Prevalence of Diabetes and Impaired Fasting Glucose in Korea

Korean National Health and Nutrition Survey 2001

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OBJECTIVE — The purpose of this study was to estimate the prevalence of diabetes and impaired fasting glucose (IFG) and their association with risk factors in the Korean population.

RESEARCH DESIGN AND METHODS — The Korean National Health and Nutrition Survey 2001 was a nationally representative survey with a stratified multistage sampling design. Data from a comprehensive questionnaire, a physical examination, and blood tests were obtained from 5,844 Korean adults (2,513 men and 3,331 women) aged >20 years.

RESULTS — The age-adjusted prevalence of diabetes in this Korean population was 7.6%, and the age-adjusted prevalences of previously diagnosed diabetes and newly diagnosed diabetes were 4.4 and 3.3%, respectively (fasting plasma glucose ≥7.0 mmol/l). Overall, these results indicate that 8.1% or 1.4 million Korean men and 7.5% or 1.3 million Korean women have diabetes. The age-adjusted prevalence of IFG was 23.9%, using the new American Diabetes Association criteria (fasting plasma glucose 5.6–6.9 mmol/l). Diabetes prevalence increased with age and peaked in the oldest age-group; however, IFG prevalence did not show the same trend. Diabetes was found to be associated with age, BMI, blood pressure, triglyceride, HDL cholesterol, education levels, alcohol consumption, exercise, and a family history of diabetes.

CONCLUSIONS — This study shows that diabetes and IFG are common in Korea, and about one-half of diabetes cases remain undiagnosed. These results emphasize the need to develop an urgent public program to improve the detection, prevention, and treatment of diabetes.

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Type 2 diabetes is recognized as a global health problem nowadays, and it has been projected that the number of diabetic patients will rise from an estimated 135 million in 1995 to 300 million in 2025 (1). Moreover, the Asia-Pacific region is considered to be on the verge of an emerging diabetes epidemic (2).

Individuals with diabetes have a higher risk of complications such as retinopathy, nephropathy, neuropathy, and cardiovascular disease (3). According to the Korea National Statistical Office, the mortality rate due to diabetes was 25.0 per 100,000 persons in 2003, and thus it is currently rated as Korea's fourth leading cause of death (4). Although the importance of early diagnosis and secondary intervention programs for the prevention of diabetes complications have been emphasized, about one-half of those with diabetes remain unidentified (5). Epidemiological studies on diabetes have a significant impact on diabetes research, care, and prevention programs.

The prevalence of diabetes varies widely among populations according to race, lifestyle, and urbanization (6). In a recent survey in the U.S., its prevalence was 8.2% in adults aged 20–74 years (7). In Korea, a number of studies have been conducted on diabetes prevalence, including one by the present authors (8–10). However, previous studies have been regionally based, and thus reliable nationwide data about the prevalence of diabetes and impaired fasting glucose (IFG) is not available.

In this study, we analyzed comprehensive nationally representative data to determine the prevalence of diabetes and IFG and examined their associations with other cardiovascular risk factors in the Korean population.

RESEARCH DESIGN AND METHODS — The Korean National Health and Nutrition Survey (KNHNS) was performed by the Korea Institute for Health and Social Affairs for the Korean Ministry of Health and Welfare. The 2001 KNHNS was a cross-sectional and nationally representative survey conducted from 1 November through 30 December 2001 and consisted of four components: a Health Interview Survey, a Health Behavior Survey, a Health Examination Survey, and a Nutrition Survey. The target population for this survey was civilian noninstitutionalized individuals aged >1 year (for the Health Interview and Nutrition Surveys) or aged >10 years (for the Health Behavior and Health Examination Surveys). A stratified multistage probability sampling design was used, and selections were made from sampling units based on geographical area, sex, and age using household registries. There were 246,097 primary sampling units, each of which contained about 60 households. Two hundred sampling frames (12,180

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Abbreviations: ADA, American Diabetes Association; IFG, impaired fasting glucose; KNHNS, Korean National Health and Nutrition Survey; OGTT, oral glucose tolerance test; WHO, World Health Organization.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

households) from primary sampling units were randomly sampled throughout South Korea, and 37,769 individuals from these sampling frames were included in the Health Interview Survey. The survey was completed by 9,770 of 12,642 individuals who participated in the Health Examination Study, which gave a participation rate of 77.3%. However, information on the total number of dropouts, including refusals and noncontacted subjects, was not obtained, and thus the response rate could not be determined. We used the data of 6,601 subjects aged >20 years for this study. Each respondent was assigned a weight, based on geographic and demographic characteristics, to allow findings to be extrapolated for the entire Korean population. Nurses were trained to perform anthropometric measurements, serum collection, and blood pressure measurement and to mange questionnaires. The questionnaires included questions concerning the demographic, socioeconomic, dietary, and medical history details for each respondent.

