Diabetes screening in South Korea: a new estimate of the number needed to screen to detect diabetes
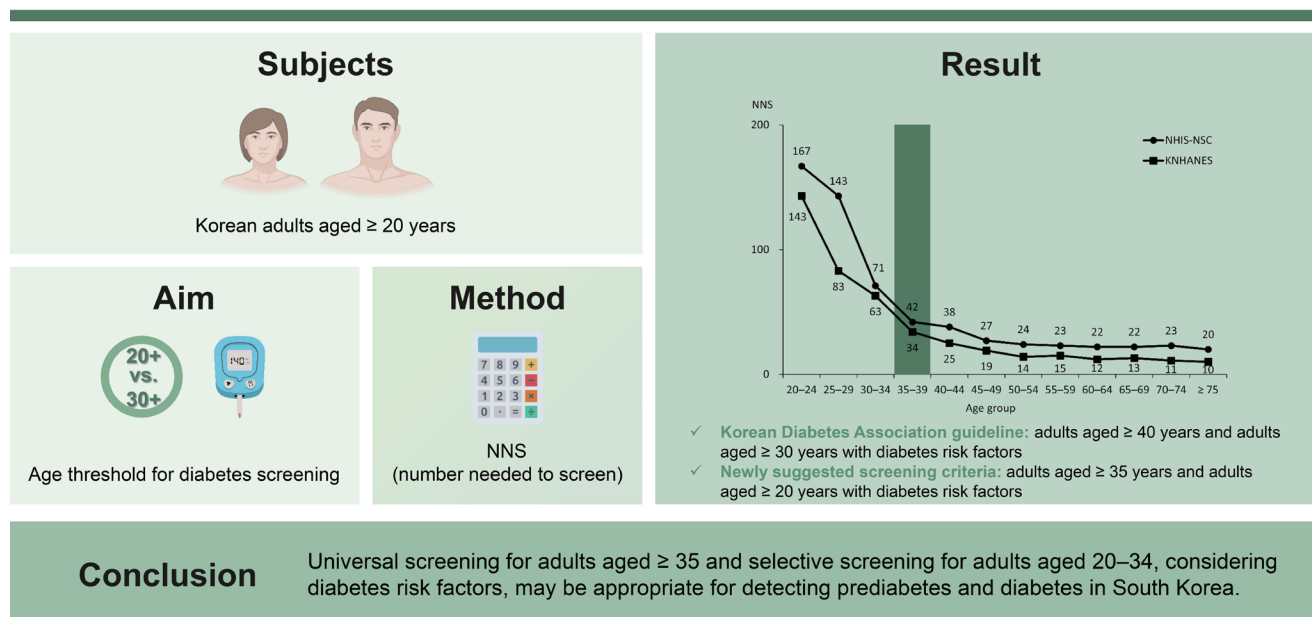
Kyoung Hwa Ha[1], Kyung Ae Lee[2], Kyung-Do Han[3], Min Kyong Moon[4], and Dae Jung Kim[1]

[1]Department of Endocrinology and Metabolism, Ajou University School of Medicine, Suwon; [2]Division of Endocrinology and Metabolism, Department of Internal Medicine, Research Institute of Clinical Medicine of Jeonbuk National University-Biomedical Research Institute of Jeonbuk National University Hospital, Jeonbuk National University Medical School, Jeonju; [3]Statistics and Actuarial Science, Soongsil University, Seoul; [4]Department of Internal Medicine, Seoul Metropolitan Government Seoul National University Boramae Medical Center, Seoul National University College of Medicine, Seoul, Korea

Diabetes screening in South Korea: a new estimate of the number needed to screen to detect diabetes

Subjects

Korean adults aged ≥ 20 years

Aim

20+ vs. 30+

Age threshold for diabetes screening

Method

NNS
(number needed to screen)

Result

✓ **Korean Diabetes Association guideline:** adults aged ≥ 40 years and adults aged ≥ 30 years with diabetes risk factors
✓ **Newly suggested screening criteria:** adults aged ≥ 35 years and adults aged ≥ 20 years with diabetes risk factors

Conclusion Universal screening for adults aged ≥ 35 and selective screening for adults aged 20–34, considering diabetes risk factors, may be appropriate for detecting prediabetes and diabetes in South Korea.

