Development and validation of prediabetes risk score for predicting prediabetes among Indonesian adults in primary care: Cross-sectional diagnostic study

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Abstract: Objective: To develop and validate a risk score model for recognizing prediabetes among Indonesian adults in primary care. Methods: This was a cross-sectional diagnostic study. After excluding subjects with diabetes from Indonesian National Basic Health Survey (INBHS) data set, 21,720 subjects who have completed fasting plasma glucose test and aged > 18 years were selected for development stage. About 6,933 subjects were selected randomly from INBHS for validation stage in different diagnostic criteria of prediabetes-based random plasma glucose. Logistic regression was used to determine significant diagnostic variable and the receiver operating characteristic analysis was used to calculate area under the curve (AUC), cutoff point, sensitivity, specificity, and predictive values. Results: Age, sex, education level, family history of diabetes, smoking habit, physical activity, body mass index, and hypertension were significant variables for Indonesian Prediabetes Risk Score (INA-PRISC). The scoring range from 0 to 24, the AUC was 0.623 (95% CI 0.616–0.631) and cutoff point of 12 yielded sensitivity/speciﬁcity (50.03%/67.19%, respectively). The validation study showed the AUC was 0.646 (95% CI 0.623–0.669) and cutoff point of 12 yielded sensitivity/speciﬁcity (55.11%/65.81%, respectively). Conclusion: INA-PRISC, which consists of eight demographical and clinical variables, is a valid and a simple prediabetes risk score in primary care.

Keywords: development, validation, risk score model, prediabetes, primary care

Introduction

Diabetes is one of the most common chronic diseases found throughout the world, where the prevalence continues to grow significantly. According to the International Diabetes Foundation, in 2013 there were approximately 382 million people with diabetes worldwide, and this is expected to rise to 592 million by 2035. Indonesia is one of the ten most populous countries with diabetes, where in 2013 the number of diabetics aged 20–79 years is 8.5 million, and estimates in 2035 the prevalence will increase to 14.1 million [1].

The Indonesian National Basic Health Survey (INBHS) 2013 found that diabetes prevalence in Indonesia is increasing, with the age-adjusted prevalence of adults (aged 15 years and above) increased from 5.7% in 2007 to 6.9% in 2013; however, only one third (2.4%) were diagnosed by health-care providers, 4.5% were...
Prediabetes is a condition where blood glucose is above normal, but it does not measure up to the criteria of diabetes mellitus. Conditions included in prediabetes are impaired glucose tolerance (IGT), impaired fasting glucose (IFG), or both [4]. For patients who carry both IGT and IFG, cumulative incidence of diabetes in the period of 6 years is 65%, compared with the person with normal blood glucose level [3]. Thus, identifying those individuals with prediabetes becomes crucial and cost-effective [5–7].

The traditional diabetes screening methods, including the fasting plasma glucose (FPG), the 2-h oral glucose tolerance test (OGTT) or HbA1c test, are invasive, inconvenient, and expensive [7], especially for large populations like Indonesia. This is also one of the important reasons why there are a large number of diabetic patients remaining undiagnosed. Until now, as far as we know, there is no scoring system for prediabetes available in Indonesia. Seeking a simple, reliable, and cost-effective screening method, such as a prediabetes risk score that can be easily conducted in clinical or community settings by primary care physicians (PCPs) is very important at this time. While the role of PCPs is essential in the early detection and prevention of prediabetes and diabetes, it has become even more important in Indonesia since Universal Health Coverage began in 2014. PCPs are the basis of a tiered health care to make health care cost-effective and cost-efficient [8].

Many diabetes risk score questionnaires have been developed and validated in various countries and ethnic groups to identify patients at high risk of diabetes, but only few for prediabetes, and most have been designed for Caucasians in developed countries, and there are only a few scoring systems for Asian populations [9]. Risk scores derived from certain populations may not be applicable to other ethnic groups [10]. Therefore, there is a need to establish a prediabetes risk score for the Indonesian adult population. Moreover, having their own score may make PCPs more motivated to use the method [11].

