.3                     | 90.7                      | 53.2                     | 40.7             | 94.1             | 0.79 (0.75–0.84)        |
| Aekplakorn et al (17)       | ≥7                          | 45.5                     | 77.1                      | 65.8                     | 44.4             | 89.0             | 0.77 (0.72–0.82)        |
| ADA questionnaire (1)       | ≥6                          | 37.3                     | 65.3                      | 72.7                     | 45.8             | 85.5             | 0.73 (0.67–0.78)        |
| Diabetes Risk Score                | Optimal Cutoff<sup>a</sup> | High Risk<sup>b</sup>, % | Sensitivity<sup>c</sup>, % | Specificity<sup>d</sup>, % | PPV<sup>e</sup>, % | NPV<sup>f</sup>, % | AROC<sup>g</sup> (95% CI) |
|-----------------------------------|-----------------------------|--------------------------|---------------------------|---------------------------|------------------|------------------|-----------------------------|
| Bang et al (2)                    | ≥2                          | 43.9                     | 74.6                      | 67.0                      | 44.4             | 88.1             | 0.75 (0.69–0.80)            |
| AUSDRISK (3)                      | ≥13                         | 37.3                     | 72.0                      | 75.1                      | 50.6             | 88.3             | 0.80 (0.76–0.85)            |
| FINDRISC (4)                      | ≥5                          | 45.2                     | 75.4                      | 65.5                      | 43.6             | 88.3             | 0.78 (0.73–0.83)            |
| Danish Risk Score (5)             | ≥18                         | 39.7                     | 71.2                      | 71.5                      | 46.9             | 87.5             | 0.75 (0.70–0.81)            |
| DESIR (6)                         | ≥3                          | 41.7                     | 63.6                      | 66.1                      | 39.9             | 83.7             | 0.71 (0.66–0.77)            |
| Rotterdam Prediction Model 1 (7)  | ≥6                          | 12.2                     | 25.4                      | 92.5                      | 54.5             | 77.8             | 0.56 (0.50–0.63)            |

| Metabolic syndrome<sup>k</sup> |                               |                          |                           |                           |                  |                  |                           |
|--------------------------------|-------------------------------|--------------------------|---------------------------|---------------------------|------------------|------------------|-----------------------------|
| IDRS (14)                       | ≥60                           | 49.0                     | 81.8                      | 65.3                      | 50.7             | 89.1             | 0.83 (0.79–0.87)            |
| Ramachandran et al (15)         | ≥22                           | 48.6                     | 78.8                      | 64.6                      | 49.3             | 87.5             | 0.79 (0.75–0.84)            |
| Chaturvedi et al (16)           | ≥21                           | 34.6                     | 75.9                      | 83.4                      | 66.7             | 88.8             | 0.87 (0.84–0.91)            |
| Aekplakorn et al (17)           | ≥7                            | 45.5                     | 81.0                      | 70.1                      | 54.1             | 89.4             | 0.83 (0.79–0.87)            |
| ADA questionnaire (1)           | ≥6                            | 37.3                     | 56.2                      | 71.0                      | 45.8             | 78.8             | 0.65 (0.59–0.71)            |
| Bang et al (2)                  | ≥2                            | 43.9                     | 63.8                      | 64.9                      | 45.4             | 79.7             | 0.65 (0.59–0.71)            |
| AUSDRISK (3)                    | ≥11                           | 48.1                     | 81.8                      | 66.6                      | 51.6             | 89.3             | 0.82 (0.78–0.86)            |
| FINDRISC (4)                    | ≥4                            | 55.4                     | 94.2                      | 61.5                      | 51.6             | 96.0             | 0.84 (0.80–0.88)            |
| Danish risk score (5)           | ≥13                           | 55.0                     | 77.4                      | 54.8                      | 42.7             | 84.7             | 0.70 (0.64–0.75)            |
| DESIR (6)                       | ≥3                            | 41.7                     | 89.1                      | 79.0                      | 64.9             | 94.3             | 0.91 (0.89–0.94)            |
| Rotterdam Prediction Model 1 (7)| ≥6                            | 12.2                     | 13.9                      | 88.5                      | 34.5             | 70.2             | 0.41 (0.35–0.46)            |

