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S7. Epidemiologic issues on diabetes
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A simple screening score for diabetes for the Korean population

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- Prediction models in Health sciences
- Prediction models in Diabetes
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What is prediction model?

- A "**prediction**" is a statement or claim that a particular event will occur in the future (or now).
- Response is often binary (event/no-event).
- Mathematical equation can be used to model the probability (or rate) of event.
  - Numeric algorithm can be derived to grade the risk, often by simplifying the mathematical model.
  - Prediction models provide diagnostic or prognostic probabilities

Why important?

- Prediction models are valuable for medical practice and for research purposes.

- People use it in real world (esp., lay and underserved people)-- used in clinical or community setting, self-use for (pre-)screening or risk assessment/prediction.
  - In public health, models may help target preventive interventions to subjects at relatively high risk of having or developing a disease.

Ewout W. Steyerberg

Why important?

- In clinical practice, prediction models may inform patients and their treating physicians on the probability that a disease is (will be) present and may also assist medical decision making.
  - When the probability is relatively high, treatment is indicated; if the probability is very low, no treatment is indicated.
  - For example, Framingham risk score for CVD

Good Modeling

If prediction model is not used in the real world, it is not a prediction model. It is a regression model (or academic glory).

- That's why it should perform well *statistically*. More importantly, it should be ***clinically relevant/meaningful***.

For good prediction models

1. Simple and easy, but not too simple
2. Variable selection
3. Variable categorization
4. Sample size (N) & data/variables
5. Population characteristics

1. Simple and easy

- User-friendliness and easy use are important!
  - if statisticians or clinicians can not use it easily, how lay persons can use?

- Interactions or nonlinear function may make prediction model/risk score more accurate but complex.

Diabetes risk score in UK

	Risk score	Characteristic
α	−6.322	Constant
$\beta_1 x_1$	−0.879	Female
$\beta_2 x_2$	1.222	Prescribed antihypertensive medication
$\beta_3 x_3$	2.191	Prescribed steroids
$\beta_4 x_4$	0.063	*x* age in years
$\beta_5 x_5$	0	Body mass index <25
	0.699	Body mass index $=25$ to 27.49
	1.970	Body mass index $=27.5$ to 29.99
	2.518	Body mass index $\geqslant 30$
$\beta_6 x_6$	0	No first degree relative had diabetes
	0.728	Parent or sibling had diabetes
	0.753	Parent and sibling had diabetes
$\beta_7 x_7$	0	Non-smoker
	−0.218	Ex-smoker
	0.855	Current smoker

[a]Probability of having Type 2 diabetes $= \frac{1}{1+e^{-(\alpha+\beta_1 x_1+\beta_2 x_2 \cdots+\beta_n x_n)}}$

Diabetes Metab Res Rev 2000; 16: 164±171

2. Variable selection

- **>10** variables may be too many.
- Not all significant predictors may be included in the final model (statistical vs. clinical significance)
  - difficult and easy variables.
- >1 model may be developed to accommodate different data availabilities, e.g. with or without blood test.

Risk score for predicting incidence of diabetes in middle-aged Korean

Table 2. Multivariate Logistic Regression for Type 2 Diabetes

	Basic model		Clinical model 1		Clinical model 2	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Age (years)	1.02 (1.01–1.03)	0.0053	1.02 (1.00–1.04)	0.0007	1.01 (1.00–1.03)	0.0528
Parental or sibling history of diabetes	1.90 (1.46–2.49)	<0.0001	1.84 (1.38–2.41)	<0.0001	1.75 (1.32–2.31)	<0.0001
Current smoking	1.68 (1.35–2.09)	<0.0001	1.35 (1.06–1.66)	0.0103	1.26 (1.00–1.58)	0.0522
BMI(kg/m^2)						
<23	1 (reference)	–	1 (reference)	–	1 (reference)	–
23–24	1.50 (1.12–2.01)	0.0064	1.21 (0.89–1.63)	0.2219	1.18 (0.87–1.59)	0.2987
25–29	2.03 (1.56–2.65)	<0.0001	1.37 (1.04–1.82)	0.0267	1.27 (0.96–1.69)	0.0939
≥30	3.17 (2.09–4.80)	<0.0001	2.07 (1.33–3.21)	0.0012	1.78 (1.15–2.77)	0.0105
Hypertension status	1.81 (1.44–2.28)	<0.0001	1.49 (1.17–1.89)	0.0012	1.51 (1.19–1.92)	0.0008
FPG (mg/dl)						
<90			0.38 (0.30–0.48)	<0.0001	0.41 (0.32–0.52)	<0.0001
90–99			1 (reference)	–	1 (reference)	–
100–125			3.34 (2.38–4.71)	<0.0001	3.19 (2.26–4.50)	<0.0001
HDL-C (mg/dl)						
<35			1.47(1.12–1.93)	0.0050	1.47 (1.12–1.93)	0.0056
35–49			1 (reference)	–	1 (reference)	–
≥50			0.83 (0.63–1.10)	0.1782	0.82 (0.62–1.08)	0.1566
TG (mg/dl)						
<120			1 (reference)	–	1 (reference)	–
120–149			1.40 (1.02–1.93)	0.0385	1.37 (1.00–1.89)	0.0537
≥150			2.12 (1.63–2.77)	<0.0001	2.00 (1.53–2.61)	<0.0001
HbA_{1c} (%)						
<5.5 (37 mmol/mol)					1 (reference)	–
5.5–6.4 (37–46 mmol/mol)					2.66 (2.02–3.51)	<0.0001
AROC	0.65 (0.62–0.68)		0.75 (0.72–0.77)		0.77 (0.74–0.79)	
Hosmer-Lemeshow	5.560	0.6964	2.090	0.9781	4.893	0.7690

3. Variable categorization

- Most statisticians agree with Royston (2005) – *Dichotomizing continuous predictors in multiple regression: a bad idea.*

- However, filling in continuous information (e.g. blood pressure, BMI, CRP) can be hard for many people.

- 'Continuous models' vs. 'Categorical models'
  – for computer-based platform vs. pencil & paper.

