Original Article
Epidemiology

Diabetes Metab J 2018;42:415-424
https://doi.org/10.4093/dmj.2018.0017
pISSN 2233-6079 · eISSN 2233-6087

dmj
DIABETES & METABOLISM JOURNAL

Diabetes Fact Sheet in Korea, 2016: An Appraisal of Current Status

Jong Chul Won[1], Jae Hyuk Lee[2], Jae Hyeon Kim[3], Eun Seok Kang[4], Kyu Chang Won[5], Dae Jung Kim[6], Moon-Kyu Lee[3]

[1]Department of Internal Medicine, Cardiovascular and Metabolic Disease Center, Inje University Sanggye Paik Hospital, Inje University College of Medicine, Seoul,
[2]Division of Endocrinology and Metabolism, Department of Internal Medicine, Myongji Hospital, Goyang,
[3]Division of Endocrinology and Metabolism, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul,
[4]Department of Internal Medicine, Yonsei University College of Medicine, Seoul,
[5]Department of Internal Medicine, Yeungnam University College of Medicine, Daegu,
[6]Department of Endocrinology and Metabolism, Ajou University School of Medicine, Suwon, Korea

Background: This report presents the recent prevalence and comorbidities related to diabetes in Korea by analyzing the nationally representative data.
Methods: Using data from the Korea National Health and Nutrition Examination Survey for 2013 to 2014, the percentages and the total number of subjects over the age of 30 years with diabetes and prediabetes were estimated and applied to the National Population Census in 2014. Diagnosis of diabetes was based on fasting plasma glucose (≥126 mg/dL), current taking of antidiabetic medication, history of previous diabetes, or glycosylated hemoglobin (HbA1c) ≥6.5%. Impaired fasting glucose (IFG) was defined by fasting plasma glucose in the range of 100 to 125 mg/dL among those without diabetes.
Results: About 4.8 million (13.7%) Korean adults (≥30 years old) had diabetes, and about 8.3 million (24.8%) Korean adults had IFG. However, 29.3% of the subjects with diabetes are not aware of their condition. Of the subjects with diabetes, 48.6% and 54.7% were obese and hypertensive, respectively, and 31.6% had hypercholesterolemia. Although most subjects with diabetes (89.1%) were under medical treatment, and mostly being treated with oral hypoglycemic agents (80.2%), 10.8% have remained untreated. With respect to overall glycemic control, 43.5% reached the target of HbA1c <7%, whereas 23.3% reached the target when the standard was set to HbA1c <6.5%, according to the Korean Diabetes Association guideline.
Conclusion: Diabetes is a major public health threat in Korea, but a significant proportion of adults were not controlling their illness. We need comprehensive approaches to overcome the upcoming diabetes-related disease burden in Korea.

Keywords: Comorbidity; Diabetes mellitus; Glycated hemoglobin A; Prediabetic state; Prevalence; Public health; Republic of Korea

INTRODUCTION

The global estimated number of people with diabetes was 415 million (8.8%) among subjects aged 20 to 79 years in 2015, and it is expected to rise by 54.7%, to 642 million (10.4%) in 2040, according to the International Diabetes Federation (IDF) atlas 2017 [1]. It was also estimated that the Western Pacific region, in terms of the IDF atlas, is the largest (153.2 million) region for prevalence of diabetes and has the highest (16%) death rate from diabetes. In Korea, diabetes is the sixth leading cause of death, accounting for 3.9% of all deaths among individuals aged 20 to 79 years in 2014 [2], and the leading cause of dis-

Corresponding authors: Dae Jung Kim https://orcid.org/0000-0002-8649-1458
Department of Endocrinology and Metabolism, Ajou University School of Medicine, 164 World cup-ro, Yeongtong-gu, Suwon 16499, Korea
E-mail: djkim@ajou.ac.kr

Moon-Kyu Lee http://orcid.org/0000-0002-8728-7184
Division of Endocrinology and Metabolism, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea
E-mail: leemk@skku.edu

Received: Jan. 29, 2018; Accepted: May 2, 2018

ability-adjusted life years in 2012 [3]. Although ranking of mortality caused by diabetes decreased from fourth place to sixth place 10 years ago, diabetes and its complications still represent an important problem for socioeconomic and public health care systems in Korea [4].