Body weight and height were measured with subjects wearing light clothing without shoes. BMI was calculated as weight in kilograms divided by the square of height in meters. Waist circumference was measured from the narrowest point between the lower borders of the rib cage and the iliac crest. Blood pressure was measured in the sitting position after a 10-min rest period. Two systolic and diastolic blood pressure readings were recorded with a 5-min interval and averaged for analysis.

Fasting blood sample were taken in the morning after at least an 8-h fast. Blood samples were centrifuged, refrigerated at the examination site, and transferred in iceboxes to a central laboratory in Seoul on the day taken. Plasma glucose, total cholesterol, triglyceride, and HDL cholesterol levels were measured using an autoanalyzer (Hitachi 747 autoanalyzer, Tokyo, Japan). LDL cholesterol was calculated using the Friedewald equation for those with serum triglyceride levels ≤400 mg/dl (11).

Diabetes was defined as a fasting plasma glucose value ≥7.0 mmol/l (126 mg/dl) or a previous diagnosis of diabetes. Diabetes was further subclassified as “known diabetes” if diabetes had been diagnosed previously by a medical practitioner or as “newly diagnosed diabetes” if diabetes was first diagnosed by this study. IFG was defined as a fasting plasma glucose value of 5.6–6.9 mmol/l (100–125 mg/dl) in the absence of a previous diagnosis of diabetes, in accord with the new American Diabetes Association (ADA) criteria (12).

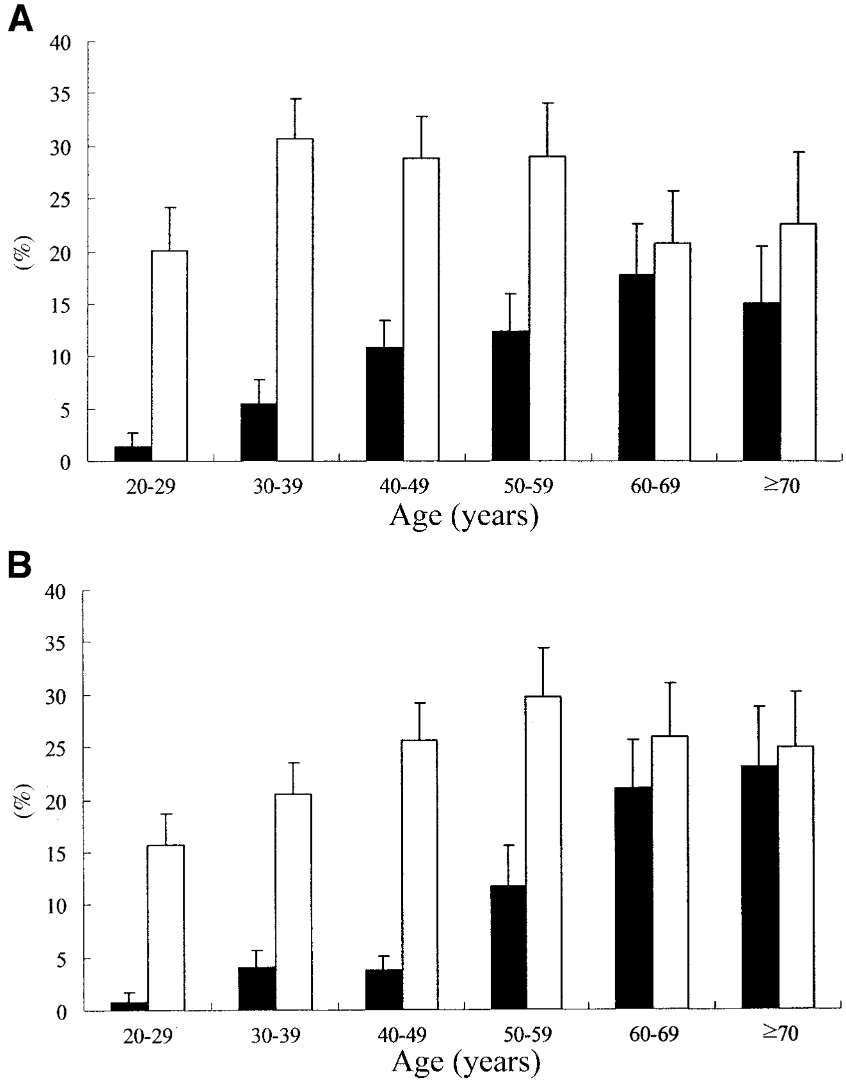

Figure 1—*Prevalence of diabetes (■) and IFG (□) among Korean men (A) and women (B). Diabetes was defined as a self-reported history of diabetes (diagnosed) or fasting plasma glucose ≥7 mmol/l (undiagnosed).*

