Increasing achievement of the target goals for glycemic, blood pressure and lipid control for adults with diagnosed diabetes in Korea

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ABSTRACT

Aims/Introduction: We investigated the prevalence, treatment and control of diagnosed diabetes in Korean adults from 1998 to 2010.

Materials and Methods: The Korean Ministry of Health and Welfare carried out the Korean National Health and Nutrition Examination Survey (KNHANES) in the years 1998 (I), 2001 (II), 2005 (III), 2007–2009 (IV) and 2010 (V). We estimated the prevalence of diagnosed diabetes in Korean adults and the proportions of well-controlled diabetes, as defined by having glycosylated hemoglobin <7.0%, blood pressure <130/80 mmHg and low density lipoprotein (LDL) cholesterol <100 mg/dL according to the American Diabetes Association.

Results: The prevalence of diagnosed diabetes increased significantly from 3.2% in 1998 to 6.4% in 2010 ($P < 0.0001$). The prevalence of adults with diagnosed diabetes achieving blood pressure and LDL cholesterol target levels increased from 23.8% to 54.2% ($P < 0.0001$), and 25.7% to 47.7% ($P<0.0001$), respectively. However, the percentage of patients achieving glycemic goals did not increase significantly from 42.5% to 49.1% ($P = 0.3034$). Furthermore, there were significant increases in the proportions of individuals achieving all three target levels, from 2.7% in 2005 to 8.7% in 2010 ($P < 0.0001$).

Conclusions: The prevalence of diagnosed diabetes in Korea increased significantly from 1998 to 2010. The percentages of those achieving all recommendations of the American Diabetes Association have increased, but are still not satisfactory.

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KEY WORDS: Diabetes mellitus, Glycosylated hemoglobin A, Prevalence

INTRODUCTION

Diabetes is one of the most challenging health problems in the world, and the social cost of diagnosing and treating the disease has been rapidly rising[1–3]. In particular, morbidity and mortality among Asians as a result of diabetes-related health problems and complications have been increasing significantly[4,5]. Chronic complications related to diabetes include macrovascular (coronary artery disease, cerebrovascular disease, peripheral artery disease) and microvascular complications (retinopathy, nephropathy, neuropathy)[6]. The degree of prevention or control of complications directly affects patients' mortality[7]. Therefore, it is crucial to control the risk factors of diabetes. Thus, the American Diabetes Association (ADA) releases updated clinical practice recommendations annually, including those related to the management of the risk factors of diabetes[8]. As a result, a significant number of physicians manage diabetes according to the ADA clinical practice recommendations[9–11].

Similar to the National Health and Nutrition Examination Survey (NHANES) in the USA, the Korean National Health and Nutrition Examination Survey (KNHANES) is a large health and nutritional survey carried out on Koreans nationwide[12]. This survey is very useful for monitoring the health status of the population in clinical practice. Previous analysis of KNHANES data has shown that the prevalence of diagnosed diabetes did not change significantly over the period studied (11.1% in 1998, 8.9% in 2001 and 9.1% in 2005). In 2005, just 43.5% and 22.9% of Korean people with diagnosed diabetes achieved the control targets of <7.0% (ADA recommended) and 6.5% (Korea Diabetes Association recommended), respectively, in their glycosylated hemoglobin level (HbA_{1c})[10]. Furthermore, no data were reported in relation to managing hypertension (<130/80 mmHg) and low-density lipoprotein

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(LDL) cholesterol (<100 mg/dL) levels in Korean adults with diagnosed diabetes.

We investigated the prevalence, treatment and control of diagnosed diabetes in Korean adults using data from the Korean National Health and Nutrition Examination Survey (KNHANES) 1998–2010.

METHODS

Participants and Data Collection

The Korean Ministry of Health and Welfare carried out the KNHANES in the years 1998 (KNHANES I), 2001 (II), 2005 (III), 2007–2009 (IV) and 2010 (V). Details of the surveys carried out in KNHANES I–IV have been described previously[12–14]. KNHANES V was carried out from January to December 2010. The survey used a stratified multistage probability sampling design for the South Korean population and a two-stage stratified systematic sampling method. Clusters of households were selected from each district, each including an average of 20–23 households. KNHANES V consisted of four different measures: a health interview, a health behavior survey, a health examination and a nutrition survey; it was a nationwide representative study for non-institutionalized civilians using a stratified, multistage probability sampling design with a rolling survey sampling model. In KNHANES V, 10,938 individuals aged >1 year were sampled by health interview and examination in 2010; these individuals represented 3,840 households in 192 districts. A total of 10,938 individuals were sampled, and 8,473 participated in the survey, for a response rate of 77.5%[15]. Sampling units were defined based on the data on household units from the 2005 National Census Registry, including geographic area, sex and age.