4. Sample size & data/variables

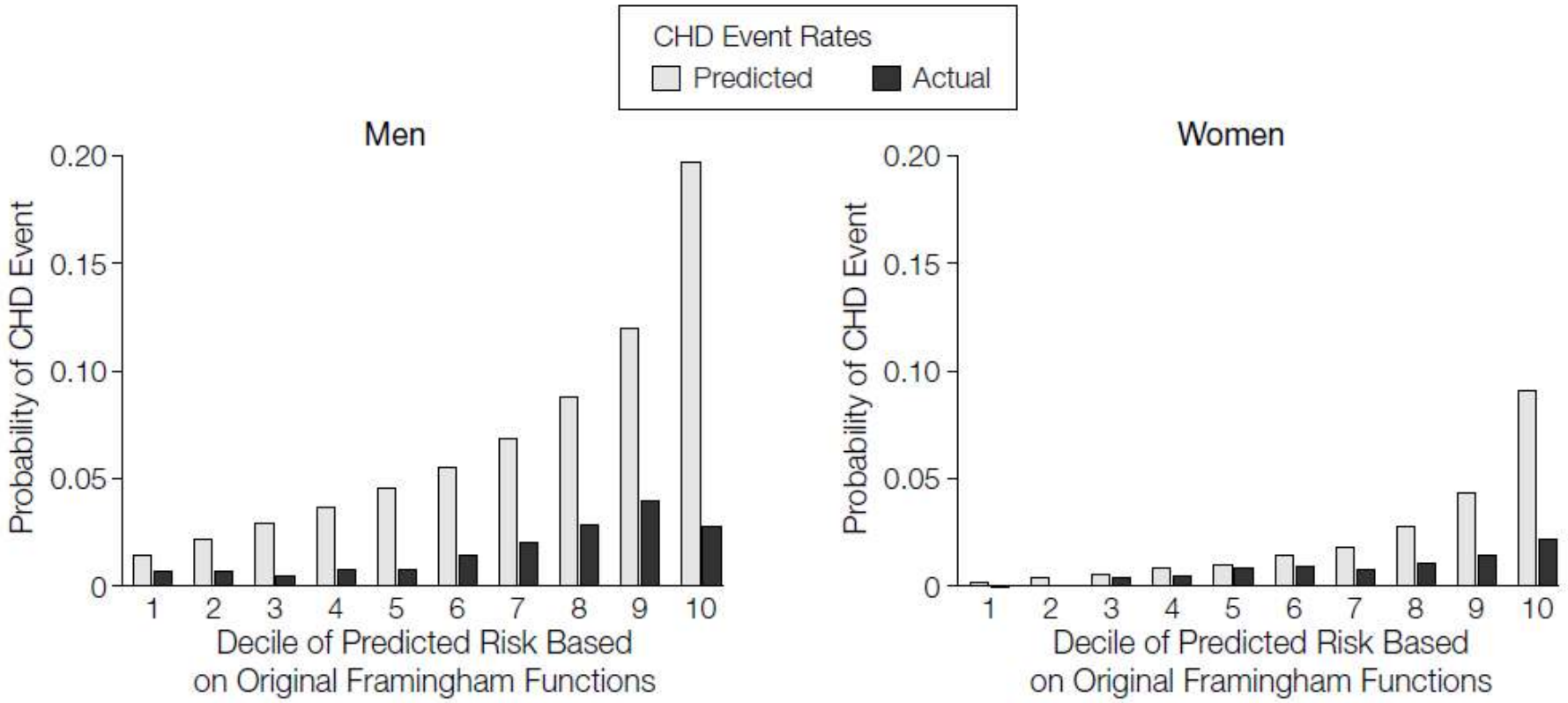
- No absolute consensus on N requirement. As the goal is a stable regression equation, larger is better.
- "***large & representative***" sample from the target population (if not, less reproducible or generalizable)
- We may need to save some N for internal validation.

5. Population characteristics

- Universal model may not exist.

- Separate models may be warranted:
  - by sex
  - by race or country (e.g. many countries have their own diabetes score)
  - by age
  - high risk (e.g. clinical setting) vs. general population
  - first vs. recurrent event

Framingham risk score in Chinese Adults



CMCS indicates Chinese Multi-provincial Cohort Study. Coronary heart disease (CHD) events included coronary death and myocardial infarction.

Liu J, et al. JAMA. 2004;291(21):2591-2599

Steps in Model development

Step 1: Model Development

Step 2: Model Evaluation

Step 3: Validations - including feasibility and usefulness

Step 4: Refinement or improvement in model or presentation (if desired)

Statistical tools for model development

- **Regression models** - linear, logistic, Cox model

  -- explicit mathematical formula and numeric scoring system can be derived (e.g. guided by regression coefficients)

- **Tree-based methods** - Classification and Regression Tree, Recursive Partitioning

  -- can handle complex interactions

  -- cut-points identified

  -- can handle numerous candidate variables

Statistical measures for model evaluation

- Sensitivity & Specificity — most popular
- Discrimination (ROC/AUC) – most popular
- Predictive values – positive, negative
- Likelihood ratio – positive, negative
- Accuracy (e.g. Youden index, Brier score)
- Number needed to treat or screen (NNT, NNS)
- Model fit (e.g. AIC, BIC)
- Lack of fit (e.g. Hosmer-Lemeshow test)
- R^2 (coefficient of determination)
- P-value (significance) – universally popular

Prevalent vs. Incident events

- **Prevalent/concurrent event**
  - cross-sectional data is used.
  - useful for ***asymptomatic*** disease for screening undiagnosed cases (e.g. breast cancer, diabetes, kidney disease), not for all diseases.
  - simplicity in prediction model/risk score is important.
- **Incident/future event**
  - prospective study of event-free cohort is needed.
  - simplicity is less important.

How to disseminate?

- Good models deserves good marketing/PR.
- How to present? Figure, score card or click-click-click?
  - computer (e.g. web-based) vs. paper-pencil method.
  - Smartphone apps
- May work with Public Affair team in your institution.
  - at times, press release/interview follow (esp., for 1st study)
  - no one reads/understands your paper as well as you do. Deliver the main findings clearly.
- May work with authority and practitioners to implement/distribute your method - preferably after validation.

Sample risk scores on internet

- **Cancer**: http://riskfactor.cancer.gov/cancer_risk_prediction/
  http://www.mskcc.org/mskcc/html/5794.cfm
  http://www4.utsouthwestern.edu/breasthealth/cagene/
- APACHE: http://www.sfar.org/scores2/apache22.html
  http://www.apache-web.com/public/pub_main.html
- Charlson comorbidity index:
  http://en.wikipedia.org/wiki/Comorbidity#Charlson_index
- **Framingham score**: http://framinghamriskscore.com/
- UK CVD score: http://www.riskscore.org.uk/
- PROCAM score: http://www.chd-taskforce.de/
- Reynolds score: http://www.reynoldsriskscore.org/
- ABCD score: http://www.strokecenter.org/Trials/scales/ABCDScore.pdf
- **Diabetes risk score**: http://www.diabetes.org/risk-test.jsp
- German diabetes risk score: http://www.dife.de/
- Angina score: http://www.anginarisk.org/
- Pneumonia score: http://www.ahrq.gov/clinic/pneuclin.htm#head1
- SCORED: http://unchealthcare.org/site/newsroom_OLD/scored.pdf
- Depression: http://www.psycom.net/depression.central.screening.html
- Autism: http://www.txautism.net/docs/Guide/Evaluation/AutismScreen_Assess.pdf
- Medical calculator: http://medcalc3000.com/

PREDICTION MODELS IN DIABETES: DIABETES RISK SCORE

FINnish Diabetes RIsk SCore (FINDRISC)

Risk model development:

FINRISK87 - SURVEY

Excluded if
- age < 35 yrs.
- DM medication
- missing variables

4435 subjects with baseline Risk Score

10 years follow-up (drug register)

182 DM cases identified

Risk model validation:

FINRISK92 - SURVEY

Excluded if
- age < 35 yrs.
- DM medication
- missing variables

4586 subjects with baseline Risk Score

5 years follow-up (drug register)

67 DM cases identified

Lindström et al.
Diabetes Care 2003; 26: 725-731

FINnish Diabetes RIsk SCore

FINDRISC

Score range 1-24 p

AUC 0.85
Sensitivity 73%
Specificity 83%

Lindström et al.
Diabetes Care 2003; 26: 725-731

Finnish Diabetes Association

TYPE 2 DIABETES RISK ASSESSMENT FORM

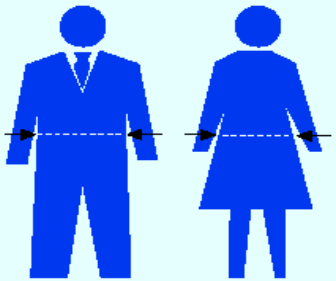
Circle the right alternative and add up your points.