Self-reported alcohol intake, smoking, and physical exercise were estimated from the questionnaire. Alcohol consumption was estimated from the usual intake amount and frequency of alcoholic beverage intake as follows: none, ≥1 cup once a week, ≥5 cups in men or ≥4 cups in women once or twice a week, or ≥5 cups in men or ≥4 cups in women three times a week or more (13). In terms of smoking, individuals were classified as nonsmokers, ex-smokers, or current smokers. Physical exercise was defined according to estimated energy consumption per week: none, <7.5 kcal · kg^{-1} · week^{-1}, 7.5–15 kcal · kg^{-1} · week^{-1}, and >15 kcal · kg^{-1} · week^{-1} (13). Using the definition applied by the Korean government, small towns and villages with a population of ≤50,000 were designated as rural areas (14). A family history of diabetes was considered positive if at least one parent or one sibling had diabetes.

Statistical analysis

The demographic characteristics of study subjects are presented using means ± SD or as numbers and percentages, as appropriate, for normal glucose, IFG, and diabetic subject groups. The age-adjusted prevalence of cardiovascular risk factors for each fasting glucose group were obtained using the direct adjustment method of standardization. National census data from the Korea National Statistical Office in 2001 was used to define the standard Korean population. Survey

Table 1—*Study participant characteristics with respect to fasting glucose level*

	Normal	IFG	New diabetes	Known diabetes
Men				
n (%)	1,576 (64.23)	696 (26.23)	106 (3.97)	135 (5.57)
Age (years)	44.39 ± 15.76	45.21 ± 14.10	48.90 ± 13.83	57.32 ± 11.68
Height (cm)	169.57 ± 6.41	169.24 ± 6.32	168.84 ± 6.33	166.70 ± 6.21
Weight (kg)	67.07 ± 10.06	69.31 ± 10.25	70.97 ± 11.23	67.72 ± 11.79
Waist circumference (cm)	83.17 ± 8.07	85.38 ± 8.32	88.47 ± 7.69	87.33 ± 9.22
Waist-to-hip ratio	0.88 ± 0.06	0.89 ± 0.06	0.92 ± 0.06	0.93 ± 0.06
Systolic blood pressure (mmHg)	125.07 ± 17.51	127.62 ± 17.24	136.04 ± 21.95	131.60 ± 17.18
Diastolic blood pressure (mmHg)	79.46 ± 10.67	81.31 ± 11.51	83.58 ± 13.31	81.28 ± 9.57
BMI (kg/m^2)	23.29 ± 2.98	24.17 ± 3.09	24.85 ± 3.36	24.28 ± 3.44
Fasting blood glucose (mmol/l)	4.89 ± 0.48	5.98 ± 0.36	8.08 ± 0.93	6.76 ± 1.41
Total cholesterol (mmol/l)	4.84 ± 0.89	5.04 ± 0.88	5.03 ± 1.02	4.95 ± 0.92
HDL cholesterol (mmol/l)	1.14 ± 0.27	1.14 ± 0.25	1.09 ± 0.24	1.05 ± 0.26
LDL cholesterol (mmol/l)	2.88 ± 0.82	3.03 ± 0.81	2.87 ± 0.91	2.95 ± 0.84
Triglyceride (mmol/l)	1.69 ± 0.93	1.89 ± 1.01	2.13 ± 1.07	2.08 ± 1.03
Women				
n (%)	2,263 (68.39)	801 (23.32)	108 (3.23)	159 (5.07)
Age (years)	42.83 ± 14.82	47.51 ± 14.90	52.66 ± 16.04	62.41 ± 10.68
Height (cm)	157.00 ± 6.17	155.63 ± 6.16	154.16 ± 7.56	152.45 ± 4.60
Weight (kg)	56.29 ± 8.06	59.09 ± 9.35	60.72 ± 12.20	59.36 ± 7.95
Waist circumference (cm)	76.88 ± 9.10	81.07 ± 9.80	84.97 ± 9.85	87.58 ± 9.09
Waist-to-hip ratio	0.83 ± 0.07	0.85 ± 0.07	0.89 ± 0.06	0.92 ± 0.08
Systolic blood pressure (mmHg)	116.65 ± 17.76	123.90 ± 19.32	131.79 ± 21.01	138.41 ± 22.46
Diastolic blood pressure (mmHg)	73.57 ± 10.89	77.21 ± 11.42	79.86 ± 10.89	80.38 ± 11.30
BMI (kg/m^2)	22.85 ± 3.12	24.39 ± 3.56	25.42 ± 4.07	25.55 ± 3.30
Fasting blood glucose (mmol/l)	4.87 ± 0.47	5.95 ± 0.34	7.86 ± 0.85	7.10 ± 1.75
Total cholesterol (mmol/l)	4.76 ± 0.89	5.02 ± 0.91	5.32 ± 1.00	5.24 ± 0.88
HDL cholesterol (mmol/l)	1.27 ± 0.28	1.21 ± 0.26	1.17 ± 0.26	1.13 ± 0.26
LDL cholesterol (mmol/l)	2.89 ± 0.76	3.11 ± 0.79	3.31 ± 0.94	3.19 ± 0.74
Triglyceride (mmol/l)	1.30 ± 0.75	1.50 ± 0.80	1.80 ± 1.01	1.97 ± 1.00