In the present study, we included all males and non-pregnant women aged 20 years and older with valid data on diabetes history and body mass index (BMI) measurement (n = 32,134,362, 33,888,464, 35,776,589, 36,940,245 and 36,956,060 in KNHANES I–V, respectively). The presence of diabetes was based on a self-reported questionnaire where the respondents answered "yes" to the interview question: "Other than during pregnancy, have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Undiagnosed patients who reported having diabetes on the health examination survey were not included in the present study, because we were assessing the prevalence, treatment and control of *diagnosed* diabetes in Korean adults. Participants with diagnosed diabetes who did not take any medication (insulin or an oral antidiabetic drug) were assumed to have diet therapy and lifestyle advice only.

BMI was calculated as weight (in kilograms) divided by the square of the height (in meters). We divided the groups by World Health Organization Western Pacific obesity categories (under or normal weight, overweight, obesity I, obesity II)[16]. Hypertension was defined as blood pressure >130/80 mmHg or self-reported use of antihypertensive drug medications. Hypercholesterolemia was defined as total serum cholesterol >240 mg/dL or self-reported use of drug medications for hypercholesterolemia[17].

Study Methods

Anthropometry

Anthropometric measurements were carried out by well-trained examiners in the same manner in the five studies. Height was measured to the nearest 0.1 cm using a portable stadiometer (Seriter, Bismarck, ND, USA). Weight was measured to the nearest 0.1 kg using a calibrated balance-beam scale (Giant-150N; Hana, Seoul, Korea). Waist circumference measurements were taken at the end of normal expiration to the nearest 0.1 cm, measuring from the narrowest point between the lower borders of the rib cage and the iliac crest.

Measurement of Metabolic Risk Factors

For each study, participants were asked to refrain from smoking or consuming caffeine before the measurement. After a 12-h overnight fast, venous blood samples were drawn. Samples were immediately sent to a central, certified laboratory and plasma was separated immediately by centrifugation. The fasting plasma concentrations of glucose and lipids were measured enzymatically in a central laboratory; a 747-chemistry analyzer (Hitachi, Tokyo, Japan) was used in the 1998 and 2001 studies, an Advia 1650/2400 (Siemens, New York, NY, USA) was used in the 2005 and 2007–2009 studies, and aHitachi automatic analyzer 7600 (Hitachi) was used in the 2010 study. HbA_{1c} was measured using high-performance liquid chromatography. To confirm and compare accuracy and consistency in each survey, commutable frozen serum samples were taken from normal participants and patients with dyslipidemia according to the Clinical and Laboratory Standards Institute guidelines. The conversion rate for KNHANES 2007 was obtained by the Passing and Bablok regression method. Conversion rates for other surveys were obtained by a similar method[18].

Blood pressure was measured three times on the right arm while the individual was in a seated position after at least 5 min of rest using a mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY, USA). The final blood pressure value was obtained by averaging the values of the second and third blood pressure measurements.

Definitions of Treatment Goals

For glycemic and blood pressure target levels, participants with diabetes should have HbA_{1c} <7.0%, blood pressure <130/80 mmHg and LDL cholesterol <100 mg/dL according to the ADA standards of medical care[8]. The HbA_{1c} data from KNHANES III (2005) were used because the data in KNHANES I and II were not sufficient for analysis.