With recognition of the rising burden of diabetes in Korea, the Korea Diabetes Association (KDA) published diabetes fact sheets in 2012, 2013, 2015, and 2016 (infographics are available at www.diabetes.or.kr). Those published in 2012, 2013, and 2016 were based on the nationwide survey, the Korea National Health and Nutrition Examination Survey (KNHANES), performed by the Ministry of Health and Welfare and the Korean Centers for Disease Control and Prevention (KCDC); the publication in 2015 was based on information provided by the National Health Insurance Service (NHIS) in Korea to provide the latest extracted, detailed information on diabetes in Korea. These statistical resources contain many contemporary aspects of diabetes and its related medical problems and present representative nationwide statistics on diabetes in Korea to researchers, clinicians, health care policy makers, and media professionals. The aim of this study is to provide the assembled accessible information about diabetes in Korea, using nationally representative data, as a valuable contribution to the estimation and understanding of the disease.

METHODS

This study analyzed data from the sixth (2013 to 2014) KNHANES. Among 15,568 participants (7,030 men and 8,538 women), 10,595 subjects aged 30 years or older were included in our final analyses (Supplementary Table 1). In brief, we estimated percentages and the total number of subjects with diabetes and prediabetes presented as age-standardized values by calculation of the survey sample weight with the sampling rate, response rate, and age/sex proportion of the reference population (national population census in 2014, 34.1 million people in Korea are aged 30 and older, 16.7 million men and 17.4 million women) to produce estimates representative of the noninstitutionalized Korean civilian population.

KNHANES data also include a standardized health interview assessing the prior history of diagnosis of diabetes, hypertension, or hypercholesterolemia and medication for those conditions. After overnight fasting, plasma glucose, total cholesterol, high-density lipoprotein cholesterol (HDL-C) and triglyceride (TG), serum and urinary concentration of creatinine were measured using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan). Low density lipoprotein cholesterol (LDL-C) was measured by direct assay in persons with TG >200 mg/dL (Hitachi Automatic Analyzer 7600; Hitachi, Tokyo, Japan; KNHANES 2012 to 2014). Thus, we used either directly measured or calculated LDL-C according to the Friedewald calculation: LDL-C=total cholesterol–HDL-C–(TGs/5) [5]. Glycosylated hemoglobin (HbA1c) was measured using high-performance liquid chromatography (HLC-723G7; Tosoh, Tokyo, Japan). Urinary albumin was measured in random urine samples using a Hitachi Automatic Analyzer 7600, and the ratio of urinary albumin to urinary creatinine was calculated as albumin-creatinine ratio (ACR) in milligrams per gram of creatinine.

Diagnosis of diabetes was based on fasting plasma glucose (FPG, ≥126 mg/dL), current taking of antidiabetic medication(s), history of previous diabetes, or HbA1c ≥6.5%. Impaired fasting glucose (IFG) was defined by FPG in the range of 100 to 125 mg/dL among those without diabetes as defined above [6]. Obesity was defined as a body mass index (BMI; weight in kilograms divided by the square of height in meters) ≥25.0 kg/m^2, in accordance with the Asia-Pacific criteria of the World Health Organization (WHO) guidelines [7,8]. Abdominal obesity was defined as waist circumference ≥90 cm in men and ≥85 cm in women. The diagnosis of hypertension (systolic and diastolic blood pressure [BP], mm Hg) was based on BP ≥140/90 mm Hg or taking antihypertensive medication(s), and control rate of hypertension was based on BP <140/85 mm Hg, according to the KDA Treatment Guideline for Diabetes 2015 (English version is available at www.diabetes.or.kr) [9]. Diagnosis and control rate of hypercholesterolemia were total cholesterol ≥240 mg/dL or taking medication(s) and LDL-C <100 mg/dL, respectively [9,10]. The definition of albuminuria or chronic kidney disease (CKD) in persons with diabetes was increased albuminuria determined by the ACR >30 μg/mg of creatinine or estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2, and GFR (mL/min/1.73 m^2) was calculated as $175\times(S_{Cr})^{-1.154}\times(Age)^{-0.203}\times(0.742$ if female), respectively [11]. Current smoking was defined as percentage of adults who had smoked at least five packs of cigarettes (100 cigarettes) during their lifetime and who are currently smokers. High-risk drinking was defined as more than seven glasses in men or five glasses in women on the same occasion on each of 2 or more days a week, and regular walking exercise activity was defined as 5 days or more per week and for 30 minutes or

Table 1. Estimated prevalence of adults (≥30 years old) with diabetes and impaired fasting glucose

