Prevalence and Management of Diabetes in Korean Adults

Korea National Health and Nutrition Examination Surveys 1998–2005

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OBJECTIVE — This research investigated recent changes in the prevalence and management status of diabetes among Korean adults.

RESEARCH DESIGN AND METHODS — The Korea National Health and Nutrition Examination Survey (KNHANES), a nationwide survey examining the general health and nutrition status of the Korean people, was conducted in 1998, 2001, and 2005. Using the first (1998; $n = 5,645$), second (2001; $n = 4,154$), and third (2005; $n = 4,628$) KNHANES datasets, in the present study, we estimated the prevalence of diabetes among Korean adults (aged ≥30 years), the proportions of known cases of diabetes, and the proportions of well-controlled cases of diabetes, as defined by either the American Diabetes Association (A1C <7%) or the International Diabetes Federation guidelines (A1C <6.5%).

RESULTS — In 2005, the prevalence of diabetes was estimated to be 9.1% (~2.58 million people: 10.2% of men and 7.9% of women), including 6.2% with known diabetes and 2.9% with newly diagnosed diabetes. The prevalence of impaired fasting glucose was 17.4% (~4.94 million people). The proportion of known cases of diabetes drastically increased from 23.2% in 1998 to 41.2% in 2001 and 68.0% in 2005 ($P < 0.0001$). Among known diabetic patients in 2005, 43.5 and 22.9% had A1C levels <7.0 and <6.5%, respectively.

CONCLUSIONS — The overall prevalence of diabetes in Korea has not changed significantly between 1998 and 2005. Physician diagnosis and treatment rates of diabetes have significantly improved during this period, but glycemic control was still poorer than that in other developed countries.

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Diabetes has emerged as an important social issue worldwide, particularly in some Asian countries (1–4). The increased prevalence is probably attributable to rapid economic development, improved living standards, an aging population, and a Westernized lifestyle (3,4). In Korea, diabetes and its complications have become a major cause of morbidity and mortality. For example, the mortality rate due to diabetes has doubled during the last decade, increasing from 17.2 per 100,000 persons in 1995 to 24.5 per 100,000 persons in 2005 (5). The prevalence of diabetes also increased rapidly in Korea. Estimated at <1% in 1970 (6) and ~7.2% in the early 1990s (7), the prevalence rose to 7.6% of the adult population according to an analysis of the 2001 Korea National Health and Nutrition Examination Survey (KNHANES) (8). Considering the impact of suboptimal diabetes control on public health, the management status of diabetes is as relevant as its prevalence. Rapid economic growth over the past 3 decades has brought many changes in Korea, such as better education, frequent oversea travels and international exchange, and the world's fastest Internet connections, enabling easy access to information nationwide and worldwide (9). These changes made Koreans more interested in a healthy life and forced the government to pay more attention to the issues of health and social welfare. The increasing attention to health and welfare is expected to improve management and control of diabetes in Korea. However, recent changes in the management status of diabetes have not been adequately studied at the national level. Thus, we investigated recent changes in the prevalence, diagnosis, treatment, and control rates of diabetes among Korean adults based on the 1998, 2001, and 2005 KNHANES data.

RESEARCH DESIGN AND METHODS

— The Ministry of Health and Welfare of Korea conducted a series of three KNHANES in 1998, 2001, and 2005 to examine the general health and nutrition status of Koreans (8). The KNHANES consists of four different surveys: a health interview survey, a health behavior survey, a health examination survey, and a nutrition survey. In the third (2005) KNHANES, 10,816 individuals aged ≥1 year (including 6,657 aged ≥30 years) were sampled as subjects of the health examination survey. Among them, 7,597 individuals (including 4,818 aged ≥30 years) participated in the examination: the response rate was 70.2% for age ≥1 year and 72.4% for age ≥30 years. In the present study, we analyzed 4,628 subjects aged ≥30 years (1,977 men and 2,651 women), after exclusion of 190 people without appropriate fasting blood tests. In addition, 4,154 subjects (75.9%; 1,802 men and 2,352 women) from the 2001

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KNHANES and 5,645 subjects (87.3%; 2,525 men and 3,120 women) from the 1998 KNHANES were analyzed for comparison between the survey years.