1. Age
0 p. Under 45 years
2 p. 45–54 years
3 p. 55–64 years
4 p. Over 64 years

2. Body-mass index
(See reverse of form)
0 p. Lower than 25 kg/m²
1 p. 25–30 kg/m²
3 p. Higher than 30 kg/m²

3. Waist circumference measured below the ribs (usually at the level of the navel)

	MEN	WOMEN
0 p.	Less than 94 cm	Less than 80 cm
3 p.	94–102 cm	80–88 cm
4 p.	More than 102 cm	More than 88 cm



4. Do you usually have daily at least 30 minutes of physical activity at work and/or during leisure time (including normal daily activity)?
0 p. Yes
2 p. No

5. How often do you eat vegetables, fruit or berries?
0 p. Every day
1 p. Not every day

6. Have you ever taken antihypertensive medication regularly?
0 p. No
2 p. Yes

7. Have you ever been found to have high blood glucose (eg in a health examination, during an illness, during pregnancy)?
0 p. No
5 p. Yes

8. Have any of the members of your immediate family or other relatives been diagnosed with diabetes (type 1 or type 2)?
0 p. No
3 p. Yes: grandparent, aunt, uncle or first cousin (but no own parent, brother, sister or child)
5 p. Yes: parent, brother, sister or own child

Total Risk Score
☐ **The risk of developing type 2 diabetes within 10 years is**

Lower than 7	**Low:** estimated 1 in 100 will develop disease
7–11	**Slightly elevated:** estimated 1 in 25 will develop disease
12–14	**Moderate:** estimated 1 in 6 will develop disease
15–20	**High:** estimated 1 in 3 will develop disease
Higher than 20	**Very high:** estimated 1 in 2 will develop disease

Please turn over

Test designed by Professor Jaakko Tuomilehto, Department of Public Health, University of Helsinki, and Jaana Lindström, MSS, National Public Health Institute

The Australian Type 2 Diabetes Risk Assessment Tool (AUSDRISK)

1. Your age group?

Under 35 years	0 points
35 – 44 years	2 points
45 – 54 years	4 points
55 – 64 years	6 points
65 years or over	8 points

2. Your gender?

Female	0 points
Male	3 points

3. Ethnicity/Country of birth:

3a. Are you of Aboriginal, Torres Strait Islander, Pacific Islander or Maori descent?

No	0 points
Yes	2 points

3b. Where were you born?

Asia (including the Indian sub-continent), Middle East, North Africa, Southern Europe	2 points
Other	0 points

4. Have either of your parents, or any of your brothers or sisters been diagnosed with diabetes (type 1 or type 2)?

No	0 points
Yes	3 points

5. Have you ever been found to have high blood glucose (sugar) (for example, in a health examination, during an illness, during pregnancy)?

No	0 points
Yes	6 points

6. Are you currently taking medication for high blood pressure?

No	0 points
Yes	2 points

7. Do you currently smoke cigarettes or any other tobacco products on a daily basis?

No	0 points
Yes	2 points

8. How often do you eat vegetables or fruit?

Everyday	0 points
Not everyday	1 point

9. On average, would you say you do at least 2.5 hours of physical activity per week (for example, 30 minutes a day on 5 or more days a week)?

Yes	0 points
No	2 points

10. Your waist measurement taken below the ribs (usually at the level of the navel)?

For those of Asian or Aboriginal or Torres Strait Islander descent:

Men	Women	
Less than 90 cm	Less than 80 cm	0 points
90 – 100 cm	80 – 90 cm	4 points
More than 100 cm	More than 90 cm	7 points

For all others:

Men	Women	
Less than 102 cm	Less than 88 cm	0 points
102 – 110 cm	88 – 100 cm	4 points
More than 110 cm	More than 100 cm	7 points

Add up your score

Your risk of developing type 2 diabetes within 5 years*:

Less than 5: Low risk

Approximately one person in every 100 will develop diabetes.

6-14: Intermediate risk

For scores of 6-8, approximately one person in every 50 will develop diabetes.

For scores of 9-14, approximately one person in every 20 will develop diabetes.

15 or more: High risk

For scores of 15-19, approximately one person in every seven will develop diabetes.

For scores of 20 and above, approximately one person in every three will develop diabetes.

If you scored 15 or more points, it is important that you discuss your score with your doctor.

*The overall score may overestimate the risk of diabetes in those aged less than 25 years and underestimate the risk of diabetes in people of Aboriginal and Torres Strait Islander descent

The Australian Type 2 Diabetes Risk Assessment Tool was originally developed by the International Diabetes Institute on behalf of the Australian, State and Territory Governments as part of the COAG Diabetes *reducing the risk of type 2 diabetes* initiative.

Annals of Internal Medicine | ARTICLE

Development and Validation of a Patient Self-assessment Score for Diabetes Risk

Heejung Bang, PhD; Alison M. Edwards, MStat; Andrew S. Bomback, MD, MPH; Christie M. Ballantyne, MD; David Brillon, MD; Mark A. Callahan, MD; Steven M. Teutsch, MD, MPH; Alvin I. Mushlin, MD, ScM; and Lisa M. Kern, MD, MPH

Risk Factor	Odds Ratio (95% CI)	*P* Value	Log (Odds Ratio)	Score Assigned
Age				
<40 y	Reference	–	–	0
40–49 y	2.6 (1.3–5.0)	0.004	0.95	1
50–59 y	4.8 (2.2–10.6)	<0.001	1.57	2
≥60 y	8.1 (3.9–16.9)	<0.001	2.09	3
Sex				
Female	Reference	–	–	0
Male	2.6 (1.8–3.7)	<0.001	0.96	1
Family history of diabetes				
No	Reference	–	–	0
Yes	2.0 (1.5–2.6)	<0.001	0.67	1
History of hypertension				
No	Reference	–		0
Yes	1.9 (1.2–2.9)	0.004	0.64	1
Obesity†				
Not overweight or obese	Reference	–	–	0
Overweight	1.3 (0.6–2.8)	0.47	0.27	1
Obese	3.1 (1.6–5.8)	<0.001	1.12	2
Extremely obese	7.3 (4.0–13.4)	<0.001	1.99	3
Physically active				
No	Reference	–	–	0
Yes	0.7 (0.5–1.0)	0.06	−0.34	−1

- **development dataset**
  - NHANES 1999 to 2004
  - 5258 participants
  - Undiagnosed diabetes of 2.8%
  - Score: 0-9
  - Cut-off point: 5
  - AUC of 0.79
- **Validation dataset**
  - NHANES 2005 to 2006
  - Sens. 79% Spec. 67%
  - AUC 0.83

ARE YOU AT RISK FOR

TYPE 2 DIABETES?