This paper aims to develop and validate Indonesian Prediabetes Risk Score (INA-PRISC) model based on INBHS 2013 data set.

Research Design and Methods

Data source and subjects

This study consists of two stages which were (1) development stage, using the INBHS FPG data set to develop prediabetes scoring system model and (2) validation stage, using the random plasma glucose (RPG) data set to validate the model.

Variables and measurements

We used demographics data including information on age, sex, and level of education. We defined un-education...
for individuals who have never been to school and individuals who have not completed primary school; low education for people who have primary school certificate, and high education defined as people who have high school certificate and above.

Family history of diabetes was restricted to first relatives only, such as father, mother, or siblings, had diabetes. Subjects were classified into smoking categories of smoker (daily smoker and occasional smoker), and non-smoker (never smoked, ex-occasional smoker, and ex-daily smoker) by self-report.

Based on physical activity, subjects were divided into heavy and moderate physical activity. Heavy physical activity is an activity that is continuously doing at least for 10 min until the pulse raised and breathing faster than normal (e.g., draw water from well, mountain climbing, sprinting, cutting trees, hoeing, etc.) for at least 3 days a week and total activity time ≥1,500 MET-min. MET-minute for physical activity is the length of time (minutes) doing activity within 1 week multiplied by a weighting of 8 calories. Moderate physical activity (sweeping, mopping, etc.) at least 5 days or more with total active duration of 150 min in 1 week. Active is doing moderate or heavy physical activities or both, whereas less active is not doing moderate or heavy physical activities. Sedentary activity is the behavior of a sitting or lying everyday both in the workplace (working at the computer, reading, etc.), at home (watching TV, playing games, etc.), on the go/transport (buses, trains, and motor), but not including bedtime, with cutoff point <3 h/day, 3–5.9 and ≥6 h/day for risky behavior.

Classification for body mass index (BMI) in this study used the criteria for Asian populations which are 18.5–22.9 kg/m² defined as normal, 23.0–24.9 kg/m² as overweight, and 25.0 kg/m² and above as obese [13].

Laboratory parameters, including FPG test were measured after overnight fasting, and RPG test based on ADA standards. Prediabetes is fasting blood glucose level of 100–125 mg/dl (IFG) or blood glucose 2-h post glucose load of 140–199 mg/dl (IGT) or both [4].

Subjects were diagnosed as hypertensive if they were documented to have hypertension diagnosed by a physician or if they were taking anti-hypertensive medication, or diagnosed as hypertensive in second measurement after 5-min rest by trained health-care nurse, based on JNC-VIII classification for hypertension [systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg] [14].

Statistical analysis

Subjects’ characteristics were summarized by descriptive statistics, and expressed as proportions with categorical in numbers and percentage. Chi-square tests were applied to compare categorical variables. These procedures allow users to specify primary sampling units, stratification identification, and sampling weights in the statistical procedures with 95% confidence interval (CI) and 5% precision of the study. For model development, we applied multiple logistic regression analysis with prediabetes at the end point. We included the variables that statistically significant in bivariate analysis based on their p values and CI, and clinically significant by comparing differences in the proportion of prediabetes in the study with reference in minimal expected effect size. The variables were considered clinically significant when the proportion of the comparison group difference of more than 1.

Backward elimination (deleting the covariate with the largest p value, one at a time) was performed from the initial model until we reached a final model with statistically significant covariates.

We double checked the final model to ensure that no important covariates were omitted in this sequential process. We intentionally used only categorized variables that captured easy but relevant and validated health information in the prediction model to develop a user-friendly screening score. Sensitivity, specificity, and predictive values were calculated. The receiver operating characteristic (ROC) with area under the curve (AUC) was constructed to visually show the relationship between true-positive (sensitivity) and specificity. The ROC curve was also used to evaluate the performance of INA-PRISC in discriminating prediabetes and normal individuals [15]. We determined cutoff points as threshold and define “risk” as very low risk (VLR), low risk (LR), medium risk (MR), and high risk (HR) based on the total score ranges of the cutoff points.