Statistical Analysis

All data were presented as estimates (standard error), where estimates were means for continuous variables and prevalence for categorical variables. To compare the differences of means or prevalence among KNHANES I–V (1998, 2001, 2005, 2007–2009 and 2010), analysis of variance (ANOVA) models and chi square-tests were carried out using survey data analysis of

STATA (version 12.0; StataCorp, College Station, TX, USA). To adjust for oversampling and non-response bias, sampling weights were used in all analyses. KNHANES consists of four different measures: a health interview, a health behavior survey, a health examination and a nutrition survey. For the present study, data from the health interview and health examination were analyzed following the recommendation on the use of sampling weights by the Korean Ministry of Health and Welfare. In particular, sampling weights were adjusted for pooling KNHANES IV-1 (2007), KNHANES IV-2 (2008) and KNHANES IV-3 (2009). *P*-values <0.05 were considered statistically significant.

RESULTS

The prevalence of diagnosed diabetes increased significantly from 3.2% in 1998 to 6.4% in 2010 ($P < 0.001$). The average of prevalence of diagnosed diabetes in the period 1998–2010 was 5.4%. The prevalence of diagnosed diabetes increased in both men and women in all age groups from 1998 to 2010. As age and BMI increased, the prevalence of diagnosed diabetes increased significantly from 1998 to 2010. The prevalence of diagnosed diabetes increased in the BMI <23.0 group. The increase here exceeds any other BMI group and, in fact, the only group that achieves statistical significance ($P < 0.001$; Table 1). The characteristics of diagnosed diabetes in the five different KNHANES phases are shown in Table 2. In all age groups, the prevalence of diabetes increased from the 1998 KNHANES to 2010 KNHANES. Based on data about diabetes distribution according to sex, men had a higher prevalence of diabetes as KNHANES years progressed, whereas in women this prevalence was lower.

There was a significant increase in antidiabetic treatment over the period studied. Oral antidiabetic medications increased significantly (70.8%, 75.7% and 80.7% in 2005, 2007–2009 and 2010, respectively). Otherwise, the average glycosylated hemoglobin level did not change from the 1998 KNHANES to 2010 KNHANES. The prevalence of hypertension in diagnosed diabetes increased (23.8%, 36.1%, 49.2%, 51.2% and 54.2% in 1998, 2001, 2005, 2007–2009 and 2010, respectively, $P < 0.001$). The proportion of individuals receiving antihypertensive medications among those with diabetes increased significantly ($P = 0.017$). The systolic blood pressure and diastolic blood pressure decreased significantly from 135.9 ± 1.1 and 80.5 ± 0.7 mmHg to 123.9 ± 1.0 and 73.6 ± 0.6 mmHg over 12 years. In the lipid profile, total cholesterol and LDL cholesterol were decreased, but high-density lipoprotein (HDL) cholesterol and triglyceride did not change significantly. There was a significant decrease in LDL cholesterol, with a significant change in drug medication use among those with hypercholesterolemia (6.8%, 12.4% and 22.9% in 2005, 2007–2009 and 2010, respectively, $P < 0.001$; Table 3).

The percentages of people achieving glycemic control target levels among those with diagnosed diabetes were 42.5%, 47.9% and 49.1% in the 2005, 2007–2009 and 2010 KNHANES, respectively. There was a significant increase in glycemic control ($P < 0.001$). Furthermore, the percentages of people achieving blood pressure control target levels among those with diagnosed diabetes were 23.8%, 36.1%, 49.2%, 51.2% and 54.2% in KNHANES I-V-1 ($P < 0.001$). In cholesterol management, the proportions below 100 mg/dL of LDL cholesterol were 25.7%, 27.0%, 26.9%, 38.9% and 47.7% in KNHANES I-V-1 ($P < 0.001$). Otherwise, there were significant increases in proportions of those achieving all three target levels (HbA_{1c}<7.0%, blood pressure <130/80 mmHg and LDL cholesterol <100 mg/dL) from 2.7% in 2005 to 8.7% in 2010 ($P < 0.001$; Table 3).

DISCUSSION

This is the first report showing the trends in prevalence and control in adults with diagnosed diabetes in the period from 1998 to 2010 in Korea. The overall prevalence of diagnosed diabetes among Koreans aged over 20 years changed significantly during this period (3.2%, 3.6%, 5.2%, 6.2%,and 6.4% in

