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

categorized as undiagnosed diabetes. Moreover, the prevalence of prediabetes in Indonesian adult population is also increasing dramatically, from 10.2% in 2007 to 36.6% in 2013 [2]. From prediabetes alone, the number of people with diabetes in Indonesia will increase by one third, hence prediabetes is a major public health problem [3].

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.

The INBHS is a nationwide, community-based survey which designed in the national level, provinces, and districts/cities. It was a cross-sectional health examination and survey regularly conducted by The National Institute of Health Research and Development, Ministry of Health in Indonesia. The purpose of the national survey is to monitor the Indonesians' health status, to evaluate the achievement of national health, and to plan the next national health programs based on the evidence in INBHS [2]. To date, INBHSs have been performed in the years 2007 (INBHS I), 2010 (INBHS II), and 2013 (INBHS III). The INBHS consists of four different surveys: a health interview survey, a health behavior survey, a health examination survey, and a nutrition survey. The survey encompasses household information including all family members, family income, health financing, access to the health care, pharmacy and traditional health, mental health, community empowerment program, sanitation, and environmental health. Individual information consist of communicable and noncommunicable diseases, genetics and family history, injuries, eye health, mouth and dental health, disabilities, knowledge, attitude and behavior toward health, mother and child health, immunization, nutrition, etc. Quality assurance of the survey and the data management had been performed by independent bodies. Similar to another national health survey, each INBHS consists of independent sets of individuals from the Indonesian population. All individuals were randomly selected from 12,000 Blocks Census randomly assigned in 33 provinces and 497 districts and cities in Indonesia. Details of the surveys available in the INBHS protocol book that can be download in the official website [12].

Subjects aged above 18 years (35,374 individuals) were selected for the study as sampling frame, assuming that the risk of prediabetes started since childhood with the increasing number of obesity in children in Indonesia [2]. Subjects who were identified in the health interview survey with a previous diagnosis of diabetes by a health-care professional or who were taking insulin or oral anti-diabetes agents, or have the classic sign and symptoms of diabetes (polyuria, polyphagia, and polydipsia) were defined as having "known diabetes," and subjects who were first diagnosed with diabetes by the survey were classified as having "undiagnosed diabetes" both were excluded from the study. Subjects with missing data in key covariates were also excluded. As results, we had 21,720 subjects who have completed data analysis based on FPG test for development stage, and 6,933 subjects completed data analysis based on RPG test for the validation stage.

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/m^2 defined as normal, 23.0–24.9 kg/m^2 as overweight, and 25.0 kg/m^2 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 I illustrates the prevalence of prediabetes in group data set based on socio-demographic characteristics and variable predictors of the participants. Of 21,720

Table I Bivariate analysis of predictors for prediabetes in the development of INA-PRISC

	Prediabetes		Normal				95% CI	
	n	%	*n*	%	*p* value	OR	Min	Max
1. Age								
>55 years	2.431	52.6	2.187	47.4	<0.001	3.069	2.737	3.443
46–55 years	2.323	48.0	2.515	52.0	<0.001	2.550	2.275	2.859
36–45 years	2.330	39.7	3.538	60.3	<0.001	1.818	1.626	2.034
26–35 years	1.295	29.5	3.100	70.5	0.018	1.154	1.025	1.299
19–25 years	532	26.6	1.469	73.4		Reference		
2. Sex								
Male	3.878	44.5	4.830	55.5	<0.001	1.273	1.205	1.345
Female	5.033	38.7	7.979	61.3		Reference		
3. Education level								
Uneducation (never been to school/not completed primary school)	2.510	49.2	2.590	50.8	<0.001	1.745	1.627	1.871
Low education (primary school certificate)	3.260	41.7	4.564	58.3	<0.001	1.286	1.208	1.369
High education (high school and above)	3.141	35.7	5.655	64.3		Reference		
4. 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		
5. 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		
6. BMI (kg/m^2)								
≥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		
7. 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		
8. 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		
9. 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		
10. 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		
11. 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)

Table I (Continued)