The scoring system was developed based on regression coefficients multiplied by 10 and rounded to the nearest integer to derive weights of the scores [16]. This scoring system then performed in a questionnaire form that can be used easily by health personnel in primary care.

To validate the prediabetes risk score, we evaluated our scoring system by filling the questionnaire using data set RPG of INBHS 2013 as external validation. Statistical analyses were conducted to calculate sensitivity, specificity, predictive values, and AUC with 95% CI.

Results

Development stage of INA-PRISC

In developing the prediabetes scoring system, we used Indonesian National Survey which comes from 33 provinces, represented by 21,720 complete data set, that were analyzed gradually.

Table 1 illustrates the prevalence of prediabetes in group data set based on socio-demographic characteristics and variable predictors of the participants. Of 21,720
### Table 1: Bivariate analysis of predictors for prediabetes in the development of INA-PRISC

| Prediabetes | Normal | p value | OR | 95% CI |
|-------------|--------|---------|----|--------|
| **Age**     |        |         |    |        |
| >55 years   | 2.431  | 52.6    | <0.001 | 3.069  | 2.737  | 3.443 |
| 46-55 years | 2.323  | 48.0    | <0.001 | 2.550  | 2.275  | 2.859 |
| 36-45 years | 2.330  | 39.7    | <0.001 | 1.811  | 1.626  | 2.034 |
| 26-35 years | 1.295  | 29.5    | 0.018  | 1.154  | 1.025  | 1.299 |
| 19-25 years | 5.32   | 26.6    |       |        |        |        |
| **Sex**     |        |         |    |        |
| Male        | 3.878  | 44.5    | <0.001 | 1.273  | 1.205  | 1.345 |
| Female      | 5.033  | 38.7    | 61.3 | Reference |
| **Education level** | | | | |
| Uneducation (never been to school/not completed primary school) | 2.510 | 49.2 | 50.8 | <0.001 | 1.745 | 1.627 | 1.871 |
| Low education (primary school certificate) | 3.260 | 41.7 | 58.3 | <0.001 | 1.286 | 1.208 | 1.369 |
| High education (high school and above) | 3.141 | 35.7 | 64.3 | Reference |
| **Diabetes history in first degree** | | | | |
| Yes | 124 | 50.8 | 120 | 49.2 | 0.002 | 1.492 | 1.159 | 1.921 |
| No/unknown | 8.787 | 40.9 | 12.689 | 59.1 | Reference |
| **Smoking habit** | | | | |
| Yes (daily and occasional smoker) | 2.920 | 45.8 | 3.454 | 54.2 | <0.001 | 1.320 | 1.244 | 1.400 |
| No (ex-daily, ex-occasional, and non-smoker) | 5.991 | 39.0 | 9.355 | 61.0 | Reference |
| **BMI (kg/m²)** | | | | |
| ≥25 (obese) | 2.706 | 43.4 | 3.526 | 56.6 | <0.001 | 1.155 | 1.085 | 1.228 |
| 23-24.9 (overweight) | 1.412 | 40.5 | 2.072 | 59.5 | 0.525 | 1.025 | 0.949 | 1.107 |
| 18.5-22.9 (normal) | 4.793 | 39.9 | 7.211 | 60.1 | Reference |
| **High physical activity** | | | | |
| No or ≤1,500 MET-min/week | 5.298 | 39.2 | 8.215 | 60.8 | <0.001 | 0.820 | 0.776 | 0.867 |
| ≥1,500 MET-min/week | 3.613 | 44.0 | 4.594 | 56.0 | Reference |
| **Moderate physical activity** | | | | |
| No or <150 min/week | 1.238 | 45.0 | 1.514 | 55.0 | <0.001 | 1.204 | 1.111 | 1.305 |
| ≥150 min/week | 7.673 | 40.5 | 11.295 | 59.5 | Reference |
| **Physical activity classification** | | | | |
| No or less active | 353 | 39.5 | 541 | 60.5 | 0.049 | 0.866 | 0.751 | 0.999 |
| High or moderate physical activity | 5.830 | 40.3 | 8.647 | 59.7 | <0.001 | 0.895 | 0.843 | 0.950 |
| Both high and moderate physical activity | 2.728 | 43.0 | 3.621 | 57.0 | Reference |
| **Sedentary lifestyle** | | | | |
| ≥6 h/day | 1.940 | 39.6 | 2.960 | 60.4 | 0.059 | 0.932 | 0.866 | 1.003 |
| 3-5.9 h/day | 3.834 | 41.6 | 5.389 | 58.4 | 0.716 | 1.011 | 0.951 | 1.076 |
| <3 h/day | 3.137 | 41.3 | 4.460 | 58.7 | Reference |
| **Diet fiber (fruits and vegetables)/day** | | | | |
| <1 serving | 1.770 | 41.7 | 2.476 | 58.3 | 0.515 | 1.062 | 0.885 | 1.275 |
| 1-<2 servings | 3.805 | 40.7 | 5.538 | 59.3 | 0.816 | 1.021 | 0.856 | 1.218 |