Background/Aims: The Korean Diabetes Association (KDA) guidelines recommend adults aged ≥ 40 years and adults aged ≥ 30 years with diabetes risk factors for diabetes screening. This study aimed to determine the age threshold for diabetes screening in Korean adults.

Methods: This study was based on the analyses of Korean adults aged ≥ 20 years using the Korea National Health and Nutrition Examination Survey (KNHANES) and the National Health Insurance Service-National Sample Cohort (NHIS-NSC). To evaluate screening effectiveness, we calculated the number needed to screen (NNS).

Results: NNS to detect diabetes decreased from 63 to 34 in the KNHANES and from 71 to 42 in the NHIS-NSC between the ages of 30–34 and 35–39. When universal screening was applied to adults aged ≥ 35, the NNS was similar to that of adults aged ≥ 40. Compared to the KDA guidelines, the rate of missed screening positive in adults aged ≥ 20 decreased from 4.0% to 0.2% when the newly suggested screening criteria were applied.

Conclusions: Universal screening for adults aged ≥ 35 and selective screening for adults aged 20 to 34, considering diabetes risk factors, may be appropriate for detecting prediabetes and diabetes in South Korea.

Keywords: Diabetes mellitus; Early diagnosis; Screening

INTRODUCTION

In recent decades, diabetes mellitus has become a major health threat worldwide. The global prevalence of diabetes in those aged 20 to 79 years has reached pandemic proportions in 2019 and has increased from 9.3% in 2019 to 10.5% in 2021 [1]. In South Korea, the prevalence of diabetes increased from 10.3% in 2011 to 13.9% in 2020 [2]. However, approximately one-third of people with diabetes aged ≥ 30 years are unaware of diabetes, and diabetes awareness has decreased from 72.4% in 2007–2009 to 67.8% in 2016–2018. Approximately one million people are estimated to live without knowing that they have diabetes [3]. In addition, the prevalence of prediabetes, an early stage in the hyperglycemic continuum, was 26.9% in 2018 [4].

Prevention of diabetic complications is a key issue in maintaining the quality of life of people with diabetes. Diabetic complications result from an abnormal metabolic environment caused by chronic hyperglycemia [5]. The duration of diabetes and degree of hyperglycemia affect the risk of diabetic complications [6-8]. Early detection and management of prediabetes and diabetes can delay the development and progression of diabetes and diabetic complications. However, diabetes is often asymptomatic in its early stages and remains undiagnosed for many years, and diabetic complications can often occur before the clinical diagnosis of type 2 diabetes [9,10]. Thus, the early identification of prediabetes and diabetes is the first step in diabetes care.

In 2021, the Korean Diabetes Association (KDA) recommended annual prediabetes and diabetes screening for adults aged ≥ 40 years and adults aged ≥ 30 years with diabetes risk factors such as overweight or obesity [11]. However, the age thresholds for screening individuals were determined based on the guidelines of other countries, and the evidence for screening for Koreans was limited [12]. In addition, in South Korea, the incidence of diabetes among adults aged 20 to 39 years has increased [13]. Therefore, this study aimed to determine the age thresholds for diabetes screening to provide evidence for screening guidelines.

METHODS

Data source

This cross-sectional study was conducted using two nationally representative datasets: the Korea National Health and Nutrition Examination Survey (KNHANES) in 2016 to 2020 and the National Health Insurance Service-National Sample Cohort (NHIS-NSC) in 2012 to 2017. The KNHANES is a national surveillance system in South Korea that has produced nationwide statistics regarding the health and nutritional status of the Korean population since 1998 [14]. The NHIS-NSC, conducted by the NHIS, is a population-based cohort comprising 2.2% of all eligible Koreans. The NHIS-NSC contains information on sociodemographic characteristics, hospital claims (defined by the International Classification of Diseases, 10th Revision, Anatomical Therapeutic Chemical

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[ATC] codes), and information on national health examinations [15].

The study protocol was reviewed and approved by the Institutional Review Board of Ajou University Hospital (approval no. AJOUIRB-EXP-2022-280) and Soongsil University (approval no. SSU-202003-HR-201-01). The requirement for informed consent was waived because all participants were de-identified.