The subjects were instructed to finish meals before 7:00 P.M. on the day before blood sampling and to drink only bottled water after 7:00 P.M. The next morning, blood (2 ml) was collected into a NaF container. On the same day, the samples were properly processed, immediately refrigerated, and transported in cold storage to the Central Testing Institute in Seoul, Korea. Plasma glucose was measured with the hexokinase method (ADVIA 1650 system, Bayer HealthCare, Tarrytown, NY) in 2005. For subjects with a history of diabetes or whose fasting plasma glucose (FPG) met the criteria for diabetes in the examination, A1C was measured using a Variant II high-performance liquid chromatography assay (Bio-Rad, Carlsbad, CA). Conversely blood was taken into a plain tube, and serum glucose was measured with the glucose oxidase/peroxidase method (Hitachi 747 autoanalyzer; Hitachi, Tokyo, Japan) in 1998 and 2001.

In 2005, the subjects were asked to confirm fasting for 8 h. Those who had not fasted for 8 h were scheduled to return for another examination. If no time was available, the food that had been eaten was recorded and the study continued; however, data from these subjects were not included in the analysis. However, in 1998 and 2001, no subjects were excluded before sampling because they were asked about fasting after the sampling. As a result, participants who had fasted for <8 h comprised 9.9, 21.8, and 2.5% of the total sample in the 1998, 2001, and 2005 surveys, respectively.

The diagnostic criteria for diabetes were obtained from the 1997 and 2003 revisions of the American Diabetes Association guidelines (10,11). Diabetes was diagnosed in subjects with an FPG >126 mg/dl; impaired fasting glucose (IFG) was defined by FPG between 100 and 125 mg/dl. Those who were identified in the health interview survey as having had a previous diagnosis of diabetes by a health care professional were classified as "known cases of diabetes." Those who were first diagnosed with diabetes in this study were classified as "newly diagnosed cases of diabetes." The number of people with diabetes was the sum of those with known cases of diabetes and those with newly diagnosed cases of diabetes. The proportion with adequate glucose control was defined as the number of patients with an A1C of <6.5 or <7.0% among those with known cases of diabetes. A1C <7.0% is the standard adopted by the American Diabetes Association (12), whereas A1C <6.5% is suggested by the International Diabetes Federation (13).

All sampling and weight variables were stratified, and the SAS survey procedure was used for the statistical analysis. For prevalence calculations, we used the stratification variables and sampling weights designated by the Korean Centers for Disease Control and Prevention, which were based on the sample design of each survey year. The sampling weights were adjusted for nonresponse according to demographic factors after surveys were completed. The SAS SurveyFreq procedure was performed with cluster as a sampling-district variable, and prevalence was reported with 95% CI. The numbers of cases of diabetes and IFG were calculated by applying the sex- and age-specific prevalence to the 2005 Korean population estimate for each sex and age stratum. The total number of adults aged ≥30 years was considered to be 28,283,845 (13,853,415 men and 14,430,430 women) in 2005. The SAS SurveyReg procedure was used to compare differences between sexes and survey years. For the purpose of comparison, prevalence, diagnosis, and treatment rates in 1998 and 2001 were also adjusted to the age structure of the 2005 Korean population. The reported P values were two-tailed, and $P < 0.05$ was considered to be significant.

RESULTS — In 2005, the prevalence of diabetes in adults aged ≥30 years was 9.1% in the population (estimated to be 2.58 million people), including 10.2% of men and 7.9% of women (Table 1). The prevalence of individuals with known cases of diabetes was 6.2% and that of individuals with newly diagnosed diabetes was 2.9%. In 2005, the prevalence of IFG was 17.4% (estimated to be 4.94 million people) of adults aged ≥30 years. Diabetes and IFG increased dramatically with age. Among patients aged ≥60 years, the prevalence of diabetes was estimated to be ~20%, and the prevalence of IFG was about 26%. Diabetes and IFG were more frequent in men than in women.