TAKE THE TEST.
YOU NEED TO KNOW.

American Diabetes Association.

www.diabetes.org
1-800-DIABETES

Diabetes Risk Test

This simple tool can help you determine your risk for having type 2 diabetes.

Write your score in the box.

1 How old are you?
- <40 years (0 points)
- 40—49 years (1 point)
- 50—59 years (2 points)
- 60 years or older (3 points)

2 Are you a man or a woman?
- Man (1 point)
- Woman (0 points)

3 If you are a woman, have you ever been diagnosed with gestational diabetes?
- Yes (1 point)
- No (0 points)

4 Do you have a mother, father, sister, or brother with diabetes?
- Yes (1 point)
- No (0 points)

5 Have you ever been diagnosed with high blood pressure?
- Yes (1 point)
- No (0 points)

6 Are you physically active?
- Yes (0 points)
- No (1 point)

7 What is your weight status? *(see chart at right)*

Height	Weight (lbs.)		
4′ 10″	119-142	143-190	191+
4′ 11″	124-147	148-197	198+
5′ 0″	128-152	153-203	204+
5′ 1″	132-157	158-210	211+
5′ 2″	136-163	164-217	218+
5′ 3″	141-168	169-224	225+
5′ 4″	145-173	174-231	232+
5′ 5″	150-179	180-239	240+
5′ 6″	155-185	186-246	247+
5′ 7″	159-190	191-254	255+
5′ 8″	164-196	197-261	262+
5′ 9″	169-202	203-269	270+
5′ 10″	174-208	209-277	278+
5′ 11″	179-214	215-285	286+
6′ 0″	184-220	221-293	294+
6′ 1″	189-226	227-301	302+
6′ 2″	194-232	233-310	311+
6′ 3″	200-239	240-318	319+
6′ 4″	205-245	246-327	328+
	(1 Point)	(2 Points)	(3 Points)

You weigh less than the amount in the green column (0 points)

Add up your score.

Adapted from Bang et al., Ann Intern Med 151:775-783, 2009.

If you scored 5 or higher:
You are at increased risk for having type 2 diabetes. However, only your doctor can tell for sure if you do have type 2 diabetes or prediabetes (a condition that precedes type 2 diabetes in which blood glucose levels are higher than normal). Talk to your doctor to see if additional testing is needed.

Diabetes Basics

Prevention
Diabetes Risk Test

Home > Diabetes Basics > Prevention > Diabetes Risk Test

Diabetes Risk Test

Listen to text

En Español

New to Type 2?

Enroll in the **Living With Type 2 Diabetes** program and let us guide you through your **first year** with type 2 diabetes.

Enroll for **free** today.

Qingdao diabetes risk score

Waist (Chinese chi*)			
Men	Score	Women	Score
≤ 2.3	1	≤ 2.0	1
2.4–2.6	4	2.1–2.3	3
2.7–2.9	8	2.4–2.6	6
≥ 3.0	12	≥ 2.7	9

Age (years)	Score
≤ 35	1
36–45	3
46–55	6
56–65	9
≥ 65	12

Diabetes in parents and/or siblings	Score
Negative	1
Positive	8
Score range	3–32

*1 Chinese chi ≈ 33 cm.

- 2002/2006 survey
  - N=1986/4336
- OGTT
- Score: 3-32
- Cut-off point: 14
- Sens. 84.2%
- Spec. 39.8%
- AUC 0.673

Diabetic Med 2010

Thai diabetes risk score

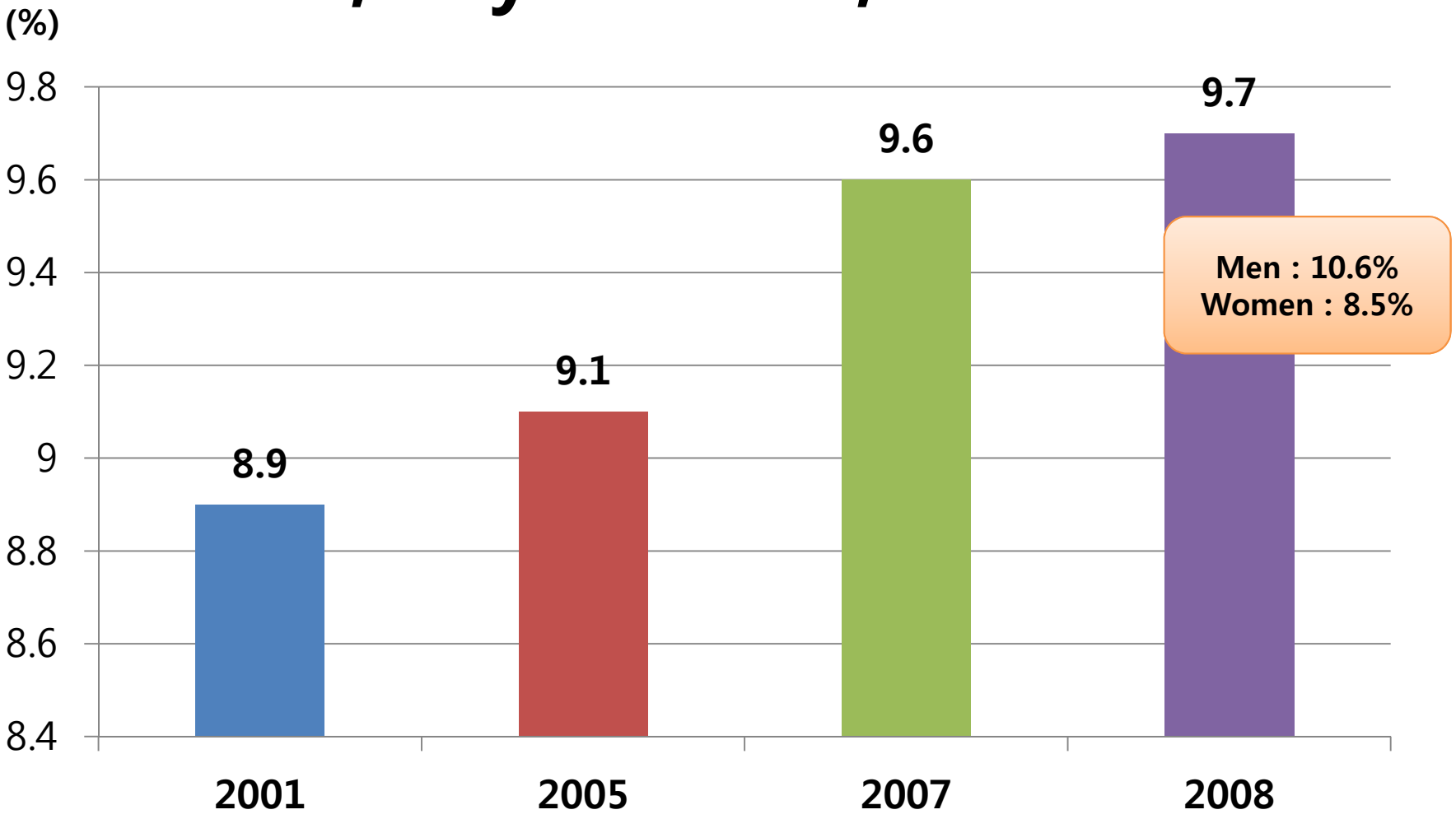
Risk factor	Coefficient	Diabetes risk score
Age (years)		
34–39		0
40–44	−0.07	0
45–49	0.27	1
≥50	0.60	2
Sex		
Women		0
Men	0.44	2
BMI (kg/m^2)		
<23		0
≥23 but <27.5	0.69	3
≥27.5	1.24	5
Waist circumference (cm)		
<90 in men, <80 women		0
≥90 in men, ≥80 in women	0.56	2
Hypertension		
No		0
Yes	0.64	2
History of diabetes in parent or sibling		
No		0
Yes	1.08	4