Study population

For analysis of the KNHANES, we identified 27,348 adults aged ≥ 20 years without a diagnosis of diabetes in KNHANES VII (2016 to 2018) and KNHANES VIII (2019 to 2020). Diagnosed diabetes was defined as a self-reported previous diagnosis of diabetes by a medical doctor or taking glucose-lowering drugs or insulin. After excluding participants with a history of pregnancy or missing values, 24,822 participants were included in the final analysis. For the analysis of the NHIS-NSC, we included adults aged ≥ 20 years who underwent national health examinations during the 2012 to 2017 period. Among 677,769 participants, we identified 417,768 who were not diagnosed with diabetes (defined as a self-reported previous diagnosis of diabetes) or were not prescribed glucose-lowering drugs or insulin (defined as ATC code A10) after excluding participants with missing values.

Positive test result for diabetes

A positive diabetes test result was defined as fasting plasma glucose ≥ 126 mg/dL and/or glycated hemoglobin (HbA1c) ≥ 6.5% for analysis of the KNHANES and fasting plasma glucose ≥ 126 mg/dL for analysis of the NHIS-NSC. A positive prediabetes test result was defined as fasting plasma glucose 100 to 125 mg/dL and/or HbA1c 5.7% to 6.4% for analysis of the KNHANES and fasting plasma glucose 100 to 125 mg/dL for analysis of the NHIS-NSC.

Risk factors for diabetes

The KDA defines diabetes risk factors to be considered for prediabetes and diabetes screening as follows: overweight or obesity, family history of diabetes, history of impaired fasting glucose and/or impaired glucose tolerance, gestational diabetes, hypertension, dyslipidemia, insulin resistance (polycystic ovary syndrome, acanthosis nigricans, etc.), history of cardiovascular disease (CVD), and use of drugs (glucocorticoids, atypical antipsychotics, etc.) [16]. Among the risk factors, we considered five (obesity, abdominal obesity, family history of diabetes, hypertension, and dyslipidemia) that were available in both the KNHANES and NHIS-NSC. We changed the definition from overweight or obesity (defined as body mass index [BMI] ≥ 23 kg/m^2) to obesity (BMI ≥ 25 kg/m^2). Obesity was categorized as class I (defined as 25 ≤ BMI < 30 kg/m^2), class II (30 ≤ BMI < 35 kg/m^2), and class III (BMI ≥ 35 kg/m^2), according to the guidelines of the Korean Society for the Study of Obesity [17]. Abdominal obesity (defined as waist circumference ≥ 90 cm in men and ≥ 85 cm in women) was an additional risk factor. Data on family history of diabetes were obtained using self-reports of the diabetes history of parents and siblings. Hypertension was defined as systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or the current use of antihypertensive medications. Dyslipidemia was defined as high-density lipoprotein cholesterol (HDL-C) level < 35 mg/dL and/or triglyceride level ≥ 250 mg/dL. However, we used the revised definition of HDL-C < 40 mg/dL and/or triglyceride ≥ 200 mg/dL based on the Korean Society of Lipid and Atherosclerosis guideline [18]. Information regarding CVD was available in both the KNHANES and NHIS-NSC but not diabetes risk factors, considering the low prevalence in young adults.

Statistical analyses

All categorical variables were presented as frequencies and percentages. Normally distributed data are presented as mean ± standard error in the KNHANES. To account for strata cluster and weight inherent to KNHANES, the SAS procedures SURVEYFREQ and SURVEYMEANS were used. We evaluated the screening effectiveness using the number needed to screen (NNS). NNS is defined as the number of people who need to be screened for disease detection [19]. It was calculated as the reciprocal of the rate of positive test results (e.g., a positive test rate of 5% translates to an NNS of 20 = 1/0.05). We calculated the NNS according to 5-year age groups from 20 to 24 years up to 75 years and above. We calculated the number and rate of screening-eligible individuals, screening-positive individuals, and missed screening-positive individuals. We evaluated the screening effectiveness according to diabetes risk factors in adults aged 20 to 34 years. All statistical analyses were performed using SAS 9.4 and SAS Enterprise Guide 7.1 (SAS Institute, Cary, NC, USA).