Data are means ± SD or *n* (%).

weights were taken into account to calculate prevalence standard errors. The linear effect of polynomial contrasts of the prevalence across glycemia categories was also examined. Polychotomous logistic regression analysis using a multinomial logit model was used to identify risk factors of diabetes or IFG. The independent variables used in this multivariable analysis were as follows: age, sex, BMI, systolic blood pressure, diastolic blood pressure, total cholesterol, triglyceride, HDL cholesterol, residential area, education level, monthly income, drinking status, smoking status, exercise status, and a family history of diabetes. Linear trend tests of odds ratios (ORs) according to each of the categorical variables in the model were also determined. All statistical analyses were performed using SUDAAN release 8.0 (Research Triangle Institute, Research Triangle Park, NC) to reflect the characteristics of the study's multistage sampling design. Reported *P* values were two-tailed, and $P < 0.05$ was considered to be statistically significant.

RESULTS — A total of 6,601 participants >20 years of age were included in this analysis. After subjects without fasting glucose information ($n = 128$), those who fasted for too short a time ($n = 401$), and those without fasting time data ($n = 236$) were excluded, 5,836 subjects remained, and of these, 8 subjects met two exclusion criteria, and thus 5,844 subjects (2,513 men and 3,331 women) were finally included in the analysis. The age-adjusted prevalence of diabetes was 7.6% (men, 8.1%; women, 7.5%). The age-standardized prevalences of self-reported diabetes were similar in men and women (4.4 and 4.5%, respectively). We found that 3.3% of subjects had previously undiagnosed diabetes (3.7% in men and 3.0% in women). In addition, age-adjusted prevalence of IFG was 23.9% (26.3% in men and 22.6% in women) in the study population according to the new ADA criteria. In contrast, when the previous IFG criterion (fasting plasma glucose 6.1–6.9 mmol/l) was used, this age-adjusted prevalence of IFG fell to 7.0% (7.9% in men and 6.5% in women). Based on prevalence estimates and national census data in 2001 from the Korea National Statistical Office, the numbers of Korean adults with diabetes or IFG were estimated to be 2.6 and 8.1 million, respectively. Moreover, it was estimated that diabetes was undiagnosed in 43.0% of those individuals.

The age-specific prevalence of diabetes increased with age and reached its peak in the oldest female age-group. However, there was a peak of age-adjusted prevalence of diabetes in men 60–69 years of age, and, after that, it decreased slightly in those ≥70 years (Fig. 1). Moreover, in men, diabetes prevalence increased steadily, whereas in women it surged abruptly at 50 years of age. Unlike the prevalence of diabetes, the prevalence of IFG did not increase significantly with age.

Table 1 presents the demographic and biological characteristics of the study subjects classified according to fasting glucose level. In Table 2, the age-adjusted

Table 2—*Age-adjusted prevalence for cardiovascular risk factors with respect to fasting glucose level*