Variable	Diabetes			Impaired fasting glucose		
	Total	Men	Women	Total	Men	Women
By age group, yr						
≥30	13.7 (4,810)	15.7 (2,580)	11.9 (2,230)	24.8 (8,259)	29.6 (4,786)	20.1 (3,473)
≥65	30.4 (1,951)	-	-	26.6 (1,684)	-	-
30–39		3.1 (124)	2.1 (80)		20.0 (796)	11.2 (425)
40–49		12.1 (521)	5.7 (239)		31.4 (1,354)	16.9 (708)
50–59		18.8 (748)	11.1 (442)		37.9 (1,511)	26.2 (1,042)
60–69		33.1 (729)	24.1 (574)		30.3 (668)	26.9 (642)
≥70		27.2 (457)	33.8 (895)		27.1 (457)	24.4 (657)
By family incomes (quartiles)[a]						
Quartile 1	15.1	17.7	12.6	22.4	27.0	17.8
Quartile 2	12.8	14.7	10.6	24.2	28.1	20.4
Quartile 3	11.7	13.3	10.2	24.6	29.2	20.3
Quartile 4	11.2	13.4	9.2	23.2	29.7	16.9

Values are presented as percentage (number) and percentage.
[a]From the lowest to the highest.

more per activity. Informed consent was obtained during the process of KNHANES and the survey protocol was approved by the Institutional Review Board of the KCDC (2013-07CON-03-4C, 2013-12EXP-03-5C).

RESULTS

Prevalence of diabetes and IFG in Korea

The estimated population of diabetes in Korean adults (≥30 years of age) is 4.8 million, which represented 13.7% of this group in 2013 to 2014 (Table 1). This means nearly one of seven Koreans had diabetes. The prevalence of diabetes increased with age up to their 60s in men and their 70s in women. In the group aged 40 to 49 years, the prevalence of diabetes was more than double in men (12.1%) compared to women (5.7%). However, in those individuals aged 70 years or older, diabetes in women was more prevalent than in men (33.8% vs. 27.2%). The prevalence of diabetes was 1.4 times more common in subjects in the lowest quartile for family income (15.1%) than in the highest quartile (11.2%). The prevalence of IFG in adults aged 30 years or older was 24.8% (8.3 million) (Table 1). This means nearly one in four nondiabetic Koreans have IFG. IFG was more prevalent in men (29.6%) than in women (20.1%), as in diabetes (15.7% vs. 11.9%). Current smoker and high-risk drinker subjects with diabetes amounted to 27.4% and 14.3%, respectively, and 21.9% of those with diabetes participated in regular walking exercise activity (Table 2).

Table 2. Estimated proportion for health behaviors in adults with diabetes

Variable	Current smoking	High-risk drinking	Regular walking exercise
Total			
≥30 yr	27.4	14.3	21.9
≥65 yr	13.7	3.7	7.6
By sex and age group, yr			
Men	44.0	23.0	38.3
30–39	61.8	34.5	38.2
40–49	57.2	39.8	46.4
50–59	46.2	25.5	32.7
60–69	41.6	14.6	18.5
≥70	18.7	7.5	12.6
Women	5.2	2.6	37.3
30–39	20.2	7.8	11.1
40–49	1.5	7.5	11.5
50–59	6.0	4.3	6.9
60–69	6.3	0.0	0.0
≥70	3.0	1.2	3.9

Values are presented as percentage.

Comorbidities in diabetic adults in Korea

The prevalence of obesity and abdominal obesity in Korean adults with diabetes was 48.6% and 58.9%, respectively (Fig. 1). Morbid obesity (BMI ≥30 kg/m^2) was 8.0% in men, 12.1% in women, and 9.7% in Korean adults with diabetes [7,8]. In addition, 54.7% and 69.1% had hypertension and reached the BP target goal, respectively. The prevalence and control rate of hypercholesterolemia were 31.6% and 49.8%, respectively. The prevalence of albuminuria and CKD in adults with diabetes was 23.9% and 12.5%, respectively. Collectively, the prevalence of nephropathy in Korean adults with diabetes (either albuminuria or CKD) was 30.3% (Table 3).

Management of diabetes

Among adults with diabetes (previously and newly diagnosed at this survey), 70.7% were aware of their condition and 63.0%