The age-standardized prevalence of diabetes among those aged ≥30 years decreased from 11.1% in 1998 to 8.9% in 2001 and then increased slightly to 9.1% in 2005 (Table 2). In men, the prevalence decreased from 12.5% in 1998 to 9.8% in 2001 and increased slightly to 10.2% in 2005, whereas in women, it decreased consistently from 9.8% in 1998 to 8.2% in 2001 and then to 7.9% in 2005. The proportion of total cases that are known was as low as 23.2% in 1998, rose to 41.2% in 2001, and increased significantly to 68.0% in 2005. When an A1C level of <7.0% was used as a criterion, adequate glucose control was achieved in 43.5% of those with known cases of diabetes in 2005, whereas only 22.9% achieved adequate glucose control based on an A1C level of <6.5%.

CONCLUSIONS — A number of epidemiological studies have investigated the prevalence of diabetes in Korea; however, no studies have assessed diabetes management among Koreans at a national level. In this regard, the present study may be a significant contribution. The 2005 KNHANES provides comprehensive insights into the management status of diabetes in Korea. In our analysis, the age-standardized (aged ≥30 years) prevalence was 9.1% (10.2% in men and 7.9% in women). From these results, Korea is estimated to rank 14th among the 30 Organization for Economic Cooperation and Development countries in terms of diabetes prevalence and 9th in terms of the number of cases (13). However, the prevalence of diabetes among Koreans aged ≥30 years did not change significantly during this period (11.1% in 1998, 8.9% in 2001, and 9.1% in 2005). Based on this trend, it may be concluded that the prevalence of diabetes in Korea has remained relatively stable over the past 7 years.

Other developing countries in Asia that have achieved rapid economic growth have witnessed a huge increase in the prevalence of diabetes. For example, the prevalence of diabetes in China has increased 119% since 1994 (14), and the prevalence of diabetes in some urban areas of India has grown from 13.9% in 2001 to 18.6% in 2006 (15). The pattern of recent changes in the prevalence of diabetes in Korea is slightly different from that in other developing countries in Asia, and Korea is assumed to be intermediate between developed countries and developing countries in terms of the prevalence of diabetes.

Our results showed that 68.0% of diabetic patients aged ≥30 years were known cases of diabetes in 2005, a 1.7-fold increase from 1998. This proportion was higher than the 33.3% found in a

Table 1—*Prevalence of diabetes and IFG among Korean adults aged ≥30 years in 2005*