	Normal	IFG	Diabetes	*P* value
Men				
Hypertension (≥140/90 mmHg)*	23.18 ± 1.15	29.31 ± 1.85	38.26 ± 5.66	0.0090
High LDL cholesterol (≥160 mg/dl)	6.64 ± 0.75	8.00 ± 1.15	15.92 ± 5.33	0.0848
High total cholesterol (≥240 mg/dl)	7.11 ± 0.76	9.40 ± 1.25	15.32 ± 4.93	0.0992
High triglyceride (≥200 mg/dl)	22.16 ± 1.20	26.32 ± 1.86	40.92 ± 6.07	0.0024
Low HDL cholesterol (<40 mg/dl)	36.32 ± 1.38	33.27 ± 1.97	43.22 ± 6.33	0.2866
BMI ≥25 kg/m^2	27.41 ± 1.28	37.46 ± 2.09	47.59 ± 6.26	0.0016
Abdominal obesity	17.99 ± 1.14	26.71 ± 1.85	44.12 ± 6.30	<0.0001
Women				
Hypertension (≥140/90 mmHg)*	17.81 ± 0.86	24.87 ± 1.53	33.86 ± 5.13	0.0020
High LDL cholesterol (≥160 mg/dl)	6.38 ± 0.59	8.90 ± 1.02	11.12 ± 2.35	0.0512
High total cholesterol (≥240 mg/dl)	7.38 ± 0.63	8.82 ± 1.02	12.28 ± 2.36	0.0447
High triglyceride (≥200 mg/dl)	10.86 ± 0.75	14.57 ± 1.41	25.89 ± 5.07	0.0034
Low HDL cholesterol (<40 mg/dl)	18.65 ± 0.95	22.79 ± 1.73	28.97 ± 5.10	0.0467
BMI ≥25 kg/m^2	22.77 ± 1.01	34.35 ± 1.78	45.88 ± 5.63	0.0001
Abdominal obesity	35.80 ± 1.07	47.67 ± 1.79	65.23 ± 6.05	<0.0001

Data are means ± SEM. Age-adjusted prevalences were standardized using the national census in 2001 from the Korean National Statistical Office. Hypertension included subjects using antihypertensive medication. Abdominal obesity: waist circumference >90 cm for men and >80 cm for women. *P* values were calculated using a linear contrast test.

prevalence of cardiovascular risk factors according to glycemia categories are presented for men and women. Compared with subjects with normal plasma glucose, men with IFG or diabetic men showed higher blood pressure, BMI, waist circumference, and triglyceride levels. In women with IFG or diabetic women, trends of increasing blood pressure, BMI, waist circumference, total cholesterol level, triglyceride level, and decreased HDL cholesterol level were observed (Table 2).

ORs and their 95% CIs for diabetes and IFG compared with the normal glucose group are shown in Table 3. Using polychotomous multiple logistic regression analysis, diabetes was found to be associated with age, BMI, blood pressure, triglyceride, HDL cholesterol, education level, alcohol consumption, exercise, and a family history of diabetes, whereas IFG was associated with BMI, systolic blood pressure, total cholesterol, HDL cholesterol, residential area, education level, alcohol consumption, and a family history of diabetes. In terms of alcohol consumption, only high-risk drinking was found to be significantly associated with both diabetes and IFG.

CONCLUSIONS — The present study provides the first representative, population-based estimates of the prevalence of diabetes and IFG in Korean adults. The KNHNS 2001 results indicate that the age-adjusted prevalence of diabetes in the Korean population is 7.6%, which includes 4.4% previously diagnosed and 3.3% newly diagnosed. These prevalences of diabetes are comparable to those of Western countries such as the U.S. (7) and Australia (15). Recent Asian studies have shown diabetes prevalences of 5.5% in China (16) and 9.6% in Thailand (17). In a study conducted in rural Japan, the prevalences of diabetes were found to be 9.1% for men and 10.8% for women (18). Several previous studies have yielded prevalence estimates for diabetes in Korea. In 1993, Korean diabetes prevalence was reported to be 7.2% in a community-based cross-sectional study (8). Another Korean study reported a prevalence of diabetes in a rural area of 7.9% according to ADA criteria (19). However, these studies were based on rural populations.

The KNHNS was designed to provide a reliable nationwide estimate of health-, nutrition-, and chronic disease–related basic statistics and was performed on a large representative sample of the Korean population. Moreover, reliable sampling designs and standardized data collection protocols were used to assure accurate estimates of diabetes in the Korean population.

In the present study, the prevalence of diabetes increased with age and peaked in the oldest age-group; however, IFG prevalence did not show this trend. These results are comparable to those previously reported in China and Japan (6).