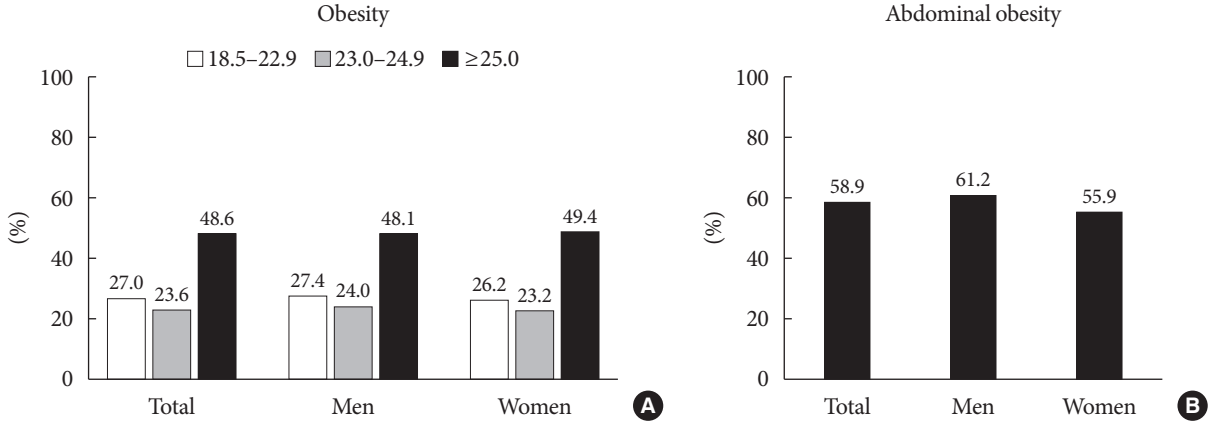

Fig. 1. Estimated proportion of adults (≥30 years old) with diabetes according to body mass index (kg/m^2) (A) and abdominal obesity (B). Abdominal obesity is defined by abdominal circumferences ≥90 cm in men and ≥85 cm in women.

Table 3. Estimated prevalence and control rate of comorbidities in adults with diabetes

Variable	Hypertension		Hypercholesterolemia		Nephropathy		
	Prevalence	Treatment rate	Prevalence	Treatment rate	Albuminuria	CKD	Total
Total							
≥30 yr	54.7	69.1	31.6	49.8	23.9	12.5	30.3
≥65 yr	71.7	76.6	31.7	51.0	26.1	23.1	39.0
By sex and age group, yr							
Men							
30–39	15.8	81.3	40.4	46.9	8.7	4.7	8.7
40–49	43.2	44.9	26.6	44.7	28.0	0.9	28.9
50–59	51.0	55.9	28.7	59.9	24.1	11.8	28.5
60–69	58.9	74.5	29.8	54.0	26.0	13.7	35.6
≥70	66.9	77.7	17.7	51.7	33.5	32.5	52.5
Women							
30–39	7.8	92.2	42.1	32.2	23.2	-	23.2
40–49	24.2	73.6	19.6	34.1	22.6	3.8	22.6
50–59	42.3	79.9	35.5	43.1	18.7	3.5	19.5
60–69	70.6	76.6	44.9	49.1	21.0	11.4	25.5
≥70	78.1	72.4	37.0	49.1	20.7	22.9	34.5

Values are presented as percentage.
CKD, chronic kidney disease.

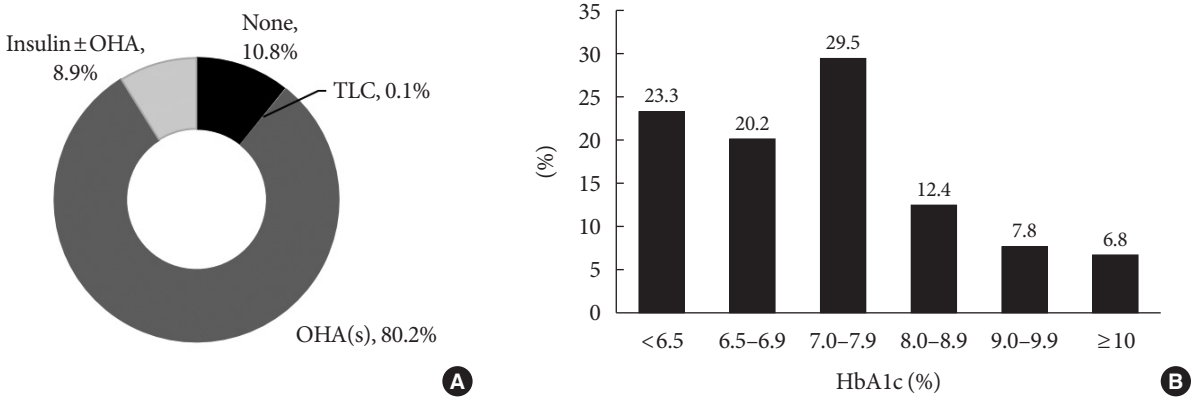

Fig. 2. Estimated proportion of adults (≥30 years old) with diabetes according to type of treatment for hyperglycemia (A) and glycosylated hemoglobin (HbA1c) (%) (B). OHA, oral hypoglycemic agent; TLC, therapeutic life style.