	Total		Men		Women	
Age	*n**	% (95% CI)	*n**	% (95% CI)	*n**	% (95% CI)
Diabetes (years)†						
30–39	119,899	1.4 (0.6–2.2)	69,946	1.6 (0.4–2.9)	49,953	1.2 (0.2–2.1)
40–49	610,673	7.4 (5.7–9.2)	397,209	9.5 (6.8–12.3)	213,464	5.3 (3.0–7.5)
50–59	716,872	14.0 (11.4–16.5)	488,435	19.0 (15.3–22.8)	228,437	8.9 (5.9–11.9)
60–69	654,298	18.1 (15.3–21.0)	295,820	17.7 (13.7–21.7)	358,478	18.5 (14.1–22.8)
70+	479,974	17.9 (13.7–22.1)	163,954	16.8 (11.6–22.0)	316,020	18.5 (13.2–23.8)
30+	2,581,716	9.1 (8.1–10.1)	1,415,364	10.2 (8.8–11.7)	1,166,352	7.9 (6.7–9.2)
Known diabetes (years)‡						
30–39	30,184	0.4 (0.0–0.8)	21,858	0.5 (0.0–1.2)	8,326	0.2 (0.0–0.6)
40–49	290,071	3.5 (2.5–4.6)	221,601	5.3 (3.5–7.2)	68,470	1.7 (0.7–2.6)
50–59	518,996	10.1 (7.9–12.2)	334,193	13.0 (9.7–16.3)	184,803	7.2 (4.3–10.0)
60–69	528,782	14.6 (12.0–17.2)	232,311	13.9 (10.2–17.5)	296,471	15.3 (11.3–19.2)
70+	391,398	14.6 (10.9–18.3)	131,749	13.5 (8.7–18.2)	259,649	15.2 (10.5–20.0)
30+	1,759,431	6.2 (5.4–7.0)	941,712	6.8 (5.6–7.9)	817,719	5.6 (4.6–6.5)
Newly diagnosed diabetes (years)§						
30–39	85,553	1.0 (0.3–1.7)	48,088	1.1 (0.0–2.2)	37,465	0.9 (0.0–1.8)
40–49	320,602	3.9 (2.6–5.2)	175,608	4.2 (2.4–6.0)	144,994	3.6 (1.5–5.7)
50–59	200,447	3.9 (2.4–5.4)	156,813	6.1 (3.3–8.9)	43,634	1.7 (0.5–2.9)
60–69	127,188	3.5 (2.1–5.0)	65,181	3.9 (1.7–6.1)	62,007	3.2 (1.3–5.1)
70+	88,576	3.3 (1.5–5.0)	32,205	3.3 (1.7–5.0)	56,371	3.3 (1.0–5.5)
30+	822,366	2.9 (2.3–3.5)	477,895	3.5 (2.5–4.4)	344,471	2.4 (1.6–3.2)
IFG (years)‖						
30–39	786,851	9.3 (7.6–10.9)	524,596	12.0 (9.2–14.8)	262,255	6.3 (4.4–8.2)
40–49	1,368,299	16.7 (14.2–19.1)	957,482	22.9 (18.9–26.8)	410,817	10.2 (7.9–12.5)
50–59	1,122,689	21.8 (18.5–25.2)	665,814	25.9 (20.9–30.8)	456,875	17.8 (13.3–22.3)
60–69	951,160	26.3 (22.8–29.9)	536,488	32.1 (26.3–37.9)	414,672	21.4 (17.1–25.7)
70+	711,781	26.5 (21.8–31.3)	269,353	27.6 (19.1–36.1)	442,428	25.9 (20.7–31.1)
30+	4,940,780	17.4 (16.1–18.7)	2,953,733	21.3 (19.2–23.5)	1,987,047	13.7 (12.2–15.1)

*The number of cases of prevalent diabetes and IFG is a 2005 population estimate. †Patients with known and newly diagnosed diabetes. ‡Patients with diabetes previously diagnosed by a doctor. §Total number of diabetic patients excluding those with known diabetes. ‖IFG is defined as FPG between 100 and 125 mg/dl.

2004 survey in China (14), the 46.7% from a 2004 survey in Thailand (16), and the 54% from a 2000 survey in Seychelles (17), but it was comparable to the 71% shown in 2005 data from the U.S. (18). Thus, the proportion of known cases of diabetes in Korea appears to be increasing to a level matching that in developed countries. The mean A1C level in our diabetic population was 7.4%, which was slightly higher than the 7.2% reported for the U.S. (NHANES III, 2003–2004) (19). When adequate glucose control was defined as an A1C level of <7.0%, the adequate control rate was 43.5%, which was lower than the 56.8% shown in the U.S. survey (19). When the more stringent criterion of the International Diabetes Federation was used (A1C <6.5%), the adequate control rate was only 22.9%, which was lower than the 31% indicated in the European Cost of Diabetes in Europe–Type II (CODE-2) study (20). Furthermore, we found that two-thirds of those with diabetes were not receiving education about diabetes and diabetes-related complications (data not shown). Therefore, although the proportion of known cases of diabetes in Korea has reached the level seen in developed countries, control of diabetes falls short of that in developed countries.

Over the years, several methodological changes, including the blood collection method and techniques for glucose measurements, have been instituted in the KNHANES. In 2005, blood was collected in NaF-containing tubes, which are known to inhibit ex vivo glycolysis (21). In contrast with 2005, plain tubes were used in 1998 and 2001. However, samples were drawn and immediately stored on ice water in the KNHANES. Although it is known that NaF-containing tubes inhibit glycolysis after sampling (21), it was also reported that the decrease in glucose concentration was similar in tubes both with or without NaF if they are stored at 4°C (22). This observation indicates that temperature is the most important stabilizing factor (22). It is unlikely that collecting samples in different tubes (plain tube and NaF-containing tube) might significantly affect the prevalence estimation. For glucose measurements, the hexokinase method was used in 2005 and the oxidase/peroxidase method was used in 1998 and 2001, which may have overestimated the glucose level, although reported differences between the two methods are minimal (23,24). A methodological difference cannot explain the decrease in the prevalence of diabetes between 1998 and 2001. There still remains a possibility that nonfasting blood samples were mistakenly regarded as fasting samples in the 1998 survey, because the 9.9% identified as nonfasting subjects in 1998 was considerably lower than the 21.8% in 2001.