Table 1 | Prevalence of diagnosed diabetes in Korea from 1998 to 2010

Population group	I (1998)	II (2001)	III (2005)	IV (2007–09)	V (2010)	*P*-value
Overall	3.22 (3.0–3.5)	3.59 (3.4–3.8)	5.26 (5.0–5.6)	6.18 (5.7–6.6)	6.40 (5.7–7.1)	<0.001
Age (years)						
20–39	0.39 (0.3–0.5)	0.41 (0.3–0.5)	0.77 (0.6–1.0)	0.89 (0.6–1.2)	1.04 (0.5–1.6)	0.038
40–59	4.39 (4.0–4.8)	4.26 (3.9–4.7)	5.94 (5.4–6.4)	6.30 (5.6–7.0)	6.25 (5.2–7.3)	0.001
60+	9.12 (8.3–10.0)	10.07 (9.2–10.9)	15.34 (14.2–16.4)	17.43 (16.2–18.7)	17.50 (15.6–19.4)	<0.001
Sex						
Male	3.38 (3.1–3.7)	3.82 (3.5–4.1)	5.64 (5.2–6.1)	6.38 (5.8–7.0)	6.82 (5.8–7.9)	<0.001
Female	3.08 (2.7–3.4)	3.39 (3.1–3.7)	4.90 (4.5–5.3)	5.97 (5.4–6.5)	5.98 (5.0–7.0)	<0.001
BMI (kg/m^2)						
<23.0	2.32 (1.8–2.8)	2.17 (1.6–2.7)	3.53 (2.8–4.3)	3.72 (3.3–4.2)	4.60 (3.8–5.4)	<0.001
23–25	4.94 (3.8–6.0)	4.30 (3.1–5.5)	6.53 (5.3–7.8)	6.53 (5.7–7.3)	6.34 (5.0–7.7)	0.18
25–30	4.68 (3.7–5.7)	6.54 (5.4–7.7)	7.76 (6.4–9.1)	9.02 (8.2–9.9)	8.48 (7.0–10.0)	0.15
≥30	7.42 (3.3–115)	8.21 (3.9–12.5)	5.56 (2.3–8.9)	11.15 (8.6–13.7)	12.50 (7.8–17.2)	0.20

BMI, body mass index. Data are expressed as mean (95% confidence interval). *P*-values were derived from chi square-tests.

Table 2 | Characteristics of people with diagnosed diabetes in Korea from 1998 to 2010

Population group	I (1998)	II (2001)	III (2005)	IV (2007–09)	V (2010)	*P*-value
Age (years)	57.7 (56.9–58.6)	59.2 (58.5–59.9)	59.1 (58.4–59.9)	59.8 (59.0–0.7)	60.4 (58.9–62.0)	0.003
20–39 years (%)	5.8 (4.0–7.7)	5.0 (3.6–6.5)	6.6 (5.1–8.2)	6.0 (4.2–7.8)	6.5 (3.3–9.7)	0.68
40–59 years (%)	47.7 (44.1–51.3)	43.9 (40.8–47.1)	42.1 (39.4–44.9)	39.9 (36.5–43.2)	39.2 (33.9–44.6)	
≥60 years	46.5 (42.8–50.2)	51.0 (47.9–54.2)	51.3 (48.4–54.1)	54.1 (50.8–57.4)	54.3 (48.9–59.7)	
Male (%)	49.8 (46.3–53.3)	50.1 (47.1–53.0)	52.9 (50.2–55.6)	51.2 (48.0–54.4)	52.8 (46.7–58.9)	0.69
Female (%)	50.2 (46.7–53.7)	49.9 (47.0–52.9)	47.1 (44.4–49.8)	48.8 (45.6–52.0)	47.2 (41.1–53.3)	
Waist circumferenc (cm)	86.5 (85.4–87.6)	87.8 (86.5–89.1)	86.8 (85.6–87.9)	87.6 (86.9–88.2)	86.7 (85.6–87.8)	0.29
BMI (kg/m^2)	24.3 (23.9–24.7)	25.1 (24.7–25.6)	24.7 (24.3–25.1)	25.0 (24.8–25.2)	24.7 (24.4–25.1)	0.026
HbA_{1c} (%)			7.7 (7.4–7.9)	7.4 (7.3–7.5)	7.4 (7.2–7.6)	0.14
SBP (mmHg)	135.9 (133.7–138.1)	135.6 (132.6–138.5)	129.1 (126.8–131.3)	125.4 (124.2–126.7)	123.9 (121.9–125.8)	<0.001
DBP (mmHg)	80.5 (79.2–81.8)	80.9 (79.4–82.3)	78.6 (77.3–79.9)	76.7 (76.0–77.4)	73.6 (72.5–74.7)	<0.001
TC (mg/dL)	201.9 (196.3–207.5)	197.5 (192.9–202.2)	194.4 (189.7–199.1)	189.2 (186.5–192.0)	182.3 (178.7–185.8)	<0.001
TG (mg/dL)	157.7 (149.4–165.9)	180.7 (168.3–193.0)	196.0 (169.6–222.4)	180.4 (169.7–191.1)	169.6 (156.3–182.8)	<0.001
HDL (mg/dL)	45.9 (44.5–47.4)	42.1 (40.6–43.6)	41.2 (39.9–42.4)	43.4 (42.8–44.0)	44.6 (43.1–46.0)	<0.001
LDL (mg/dL)	124.6 (119.2–129.9)	119.7 (115.4–124.0)	118.2 (114.0–122.4)	112.1 (109.8–114.4)	105.1 (101.7–108.5)	<0.001