Abbreviations: PPV, positive predictive value; NPV, negative predictive value; AROC, area under the receiver operating characteristic curve; CI, confidence interval; IDRS, Indian Diabetes Risk Score; ADA, American Diabetes Association; AUSDRISK, Australian type 2 Diabetes Risk Assessment Tool; FINDRISC, Finnish Diabetes Risk Score; DESIR, Data From the Epidemiological Study on the Insulin Resistance Syndrome; HDL, high-density lipoprotein.

<sup>a</sup> Score value with maximum sensitivity and specificity.
<sup>b</sup> Proportion of people requiring confirmatory biochemical testing.
<sup>c</sup> True positives/true positives + false negatives.
<sup>d</sup> True negatives/true negatives + false positives.
<sup>e</sup> True positives/true positives + false positives.
<sup>f</sup> True negatives/true negatives + false negatives.
<sup>g</sup> Derived by plotting 1-specificity on the x-axis and sensitivity on the y-axis.
<sup>h</sup> Fasting plasma glucose ≥126 mg/dL or on antidiabetes medication, or both.
<sup>i</sup> Clinical risk score.
<sup>j</sup> Impaired fasting glucose (fasting plasma glucose 110–125 mg/dL and not on antidiabetes medication) or diabetes (fasting plasma glucose ≥126 mg/dL or on antidiabetes medication, or both).
<sup>k</sup> Three or more of the following: raised triglycerides (≥150 mg/dL or treatment of this lipid abnormality), reduced HDL cholesterol (<40 mg/dL in men and <50 mg/dL in women, or treatment of this lipid abnormality), raised blood pressure.
(systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or treatment of previously diagnosed hypertension), or raised fasting plasma glucose (≥100 mg/dL or previously diagnosed type 2 diabetes).

Table 2. Range of AROCs of Asian and White DRSs for Diabetes, Dysglycemia, and Metabolic Syndrome Among 451 Participants in Rural Kerala, India

| Outcome Variable         | Range of AROCs of Asian DRSs | Range of AROCs of White DRSs<sup>a</sup> |
|--------------------------|------------------------------|-----------------------------------------|
| Diabetes<sup>b</sup>     | 0.776–0.802                  | 0.716–0.828                              |
| Dysglycemia<sup>c</sup>  | 0.771–0.801                  | 0.713–0.804                              |
| Metabolic syndrome<sup>d</sup> | 0.793–0.874                  | 0.651–0.911                              |

Abbreviations: AROCs, areas under the receiver operating characteristic curves; DRSs, diabetes risk scores.

<sup>a</sup> Excluding Rotterdam Prediction Model 1 (7).

<sup>b</sup> Fasting plasma glucose ≥126 mg/dL or on antidiabetes medication, or both.

<sup>c</sup> Impaired fasting glucose (fasting plasma glucose 110–125 mg/dL and not on antidiabetes medication) or diabetes (fasting plasma glucose ≥126 mg/dL, or on antidiabetes medication, or both).

<sup>d</sup> Three or more of the following: raised triglycerides (≥150 mg/dL, or treatment of this lipid abnormality), reduced HDL cholesterol (<40 mg/dL in men and <50 mg/dL in women, or treatment of this lipid abnormality), raised blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg or treatment of previously diagnosed hypertension), or raised fasting plasma glucose (≥100 mg/dL or previously diagnosed type 2 diabetes).

The opinions expressed by authors contributing to this journal do not necessarily reflect the opinions of the U.S. Department of Health and Human Services, the Public Health Service, the Centers for Disease Control and Prevention, or the authors’ affiliated institutions.