The KNHANES sampling procedure was designed to produce a nationally rep-

Table 2—*Changes in prevalence and management of diabetes among adults aged ≥30 years*

	1998 KNHANES	2001 KNHANES	2005 KNHANES	*P* for difference 1998 vs. 2001	*P* for difference 2001 vs. 2005
Prevalence					
Men	12.5 (10.9–14.0)	9.8 (8.2–11.4)	10.2 (8.8–11.7)	0.007	0.021
Women	9.8 (8.5–11.1)	8.2 (7.0–9.4)	7.9 (6.7–9.2)	0.028	0.787
Total	11.1 (10.0–12.2)	8.9 (7.8–9.9)	9.1 (8.1–10.1)	0.0005	0.157
Physician diagnosis					
Men	18.6 (14.0–23.2)	39.3 (32.3–46.4)	66.4 (59.3–73.5)	<0.0001	<0.0001
Women	28.4 (22.5–34.3)	42.7 (34.9–50.6)	70.0 (61.9–78.1)	0.001	<0.0001
Total	23.2 (19.2–27.2)	41.2 (36.0–46.3)	68.0 (62.8–73.2)	<0.0001	<0.0001
Treatment					
Men	19.5 (14.8–24.1)	31.8 (23.3–40.2)	44.4 (37.1–51.8)	0.057	<0.0001
Women	35.2 (28.9–41.6)	38.4 (30.3–46.5)	54.2 (45.7–62.6)	0.433	<0.0001
Total	26.8 (22.6–31.0)	35.4 (30.3–40.5)	48.8 (42.9–54.7)	0.053	<0.0001
Control, A1C <7.0%*					
Men			49.3 (41.0–57.5)		
Women			36.7 (28.6–44.8)		
Total			43.5 (37.8–49.2)		
Control, A1C <6.5%*					
Men			26.0 (18.8–33.3)		
Women			19.4 (13.3–25.4)		
Total			22.9 (18.1–27.8)		

Data are % (95% CI). *Control rate was not compared between years because of differences in the test methods.

resentative sample, and the sampling weights were further adjusted for nonresponse according to demographic factors. However, selective nonresponse still may have had effects on prevalence estimates. The response rate of health examination in the 2005 KNHANES (72.4% for age ≥30 years) was slightly higher than that of the U.S. NHANES 2005–2006 (69.4% for age ≥30 years). To indirectly assess the effects of nonresponse bias, we compared several characteristics obtained from the health interview survey between participants and nonparticipants in the health examination. Participants were older (male only), more likely to have hypertension (male only) and hypercholesterolemia (male and female), less educated (male only), and less likely to be smokers (male and female) than nonparticipants. Monthly income, history of diabetes, and hospital admission for the last year were not significantly different between nonparticipants and participants. After age adjustment, only smoking and history of hypercholesterolemia were different between nonparticipants and participants. Even though the difference was not statistically significant, more participants reported a history of diabetes than did nonparticipants: 8.5 vs. 7.4% in men ($P = 0.303$) and 6.2 vs. 5.3% in women ($P = 0.343$). Thus, we could not rule out the possibility that nonresponse bias leads to overestimation of diabetes or IFG.

To summarize, the prevalence of diabetes in Korea has not changed significantly since 1998, but there has been a substantial increase in the proportion of known cases of diabetes. Nevertheless, the proportion of patients receiving drug treatment and with adequate glucose control has yet to reach the level seen in developed countries. More intense efforts for the prevention and treatment of diabetes will lead to further improvement in the management of diabetes.

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