BMI, body mass index; DBP, diastolic blood pressure; HbA_{1c}, glycosylated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SBP, systolic blood pressure; TC, total cholesterol; TG, triacylglycerol. Data are expressed as mean (95% confidence interval). *P*-values were derived from ANOVA models and chi square-tests for continuous and categorical variables, respectively.

1998, 2001, 2005, 2007–2009 and 2010, respectively). Based on this trend, it might be concluded that the prevalence of diagnosed diabetes in Korea has increased over the past 12 years. Choi *et al.*[10] reported that the prevalence of diagnosed diabetes in Korea increased 1.7-fold from 1998 to 2005 among those aged over 30 years.

The significant increase in diagnosed diabetes might be explained by a better detection rate and better health education, as well as an improved national healthcare system. Partly, this results from the bi-annual fasting blood glucose testing carried out by the National Health Insurance in Korea for the country's nationals.

In 2005, 42.5% of the individuals with diagnosed diabetes were able to achieve the recommended glycemic target levels, but 49.1% of diagnosed diabetes patients had achieved glycemic control in 2010. This represents only approximately half of individuals with diagnosed diabetes, but it is encouraging that there was significant improvement in glycemic control from 2005 through 2010, which showed results that were similar to or a little lower than those of the USA survey[11,19]. The control rate among Koreans was found to be lower than that of white Americans (59.5%), whereas the rate was higher when compared with the rate of Mexican Americans (39.6%)[11].

Just 27.4% of diabetic adults met the recommendations for blood pressure control in 1998. However, 47.9% of the individuals with diagnosed diabetes had achieved the recommended blood pressure target levels in 2010; this is a significant increase over a 12-year period; and this achievement of blood pressure goal was similar to those of the USA survey from 29.0% (NHANES 1988–1994) to 50.4% (NHANES 2003–2004)[20].

The number of diabetic patients diagnosed with hypertension more than doubled, from 21.2% to 54.2%, over the period; however, the control rate for hypertension increased significantly. This might be due to increased evaluation and treatment for diabetic patients with hypertension. Increased uptake of medications for hypertension by people with diabetes likely contributed to the improvements in this risk factor.

In 1998–2010, the prevalence of hypercholesterolemia increased significantly among people with diagnosed diabetes. There were significant increases in the proportions of individuals taking medications for hypercholesterolemia among people with diagnosed diabetes. As a result, total cholesterol and LDL cholesterol decreased significantly among those with diagnosed diabetes.

Although 25.7% of the individuals with diagnosed diabetes were able to achieve the recommended LDL cholesterol target levels in 1998, 47.7% of those with diagnosed diabetes had a level of LDL cholesterol that was below 100 mg/dL in 2010. These results are in accordance with the data from 2005 to 2010, which show an increasing trend for hypercholesterolemia treatment (6.9% and 23.5% in 2005 and 2010, respectively, $P < 0.001$).

The incidence and prevalence of type 2 diabetes increased in the obese population[21]. However, in KNHANES from 1998 to 2010, the prevalence of diabetes increased significantly in the BMI <23.0 group. In the obese population, insulin sensitivity declined due to increased tumor necrosis factor-α, resistin and retinol binding protein 4, and mitochondrial dysfunction. Insulin resistance also increased. However, diabetes patients in East Asia have lower BMI compared with Caucasians[21].