RESULTS

In the KNHANES, there were 24,822 adults aged ≥ 20 years without diagnosed diabetes, representing 35,151,173 Korean adults (Supplementary Table 1). In the NHIS-NSC, there were 417,768 adults aged ≥ 20 years without diagnosed diabetes.

When classified by age group at 5-year intervals, the NNS to detect diabetes decreased from 63 to 34 between the ages of 30–34 years and 35–39 years in the KNHANES. In the NHIS-NSC, the NNS decreased from 71 to 42 in the same age range, and the greatest declines were noted between the ages of 25–29 year and 30–34 years (from 143 to 71) (Fig. 1 and Supplementary Table 2). In detecting predia-
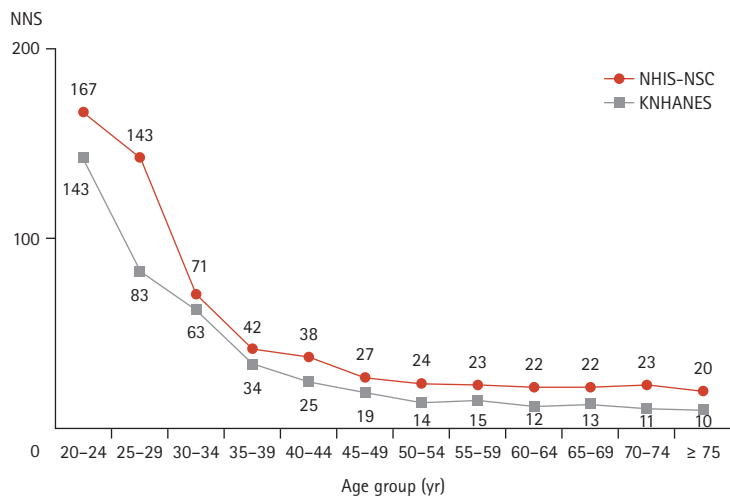

Figure 1. Number needed to screen to detect diabetes according to age group. NNS, number needed to screen; NHIS-NSC, National Health Insurance Service-National Sample Cohort; KNHANES, Korea National Health and Nutrition Examination Survey.

Table 1. Diabetes screening effectiveness according to the change in the KDA guideline in the Korea National Health and Nutrition Examination Survey

Type of screening	Screening-eligible individuals		Screening-positive individuals		NNS	Missed screening-positive individuals	
	Weighted no.	%	Weighted no.	%		Weighted no.	%
Universal screening							
Age ≥ 40 years	22,055,396	100.0	1,496,925	6.8	15	0	0.0
Age ≥ 35 years	25,671,128	100.0	1,603,037	6.2	16	0	0.0
Age ≥ 30 years	28,730,815	100.0	1,650,930	5.7	18	0	0.0
Age ≥ 20 years	35,151,173	100.0	1,711,071	4.9	20	0	0.0
KDA guideline							
Age ≥ 40 years	22,055,396	100.0	1,496,925	6.8	15	0	0.0
Aged 30–39 years with risk factor	3,924,635	58.8	146,283	3.7	27	7,722	5.0
Aged 20–29 years	0	0.0	0	0.0	NA	60,141	100.0
Total	25,980,031	73.9	1,643,208	6.3	16	67,863	4.0
Newly suggested criteria							
Age ≥ 35 years	25,671,128	100.0	1,603,037	6.2	16	0	0.0
Aged 20–34 years with risk factor	4,717,542	49.8	103,974	2.2	45	4,060	3.8
Total	30,388,670	86.5	1,707,011	5.6	18	4,060	0.2

KDA, Korean Diabetes Association; NNS, number needed to screen.

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betes and diabetes, the NNS was approximately 10 in those aged 20 to 24 years, which continued to decrease with age (Supplementary Table 3).

When universal screening was applied by age, in the KN-HANES, the NNS slightly increased from 15 (rate of positive test = 6.8%) in adults aged ≥ 40 years (age threshold of the KDA recommendation for universal screening) to 20 (rate of positive test = 4.9%) in adults aged ≥ 20 years (Table 1). In the NHIS-NSC, the NNS increased from 26 to 33 (rate of positive test, 3.8% to 3.0%) in the same age groups (data not shown). When universal screening was applied to adults aged ≥ 35 years, the NNS was similar to that of adults aged ≥ 40 years (Table 1).