In this study, the prevalence of IFG was determined to be 23.9% (26.3% in men and 22.6% in women) using the new ADA criteria (fasting plasma glucose 5.6–6.9 mmol/l). This is considerably higher than expected in both men and women. With the previous criteria (fasting plasma glucose 6.1–6.9 mmol/l), this prevalence was 7.0% (7.9% in men and 6.5% in women), which is similar to or higher than those reported in other Asian countries (16,17) and might predict a future diabetes epidemic in the Korean population. Thus, the findings of the present study have important public health implications. Diabetes gives rise to micro- and macrovascular complications and results in an enormous economic burden. Patients with IFG are now referred to as having "pre-diabetes," which reflects a high risk of diabetes development. IFG is not a clinical entity but rather a risk factor for future diabetes and cardiovascular disease (12). Furthermore, IFG is known to be associated with the metabolic syndrome, which includes components of obesity, dyslipidemia, and hypertension. Therefore, public attention to the high prevalence of IFG and diabetes is requested.

This study endorses the fact that established risk factors, such as aging, hypertension, dyslipidemia, and a family history of diabetes, are associated with diabetes in the Korean population and concurs with the results of studies in Western populations in this respect (20,21). Moreover, when only patients with newly diagnosed diabetes are considered (i.e., by excluding subjects with known diabetes from the analysis), its association with normal subjects became insignificant for

Table 3—*ORs and 95% CIs for diabetes and IFG compared with normal glucose, as determined by polychotomous multiple logistic regression analysis using the generalized logit model*

		Diabetes		IFG	
Variables	*n*	OR (95% CI)	*P**	OR (95% CI)	*P**
Age (per 10 years)	5,844	1.406 (1.233–1.604)		0.965 (0.894–1.041)	
Sex (female vs. male)					
Male	2,513	1.0		1.0	
Female	3,331	0.947 (0.606–1.481)		1.039 (0.794–1.360)	
BMI (per 5 kg/m^2)	5,829	1.806 (1.420–2.296)		1.482 (1.288–1.705)	
SBP (per 10 mmHg)	5,371	1.283 (1.158–1.420)		1.089 (1.013–1.171)	
DBP (per 10 mmHg)	5,371	0.793 (0.673–0.935)		1.013 (0.902–1.137)	
Cholesterol (mmol/l)	5,794	1.111 (0.928–1.330)		1.217 (1.103–1.343)	
Triglyceride (mmol/l)	5,699	1.230 (1.035–1.463)		1.001 (0.899–1.114)	
HDL cholesterol (mmol/l)	5,795	0.474 (0.267–0.843)		0.638 (0.453–0.898)	
Residential area					
Urban area	4,435	1.0		1.0	
Rural area	1,409	0.982 (0.724–1.333)		1.624 (1.364–1.935)	
Education levels					
Less than high school	2,109	1.0	<0.0001	1.0	0.0010
High school	2,101	0.676 (0.461–0.992)		0.977 (0.775–1.232)	
College or more	1,481	0.429 (0.267–0.690)		0.756 (0.578–0.991)	
Monthly income†					
≤50	664	1.0	<0.0001	1.0	<0.0001
51–100	1,008	1.072 (0.708–1.623)		0.868 (0.644–1.170)	
101–200	2,299	0.842 (0.551–1.288)		0.764 (0.579–1.008)	
201–300	1,022	0.995 (0.598–1.655)		0.895 (0.648–1.237)	
≥300	524	1.176 (0.645–2.141)		0.859 (0.601–1.227)	
Alcohol consumption					
None	2,838	1.0	<0.0001	1.0	<0.0001
Current drinker	1,570	1.063 (0.734–1.540)		1.035 (0.851–1.258)	
Risk drinker	457	1.412 (0.786–2.537)		0.925 (0.677–1.264)	
High-risk drinker	368	2.374 (1.452–3.882)		1.597 (1.123–2.271)	
Smoking					
None	3,381	1.0	0.1371	1.0	0.4795
Ex-smoker	489	1.028 (0.600–1.760)		1.121 (0.775–1.622)	
Current smoker	1,550	1.161 (0.755–1.786)		1.029 (0.791–1.338)	
Regular exercise					
None	3,851	1.0	<0.0001	1.0	<0.0001
Low exercise	800	1.231 (0.773–1.962)		1.187 (0.944–1.493)	
Middle exercise	374	1.868 (1.131–3.087)		1.241 (0.909–1.692)	
High exercise	347	1.064 (0.617–1.835)		1.067 (0.779–1.462)	
Family history of diabetes					
No	5,265	1.0		1.0	
Yes	578	2.953 (1.996–4.369)		1.435 (1.113–1.850)	

**P* values are for a linear trend test of ORs. †Units are 10,000 Korean won/month. DBP, diastolic blood pressure; SBP, systolic blood pressure.

age, triglyceride level, and a family history of diabetes, whereas the significances of other variables remain unchanged (data not provided). Previous studies in the U.S. and Europe have reported an inverse correlation between alcohol intake and type 2 diabetes (22) or have suggested no significant association with diabetes (23). However, a recent study revealed that moderate to high alcohol consumption is positively associated with the incidence of diabetes in lean Japanese men (24). In the present study, only heavy drinkers were found to be at risk of diabetes and IFG.