Table 4. Estimated proportion of awareness, treatment, and comprehensive management[a] in adults with previously diagnosed diabetes

Variable	Awareness	Treatment	Comprehensive management	
			<6.5	<7.0
Total				
≥30 yr	70.7	63.0	9.4	16.8
≥65 yr	85.2	77.6	12.0	22.0
By sex and age group, yr				
Men				
30–39	-	-	18.6	29.7
40–49	46.0	32.9	7.0	8.0
50–59	65.5	59.3	7.9	14.9
60–69	78.4	72.2	9.0	19.5
≥70	82.0	73.6	15.0	26.0
Women				
30–39	-	-	13.4	13.4
40–49	56.9	52.8	5.6	9.1
50–59	68.7	59.7	5.6	13.1
60–69	81.5	75.6	10.7	16.9
≥70	87.4	80.8	10.3	20.9

Values are presented as percentage.
[a]Comprehensive management included treatment of hyperglycemia, hypertension, and hypercholesterolemia.

were in treatment. Most adults with previously diagnosed diabetes were treated with oral hypoglycemic agents (80.2%), while 8.9% were treated with insulin with or without an oral hypoglycemic agent; 10.8% were maintained without pharmacologic treatment. The control rate among those with previously diagnosed diabetes was 23.3% for a target goal of HbA1c <6.5% or 43.5% for <7%. Fourteen point six percent (14.6%) of Korean diabetic adults remained above 9.0% of HbA1c (Fig. 2). Only 9.4% were under effective comprehensive management (namely, HbA1c <6.5%, systolic and diastolic BP <140/85 mm Hg, and LDL-C <100 mg/dL) based on the KDA treatment guideline 2015 (Table 4) [9].

DISCUSSION

Since 2012, the KDA has been working with the KCDC to derive regular statistics for the diabetes fact sheets in Korea [4,12-15]. In 2013 to 2014, an estimated 4.8 million Korean adults had diabetes, and 8.3 million had IFG (prediabetes). The prevalence of diabetes steadily increased (Δ59.3%) over 15 years from 2001 (8.6%) to 2014 (13.7%) in a nationally representative sample of Koreans aged ≥30 years [16]. Because the measurement of HbA1c was available and included in the diagnostic criteria since KNHANES 2011 [13], there was a difference in the criteria for diagnosis of diabetes between studies. In addition, this increase is due to the aging of the population and increasing obesity [13,17]. Moreover, differences in prevalence by family income were clearly observed in both men and women; therefore, older people or subjects with low income bear a strikingly disproportionate burden of diabetes in Korea. Among Korean adults with diabetes, seven out of 10 (70.7%) were aware of their condition, and about two-thirds (63.0%, both diagnosed and undiagnosed) were in treatment, but only one of four of those with documented diabetes reached the target levels defined by HbA1c <6.5%.

Among Koreans ≥30 years of age, 15.7% of men and 11.9%

of women had diabetes. Of older people (≥65 years of age), 30.4% had diabetes. The highest prevalence was among those aged 60 to 69 years old (33.1%) in men and ≥70 years old in women (33.8%), which is consistent with global age-specific prevalence figures of diabetes provided by the IDF [1]. Interestingly, the highest prevalence of IFG was observed in a 10-year younger group compared to that of diabetes in men in their 50s or women in their 60s. Therefore, it is predicted that older people with diabetes will increase in the aging society of Korea when those with IFG, who are at increased risk of diabetes [18], are incorporated into the diabetes risk model [19]. This reflects concomitant changes in increased intakes of calories and sedentary lifestyle [20] and calls for lifestyle interventions to prevent or delay progression from IFG to type 2 diabetes mellitus in Korea. In addition, the awareness and treatment rate for diabetes, and the control rate for hypertension, hypercholesterolemia, and comprehensive management for diabetes were lowest in subjects 40 to 49 years in both sexes. Current smoking, high-risk drinking, and sedentary lifestyles were prominently prevalent in this age group. This emphasized that there is also a need to encourage educational support and implementation of intensive intervention, especially for subjects with diabetes in their 40s, to prevent diabetes-related health and socioeconomic burden in the coming decades in Korea.