- Score: 1-17
- Cutoff score:
  - **6**
  - Sens. 77%; Spec. 60%
- AUC: 0.74

Diabetes Care 29:1872–1877, 2006

DIABETES SCREENING SCORE FOR KOREAN ADULTS

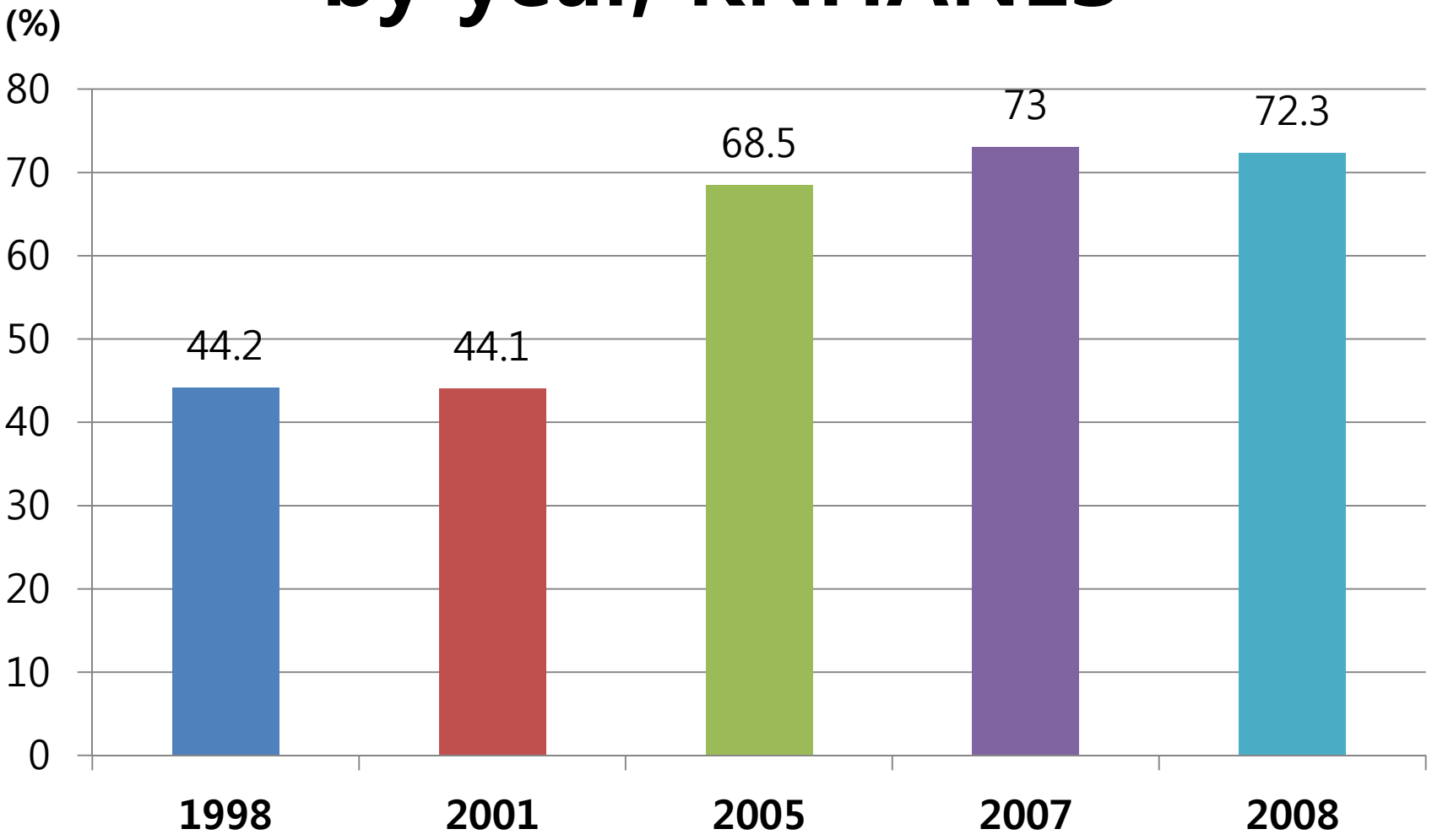
Prevalence of diabetes in Korean adults, 30y or older, KNHANES



Diagnosis of diabetes: FPG≥126mg/dl, or physician diagnosis or oral hypoglycemic agents or insulin use