*Continued*
adults above 18 years old that underwent fasting blood glucose test, a prevalence 41.0% of IFG were found. Prediabetes tends to increase with age, more frequent in males, more in active smokers. It also increased in higher BMI and higher blood pressure, i.e., SBP and DBP. But, in subjects with sedentary activities more than 6 h, less than 3 h, and fiber-based diet, there were almost no differences.

In the bivariate analysis, of 13 variables only 11 variables that were statistically significant with p value less than 0.05 and clinically significant with odds ratio (OR) more than 1 were included in the multivariate analysis. The other variables were sedentary activity and fiber consumption that have p value greater than 0.05 and were excluded from the analysis.

Table II describes the final regression model. We included eight predictor variables for prediabetes: they were (1) age, (2) gender, (3) level of education, (4) diabetes history in first degree, (5) smoker, (6) moderate physical activity, (7) BMI, and (8) SBP. These variables were predictors which used for INA-PRISC epidemiological model. In daily practice, this epidemiological model would very hard to implement, and because of that, we simplified the epidemiological model into scoring system as shown in Table III. Subsequently, for each participant, the total scores were estimated by this scoring rule. The total score of the participants ranged from 0 to 24 points. The minimum score 0 obtained when the participant does not have risk factors, and maximum score of 24 was obtained when the participant have all the risk factors for prediabetes. The eight predictor variables jointly yielded an AUC of 0.623 (95% CI 0.616–0.631) in the development model. A cut point of 12 of total score was selected as optimal point with the optimal value both sensitivity of 50.03% (95% CI 48.98–51.07) and specificity of 67.19% (95% CI 66.37–68.00).

We divided the risk of having prediabetes into four categories. The observed prevalence of prediabetes among very low-risk participants (0–6 points) was 28% (1,767 out of 6,374 participants), 40% (2,686 out of 6,685 participants) among low risk (7–11 points), 51% (4,249 out of 8,285 participants) among medium risk (12–17 points), and 56% (209 out of 376 participants) among high-risk participants (18–23 points) (Table IV). Dichotomizing scale at, for example, 18 points (at <18 points the diagnosis was normal glucose and ≥18 it was prediabetes) yielded a positive predictive value (PPV) of 55.59% and a negative predictive value (NPV) of 59.23% (Table IV).

Validation stage of INA-PRISC

We assessed the performance of the INA-PRISC using the RPG of INBHS 2013 complete data set (n = 6,933) as external validation. The purpose of validation was to evaluate the ability of generalizability of the risk score, which provided accurate predictions in terms of calibration and discrimination on a new subject from the identical population with different clinical criteria, such as RPG. We chose RPG data set considering that the RPG data set drawn from the same population characteristics and clinical history but different subjects with FPG data set.
In validation stage, we investigated the diagnostic characteristics using a sample of risk questionnaire shown in Table III. The optimal cutoff point for RPG was 12 resulted in overall test consistent results with AUC = 0.646 (95% CI 0.623–0.669), compared with FPG where the optimal cutoff point is 12 and AUC = 0.623 (95% CI 0.614–0.629). This result shows that the questionnaires filled out by participants in these two groups have similar AUC values.