Half of the adults aged 20 to 34 years were overweight or obesity, and approximately 20% had abdominal obesity (Supplementary Table 1). In adults aged 20 to 34 years who were overweight or obesity, the rate of missed screening positive was the lowest at 10.6% compared to the other risk factors (obesity, 20.0%; abdominal obesity, 17.6%; family history of diabetes, 55.6%; hypertension, 67.5%; and dyslipidemia, 43.8%). However, NNS was the highest at 48 (Table 2). When considering the risk factors of obesity and/or abdominal obesity, the rate of missed screening positive increased from 10.6% to 17.6%; however, NNS decreased from 48 to 34 compared to overweight or obesity (Table 2).

Supplementary Table 4 shows the diabetes screening effectiveness according to age groups from 20–24 years and up to 35–39 years for each diabetes risk factor.

Compared to the KDA guidelines, NNS was slightly increased when applying the newly suggested screening criteria (adults aged ≥ 35 years and adults aged ≥ 20 years with diabetes risk factors). However, the rate of missed screening positive in adults aged ≥ 20 years decreased substantially from 4.0% to 0.2% in the KNHANES (Table 1).

DISCUSSION

This study provides estimates of the NNS to detect diabetes in adults in South Korea. When NNS is estimated by 5-year age categories, the NNS noticeably begins to decrease after 35 years and continues to decline until 75 years and older. When universal screening was applied to adults aged ≥ 35 years, the NNS was similar to that of adults aged ≥ 40 years.

In 2021, the KDA recommended annual universal screening for the detection of prediabetes and diabetes in adults aged ≥ 40 years and adults aged ≥ 30 years with diabetes risk factors [11]. It was established by considering to the prevalence of diabetes by age in Korea and previous studies in other countries [12]. However, in the United States, the

Table 2. Diabetes screening effectiveness in adults aged 20 to 34 years according to diabetes risk factors in the Korea National Health and Nutrition Examination Survey

Risk factors	Screening-eligible individuals		Screening-positive individuals		NNS	Missed screening-positive individuals	
	Weighted no.	%	Weighted no.	%		Weighted no.	%
Overweight or obesity	4,616,627	48.7	96,630	2.1	48	11,404	10.6
Obesity	2,979,256	31.4	86,375	2.9	34	21,659	20.0
Abdominal obesity	2,017,653	21.3	88,966	4.4	23	19,068	17.6
Overweight or obesity and/or abdominal obesity	4,626,056	48.8	96,630	2.1	48	11,404	10.6
Obesity and/or abdominal obesity	3,064,157	32.3	88,966	2.9	34	19,068	17.6
Family history of diabetes	1,672,000	17.6	47,930	2.9	34	60,104	55.6
Hypertension	591,670	6.2	35,161	5.9	17	72,873	67.5
Dyslipidemia	1,615,133	17.0	60,722	3.8	26	47,312	43.8
Any of all risk factors excluding overweight	4,717,542	49.8	103,974	2.2	45	4,060	3.8
Any of all risk factors including overweight	5,753,275	60.7	103,974	1.8	56	4,060	3.8

NNS, number needed to screen.

optimal age cut-point for opportunistic universal screening based on the NNS was suggested as 35 years old [20]. Recently, the U.S. Preventive Services Task Force recommended screening in adults aged 35 to 70 years who are overweight or obesity, which decreases the age from 40 to 35 years to consider the increase in diabetes incidence in young adults [21]. The American Diabetes Association also recommends universal screening for adults aged ≥ 35 years and adults of any age with overweight or obesity (BMI ≥ 25 or ≥ 23 kg/m² in Asian Americans) who have one or more risk factors, such as a history of CVD, hypertension, and dyslipidemia [22]. The Diabetes Canada Clinical Practice Guidelines Expert Committee suggested that the age to begin screening is 40 years, based on the Diabetes Screening in Canada Study [23,24]. Adults at high risk on the Canadian Diabetes Risk were also included for prediabetes and diabetes screening [24].