Choi YJ, et al. Diabetes Care 32:2016–2020, 2009
2008 KNHANES reports

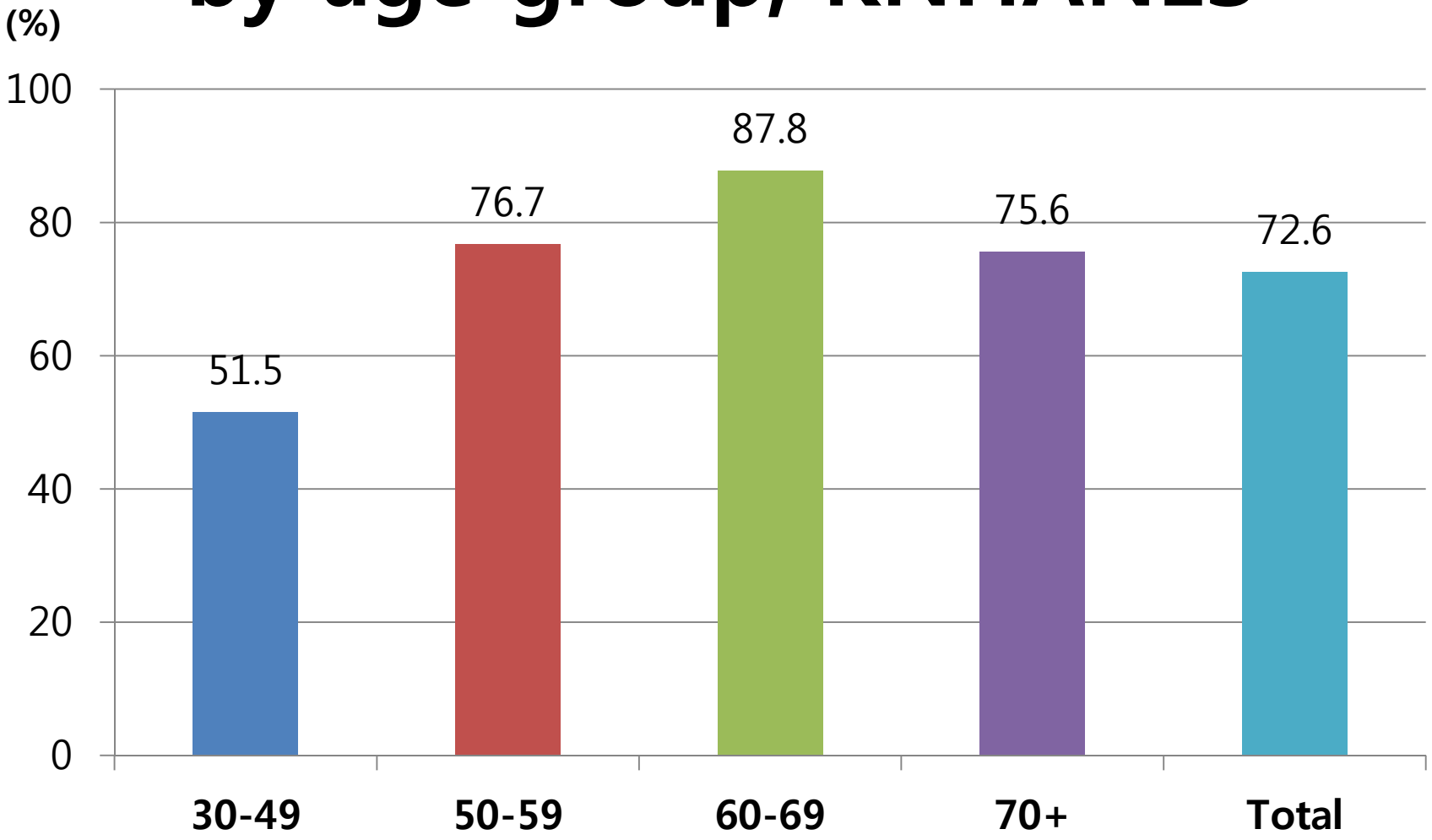
Awareness of Diabetes, by year, KNHANES



Awareness: proportion of known diabetes among total diabetes

Choi YJ, et al. Diabetes Care 32:2016–2020, 2009
2008 KNHANES reports

Awareness of Diabetes, by age group, KNHANES



Awareness: proportion of known diabetes among total diabetes

Choi YJ, et al. Diabetes Care 32:2016–2020, 2009
2008 KNHANES reports

Aim of our study

- To develop and validate a self-assessment score for diabetes risk in Korean adults using simple clinical parameters to provide a reliable and easy tool for the layperson without the need for a clinician's input.
- To compare the new algorithm with other existing screening models from different ethnic populations

Lee YH, et al. Diabetes Care. 2012 Aug;35(8):1723-30

Research design and methods

- **Korea National Health and Nutrition Examination Survey (KNHANES)**
  - Population-based, cross-sectional health survey
  - Korea Centers for Disease Control and Prevention (KCDC)
  - To monitor the general health and nutrition status of Koreans

- **Development data sets**
  - KNHANES 2001 and 2005

- **Validation data sets**
  - KNHANES 2007-2008

Lee YH, et al. Diabetes Care. 2012 Aug;35(8):1723-30

Ascertainment of Diabetes

① **Known diabetes (Known DM)**

- previous diagnosis by physician
- Use of insulin or oral anti-diabetic medications

② **Undiagnosed diabetes (New DM)**

- Fasting glucose ≥ 126 mg/dl
- Non-fasting glucose ≥ 200 mg/dl

③ **Impaired fasting glucose (IFG)**

- Fasting glucose 100-125 mg/dl

Lee YH, et al. Diabetes Care. 2012 Aug;35(8):1723-30

Definition of Co-variables

- **Age**: <35, 35-44, ≥45 years
- **Sex**: male, female
- **Body mass index (BMI)**: <23, 23-24.9, ≥25 kg/m^2
- **Waist circumferences (WC)**: <84/77, 84-89.9/77-83.9, ≥90/84cm (M/F) by 50 & 75 percentile
- **Family history of DM**: no, yes (father, mother, or siblings)
- **Hypertension**: no, yes (physician diagnosis or medication or ≥140/90 mmHg)
- **Smoking**: never or ex-smoker, current smoker
- **Alcohol**: none or <1, 1-4.99, ≥5 of daily intake of soju (drink/day)
- **Physical activity**: sedentary+light, ≥moderate+vigorous

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Statistical analyses

- **Model development**
  - Multiple logistic regression analysis
  - Predictors; continuous variables first,
    categorized in the final model
  - Backward elimination
  - Weighted scoring system, ORs
    (e.g. 1 for OR 1.52, 3 for OR 3.19)
- **Established screening models**
  - ADA diabetes risk questionnaire II, US screening score, Rotterdam model, Qingdao diabetes risk score, Thai risk score,

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Standard validation measures

- Proportion of high-risk individuals
- Sensitivity, Specificity
- Positive predictive value (PPV)
- Negative predictive value (NPV)
- Positive/Negative likelihood ratio
- Youden index
- AUC

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Clinical characteristics of participants in KNHANES 2001-2005 by diabetes status