Analysis of data from two studies shows a prominent difference in the average BMI of type 2 diabetes (white individuals from the UK Prospective Diabetes Study and Japanese patients from the Japan Diabetes Complication Study)[22,23]. The cause of

Table 3 | Percentage of people achieving glycemic, blood pressure and low-density lipoprotein cholesterol target levels among those with diagnosed diabetes in Korea from 1998 to 2010

Population group	I (1998)	II (2001)	III (2005)	IV (2007–9)	V (2010)	*P*-value
n			1,255,824	1,962,105	2,039,591	
HbA_{1c} <6.5%			22.2 (16.4–28.0)	26.7 (23.7,29.7)	31.1 (25.4,36.8)	0.0996
HbA_{1c} <7%			42.5 (35.8–49.2)	47.9 (44.4–51.4)	49.1 (43.2–55.0)	0.3034
Type of antidiabetes treatment						
Oral hypoglycemic agents (%)			70.8 (68.1–73.4)	75.7 (72.8–78.6)	80.7 (76.0–85.4)	0.003
Insulin injections (%)			8.1 (6.5–9.6)	7.8 (6.10–9.5)	8.7 (5.7–11.7)	0.77
n	1,026,490	1,114,705	1,616,881	2,050,728	1,972,965	
LDL cholesterol <100 mg/dL	25.7 (19.8–31.6)	27.0 (20.7–33.3)	26.9 (21.2–32.6)	38.9 (35.6–42.2)	47.7 (42.2–53.2)	<0.001
Hypercholesterolemia (%)			10.9 (9.2–12.6)	20.3 (17.7–22.9)	33.3 (27.5–39.1)	<0.001
Hypercholesterolemia treatment (%)			6.8 (5.5–8.1)	12.4 (10.4–14.5)	22.9 (17.7–28.1)	<0.001
n	1,025,786	1,157,084	1,779,409	2,249,601	2,347,828	
Blood pressure <130/80 mmHg	25.9 (20.8–31.0)	26.3 (19.6–33.0)	36.1 (30.2–42.0)	47.4 (44.3–50.5)	57.2 (51.9–62.5)	<0.001
Hypertension (%)	23.8 (20.9–26.7)	36.1 (33.0–39.2)	49.2 (46.2–52.1)	51.2 (47.9–54.4)	54.2 (48.6–59.8)	<0.001
Hypertension treatment (%)			42.2 (39.4–45.1)	48.1 (44.9–51.3)	51.7 (45.7–57.7)	0.017
HbA_{1c} <7%, LDL cholesterol <100 mg/dL and blood pressure <130/80 mmHg						
n			1,783,640	2,258,299	2,363,697	
Overall			2.7 (1.1–4.3)	8.7 (6.9–10.5)	8.7 (5.8–11.6)	<0.001

BMI, body mass index; HbA_{1c}, glycosylated hemoglobin. Data are expressed as mean (95% confidence interval). *P*-value was derived from the chi square-test.

this difference is unknown, but it results from the differences in insulin secretion and insulin resistance between Caucasians and Asians[24].

A major limitation of the present study was that interviews rather than medical records were used to detect patients' medical history in KNHANES. However, we analyzed the percentages of adults with diagnosed diabetes achieving glycemic, blood pressure and LDL cholesterol target levels in clinical practice. Thus, we determined the current extent to which Koreans were satisfying the clinical practice. The prevalence of diagnosed diabetes in Korea has increased significantly since 1998. However, the proportions of those achieving all three target levels were just 2.7%, 8.7% and 8.7% in KNHANES III, IV and V, respectively. These levels were lower than in the diabetes data from NHANES 2003–2004 (13.2%)[20]. This means that the percentage of those not achieving all three goals was over 90%. The achievement of ADA clinical practice recommendations continues to be far from optimal in Korea.

Our findings show that outstanding progress has been made in reducing cardiovascular risk factors among patients with diagnosed diabetes. This finding might be from the increased percentages of treatment of hyperglycemia (oral hypoglycemic agents and insulin), hypertension and dyslipidemia. However, more aggressive efforts should be made in regards to diabetes treatments to overcome the diverse complications of this disease.

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