In South Korea, the incidence of diabetes has increased from 1.3 to 1.7 per 1,000 individuals in adults aged 20 to 39 years, with increasing obesity from 2006 to 2015 [13]. People diagnosed at 20 to 39 years of age had worse status of insulin resistance and β-cell function with severe obesity than those diagnosed at older ages [25]. In addition, the proportion of diabetes awareness was 76.4% in adults aged 65 years or older but decreased to 65.8% in adults aged 30 years or older [26]. The onset of diabetes at a younger age is associated with prolonged disease exposure and increased risk of diabetic complications [27]. Thus, active diabetes screening is required in young adults. However, screening individuals unlikely to benefit can result in unnecessary test burdens and costs for the healthcare system. In this study, the evidence for screening all adults aged 20 to 34 years is unclear. Compared to screening people aged 35 to 39 years, the NNS increased markedly from 34 to 63 in the KNHANES and from 42 to 71 in the NHIS-NSC for ages 30 to 34 years. In addition, when universal screening was changed from ≥ 35 to ≥ 20 years, the NNS increased from 16 to 20. However, excluding young adults from diabetes screening would have resulted in almost 100,000 people potentially being missed. Thus, we need to screen adults aged 20 to 34 years with diabetes risk factors. When adults were overweight or obesity based on the KDA guideline, the rate of missed screening positive was the lowest, but NNS was the highest among the diabetes risk factors. In addition, approximately 50% of adults aged 20 to 34 years must be screened. However, although the rate of missed screening

positive increased, adults with obesity or abdominal obesity had a relatively low NNS and screening eligibility rate. Thus, diabetes screening may be more beneficial for adults aged 20 to 34 years with obesity and/or abdominal obesity than for those who are overweight or obesity.

Prediabetes may be an important stage for early intervention to prevent the development of diabetes and its complications. A lifestyle intervention based on a healthy diet or physical activity prevented the progression of prediabetes to diabetes [28]. The Diabetes Prevention Program trial showed that weight loss through lifestyle intervention reduced the risk of developing diabetes by 44% [29]. In addition, lifestyle interventions in prediabetes reduced the risk of diabetic complication and diabetes-related mortality [30,31]. In this study, the NNS to detect prediabetes or diabetes remained stable under 10 among adults of all ages. Thus, the early detection of prediabetes through the screening may be an effective strategy to delay the development of diabetes and its complications.

The benefits of diabetes screening in older adults remain controversial. In the United States, the proportion of deaths or regression to normoglycemia from prediabetes was higher than progression to diabetes in older adults aged > 70 years with prediabetes [32]. The U.S. Preventive Services Task Force does not recommend diabetes screening for adults aged > 70 years [21]. In South Korea, almost 20% of adults aged ≥ 65 years with prediabetes progress to diabetes. In addition, in adults aged ≥ 75 years diagnosed with prediabetes or diabetes, the risk of diabetic complications did not increase [33]. However, in the current study, we included all adults aged ≥ 20 years, including older adults, to evaluate the effectiveness of screening for diabetes. Thus, further studies on the upper age limit for diabetes screening are required.

In the current study, compared to when fasting plasma glucose used alone as the positive test definition, the rates of positive test result were higher when both fasting plasma glucose and HbA1c were used simultaneously. In general, fasting plasma glucose, 2-hour plasma glucose during a 75g oral glucose tolerance test (OGTT), or HbA1c are all needed for diagnosing prediabetes and diabetes. Among the tests, OGTT is the diagnostic standard for diabetes. However, it is difficult to use for screening purposes because of time-consuming and inconvenient to the patient. Although fasting plasma glucose and HbA1c test is a simple and time-saving test that can be performed instead of OGTT, the measure-

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ment of HbA1c is a more reliable than fasting plasma glucose. And, HbA1c is better associated with diabetic complications than fasting plasma glucose [34]. In addition, the combination of fasting plasma glucose and HbA1c may be a more sensitive and specific screening tool for early identification of high-risk individuals with early diabetes [35]. Thus, it is necessary to consider HbA1c as well as fasting plasma glucose for diabetes screening.