Several limitations of this study need to be considered. First, no oral glucose tolerance tests (OGTTs) were conducted, which indicates that the prevalence of diabetes could have been underestimated. In our previous study of elderly Koreans, the prevalence of newly diagnosed diabetes was higher according to World Health Organization (WHO) criteria using OGTTs than by ADA criteria using fasting glucose alone (9). In addition, several studies have indicated that IFG might not be as sensitive a predictor of diabetes as impaired glucose tolerance (25,26). OGTTs are capable of identifying individuals at increased with risk of cardiovascular complications who would not be detected by fasting glucose testing alone. Furthermore, the ADA and WHO criteria might identify different groups of individuals. In the Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe (DECODE) study, ADA criteria were found to be more likely to identify obese individuals ≤65 years old, whereas WHO criteria showed a tendency to diagnose diabetes in lean individuals (27). Moreover, OGTT is less reproducible than fasting plasma glucose testing (28). In an epidemiological study, use of a fasting glucose measurement is recommended because of its convenience and reproducibility (12). Second, the present study was limited by its cross-sectional nature, which prevents our defining causal relationships. Third, this survey does not provide information on subject refusals and/or noncontacted subjects, and thus, even though the participant rate was 77.3%, the response rate could not be calculated. Nevertheless, this study does provide the most reliable up-to-date information on the prevalences of diabetes and IFG and on their relationships with cardiovascular risk factors in the Korean population.

Summarizing, the present study shows that diabetes and IFG are common and that they are associated with cardiovascular risk factors in Korean adults. Without vigorous efforts to prevent and treat diabetes, the socioeconomic burden is predicted to be enormous. Prompt public action is requested to control diabetes in Korea.