Type 2 diabetes mellitus is associated with clustered risk factors for cardiovascular diseases (CVDs) [21]. The prevalence was 54.7% for hypertension, 31.6% for hypercholesterolemia, and 48.6% for obesity among adults with diabetes. Although aggressive treatment of hypertension and hypercholesterolemia is recommended for adults with diabetes to prevent micro- and macrovascular complications, the proportion of adults with diabetes who achieved targets for control of BP and LDL-C were 69.1% and 49.8%, respectively [22,23]. CKD is also known to increase the risk of CVD, CVD outcomes, and all causes of mortality [24]. The prevalence of albuminuria and reduced eGFR (<60 mL/min/1.73 m^2) in Korean adults with diabetes was 23.9% and 12.5%, respectively. Compared to previous studies conducted by the task force team of fact sheets of the KDA [12-15], there are some discrepancies regardless of the study population, statistical methods such as adjustment and sampling weight, and extrapolations of rates beyond the data collection period. The definition of IFG by using KNHANES 2011 included the value of FPG, HbA1c, or both between 5.7% and 6.4% [13], but in this study, we defined IFG by only the FPG level in nondiabetic subjects. The control rate of hypertension (33.3%) based on KNHANES 2011 was much lower than observed in this study (69.1%) [14]; we thought that this difference was largely caused by the difference in BP levels defined as controlled based on KDA guidelines between 2012 (<130/80 mm Hg) and 2015 (<140/85 mm Hg) [9,25]. The prevalence and control rate of hypercholesterolemia were 36.0% and 62.6% in studies using KNHANES 2010, respectively [15]. Compared to this study (31.6% and 49.8%, respectively), a relatively higher prevalence of hypercholesterolemia and treatment rate of hypercholesterolemia might be caused by a higher rate of self-reported diagnosis by a physician and use of lipid-lowering drugs. Although the prevalence of albuminuria in this study (23.7%) is comparable to previous studies using KNHANES 2011 (26.7%) [12], there is a relatively large difference in the prevalence of decreased eGFR (<60 mL/min/1.73 m^2, 12.5% in 2013 to 2014 and 8.6% in 2011). The main difference between these two studies is that we used revised modification in diet renal disease (MDRD) 175 equations rather than the traditional MDRD 186 equations used in previous studies. Despite the same source of data, such as the KNHANES, we need to take differences in population estimates into account in comparing possible trends in prevalence.

Previously, data from the health insurance claims database of Korea NHIS showed that the prevalence of type 2 diabetes mellitus among adults aged ≥30 years, based on the claim history for antidiabetic medications in subjects with International Classification of Diseases 10th (ICD-10) codes E11-E14, increased from 5.6% to 8% from 2006 to 2013 [26]. Although the NHIS data used information about ICD-10 codes and billing for reimbursement of health care services eligible for coverage based mainly on pharmacologically treated diabetes [27], this update used data containing the laboratory and health behavioral information, and diagnoses of diabetes and comorbidities (hypertension, hypercholesterolemia, and obesity) were based on measurements of FPG, HbA1c, BP, lipid profile, BMI, and abdominal circumferences. In addition, previous studies found that the diagnostic validity of health insurance data for diabetes was only 62.7% [28]. In addition, health insurance claim data would not include the information about subjects with undiagnosed or untreated diabetes, and it was estimated that more than 50% of adults with diabetes in the Western Pacific regions were undiagnosed according to the IDF diabetes atlas [1]. Therefore, we need more accurate national estimates of diabetes prevalence for planning and monitoring prevention and treatment strategies to reach the goals developed by the WHO.

Thus, our analysis, based on the natinal level health examination survey data, would be representative of the nationwide prevalence of diabetes in Koreans. However, our study has some limitations. First, it is difficult to prove that those studies and this one correlate, because this study is a cross-sectional, descriptive study, and we provided the actual estimated data rather than statistical powers to analyze or compare these estimates to prove the relationship between variables or the comparison between subjects with and without diabetes or different data sets. Second, most estimations of our variables were carried out by self-reported questionnaires and face-to-face interviews, which always implies the possibility of recall bias. However, there was a high concordance between the self-administered questionnaire and the actual measurement of diabetes ($\kappa=0.82$) in the KNHANES [29]. Third, with these analyses, it was not possible to estimate the relative proportion of the population with type 1 diabetes mellitus from the total estimates because there were no measurable biomarkers or medical records to identify type 1 diabetes mellitus.

Although accumulating evidence has suggested that the importance of glycemic control and availability of newly developed antidiabetic treatment has increased over the past few decades, the control rate of diabetes (defined by HbA1c <6.5%) in Korean adults remains unsatisfactory between 2005 (22.9%) and 2014 (23.3%) [30]. In addition, one out of seven adults (14.6%) with diabetes has remained in a poorly controlled state (HbA1c ≥9.0%) in Korea. We are now facing serious threats: increased prevalence of diabetes, much higher prevalence of IFG, putative undiagnosed diabetes, and poorly controlled diabetes and comorbidities, especially in middle-aged subjects with diabetes. Thus, it is crucial for the government to understand the magnitude of the current status accurately; monitor its trend; and provide appropriate and timely interventions, funds, and educational programs both to prevent or delay the development of diabetes and to help individuals with diabetes.

Diabetes continues to be a major public health threat in Korea, affecting one in seven adults. However, a significant proportion of the adult population is not controlling their illness. It is critical to monitor this situation continuously through nationally representative data and to establish a program for the prevention of diabetes and its related comorbidities to reach the nation's urgent goals.