The current study had several limitations. First, diabetes is diagnosed based on the two or more abnormal test results using fasting plasma glucose, 2-hour plasma glucose during a 75 g OGTT, or HbA1c value [11]. However, our study considered only one positive screening test. Second, the NNS is easy to calculate and intuitively shows the effectiveness of screening for clinicians and patients. However, we were unable to consider the risk and cost of screening.

In conclusion, universal screening for adults aged ≥ 35 years and selective screening for adults aged 20 to 34 years, considering diabetes risk factors such as obesity and/or abdominal obesity, may be appropriate for detecting prediabetes and diabetes in South Korea.

KEY MESSAGE

1. To determine the age thresholds for diabetes screening, we estimated the number needed to screen (NNS).
2. When universal screening was applied to adults aged ≥ 35 years, the NNS was similar to that of adults aged ≥ 40 years.
3. NNS was slightly increased when applying the newly suggested screening criteria (adults aged ≥ 35 years and adults aged ≥ 20 years with diabetes risk factors). However, the rate of missed screening positive in adults aged ≥ 20 years decreased.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

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Supplementary Table 1. Baseline characteristics in the Korea National Health and Nutrition Examination Survey

Variable	Total (n = 24,822, weighted n = 35,151,173)				Adults aged 20–34 years (n = 4,918, weighted n = 9,480,045)			
	No.	%	Weighted no.	%	No.	%	Weighted no.	%
Age, yr, mean ± SE	46.2 ± 0.2				27.0 ± 0.1			
Age group, yr								
20–34	4,918	19.8	9,480,045	27.0	NA		NA	
35–64	14,489	58.4	20,798,607	59.2	NA		NA	
≥ 65	5,415	21.8	4,872,521	13.9	NA		NA	
Men	10,889	43.9	17,559,563	50.0	2,375	48.3	5,112,327	53.9
Overweight or obesity	14,149	57.0	20,144,905	57.3	2,309	46.9	4,616,627	48.7
Overweight	5,676	22.9	7,933,443	22.6	838	17.0	1,637,371	17.3
Obesity	8,473	34.1	12,211,462	34.7	1,471	29.9	2,979,256	31.4
Class I	7,181	28.9	10,245,899	29.1	1,101	22.4	2,228,349	23.5
Class II	1,103	4.4	1,639,666	4.7	284	5.8	561,020	5.9
Class III	189	0.8	325,897	0.9	86	1.7	189,887	2.0
Abdominal obesity	7,594	30.6	10,357,504	29.5	1,006	20.5	2,017,653	21.3
Family history of diabetes	5,390	21.7	7,808,629	22.2	893	18.2	1,672,000	17.6
Hypertension	7,168	28.9	8,737,222	24.9	280	5.7	591,670	6.2
Dyslipidemia	5,894	23.7	8,460,210	24.1	800	16.3	1,615,133	17.0

SE, standard error; NA, not applicable.

Supplementary Table 2. Number needed to screen to detect diabetes according to age group

Age group, yr	KNHANES				NHIS-NSC			
	No. of people	Screening-positive individuals		NNS	No. of people	Screening-positive individuals		NNS
		No.	%			No.	%	
20–24	3,241,699	23,107	0.7	143	18,635	103	0.6	167
25–29	3,178,659	37,034	1.2	83	43,252	316	0.7	143
30–34	3,059,687	47,893	1.6	63	39,224	545	1.4	71
35–39	3,615,732	106,112	2.9	34	35,900	872	2.4	42
40–44	3,554,636	143,959	4.0	25	66,376	1,707	2.6	38
45–49	3,972,430	205,521	5.2	19	46,659	1,736	3.7	27
50–54	3,568,192	260,040	7.3	14	55,904	2,287	4.1	24
55–59	3,462,634	234,657	6.8	15	34,348	1,521	4.4	23
60–64	2,624,983	214,022	8.2	12	30,938	1,400	4.5	22
65–69	1,754,349	141,080	8.0	13	18,330	834	4.5	22
70–74	1,235,052	114,570	9.3	11	16,824	721	4.3	23
≥ 75	1,883,120	183,076	9.7	10	11,378	562	4.9	20

Values are presented as weighted numbers in the KNHANES.