	Prediabetes		Normal				95% CI	
	n	%	*n*	%	*p* value	OR	Min	Max
2–<3 servings	1.757	41.6	2.471	58.4	0.553	1.057	0.881	1.268
3–<4 servings	1.091	40.6	1.597	59.4	0.874	1.015	0.841	1.226
4–<5 servings	270	40.1	403	59.9	0.971	0.996	0.791	1.254
≥5 servings	218	40.2	324	59.8		Reference		
12. SBP								
≥160 mmHg	971	51.5	914	48.5	<0.001	2.013	1.820	2.225
140–159 mmHg	1.441	48.0	1.560	52.0	<0.001	1.750	1.609	1.904
120–139 mmHg	3.474	43.0	4.604	57.0	<0.001	1.430	1.343	1.521
<120 mmHg	3.025	34.5	5.731	65.5		Reference		
13. DBP								
≥100 mmHg	888	47.3	988	52.7	<0.001	1.451	1.314	1.603
90–99 mmHg	1.430	43.3	1.869	56.7	<0.001	1.235	1.140	1.338
80–89 mmHg	2.908	42.1	4.003	57.9	<0.001	1.173	1.101	1.249
<80 mmHg	3.685	38.2	5.949	61.8		Reference		
Total	8.911	41.0	12.809	59.0				

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 occurred more in low and uneducated subjects. 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.

Table II Multivariate analysis of predictors for prediabetes and score assigned in the development of INA-PRISC

Risk factors	*B* (coefficient β)	*p* value	OR (Exp *B*)	95% CI Min	95% CI Max	Score assigned*
Intercept	−1.257					
1. Age						
>55 years	0.873	<0.001	2.393	2.108	2.716	9
46–55 years	0.735	<0.001	2.085	1.846	2.353	7
36–45 years	0.459	<0.001	1.582	1.409	1.777	5
26–35 years	0.074	0.225	1.077	0.955	1.215	1
19–25 years			Reference			0
2. Sex						
Male	0.083	0.048	1.087	1.001	1.181	1
Female			Reference			0
3. Education level						
Uneducation (never been to school/not completed primary school)	0.267	<0.001	1.306	1.207	1.413	3
Low education (primary school certificate)	0.065	0.057	1.067	0.998	1.141	1
High education (high school and above)			Reference			0
4. Diabetes history in first degree						
Yes	0.314	0.017	1.369	1.057	1.774	3
No/unknown			Reference			0
5. Smoking habit						
Yes	0.227	<0.001	1.255	1.151	1.368	2
No			Reference			0
6. Moderate physical activity						
No or <150 min/week	0.094	0.030	1.098	1.009	1.196	1
≥150 min/week			Reference			0
7. BMI for Asian population						
≥25 (obese)	0.226	<0.001	1.253	1.171	1.341	2
23–24.9 (overweight)	0.066	0.103	1.069	0.987	1.157	1
18.5–22.9 (normal)			Reference			
8. Hypertension						
SBP ≥160 mmHg or DBP ≥100 mmHg	0.251	<0.001	1.285	1.152	1.434	3
SBP 140–159 mmHg or DBP 90–99 mmHg	0.191	<0.001	1.211	1.105	1.326	2
SBP 120–139 mmHg or DBP 80–89 mmHg	0.167	<0.001	1.182	1.107	1.262	2
SBP 120 mmHg and DBP 80 mmHg			Reference			

Based on the final regression model in the development data set, Indonesian National Basic Health Survey 2013 [$n = 21.720$; AUC = 0.623 (95% CI 0.616–0.631); Hosmer–Lemeshow test, $p < 0.001$]

*Beta coefficients were multiplied by 10 and rounded to the nearest integer to derive scores

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

Table III Screening questionnaire for participants, recommended for use by health-care providers

Risk factors	Individual data	Score
1. Age		
>55 years		9
46–55 years		7
36–45 years		5
26–35 years		1
19–25 years		0
2. Sex		
Male		1
Female		0
3. Education level		
Uneducation (never been to school/not completed primary school)		3
Low education (primary school certificate)		1
High education (high school and above)		0
4. Diabetes history in first degree		
Yes		3
No/unknown		0
5. Smoking habit		
Yes		2
No		0
6. Physical activity		
No or <150 min/week		1
≥150 min/week		0
7. BMI		
≥25 (obese)		2
23–24.9 (overweight)		1
18.5–22.9 (normal)		0
8. Hypertension		
SBP ≥160 mmHg or DBP ≥100 mmHg		3
SBP 140–159 mmHg or DBP 90–99 mmHg		2
SBP 120–139 mmHg or DBP 80–89 mmHg		2
SBP 120 mmHg and DBP 80 mmHg		
Total score		