CONFLICTS OF INTEREST

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

REFERENCES

1. Ogurtsova K, da Rocha Fernandes JD, Huang Y, Linnenkamp U, Guariguata L, Cho NH, Cavan D, Shaw JE, Makaroff LE. IDF diabetes atlas: global estimates for the prevalence of diabetes for 2015 and 2040. Diabetes Res Clin Pract 2017;128:40-50.
2. Shin HY, Lee JY, Song J, Lee S, Lee J, Lim B, Kim H, Huh S. Cause-of-death statistics in the Republic of Korea, 2014. J Korean Med Assoc 2016;59:221-32.
3. Yoon J, Seo H, Oh IH, Yoon SJ. The non-communicable disease burden in Korea: findings from the 2012 Korean Burden of Disease Study. J Korean Med Sci 2016;31 Suppl 2:S158-67.
4. Choi YJ, Lee MS, An SY, Kim TH, Han SJ, Kim HJ, Chung YS, Lee KW, Kim DJ. The relationship between diabetes mellitus and health-related quality of life in Korean adults: the Fourth Korea National Health and Nutrition Examination Survey (2007-2009). Diabetes Metab J 2011;35:587-94.
5. 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 1972;18:499-502.
6. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2014;37(Suppl 1):S81-90.
7. Bassett J; International Diabetes Institute; World Health Organization Regional Office for the Western Pacific; International Association for the Study of Obesity; International Obesity Task Force. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia; 2000.
8. Oh SW, Shin SA, Yun YH, Yoo T, Huh BY. Cut-off point of BMI and obesity-related comorbidities and mortality in middle-aged Koreans. Obes Res 2004;12:2031-40.
9. Korean Diabetes Association. Treatment guideline for diabetes. 5th ed. Seoul: Gold' Planning and Development; 2015.
10. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, Dai S, Ford ES, Fox CS, Franco S, Fullerton HJ, Gillespie C, Hailpern SM, Heit JA, Howard VJ, Huffman MD, Judd SE, Kissela BM, Kittner SJ, Lackland DT, Lichtman JH, Lisabeth LD, Mackey RH, Magid DJ, Marcus GM, Marelli A, Matchar DB, McGuire DK, Mohler ER 3rd, Moy CS, Mussolino ME,