Characteristics	NGT	IFG	Undiagnosed DM	Known DM	p
n	7,052	2,209	341	600	
Age, y	42.1 (0.3)	48.6 (0.5)	51.2 (0.8)	59.8 (0.6)	<0.001
Men, %	44.4	50.5	51.9	49.1	<0.001
FH of DM, %	14.1	14.9	22.6	28.4	0.006
Smoking, Current %	25.8	27.2	36.4	28.7	0.004
Alcohol, drink/day	0.7 (0.0)	1.0 (0.1)	1.5 (0.2)	0.9 (0.1)	<0.001
≥5 drink/day, %	3.7	6.3	10.9	6.6	<0.001
Physically active, %	9.4	12.6	11.3	7.5	0.001
BMI, kg/m^2	23.2 (0.1)	24.6 (0.1)	25.3 (0.2)	24.9 (0.2)	<0.001
Waist, cm					
Male	82.7 (0.2)	86.3 (0.3)	88.4 (0.7)	87.7 (0.6)	<0.001
Female	76.8 (0.2)	82.0 (0.4)	85.6 (0.9)	86.7 (0.6)	<0.001
FPG, mg/dl	87.6 (0.2)	107.4 (0.2)	150.0 (2.2)	133.7 (2.2)	<0.001
Systolic BP, mmHg	117.0 (0.4)	125.9 (0.5)	131.4 (1.2)	131.6 (1.0)	<0.001
Diastolic BP, mmHg	76.0 (0.2)	80.1 (0.4)	82.5 (0.8)	79.6 (0.5)	<0.001
HTN, %	19.4	37.4	45.8	58.2	<0.001
Total Chol., mg/dl	182.1 (0.6)	194.5 (0.9)	201.7 (2.7)	195.9 (1.7)	<0.001
Triglycerides, mg/dl	123.1 (1.4)	156.9 (2.7)	215.4 (17.9)	189.1 (8.7)	<0.001
HDL Chol., mg/dl	46.0 (0.2)	44.6 (0.3)	42.9 (0.6)	41.7 (0.5)	<0.001

Data are mean (SE) or %. N; by un-weighted number. FPG, fasting plasma glucose. P value; comparison between NGT, IFG and undiagnosed DM group excluding known DM group

Logistic regression analyses for related factors for undiagnosed diabetes

Variables	β coefficient	Odds ratio (95% CI)	p	Score assigned
Intercept	-5.608			
Age, y				
< 35		Ref		**0**
35-44	1.068	2.91 (1.74, 4.88)	<0.0001	**2**
≥ 45	1.305	3.69 (2.23, 6.11)	<0.0001	**3**
Family history of DM				
No		Ref		**0**
Yes	0.621	1.86 (1.29, 2.68)	0.0008	**1**
Hypertension				
No		Ref		**0**
Yes	0.417	1.52 (1.17, 1.97)	0.0018	**1**
Waist circumference, cm				
< 84/77 (M/F)		Ref		**0**
84-89.9/77-83.9	0.779	2.18 (1.47, 3.24)	0.0001	**2**
≥ 90/84	1.161	3.19 (2.20, 4.64)	<0.0001	**3**
Smoking status				
Non or ex-smoker		Ref		**0**
Current smoker	0.386	1.47 (1.08, 2.01)	0.0155	**1**
Alcohol intake, drink/day				
Never or <1		Ref		**0**
1-4.9	0.493	1.64 (1.16, 2.32)	0.0055	**1**
≥ 5	0.795	2.21 (1.42, 3.45)	0.0004	**2**

AUC = 0.730. maximal score is 11.

Performance of diabetes screening method in development & validation datasets

Method, by dataset	High risk, %	Sensitivity (%)	Specificity (%)	PPV	NPV	Positive LR	Negative LR	Youden index	AUC
Development dataset	KNHANES 2001-2005								
≥4	60	89	41	5	99	1.52	0.27	30	
≥5*	**47**	**81**	**54**	**6**	**99**	**1.75**	**0.36**	**35**	**0.730**
≥6	34	65	67	7	98	2.00	0.51	33	
Validation dataset	KNHANES 2007-2008								
After imputation; ≥5†	**48**	**80**	**53**	**4**	**99**	**1.68**	**0.39**	**32**	**0.742**

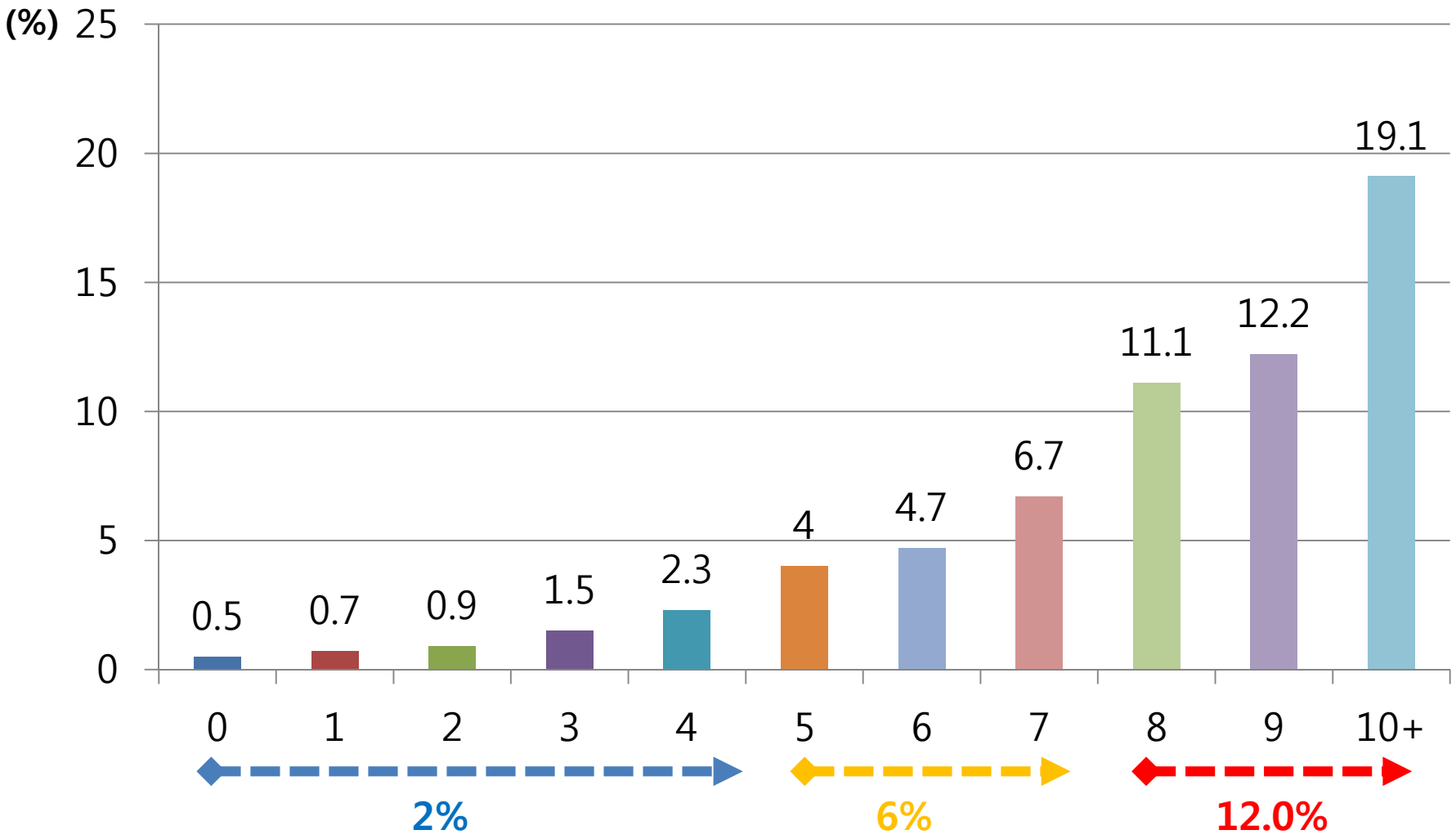
* best cut-point; area Under the ROC curve (AUC) : 0.730 (95% CI: 0.720-0.739), p=0.0001
† after imputing the missing data of family history of diabetes