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References

1. King H, Aubert RE, Herman WH: Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 21:1414–1431, 1998
2. Amos AF, McCarty DJ, Zimmet P: The rising global burden of diabetes and its complications: estimates and projections to the year 2010. *Diabet Med* 14 (Suppl 5): S1–S85, 1997
3. American Diabetes Association: Standards of medical care for patients with diabetes mellitus (Position Statement). *Diabetes Care* 26 (Suppl. 1):S33–S50, 2003
4. *2003 Statistical Results About Cause of Death*. Daejeon, Korea, National Statistical Office, 2004
5. Roman SH, Harris MI: Management of diabetes mellitus from a public health perspective. *Endocrinol Metab Clin North Am* 26:443–474, 1997
6. Qiao Q, Hu G, Tuomilehto J, Nakagami T, Balkau B, Borch-Johnsen K, Ramachandran A, Mohan V, Iyer SR, Tominaga M, Kiyohara Y, Kato I, Okubo K, Nagai M, Shibazaki S, Yang Z, Tong Z, Fan Q, Wang B, Chew SK, Tan BY, Heng D, Emmanuel S, Tajima N, Iwamoto Y, Snehalatha C, Vijay V, Kapur A, Dong Y, Nan H, Gao W, Shi H, Fu F: Age- and sex-specific prevalence of diabetes and impaired glucose regulation in 11 Asian cohorts. *Diabetes Care* 26:1770–1780, 2003
7. Gregg EW, Cadwell BL, Cheng YJ, Cowie CC, Williams DE, Geiss L, Engelgau MM, Vinicor F: Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. *Diabetes Care* 27:2806–2812, 2004
8. Park Y, Lee H, Koh CS, Min H, Yoo K, Kim Y, Shin Y: Prevalence of diabetes and IGT in Yonchon County, South Korea. *Diabetes Care* 18:545–548, 1995
9. Choi KM, Lee J, Kim DR, Kim SK, Shin DH, Kim NH, Park IB, Choi DS, Baik SH: Comparison of ADA and WHO criteria for the diagnosis of diabetes in elderly Koreans. *Diabet Med* 19:853–857, 2002
10. Kim SG, Yang SW, Jang AS, Seo JP, Han SW, Yeom CH, Kim YC, Oh SH, Kim JS, Nam HS, Chung DJ, Chung MY: Prevalence of diabetes mellitus in the elderly of Namwon County, South Korea. *Korean J Intern Med* 17:180–190, 2002
11. Friedewald WT, Levy RI, Fredrickson DS: Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 18:499–502, 1972
12. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 28:S37–S42, 2005
13. *Analysis of Major Disease and Health Behavior in Koreans*. Gyeonggi-do, Korea, Ministry of Health and Welfare, 2003
14. *Report on 1998 National Health and Nutrition Survey*. Gyeonggi-do, Korea, Ministry of Health and Welfare, 1999
15. Dunstan DW, Zimmet PZ, Welborn TA, De Courten MP, Cameron AJ, Sicree RA, Dwyer T, Colagiuri S, Jolley D, Knuiman M, Atkins R, Shaw JE: The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle study. *Diabetes Care* 25: 829–834, 2002
16. Gu D, Reynolds K, Duan X, Xin X, Chen J, Wu X, Mo J, Whelton PK, He J: Prevalence of diabetes and impaired fasting glucose in the Chinese adult population: International Collaborative Study of Cardiovascular Disease in Asia (InterASIA). *Diabetologia* 46:1190–1198, 2003
17. Aekplakorn W, Stolk RP, Neal B, Suriyawongpaisal P, Chongsuvivatwong V, Cheepudomwit S, Woodward M: The prevalence and management of diabetes in Thai adults: the International Collaborative Study of Cardiovascular Disease in Asia. *Diabetes Care* 26:2758–2763, 2003
18. Sekikawa A, Eguchi H, Tominaga M, Igarashi K, Abe T, Manaka H, Sasaki H, Fukuyama H, Kato T, Kiyohara Y, Fujishima M: Prevalence of type 2 diabetes mellitus and impaired glucose tolerance in a rural area of Japan: the Funagata Diabetes Study. *J Diabetes Complications* 14: 78–83, 2000
19. Park JY, Kim YI, Choi CS, Chung YE, Kim SW, Lee MS, Lee SI, Hong SK, Lee KU: Prevalence of diabetes, impaired glucose tolerance, and impaired fasting glucose in a rural population of Korea, according to 1997 American Diabetes Association and 1985 World Health Organization criteria. *Diabetes Care* 23:707–708, 2000
20. Wilson PW, Anderson KM, Kannel WB: Epidemiology of diabetes mellitus in the elderly: the Framingham study. *Am J Med* 80:3–9, 1986
21. Burchfiel CM, Curb JD, Rodriguez BL, Yano K, Hwang LJ, Fong KO, Marcus EB: Incidence and predictors of diabetes in Japanese-American men: the Honolulu Heart Program. *Ann Epidemiol* 5:33–43, 1995
22. Ajani UA, Hennekens CH, Spelsberg A, Manson JE: Alcohol consumption and risk of type 2 diabetes mellitus among US male physicians. *Arch Intern Med* 160: 1025–1030, 2000
23. Perry IJ, Wannamethee SG, Walker MK, Thomson AG, Whincup PH, Shaper AG: Prospective study of risk factors for development of non-insulin dependent diabetes in middle aged British men. *BMJ* 310: 560–564, 1995
24. Waki K, Noda M, Sasaki S, Matsumura Y, Takahashi Y, Isogawa A, Ohashi Y, Kadowaki T, Tsugane S: Alcohol consumption and other risk factors for self-reported diabetes among middle-aged Japanese: a population-based prospective study in the JPHC study cohort I. *Diabet Med* 22:323–331, 2005
25. Shaw JE, Zimmet PZ, de Courten M, Dowse GK, Chitson P, Gareeboo H, Hemraj F, Fareed D, Tuomilehto J, Alberti KG: Impaired fasting glucose or impaired glucose tolerance: what best predicts future diabetes in Mauritius? *Diabetes Care* 22: 399–402, 1999
26. Gabir MM, Hanson RL, Dabelea D, Imperatore G, Roumain J, Bennett PH, Knowler WC: The 1997 American Diabetes Association and 1999 World Health Organization criteria for hyperglycemia in the diagnosis and prediction of diabetes. *Diabetes Care* 23:1108–1112, 2000
27. The DECODE Study Group, the European Diabetes Epidemiology Study Group: Will new diagnostic criteria for diabetes mellitus change phenotype of patients with diabetes? Reanalysis of European epidemiological data. *BMJ* 317: 371–375, 1998
28. Mooy JM, Grootenhuis PA, de Vries H, Kostense PJ, Popp-Snijders C, Bouter LM, Heine RJ: Intra-individual variation of glucose, specific insulin and proinsulin concentrations measured by two oral glucose tolerance tests in a general Caucasian population: the Hoorn Study. *Diabetologia* 39:298–305, 1996