KNHANES, Korea National Health and Nutrition Examination Survey; NHIS-NSC, National Health Insurance Service-National Sample Cohort; NNS, number needed to screen.

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Supplementary Table 3. Number needed to screen to detect prediabetes and diabetes according to age group

Age group, yr	KNHANES				NHIS-NSC			
	No. of people	Screening-positive individuals		NNS	No. of people	Screening-positive individuals		NNS
		No.	%			No.	%	
20–24	3,241,699	382,575	11.8	8	18,635	1,876	10.1	10
25–29	3,178,659	500,678	15.8	6	43,252	5,479	12.7	8
30–34	3,059,687	755,591	24.7	4	39,224	7,160	18.3	5
35–39	3,615,732	1,201,643	33.2	3	35,900	8,354	23.3	4
40–44	3,554,636	1,408,017	39.6	3	66,376	16,852	25.4	4
45–49	3,972,430	1,886,942	47.5	2	46,659	14,094	30.2	3
50–54	3,568,192	2,041,588	57.2	2	55,904	18,396	32.9	3
55–59	3,462,634	2,079,770	60.1	2	34,348	12,235	35.6	3
60–64	2,624,983	1,729,276	65.9	2	30,938	11,203	36.2	3
65–69	1,754,349	1,215,520	69.3	1	18,330	6,782	37.0	3
70–74	1,235,052	872,477	70.6	1	16,824	6,131	36.4	3
≥ 75	1,883,120	1,340,935	71.2	1	11,378	4,301	37.8	3

Values are presented as weighted numbers in the KNHANES.
KNHANES, Korea National Health and Nutrition Examination Survey; NHIS-NSC, National Health Insurance Service-National Sample Cohort; NNS, number needed to screen.

Supplementary Table 4. Diabetes screening effectiveness in adults aged 20 to 39 years according to age and diabetes risk factors in the Korea National Health and Nutrition Examination Survey

Risk factor	Screening-eligible individuals		Screening-positive individuals		NNS	Missed screening-positive individuals	
	Weighted no.	%	Weighted no.	%		Weighted no.	%
Obesity and/or abdominal obesity							
Age 20–24 years	810,813	25.0	17,184	2.1	48	5,923	25.6
Age 25–29 years	1,063,284	33.5	36,128	3.4	29	906	2.4
Age 30–34 years	1,105,159	36.1	35,654	3.2	31	12,239	25.6
Age 35–39 years	1,301,832	36.0	91,842	7.1	14	14,270	13.4
Family history of diabetes							
Age 20–24 years	446,192	13.8	10,011	2.2	45	13,096	56.7
Age 25–29 years	571,641	18.0	11,435	2.0	50	25,599	69.1
Age 30–34 years	654,167	21.4	26,484	4.0	25	21,409	44.7
Age 35–39 years	936,927	25.9	57,181	6.1	16	48,931	46.1
Hypertension							
Age 20–24 years	111,927	3.5	2,065	1.8	56	21,042	91.1
Age 25–29 years	201,514	6.3	13,701	6.8	15	23,333	63.0
Age 30–34 years	278,229	9.1	19,395	7.0	14	28,498	59.5
Age 35–39 years	434,435	12.0	29,032	6.7	15	77,080	72.6
Dyslipidemia							
Age 20–24 years	393,950	12.2	11,204	2.8	36	11,903	51.5
Age 25–29 years	533,583	16.8	22,758	4.3	23	14,276	38.5
Age 30–34 years	687,600	22.5	26,760	3.9	26	21,133	44.1
Age 35–39 years	859,363	23.8	54,675	6.4	16	51,437	48.5
Any of all risk factors							
Age 20–24 years	1,315,181	40.6	21,215	1.6	63	1,892	8.2
Age 25–29 years	1,670,982	52.6	37,034	2.2	45	0	0.0
Age 30–34 years	1,731,379	56.6	45,725	2.6	38	2,168	4.5
Age 35–39 years	2,193,255	60.7	100,558	4.6	22	5,554	5.2

Diabetes risk factors included obesity and/or abdominal obesity, family history of diabetes, hypertension, and dyslipidemia.
NNS, number needed to screen.