Performance of new and existing diabetes screening method in development datasets

Method, by dataset	High risk, %	Sensitivity (%)	Specificity (%)	PPV	NPV	Positive LR	Negative LR	Youden index	AUC
Development dataset	KNHANES 2001-2005								
New Score (≥5)	47	81	54	6	99	1.75	0.36	35	0.730
ADA questionnaire II	21	41	79	7	97	2.01	0.74	21	0.604
US screening score	14	33	86	8	97	2.44	0.77	20	0.685
Rotterdam model	29	53	72	7	98	1.89	0.65	25	0.661
Qingdao risk score	36	62	65	6	98	1.77	0.59	27	0.693
Thai risk score	46	74	55	6	98	1.64	0.48	29	0.689

* best cut-point; area Under the ROC curve (AUC) : 0.730 (95% CI: 0.720-0.739), p=0.0001
† after imputing the missing data of family history of diabetes

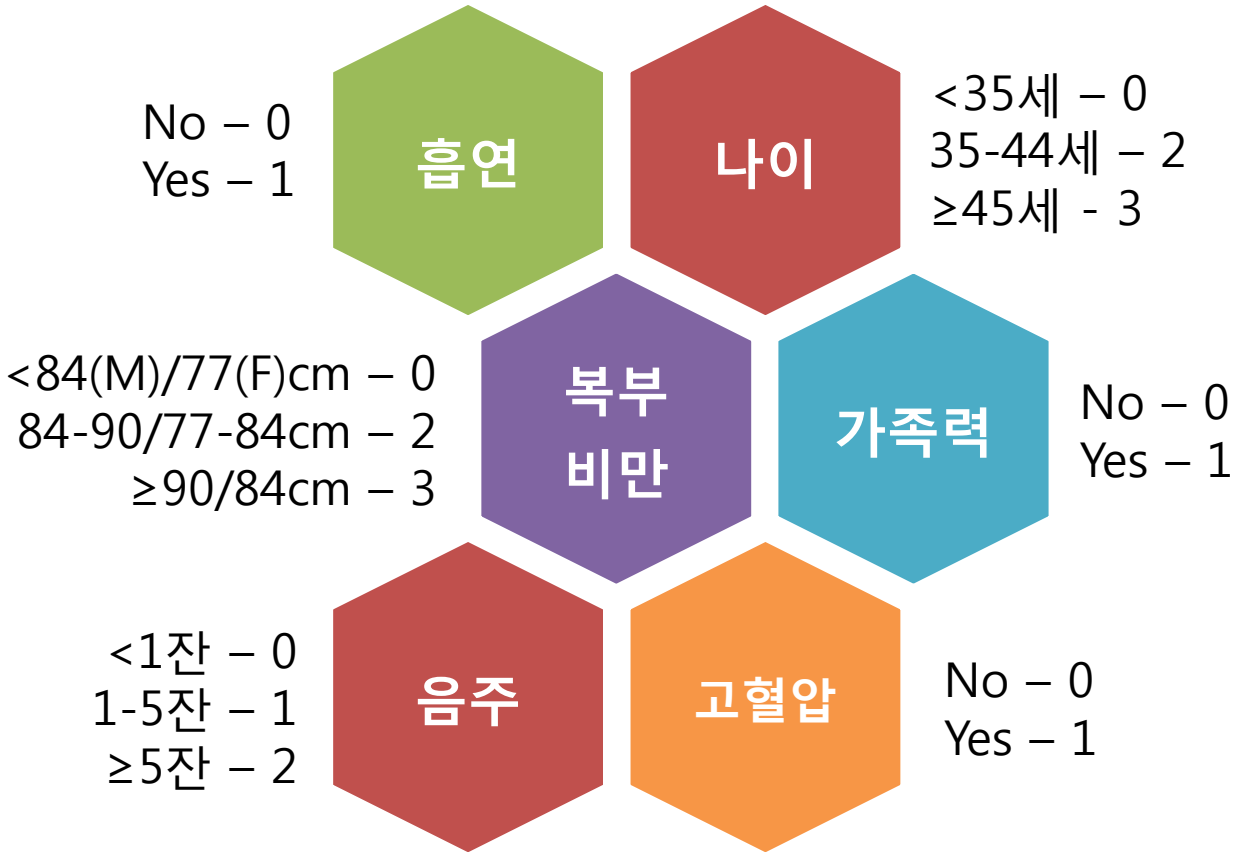
Prevalence of undiagnosed diabetes according to the risk score



Self-assessment screening questionnaire for undiagnosed diabetes

Question	Answer (Score)		Enter your Score (Enter 0 if you don't know)
1. Your age group?	< 35 y (0 point) 35–44 y (2 points) ≥ 45 y (3 points)		
2. Have either of your parents or siblings been diagnosed with diabetes?	No (0 point) Yes (1 point)		
3. Are you currently taking medication for hypertension or do you have hypertension (i.e.g, blood pressures greater than 140/90 mmHg)?	No (0 point) Yes (1 point)		
4. What is your waist circumference (taken below the ribs, usually at the level of the navel) ?	Men < 84 cm (33 inch) (0 point) 84–89.9 cm (33–34.9 inch) (2 points) ≥ 90 cm (35 inch) (3 points)	Women < 77 cm (30 inch) (0 point) 77–83.9 cm (30–32.9 inch) (2 points) ≥ 84 cm (33 inch) (3 points)	
5. Do you currently smoke cigarettes on a daily basis?	Never or Ex-smoker (0 point) Current smoker (1 point)		
6. How much alcohol do you drink on a daily basis? (regardless of types of alcohols)	Never or less than 1 drink / day (0 point) 1–4.9 drinks /day (1 point) ≥ 5 drinks /day (2 points)		
TOTAL SCORE (add points from questions 1–6)			
If the TOTAL SCORE is ≥5, you are at high risk for diabetes, so see your doctor for a blood test.			

한국인 당뇨병 위험지수



총점이 **5점** 이상이면 혈당 검사를 해봐야 한다.

이용호, 김대중, 박석원 등. Diabetes Care 2012

Summary & Conclusions

- We developed and validated a simple and practical tool to identify high-risk subjects for diabetes in a Korean population.
  - We intended to establish a simple risk score model without using laboratory tests or difficult calculations such as BMI
- The model included age, family history of diabetes, hypertension, waist circumference, smoking status and alcohol intake.

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Summary & Conclusions

- Diabetes risk assessment models developed in white populations tend to poorly predict high-risk subjects for diabetes in Korean populations.
- Our risk model is an alternative approach that easily can be used in communities and clinical settings to screen individuals at high risk for diabetes.

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THANK YOU
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