clinical profile. 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				
LR (score 7), $n = 6.685$	2.686	3.999	80.17 (79.33–80.99)	35.97 (35.14–36.80)	46.55 (46.14–46.97)	72.28 (71.31–73.22)
MR (score 12), $n = 8.285$	4.249	4.036	50.03 (48.98–51.07)	67.19 (66.37–68.00)	51.47 (50.66–52.28)	65.90 (65.36–66.44)
HR (score 18), $n = 376$	209	167	2.35 (2.04–2.68)	98.70 (98.48–98.89)	55.59 (50.57–60.49)	59.23 (59.14–59.32)
			Validation stage			
Risk category	Prediabetes ($n = 548$)	Normal ($n = 6.385$)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
VLR (score 0–6), $n = 2.451$	90	2.361				
LR (score 7), $n = 1.997$	156	1.841	83.58 (80.20–86.58)	36.98 (35.79–38.17)	10.22 (9.84–10.61)	96.33 (95.59–96.95)
MR (score 12), $n = 2.366$	286	2.080	55.11 (50.84–59.33)	65.81 (64.63–66.97)	12.15 (11.30–13.07)	94.47 (93.95–94.94)
HR (score 18), $n = 119$	16	103	2.92 (1.68–4.70)	98.39 (98.05–98.68)	13.45 (8.46–20.71)	92.19 (92.08–92.30)

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, $p < 0.001$]

Compared with other Asian countries, the prevalence of prediabetes in Indonesia is quite high [17]. For that, we developed a scoring system that is simple, easily use by a health-care provider, does not require any blood assays, and does not require a long time to identify individuals who have a risk of prediabetes.

To date, most risk assessment scores for diabetes and not many for prediabetes. We focus to identify prediabetes, but when category high-risk subjects undergo confirmation test, we can also expect to find undiagnosed diabetes. Thus, it is expected that there will be many case findings for early treatment. As far as we know, our prediabetes risk score model is the first model in Indonesia. Other known scoring system is for undiagnosed diabetes [18].

Prediabetes is a high-risk state for diabetes [19]. Around 8%–10% of people with prediabetes become diabetic annually although conversion rate varies by population characteristics [4]. In the Diabetes Prevention Program (DPP) Outcomes Study, progression estimates have been similar: the annualized incidence was 11% [20]. Fortunately, prediabetes is now recognized as a reversible condition that can be prevented from becoming diabetic. Increase of awareness and risk stratification of individuals with prediabetes may help physicians understand potential interventions that may help decrease the conversion rate [21]. Many studies suggest that lifestyle intervention may decrease the risk of prediabetes progressing to diabetes up to 58% [20, 22].

The prediabetes risk score will be used as a screening tool that is cheap and easily performed on individuals who appears to be healthy in general population to determine the population at risk in accordance with the basic principles of screening [23].

Comparing to other prediabetes studies that exist today, INA-PRISC discrimination capability as measured by ROC was 62.3% lower than another prediabetes risk score. However, we found that one of the variables was race/specific ethnicity which will be limit the generalizability of the model on specific population [24, 25], that might not be relevant to our population.

INA-PRISC includes three non-modifiable risk factors: (1) age: IFG and IGT, varied in accordance with ethnicity, but have something in common, that is, it is more frequent in the older age group [26]; (2) history with diabetes in first degree: study on different ethnic groups reported that a family history of diabetes increased the risk of having diabetes 2–6 times greater in those who did not have family history of diabetes [27]; (3) sex: this study showed that in Indonesia, IFG affected more in males (44.5%) than females (38.7%). Consistent with another study that stated IFG found more in males than females [26].

Five modifiable factors included in INA-PRISC are (1) smoking habit: exposure to both acute and chronic nicotine could have negative effects on insulin action, in

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.

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Ethics: Ethics approval and consent to participate applicable in Indonesian National Basic Health Survey document at the Data Management Laboratory of the National Institute of Health Research and Development Indonesia. The study protocol was reviewed and approved by Health Research Ethical Committee, Medical Faculty of University of Sumatera Utara, Medan, Indonesia (no. 473/KOMET/FK USU/2015).

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