Using the formula of the questionnaire in Table III, we could estimate participant’s probability of prediabetes based on his or her demographic characteristics and
The observed prevalence of prediabetes among very low-risk participants (0–6 points) was 3.6% (90 out of 2,451 participants), 7.8% (156 out of 1,997 participants) among low risk (7–11 points), 12% (286 out of 2,366 participants) among medium risk (12–17 points), and 13.4% (209 out of 376 participants) among high-risk participants (18–23 points) (see Table IV). Dichotomizing scale at, for example, 18 points (at <18 points the diagnosis was normal glucose and ≥18 it was prediabetes) yielded a PPV of 13.45% and an NPV of 92.19% (Table IV). The overall prevalence of prediabetes in RPG was 7.9% (548 out of 6,933 participants). Predictive values were affected by the prevalence of prediabetes, as shown in Table IV.

**Discussion**

In this study, the prevalence of prediabetes in individuals aged above 18 years was found to be 41% based on FPG test results. At the INBHS 2013 report, IFG in the population aged 15 years and above was 36.6%.
Table IV | Distribution of presence and absence of prediabetes per score category and corresponding sensitivity, specificity, and predictive values when dichotomized at different cutoff points

| Risk category | Prediabetes (n = 8,911) | Normal (n = 12,809) | Development stage | Sensitivity (95% CI) | Specificity (95% CI) | PPV (95% CI) | NPV (95% CI) |
|---------------|------------------------|---------------------|-------------------|---------------------|---------------------|--------------|--------------|
| VLR (score 0–6), n = 6,374 | 1.767 | 4.607 | 80.17 (79.33–80.99) | 35.97 (35.14–36.80) | 46.55 (46.14–46.97) | 72.28 (71.31–73.22) |
| LR (score 7), n = 6,685 | 2.686 | 3.999 | 50.03 (48.98–51.07) | 67.19 (66.37–68.00) | 51.47 (50.66–52.28) | 65.90 (65.36–66.44) |
| MR (score 12), n = 8,285 | 4.249 | 4.036 | 2.35 (2.04–2.68) | 98.70 (98.48–98.89) | 55.59 (50.57–60.49) | 72.28 (71.31–73.22) |
| HR (score 18), n = 376 | 209 | 167 | 98.39 (98.05–98.68) | 13.45 (8.46–20.71) | 92.19 (92.08–92.30) | 96.33 (95.59–96.95) |

In development stage: AUC = 0.623 (95% CI 0.616–0.631), whereas in validation stage by random plasma glucose [n = 6,993; AUC = 0.646 (95% CI 0.623–0.669); Hosmer–Lemeshow test, p < 0.001]
subjects who smoked before or smoked after the diagnosis of diabetes was performed with the occurrence of insulin resistance [28]; (2) body weight: in East Asian countries, diabetes occurred at a much lower BMI compared with the US and European countries [29]; (3) physical activity; (4) education; and (5) hypertension.

INA-PRISC could assess individual using modifiable factors and not only from unmodifiable factors which cannot be changed. These provide many opportunities for prevention, such as lifestyle modification.

We performed external validation of INA-PRISC by RPG. RPG recommended by the Screening for Impaired Glucose Tolerance (SIGT) could be used to prompt further evaluation with an OGTT. Discriminative effectiveness of RPG evaluated by ROC analysis, defining OGTT as the gold standard that identified ROCs 0.81 and 0.72 [30]. RPG is convenient, inexpensive, and commonly used in primary care. INA-PRISC can be used as a cost-effective and feasible screening tool for a large country like Indonesia with a population of over 250 millions.

The strengths of this study include large sample size, sex balance, range of age, and BMI, and taking into consideration the education level as a variable that affected the subjects’ knowledge in deciding to have a healthy lifestyle. However, the limitation of this study was the lack of information on easily measurable risk factor that may be important predictor of prediabetes, such as waist circumference. This, unfortunately, precludes the chance to investigate potentially important variable in the optimum risk score. Among the modifiable risk factors that played a substantial role in previous studies was obesity, measured by BMI or waist circumference. Both BMI and waist circumference were found to increase diabetes risk at cutoff points suggested for Asian populations that are lower than those used for people in Western countries [31]. Therefore, further studies will be required to increase the discriminative ability of INA-PRISC in recognizing prediabetes in primary care.

Conclusion

INA-PRISC is a simple prediabetes scoring system to identify people at high risk of developing diabetes in the future. Given the resourcing issues required for laboratory tests and the difficulty accessing such tests for rural and remote populations, the INA-PRISC only includes items that are easy to measure in primary care facilities throughout Indonesia, thereby increasing the feasibility of implementation.

References

1. Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw JE: Global estimates of diabetes prevalence for 2013 and projections for 2035. Diabetes Res Clin Pract 103, 137–149 (2014)
2. Indonesia Ministry of Health (2013): The National Institute of Health Research and Development Indonesia National Basic Health Survey (INHBS). Indonesia Ministry of Health, Jakarta
3. Garber A, Handelman Y, Einhorn D, Bergman D, Bloomgarden Z, Fonseca V, Timothy Garvey W, Gavin J III, Grunberger G, Horton E: Diagnosis and management of prediabetes in the continuum of hyperglycemia – When do the risks of diabetes begin? A consensus statement from the American College of Endocrinology and the American Association of Clinical Endocrinologists. Endocr Pract 14, 933–946 (2008)
4. American Diabetes Association: Standards of medical care in diabetes. Diabetes Care 38, S10 (2015)
5. Herman WH: The economic costs of diabetes: Is it time for a new treatment paradigm? Diabetes Care 36, 775–776 (2013)
6. Herman WH, Hoerger TJ, Brandle M, Hicks K, Sorensen S, Zhang P, Hamman RF, Ackermann RT, Engelgau MM, Ratner RE: The cost-effectiveness of lifestyle modification or metformin in preventing type 2 diabetes in adults with impaired glucose tolerance. Ann Intern Med 142, 323–332 (2005)
7. Icks A, Haaster B, Gandjour A, John J, Löwel H, Holle R, Giani G, Rathmann W: Cost-effectiveness analysis of different screening procedures for type 2 diabetes: The RORA Survey 2000. Diabetes Care 27, 2120–2128 (2004)
8. National Social Security Board (2014): Tiered Referral System Protocol. BPJS, Jakarta
9. Noble D, Mathur R, Dent T, Meads C, Greenhalgh T: Risk models and scores for type 2 diabetes: Systematic review. BMJ 343, d7163 (2011)
10. Glümer C, Vistisen D, Borch-Johnsen K, Colagiuri S: Risk scores for type 2 diabetes can be applied in some populations but not all. Diabetes Care 29, 410–414 (2006)

11. Lee Y-H, Bang H, Kim HC, Kim HM, Park SW, Kim DJ: A simple screening score for diabetes for the Korean population: Development, validation, and comparison with other scores. Diabetes Care 35, 1723–1730 (2012)

12. Atmarita, Pradono J, Permaesih D, Isfandari S, Pratiwi NL, Konadi L, Anwar A, Putro G, Rofiq A, Ra’atli L, Agtini MD, Idaiani S, Kartono J, Laksono AD, Nugraheni WP, Riyadina W, Afifah T, Widodo Y, Irawati A, Prihatin S, Lasdawati V, Purwanto E, eds (2013): Protocol of Indonesia National Basic Health Survey (INBHS). The National Institute of Health Research and Development, Indonesia Ministry of Health, Jakarta, pp. 12–21

13. Hsu WC, Araneta MRG, Kanaya AM, Chiang JL, Fujimoto W: BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. Diabetes Care 38, 150–158 (2015)

14. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, Lackland DT, LeFevre ML, MacKenzie TD, Ogedegbe O, Smith SC: 2014 evidence-based guideline for the management of high blood pressure in adults: Report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 311, 507–520 (2014)

15. Dahlan MS (2009): Penelitian Diagnostik (Diagnostic Study). Salemba Medika, Jakarta

16. Mehta HB, Mehta V, Girman CJ, Adhikari D, Johnson ML: Regression coefficient-based scoring system should be used to assign weights to the risk index. Int J Epidemiol 79, 22–28 (2016)

17. Jayawardena R, Ranasinghe P, Byrne NM, Soares MJ, Katulanda P, Hills AP: Prevalence and trends of the diabetes epidemic in South Asia: A systematic review and meta-analysis. BMC Public Health 12, 1–11 (2012)

18. Pramono LA, Setiati S, Soewondo P, Subekti I, Adisasmita A, Kodim N, Sutrisna B: Prevalence and predictors of undiagnosed diabetes mellitus in Indonesia. Acta Med Indones 46, 216–223 (2010)

19. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M: Prediabetes: A high-risk state for diabetes development. Lancet 379, 2279–2290 (2012)

20. Diabetes Prevention Program Research Group: 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. Lancet 374, 1677–1686 (2009)

21. Tuso P: Prediabetes and lifestyle modification: Time to prevent a preventable disease. Perm J 18, 88–93 (2014)

22. Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, Hu ZX, Xiao JZ, Cao HB, Liu PA, Jiang XG: Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: The Da Qing IGT and Diabetes Study. Diabetes Care 20, 537–544 (1997)

23. Evans MI, Galen RS, Britt DW: Principles of screening. Semin Permornatol 29, 364–366 (2005)

24. Heikes KE, Eddy DM, Aronekbar L, Schlessinger L: Diabetes risk calculator: A simple tool for detecting undiagnosed diabetes and prediabetes. Diabetes Care 31, 1040–1045 (2008)

25. Lalla E, Kanzel C, Burckett S, Cheng B, Lamster IB: Identification of unrecognized diabetes and prediabetes in a dental setting. J Dent Res 90, 855–860 (2011)

26. Cowie CC, Rust KF, Ford ES, Eberhardt MS, Byrd-Holt DD, Li C, Williams DE, Gregg EW, Bambidge KE, Saydah SH, Geiss LS: Full accounting of diabetes and prediabetes in the US population in 1988–1994 and 2005–2006. Diabetes Care 32, 287–294 (2009)

27. Yang Q, Liu T, Valdez R, Moonesinghe R, Khoury MJ: Improvements in ability to detect undiagnosed diabetes by using information on family history among adults in the United States. Am J Epidemiol 171, 1079–1089 (2010)

28. Xie XT, Liu Q, Wu J, Wakui M: Impact of cigarette smoking in type 2 diabetes development. Acta Pharmacol Sin 30, 784–787 (2009)

29. Yoon KH, Lee JH, Cho JH, Choi YH, Ko SH, Zimmet P, Son HY: Epidemic obesity and type 2 diabetes in Asia. Lancet 368, 1681–1688 (2006)

30. Ziemer DC, Kolm P, Weintrob WS, Vaccarino V, Rhee MK, Caudle JM, Irving JM, Koch DD, Narayan KV, Phillips LS: Age, BMI, and race are less important than random plasma glucose in identifying risk of glucose intolerance: The Screening for Impaired Glucose Tolerance Study (SIGT 5). Diabetes Care 38, 884–886 (2008)

31. Boffetta P, McLerran D, Chen Y, Inoue M, Sinha R, He J, Gupta PC, Tsugane S, Ise E, Tamakoshi A, Gao YT: Body mass index and diabetes in Asia: A cross-sectional pooled analysis of 900,000 individuals in the Asia cohort consortium. PLoS One 6, e19930 (2011)