Neumar RW, Nichol G, Pandey DK, Paynter NP, Reeves MJ, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Wong ND, Woo D, Turner MB; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics: 2014 update: a report from the American Heart Association. Circulation 2014;129:e28-92.
11. Levey AS, Coresh J, Greene T, Stevens LA, Zhang YL, Hendriksen S, Kusek JW, Van Lente F; Chronic Kidney Disease Epidemiology Collaboration. Using standardized serum creatinine values in the modification of diet in renal disease study equation for estimating glomerular filtration rate. Ann Intern Med 2006;145:247-54.
12. Ahn JH, Yu JH, Ko SH, Kwon HS, Kim DJ, Kim JH, Kim CS, Song KH, Won JC, Lim S, Choi SH, Han K, Cha BY, Kim NH; Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association. Prevalence and determinants of diabetic nephropathy in Korea: Korea National Health and Nutrition Examination Survey. Diabetes Metab J 2014;38:109-19.
13. Jeon JY, Ko SH, Kwon HS, Kim NH, Kim JH, Kim CS, Song KH, Won JC, Lim S, Choi SH, Jang MJ, Kim Y, Oh K, Kim DJ, Cha BY; Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association. Prevalence of diabetes and prediabetes according to fasting plasma glucose and HbA1c. Diabetes Metab J 2013;37:349-57.
14. Ko SH, Kwon HS, Kim DJ, Kim JH, Kim NH, Kim CS, Song KH, Won JC, Lim S, Choi SH, Han K, Park YM, Cha BY; Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association. Higher prevalence and awareness, but lower control rate of hypertension in patients with diabetes than general population: the Fifth Korean National Health and Nutrition Examination Survey in 2011. Diabetes Metab J 2014;38:51-7.
15. Roh E, Ko SH, Kwon HS, Kim NH, Kim JH, Kim CS, Song KH, Won JC, Kim DJ, Choi SH, Lim S, Cha BY; Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association. Prevalence and management of dyslipidemia in Korea: Korea National Health and Nutrition Examination Survey during 1998 to 2010. Diabetes Metab J 2013;37:433-49.
16. Kim DJ. The epidemiology of diabetes in Korea. Diabetes Metab J 2011;35:303-8.
17. Kim CS, Ko SH, Kwon HS, Kim NH, Kim JH, Lim S, Choi SH, Song KH, Won JC, Kim DJ, Cha BY; Taskforce Team of Diabetes Fact Sheet of the Korean Diabetes Association. Prevalence, awareness, and management of obesity in Korea: data from the Korea National Health and Nutrition Examination Survey (1998-2011). Diabetes Metab J 2014;38:35-43.
18. Warren B, Pankow JS, Matsushita K, Punjabi NM, Daya NR, Grams M, Woodward M, Selvin E. Comparative prognostic performance of definitions of prediabetes: a prospective cohort analysis of the Atherosclerosis Risk in Communities (ARIC) study. Lancet Diabetes Endocrinol 2017;5:34-42.
19. Razavian N, Blecker S, Schmidt AM, Smith-McLallen A, Nigam S, Sontag D. Population-level prediction of type 2 diabetes from claims data and analysis of risk factors. Big Data 2015;3:277-87.
20. Kim S, Moon S, Popkin BM. The nutrition transition in South Korea. Am J Clin Nutr 2000;71:44-53.
21. Gaede P, Vedel P, Larsen N, Jensen GV, Parving HH, Pedersen O. Multifactorial intervention and cardiovascular disease in patients with type 2 diabetes. N Engl J Med 2003;348:383-93.
22. Grundy SM, Cleeman JI, Merz CN, Brewer HB Jr, Clark LT, Hunninghake DB, Pasternak RC, Smith SC Jr, Stone NJ; National Heart, Lung, and Blood Institute; American College of Cardiology Foundation; American Heart Association. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. Circulation 2004;110:227-39.
23. Ford ES. Trends in the control of risk factors for cardiovascular disease among adults with diagnosed diabetes: findings from the National Health and Nutrition Examination Survey 1999-2008*. J Diabetes 2011;3:337-47.
24. Go AS, Chertow GM, Fan D, McCulloch CE, Hsu CY. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004;351:1296-305.
25. Ko SH, Kim SR, Kim DJ, Oh SJ, Lee HJ, Shim KH, Woo MH, Kim JY, Kim NH, Kim JT, Kim CH, Kim HJ, Jeong IK, Hong EK, Cho JH, Mok JO, Yoon KH; Committee of Clinical Practice Guidelines, Korean Diabetes Association. 2011 Clinical practice guidelines for type 2 diabetes in Korea. Diabetes Metab J 2011;35:431-6.
26. Noh J, Han KD, Ko SH, Ko KS, Park CY. Trends in the pervasiveness of type 2 diabetes, impaired fasting glucose and comorbidities during an 8-year-follow-up of nationwide Korean population. Sci Rep 2017;7:46656.
27. Kim JA, Yoon S, Kim LY, Kim DS. Towards actualizing the value potential of Korea Health Insurance Review and Assessment (HIRA) data as a resource for health research: strengths, limitations, applications, and strategies for optimal use of HIRA data. J Korean Med Sci 2017;32:718-28.
28. Task Force Team for Basic Statistical Study of Korean Diabetes Mellitus of Korean Diabetes Association, Park IeB, Kim J, Kim

DJ, Chung CH, Oh JY, Park SW, Lee J, Choi KM, Min KW, Park JH, Son HS, Ahn CW, Kim H, Lee S, Lee IB, Choi I, Baik SH. Diabetes epidemics in Korea: reappraise nationwide survey of diabetes "diabetes in Korea 2007". Diabetes Metab J 2013;37:233-9.

29. Chun H, Kim IH, Min KD. Accuracy of self-reported hypertension, diabetes, and hypercholesterolemia: analysis of a representative sample of Korean older adults. Osong Public Health Res Perspect 2016;7:108-15.
30. Choi YJ, Kim HC, Kim HM, Park SW, Kim J, Kim DJ. Prevalence and management of diabetes in Korean adults: Korea National Health and Nutrition Examination Surveys 1998-2005. Diabetes Care 2009;32:2016-20.

Supplementary Table 1. Demographic and clinical characteristics of 10,595 subjects aged 30 years or older

Variable	Value
Male sex	4,574 (43.2)
Age, yr	54.1±14.5
BMI, kg/m^2	23.9±3.3
Systolic BP, mm Hg	119.2±17.1
Diastolic BP, mm Hg	75.0±10.6
FPG, mg/dL	101.2±23.4
HbA1c, %	5.9±0.8
TC, mg/dL	190.3±35.4
HDL-C, mg/dL	50.6±11.9
Triglyceride, mg/dL	141.0±109.5
LDL-C, mg/dL	115.8±34.3

Values are presented as number (%) or mean±standard deviation.
BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; HbA1c, glycosylated hemoglobin; TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol.