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Utilization of Glucose, Blood Pressure and Lipid Lowering Medications among people with type 2 diabetes in the United States 1999-2010

Short title: Drug utilization of diabetic patients in the US

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Abstract

Background: Changes in relation to drug treatment to various control targets for diabetes were studied using the National Health and Nutrition Examination Survey (NHANES) 1999-2010.

Methods: Data on 3094 participants aged ≥20 with diagnosed type 2 diabetes were analyzed. Use of medications for lowering glucose, blood pressure, and lipids in the past month was assessed by questionnaire. Data from two survey cycles were combined together to produce estimates for each four-year period.

Results: Usage of metformin increased from 34.8% to 53.8% and was the most prevalent medications during this period (P<0.001), and half of subjects taking metformin could achieve HbA_{1c} <7.0% in 2007-2010. Dipeptidyl peptidase-4 (DPP-4) inhibitors, were used by 7.4% of participants in 2007-2010. Usage of angiotensin receptor blockers (ARB) and beta-blockers increased significantly from 7.4% to 21.4% and from 15.3% to 31.8%, respectively from 1999-2010 (P≤0.001). 64.7% of participants could attain blood pressure control by 2007-2010. Usage of statins doubled in 1999-2010 and 52.2% of subjects took statins by 2007-2010 (P<0.001).

Conclusions: Metformin is the first line drug for diabetes while DPP-4 inhibitors started to be used since 2007. Blood pressure control improved in 1999-2010 partly due to increased drug prescriptions. Although statins were widely used about half of the participants did not take them. (209 words)

Key words: diabetes, prescription medications, NHANES

Abbreviations: ACCORD, Action to Control Cardiovascular Risk in Diabetes Study; ACEI, angiotensin-converting enzyme inhibitor; ADA, American Diabetes Association; ARA, aldosterone receptor antagonist; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; DPP-4, dipeptidyl peptidase-4; GLP-1, glucagon-like-peptide-1; $HbA1_c$, glycated haemoglobin; HDL, High density lipoprotein; LDL, Low density lipoprotein; NHANES, National Health and Nutrition Examination Survey

Introduction

Type 2 diabetes affects more than 1 in 10 of the US population according to a recent report (1), and imposes a huge burden on healthcare expenses. Previous findings from the United States National Health and Nutrition Examination Survey (NHANES) showed that the prevalence of diagnosed diabetes increased significantly from 1999 to 2006 (2). Good control of glycemic and blood pressure targets is important in the management of type 2 diabetes. Good control of blood glucose and blood pressure reduces microvascular and macrovascular complications (3-5).

Our previous reports have evaluated the prevalence and therapeutic target achievement in the US adults using data from the NHANES studies (2, 6). A recent study has also shown that about 33-48% of subjects with diabetes did not meet the targets for glycemic, blood pressure or LDL cholesterol control in US NHANES 1999-2010 (7). Better utilization of medications might improve the control of these targets. In US, eleven unique types of drugs have been approved to treat type 2 diabetes, and 9 of them have become available since 1995 (8). New pharmacotherapies have become available, ranging from established agents to new drugs acting on the incretin pathway (9). Therefore it is necessary for clinicians to have a rational approach for the choice of therapy.

Although we previously investigated the achievement of glycemic, blood pressure and low-density lipoprotein (LDL) targets in NHANES 1999-2006 (2), utilization of medications in people with diabetes has not been updated. The present study provides an update on the utilization of prescribed medications for lowering blood glucose, lipids and blood pressure from 1999 to 2010.

Methods

Study design and subjects

NHANES was conducted by the National Center of Health Statistics, Centers for Disease Control and Prevention, with a stratified, multistage probability sampling design (10). Written informed consent was obtained from all participants. In NHANES 1999-2010, there were 30,752 subjects aged ≥20 years who were both interviewed and examined in the mobile examination center. After

excluding all pregnant women and subjects with missing data, 28,774 subjects were included in the analysis. Among them, 3,168 subjects had self-reported diagnosis of diabetes. Subjects who 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?" were categorized as having diagnosed diabetes. In NHANES, diabetes was not classified into type 1 or 2, therefore 74 participants with diabetes diagnosed at age < 30 years and treated with insulin alone were further excluded in the analysis as they were considered as having type 1 diabetes (2, 11). Therefore, a total of 3,094 subjects were included in this analysis.

Type of treatment and prescription medications

The use of prescription medications for lowering blood lipids, glucose, and blood pressure in the past month was assessed by questionnaires. Participants were asked whether they had taken or used any prescription medicine in the past month and showed the interviewer the medication containers and the exact name of all the products. If the container was unavailable, the interviewer asked the participants to verbally report this information. Details on the classification of the prescription medications have been described as previously (12, 13). A participant, who took two or more different classes of medications for the same therapeutic use (lowering either blood lipids, glucose, or blood pressure), either as a single combination pill or several different pills, was defined as receiving polytherapy. Participants with diagnosed diabetes who were not on medication (insulin or an oral anti-diabetic drug) were assumed to have non-pharmacologic therapy (diet and lifestyle changes).

Other variables of interest

Information on race/ethnicity, education, history of cardiovascular diseases, smoking, alcohol consumption, family history of diabetes and age of diabetes diagnosis was obtained from self-reported questionnaires at baseline (2, 10, 12-15). Ever smokers were defined as subjects who

had smoked ≥100 cigarettes in their lives. Regular alcohol drinking was defined as consumption of any type of alcoholic beverage at least once a week in the past year. Details on the laboratory measurement methods of other biochemical variables have been described as previously (2, 6, 11-15). Microalbuminuria was defined as a urinary albumin-to-creatinine ratio ≥30 μg/mg (16). Triglyceride levels were log-transformed before analysis

Treatment goals for diagnosed diabetes

The definitions of different treatment goals for diagnosed diabetes were based on the recent American Diabetes Association (ADA) guidelines (16). Patients with diabetes should be treated with the glycemic, blood pressure, and lipid targets being HbA_{1c} <7.0%, blood pressure <140/80 mmHg, and LDL cholesterol <100 mg/dL. We also examined the secondary lipid targets, i.e. triglycerides <150 mg/dL, and HDL cholesterol >40 mg/dL in men and >50 mg/dL in women in a separate analysis.

Statistical analysis

Data analysis was performed using the complex sampling function of SPSS version 20.0 (SPSS Inc, Chicago, IL). Variables with skewed distribution were log-transformed before analysis. Examination sampling weights were used in all analyses to obtain estimates representative of the United States Census civilian non-institutionalized population (17). Separate fasting sampling weights were used for the analysis involving serum triglycerides and LDL cholesterol as they were measured only in subjects who were examined in the morning session and had fasted for 8-24 hours, To obtain more reliable estimates, data from two survey cycles were combined together to produce estimates for each four-year period. To analyze the trends over time, multiple logistic or linear regression models were used, in which survey year (1999-2002, 2003-2006 and 2007-2010) was included as an independent continuous variable. A two-tailed $P<0.05$ was considered statistically significant.

Results

Table 1 shows the characteristics of 3094 participants aged ≥ 20 years with diagnosed type 2 diabetes. The majority of this population were above 40 years old and non-Hispanic whites. There was a significant increase in waist circumference and BMI (both P≤0.001). There was a significant increase in the proportion of obese people with BMI ≥30 kg/m^2 from 1999-2010 (P<0.001). During the same period, there were significant decreases in systolic blood pressure (from 133.0 mmHg to 128.9 mmHg, P<0.001), total cholesterol (from 208.2 mg/dL to 183.0 mg/dL, P<0.001), LDL cholesterol (from 117.6 mg/dL to 99.8 mg/dL, P<0.001), and triglycerides (from 160.9 mg/dL to 133.4 mg/dL, P≤0.002).

Utilization of different types of medications among people with diagnosed diabetes is shown in Tables 2-4. Among different glucose lowering medications prescribed, metformin is the recommended drug for diabetes according to the ADA guideline (11). Usage of metformin increased significantly from 34.8% to 53.8% from 1999-2010 (P<0.001) (Table 2), and became the most common medication for diabetes in 2003-2010. DPP-4 inhibitors started to be used by 7.4% of the patients in 2007-2010. Regarding glycemic control, about half of the participants taking metformin could achieve glycemic target by 2007-2010 (Figure 1a). There was also a doubling in the proportion of subjects who took thiazolidinediones achieving glycemic control from 1999-2010 (P=0.017). About 33.4% of people taking DPP-4 inhibitors could achieve glycemic control.

Increased usage of anti-hypertensive medications such as angiotensin-converting enzyme inhibitor (ACEI), aldosterone receptor antagonist (ARB), beta-blockers and diuretics was observed (P≤0.001) (Table 3). The ADA guideline recommends the use of either ARB or ACEI to treat subjects with both hypertension and diabetes (11). There was a significant increase in proportion of people taking either ARB or ACEI who could achieve blood pressure control (P=0.009) (Figure 1b). Significant improvement could also be seen in people taking β-blockers and people taking diuretics (P<0.05). Overall by 2007-2010 60% of subjects with any anti-hypertensive drug treatment could achieve the blood pressure target (<140/80 mmHg).

Among different lipid lowering medications, statin remained the most common type of drugs across the 12-year period, and the proportions of subjects on statins increased significantly from 28.5% to 52.1% (P<0.001) (Table 4). The LDL cholesterol control rate among people taking statins increased significantly from less than half in 1999-2002 to about three-quarters in 2007-2010 (P<0.001) (Figure 1c).

Supplementary Table S1 shows the overall glycemic, blood pressure and LDL cholesterol control rates in 1999-2010. During the 12-year period, the glycemic control rate increased significantly. Using the revised blood pressure target of <140/80 mmHg, blood pressure control rate increased significantly from 55.2% to 64.7% (P=0.002). There was also a significant increase in LDL cholesterol control rate from 35.0% to 56.5% across the same period (P<0.001). The overall proportion of people achieving all the glycemic, blood pressure and LDL cholesterol target levels increased from 8.7% in 1999-2002 to 24.0% in 2007-2010 (P<0.001).

The proportions of people achieving other lipid targets are shown in Supplementary Table S2. There was no significant trend in percentages of people achieving HDL cholesterol target level, while the proportions of people achieving triglycerides target level increased significantly from 45.8% to 57.5% from 1999-2010 (P=0.023).

Discussion

The prevalence of diabetes has increased dramatically in the U.S. in the last two decades (18). In 2010, about 21 million adult Americans had diagnosed diabetes. Fortunately, recent evidence suggested that diabetes-related complications, such as heart attacks, have declined substantially in the U.S. (19). Improved control of cardiovascular risk factors might have contributed to the decrease in myocardial infarction. Our study generates information on the recent trend of usage of different diabetic medications using large and nationally representative multi-stage surveys. Favorable trends in controlling glycemia, blood pressure and dyslipidemia might reflect better utilization of medications, however from our data greater prevalence of obesity and decreased

prevalence of family history of diabetes were observed in the populations from 1999-2010, and these changes should not be neglected as they may also have impact on various risk factors control as well. Despite the significant increase in the use of glucose, blood pressure and lipid lowering drugs from 1999-2010, about a quarter of the participants achieved all the control targets for diabetes. Therefore efforts should be made to look for better treatment and control of diabetes.

Although by 2010 more than 80% of diabetes patients have been on glucose lowering medications, merely half of them showed good glycemic control (Table 2 and Figure 1a). This suggests that there is still improvement to be made in order to enhance the efficacy of the use of anti-diabetic drugs. Since 2003, metformin has become the most commonly used glucose lowering drug. It is the recommended first line therapy because of its effectiveness in weight reduction, low cost and low risk for hypoglycemia (9). Studies also showed reduction in cardiovascular and all-cause mortality and reduction in cancer risks with metformin use (20). About half of the people taking metformin reached HbA_{1c} control target, which meant that additional diabetic medications might be necessary. The use of thiazolidinediones was at a peak during 2003-2006 and the percentage of use decreased in 2007-2010. A shift from rosiglitazone to pioglitazone was expected during this period, as rosiglitazone was suspected to be associated with myocardial ischemia (21, 22). Restrictions were made by the FDA in 2010 on the use of rosiglitazone (23), therefore its use of rosiglitazone would be expected to decline.

The use of DPP-4 inhibitors was first observed in 2007. In our sample population about 33% of participants taking the drug could achieve glycemic control, which was less than those taking other medications like metformin. This agrees with previous finding that DPP-4 inhibitors could improve $HbA1_c$ level to a lesser extent than metformin (23). The drug is not widely used for several considerations. These agents are not more effective in glucose lowering than other prevalent medications; there are also reservations of long-term safety of these agents; these agents are expensive and result in greater prescription costs than sulfonylurea and metformin (8). Despite the above reservations on DPP-4 inhibitors, a potential advantage of these types of drug is their

relatively fewer adverse effects. Compared to sulphonylureas, they cause less hypoglycemia and weight gain (24). Such advantage makes this drug attractive to the elderly, especially for those with co-morbidities that prevent the use of other medications.

Overall more than half of the participants could achieve blood pressure control from 1999-2010, and the percentage has been significantly increasing across the period. Also, about 60% of subjects taking various anti-hypertensive medications could generally achieve the control targets. Considering the various anti-hypertensive medications, there was increasing utilization of ARB, diuretics and beta-blockers. In particular, the percentage of subjects using beta-blockers and ARB doubled and tripled respectively from 1999-2010. Diuretics and beta-blockers are the traditional classes of anti-hypertensive agents. However there has been controversy over the adverse effects of these traditional drugs on glucose homeostasis. Beta-blockers and diuretics are generally regarded as agents that can increase the risk of new onset diabetes (25). Therefore it has been argued that those at risk of developing diabetes should avoid taking beta-blockers and diuretics, though there is a debate on the clinical significance of new onset diabetes associated with these drugs (26). The increasing use of diuretics and beta-blockers in this study is probably due to the fact that diuretics are more commonly used by the elderly while beta-blockers are used to treat hypertensive patients with angina. Nevertheless, regular monitoring should be considered to manage the metabolic adverse effects at an early stage while maintaining good blood pressure control (27).

Statins have been increasingly prescribed in 1999-2010 and more than half of the participants were on this class of drugs. Our data shows that there was significant improvement in LDL cholesterol control, probably due to the effects of statins and a decline in hypertriglyceridemia. There have been discussions on whether statins confer more benefits in diabetic patients, and their effects on glycemic control (28, 29). The trend in the use of statins to lower lipid levels is promising, while the effect of statins on glycemic control in diabetic patients remains controversial (30). However, considering their efficacy in reducing cardiovascular events, stains will remain as one common drug class to treat dyslipidemia.

In summary, an increasing use of prescription medications for lowering blood glucose, blood pressure and LDL-cholesterol were observed over the period of 1999-2010. Metformin and statins were the most commonly used medications for lowering blood glucose and lipids respectively, whereas DPP-4 inhibitors started to be used since 2007. Usage of ARB, diuretics and beta-blockers also increased from 1999-2010. The changing practice in the use of glucose lowering medications has resulted in significant increase in glycemic control, whereas more than half of the participants could attain good blood pressure control partly due to increased drug prescriptions. Despite the slight changes in the characteristics of the US population with type 2 diabetes from 1999 to 2010, improvement of risk factor control in recent surveys was associated with increases in prescribed medications for lowering blood glucose, lipids and blood pressure and with polypharmacy.

Conflict of Interest

KL Ong has consulted and received honoraria from Pfizer. Other authors declare no conflict of interest.

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Contributors' statement

HK Wong: Responsible for study design, data analysis and interpretation, and drafting the manuscript

BMY Cheung: Responsible for study design, data interpretation, drafting the manuscript and approving the final version

KL Ong: Responsible for study design, data interpretation, and revising the manuscript

CL Cheung: Responsible for interpretation of data and revising the manuscript

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Figure Legends

Figure 1. Control rates of treated people with diagnosed diabetes. *P* value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates). *P<0.05, #P<0.01 and ‡P<0.001

Table 1. Characteristics of people with diagnosed diabetes in the United States, 1999-2010

Characteristics	**1999-2002 (n=812)**	**2003-2006 (n=930)**	**2007-2010 (n=1352)**	***P* for trend**
Age (y)	59.1 (57.8-60.3)	60.0 (58.6-61.4)	60.5 (59.4-61.5)	0.093
Age distribution (%)				0.368
20-39 y	8.9 (1.5)	7.3 (1.1)	6.8 (0.7)	
40-59 y	39.0 (2.1)	41.1 (2.1)	38.4 (1.8)	
≥ 60 y	52.1 (2.1)	51.6 (2.5)	54.8 (1.9)	
Women (%)	50.1 (2.1)	54.4 (1.8)	51.6 (2.1)	
Race/Ethnicity (%)‡				0.672
Non-Hispanic white	61.4 (3.6)	63.5 (3.1)	60.4 (3.7)	
Non-Hispanic black	15.5 (2.5)	16.7 (2.2)	18.2 (2.2)	
Mexican American	6.9 (1.3)	8.1 (1.6)	8.6 (1.9)	
Other	16.1 (3.8)	11.6 (1.4)	12.9 (1.8)	
Education (%)‡				0.076
Less than high school	35.7 (2.3)	29.0 (1.6)	31.8 (1.4)	0.062
High school diploma	26.3 (2.3)	26.9 (1.9)	24.0 (2.4)	0.390
More than high school	38.0 (2.5)	44.1 (2.7)	44.3 (2.2)	0.032
Waist circumference (cm)	107.8 (105.7-109.9)	109.6 (107.9-111.4)	111.2 (109.0-112.5)	0.001
BMI (kg/m^2)	31.83 (31.1-32.6)	32.48 (31.7-33.3)	33.32 (32.7-33.9)	<0.001
BMI distribution (%)‡				<0.001
< 25.0 kg/m^2	16.7 (2.0)	13.6 (1.7)	11.2 (1.0)	
25.0-29.9 kg/m^2	30.5 (2.2)	28.9 (1.9)	23.5 (1.6)	
≥30.0 kg/m^2	52.8 (2.8)	57.5 (2.4)	65.3 (1.9)	
$HbA1_c$ (%)	7.60 (7.37-7.82)	7.14 (6.99-7.29)	7.21 (7.09-7.33)	0.006
Blood pressure (mmHg)				
Systolic	133.0 (131.1-134.9)	131.0 (129.1-132.9)	128.9 (127.3-130.5)	<0.001
Diastolic	70.0 (68.2-71.8)	68.2 (66.7-69.7)	67.4 (66.0-68.7)	0.065
Total cholesterol (mg/dL)	208.2 (201.7-214.6)	196.8 (192.3-201.4)	183.0 (179.9-186.1)	<0.001
HDL cholesterol (mg/dL)	45.8 (44.4-47.2)	50.2 (48.9-51.5)	46.7 (45.7-47.6)	0.870
LDL cholesterol (mg/dL)*	117.6 (114.5-120.8)	107.8 (102.7-113.1)	99.0 (96.2-101.7)	<0.001
Triglycerides (mg/dL)*†	160.9 (148.3-174.5)	166.5 (151.1-183.4)	133.4 (125.1-142.3)	0.002
Smoking (%)‡				0.992
Never	48.7 (2.8)	49.3 (2.2)	48.5 (1.4)	
Former	32.3 (2.0)	32.6 (1.5)	34.6 (1.4)	
Current	19.0 (1.6)	18.2 (1.6)	16.9 (1.0)	
Alcohol drinking (%)	12.9 (1.8)	18.3 (1.7)	16.1 (1.5)	0.065
History of CVD (%)				
Congestive heart failure	8.4 (1.2)	12.3 (1.1)	10.3 (1.2)	0.519
Coronary heart disease	13.0 (1.6)	12.8 (1.5)	12.4 (0.9)	0.532

Angina	11.0 (1.5)	9.9 (1.3)	8.2 (1.1)	0.086
Heart attack	11.2 (1.9)	13.0 (1.4)	11.7 (1.0)	0.951
Stroke	7.4 (1.1)	10.7 (1.3)	10.4 (1.0)	0.121
Any of the above	23.3 (2.2)	31.0 (2.2)	27.9 (1.9)	0.303
Family history of diabetes (%)	78.6 (1.7)	72.9 (2.5)	68.7 (1.7)	<0.001
Microalbuminuria (%)	35.9 (1.7)	32.2 (2.0)	30.5 (1.5)	0.010

BMI = body mass index; CVD = cardiovascular disease; HbA_{1c} = glycosylated haemoglobin; HDL = high-density lipoprotein; LDL = low-density lipoprotein.

Data are expressed as percentage or mean (standard error or 95% CI) unless otherwise specified. *P* value was obtained from multiple linear or logistic regression models after adjusting for age (except age-specific estimates), sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).

‡ *P* values were calculated by ordinal regression after adjusting for age (except age-specific estimates), sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).

*Data were only available in a sub-sample of subjects that had fasted for 8-24 hours (n = 237, 344, and 543 for LDL cholesterol, and n = 259, 367, and 566 for triglycerides, in NHANES 1999-2002, 2003-2006, and 2007-2010 respectively).

†Data were expressed as geometric mean (95% CI) and log-transformed before analysis.

Table 2. Utilization of blood glucose lowering medications among subjects with diagnosed diabetes in the United States, 1999-2010

Characteristics	1999-2002	2003-2006	2007-2010	*P* for trend
Metformin	34.8 (2.0)	46.1 (2.8)	53.8 (1.8)	<0.001
Sulfonylureas	41.4 (2.2)	39.8 (2.5)	37.5 (1.6)	0.064
Thiazolidinediones	12.1 (1.4)	25.9 (1.8)	17.6 (1.2)	0.028
Insulin	16.3 (2.1)	17.2 (0.9)	20.5 (1.3)	0.085
Others (including DDP-4 inhibitors)	2.4 (0.7)	1.8 (0.5)	11.2 (1.1)	<0.001
DDP-4 inhibitors	0.0 (0.0)	0.0 (0.0)	7.4 (1.1)	-
Polytherapy	27.9 (2.0)	40.7 (2.3)	42.8 (1.6)	<0.001
Any of the above	73.7 (2.3)	77.7 (2.1)	82.1 (1.7)	0.003

Abbreviation: DPP-4, dipeptidyl peptidase-4.
P value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).

Table 3. Utilization of blood pressure lowering medications among subjects with diagnosed diabetes in the United States, 1999-2010

Characteristics	1999-2002	2003-2006	2007-2010	*P* for trend
ACEI	31.5 (1.8)	40.1 (1.8)	41.2 (1.7)	<0.001
ARB	7.4 (0.8)	14.9 (1.6)	21.4 (1.6)	<0.001
CCB	21.5 (1.9)	19.1 (1.3)	21.0 (1.6)	0.610
ARA	1.1 (0.5)*	1.3 (0.4)*	2.4 (0.6)	0.101
β-blockers	15.3 (1.9)	26.3 (1.9)	31.8 (1.5)	<0.001
Diuretics	25.8 (2.0)	31.9 (2.0)	36.0 (1.8)	0.001
Others	10.9 (1.5)	10.1 (1.4)	9.9 (0.7)	0.336
Polytherapy	34.9 (2.6)	43.2 (1.7)	50.5 (2.0)	<0.001
Any of the above	58.4 (2.3)	70.8 (1.8)	76.9 (1.9)	<0.001

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARA, aldosterone receptor antagonist; ARB, angiotensin receptor blocker; CCB, calcium channel blocker;
P value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).
*Estimate should be interpreted with caution as coefficient of variation >0.30.

Table 4. Utilization of lipid lowering medications among subjects with diagnosed diabetes in the United States, 1999-2010

Characteristics	**1999-2002**	**2003-2006**	**2007-2010**	***P* for trend**
Statin	28.5 (2.1)	44.8 (2.0)	52.2 (1.4)	<0.001
Fibrate	4.4 (1.0)	4.8 (1.0)	6.6 (1.0)	0.111
Bile acid sequestrant	0.1 (0.1)*	0.8 (0.5)*	0.5 (0.1)*	0.202
Nicotinic acid	0.1 (0.2)*	1.1 (0.2)	2.3 (0.5)	<0.001
Cholesterol adsorption inhibitor	0.0 (0.0)	4.2 (0.8)	7.8 (1.3)	<0.001
Others	0.5 (0.0)	0.0 (0.0)	0.1 (0.1)*	0.107
Polytherapy	1.2 (0.7)*	6.7 (1.1)	11.6 (1.7)	<0.001
Any of the above	32.5 (1.8)	48.6 (2.1)	57.5 (1.5)	<0.001

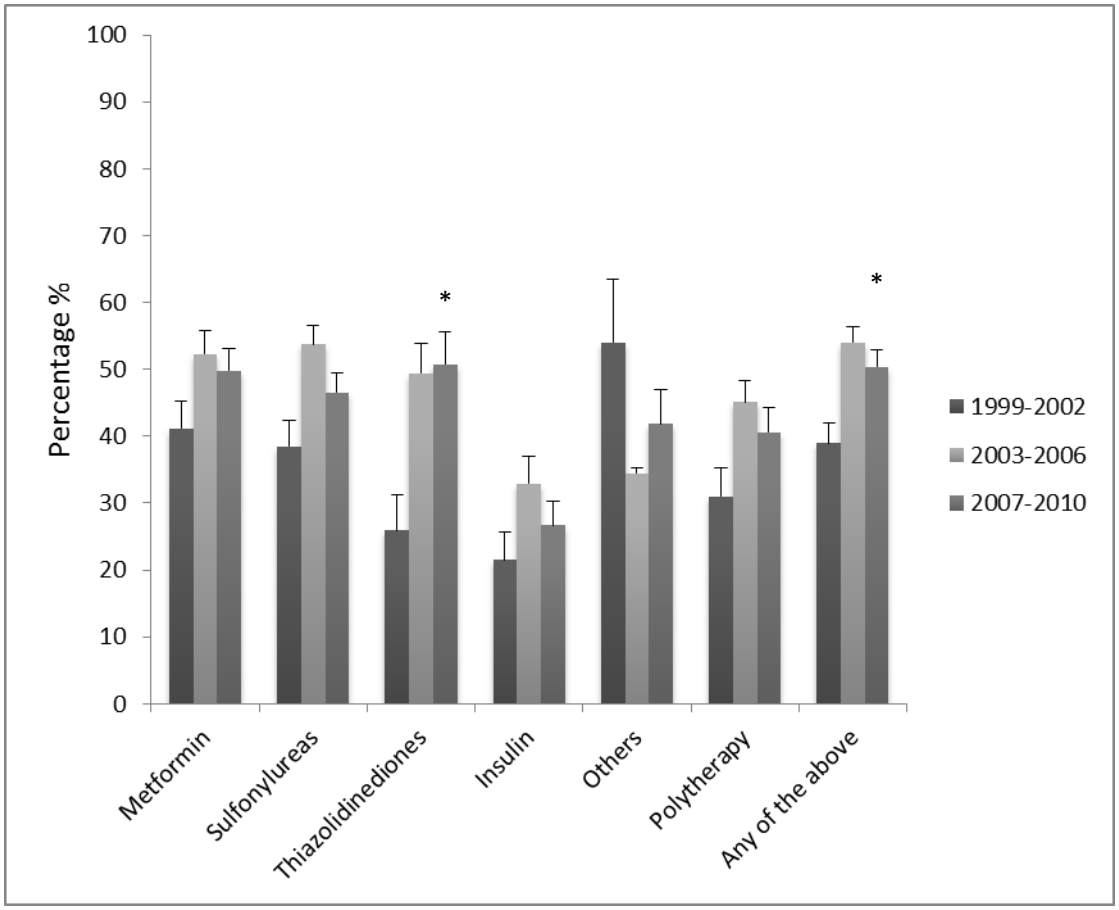
Abbreviation: LDL, low-density lipoproteins

P value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).

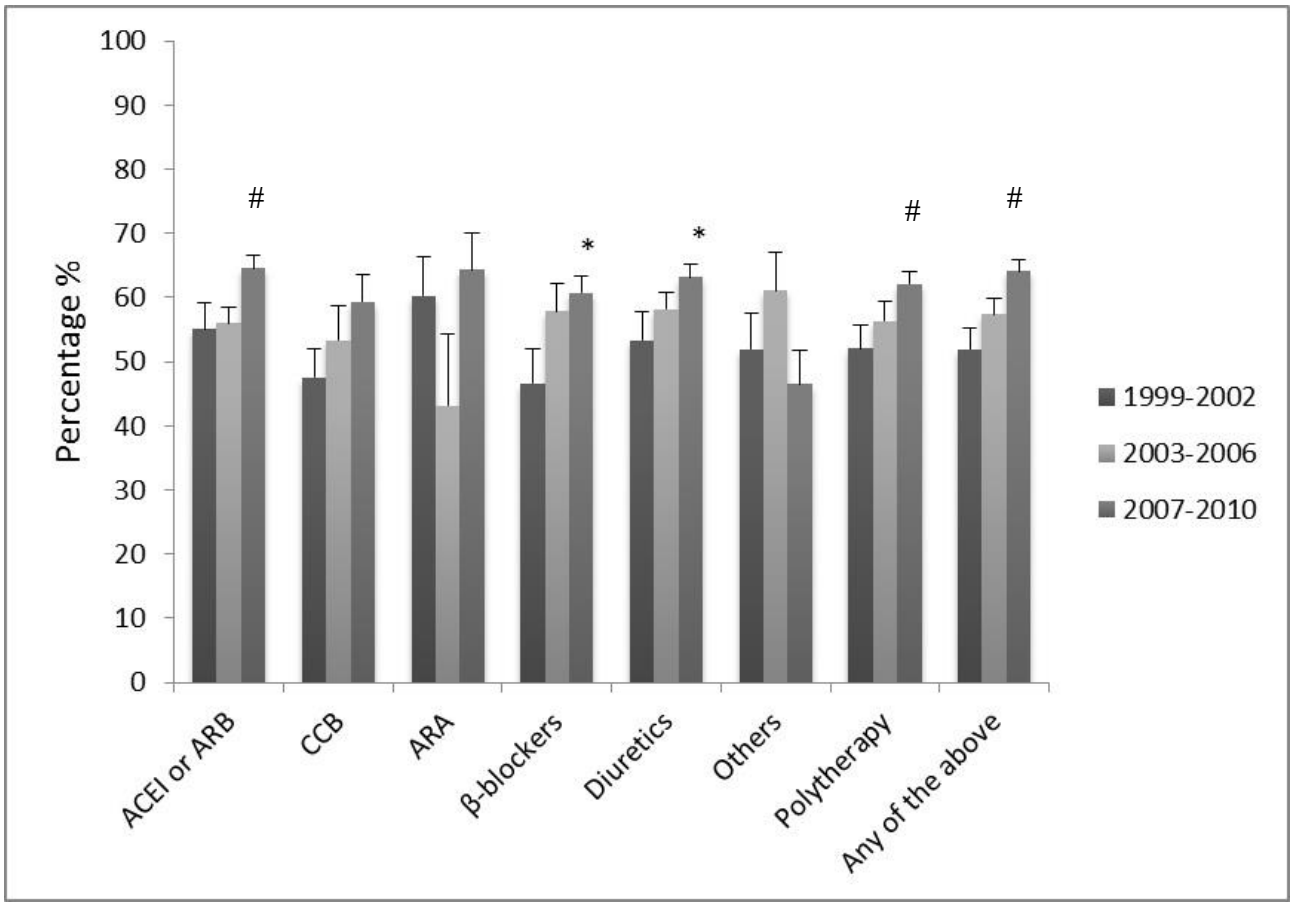
*Estimate should be interpreted with caution as coefficient of variation >0.30.

Figure 1.

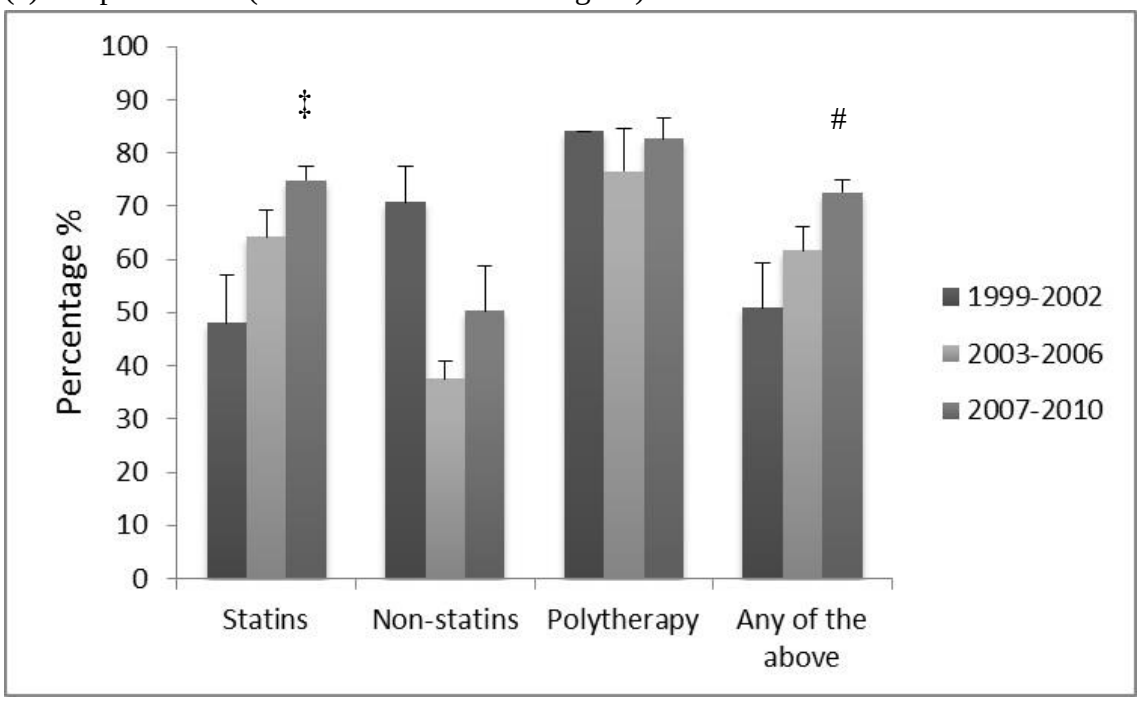
(a) Glycemic control (HbA_{1c} <7.0%)



(b) Blood pressure control (Blood pressure <140/80 mmHg)



(c) Lipid control (LDL cholesterol <100 mg/dL)



Supplementary Table S1. Proportions of people achieving glycemic, blood pressure, and LDL cholesterol target levels among those with diagnosed diabetes in the United States, 1999-2010

Population group	1999-2002	2003-2006	2007-2010	*P* for trend
		HbA_{1c} <7.0%		
n	775	882	1266	-
Overall	43.8 (2.8)	58.1 (2.3)	54.0 (2.5)	0.019
Age				
20-39 years	34.4 (11.0)*	54.3 (7.7)	53.3 (8.3)	0.197
40-59 years	44.1 (3.9)	51.9 (4.0)	50.6 (4.0)	0.266
≥60 years	45.2 (3.2)	63.6 (3.0)	56.5 (2.4)	0.020
Sex				
Men	42.1 (3.0)	55.6 (2.9)	52.4 (3.6)	0.068
Women	45.6 (3.9)	60.3 (3.0)	55.5 (2.4)	0.060
Race/ethnicity				
Non-Hispanic white	48.5 (3.9)	64.5 (3.0)	55.6 (3.1)	0.303
Non-Hispanic black	38.1 (3.5)	44.4 (3.6)	52.2 (2.8)	0.004
Mexican American	34.0 (3.1)	39.9 (3.4)	42.0 (3.6)	0.211
Other	35.3 (5.9)	53.9 (7.0)	57.3 (5.6)	0.014
BMI‡				
<25.0 kg/m^2	43.5 (6.3)	54.6 (5.3)	60.8 (4.8)	0.045
25.0-29.9 kg/m^2	47.8 (5.8)	57.8 (3.8)	60.5 (4.1)	0.057
≥30.0 kg/m^2	41.6 (3.5)	59.1 (2.8)	50.5 (2.8)	0.178
		Blood pressure <140/80 mmHg		
n	783	862	830	-
Overall	55.2 (2.6)	59.4 (2.2)	64.7 (1.9)	0.002
Age				
20-39 years	50.6 (11.6)	80.2 (5.4)	58.6 (7.4)	0.500
40-59 years	57.1 (4.4)	56.3 (4.4)	63.6 (3.4)	0.241
≥60 years	54.5 (2.6)	58.9 (3.2)	66.2 (2.5)	0.002
Sex				
Men	57.7 (3.1)	63.9 (3.3)	67.1 (3.2)	0.051
Women	52.6 (4.4)	55.3 (3.3)	62.5 (2.3)	0.033
Race/ethnicity				
Non-Hispanic white	59.0 (3.7)	60.1 (3.6)	66.1 (3.0)	0.108
Non-Hispanic black	42.5 (4.4)	58.6 (3.0)	58.0 (2.6)	0.007
Mexican American	53.6 (3.1)	64.2 (4.5)	65.1 (3.2)	0.012
Other	53.3 (6.9)	52.9 (6.3)	66.9 (4.7)	0.095
BMI				
<25.0 kg/m^2	62.4 (6.5)	62.9 (7.0)	61.6 (5.2)	0.018
25.0-29.9 kg/m^2	51.4 (3.8)	57.1 (3.8)	65.5 (3.4)	0.004
≥30.0 kg/m^2	55.0 (4.3)	59.6 (2.6)	65.0 (2.2)	0.026
		LDL cholesterol <100 mg/dL		
n	237	344	543	-
Overall	35.0 (3.9)	46.9 (3.2)	56.5 (2.3)	<0.001
Age				
20-39 years	30.3 (8.2)	45.1 (12.9)	48.3 (11.8)	0.167
40-59 years	31.2 (5.5)	38.7 (5.4)	46.7 (4.9)	0.030
≥60 years	40.2 (7.5)	53.5 (3.4)	64.4 (2.7)	0.001
Sex				

Men	41.4 (5.3)	52.7 (3.8)	62.1 (3.3)	0.002
Women	27.3 (4.9)	42.5 (4.4)	51.1 (3.4)	0.001
Race/ethnicity				
Non-Hispanic white	39.5 (6.0)	48.3 (4.5)	63.3 (3.5)	0.001
Non-Hispanic black	27.4 (6.4)	51.2 (4.7)	40.8 (5.0)	0.305
Mexican American	31.3 (6.1)	33.7 (6.0)	45.4 (4.2)	0.092
Other	26.3 (12.5)*	43.3 (11.1)	50.9 (8.9)	0.237
BMI				
<25.0 kg/m^2	29.1 (10.1)*	43.1 (6.4)	60.8 (7.6)	0.031
25.0-29.9 kg/m^2	38.9 (7.4)	37.6 (7.0)	56.1 (5.9)	0.065
≥30.0 kg/m^2	34.9 (6.1)	51.9 (3.8)	55.8 (3.3)	0.012
HbA$_{1c}$ <7.0%, blood pressure <140/80 mmHg, and LDL cholesterol <100 mg/dL				
n	231	322	524	-
Overall	8.7 (1.8)	16.9 (2.9)	24.0 (2.9)	<0.001

Data are expressed as percent (standard error).
P value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).
*Estimate should be interpreted with caution as coefficient of variation >0.30.

Supplementary Table S2. Proportions of people achieving other lipid target levels among those with diagnosed diabetes in the United States, 1999-2010

Population group	1999-2002	2003-2006	2007-2010	*P* for trend
HDL cholesterol >40 mg/dL in men and >50 mg/dL in women				
n	751	871	1247	-
Overall	43.2 (2.8)	57.1 (2.2)	48.0 (2.1)	0.506
Age				
20-39 years	28.9 (5.8)	41.6 (8.0)	46.4 (7.9)	0.067
40-59 years	44.8 (5.2)	51.6 (3.4)	40.3 (3.0)	0.320
≥60 years	44.6 (2.6)	63.8 (2.8)	53.6 (2.4)	0.098
Sex				
Men	48.1 (3.7)	60.4 (3.0)	57.4 (2.4)	0.124
Women	38.2 (3.4)	54.3 (3.4)	38.9 (2.6)	0.616
Race/ethnicity				
Non-Hispanic white	40.9 (3.8)	55.5 (3.0)	43.7 (3.0)	0.865
Non-Hispanic black	52.6 (4.9)	71.3 (3.1)	58.1 (3.1)	0.817
Mexican American	44.3 (4.5)	51.2 (2.9)	51.5 (3.3)	0.379
Other	43.5 (6.2)	51.6 (5.8)	52.7 (5.5)	0.287
BMI				
<25.0 kg/m^2	61.1 (6.5)	71.3 (5.1)	65.3 (4.6)	0.621
25.0-29.9 kg/m^2	46.4 (4.4)	60.1 (3.6)	57.8 (3.5)	0.074
≥30.0 kg/m^2	35.8 (3.8)	52.4 (3.0)	41.4 (2.5)	0.767
Triglycerides <150 mg/dL				
n	259	367	566	-
Overall	45.8 (3.5)	45.7 (3.2)	57.5 (2.5)	0.023
Age				
20-39 years	48.7 (8.8)	32.8 (16.1)*	52.5 (11.6)	0.860
40-59 years	48.3 (6.3)	36.9 (4.7)	54.9 (5.0)	0.399
≥60 years	42.7 (5.8)	54.8 (4.2)	60.0 (2.8)	0.014
Sex				
Men	46.5 (4.4)	50.1 (4.4)	58.9 (3.2)	0.066
Women	45.0 (6.8)	42.4 (4.2)	56.1 (3.8)	0.102
Race/ethnicity				
Non-Hispanic white	42.5 (4.8)	41.9 (4.4)	55.1 (3.7)	0.022
Non-Hispanic black	65.3 (8.7)	71.1 (6.0)	73.7 (4.7)	0.603
Mexican American	37.4 (5.4)	30.2 (6.7)	54.5 (6.0)	0.019
Other	47.3 (13.1)	39.9 (10.0)	51.1 (6.1)	0.844
BMI				
<25.0 kg/m^2	31.9 (8.8)	61.3 (7.5)	75.5 (5.8)	0.001
25.0-29.9 kg/m^2	55.6 (6.3)	42.2 (6.8)	62.3 (4.9)	0.488
≥30.0 kg/m^2	45.1 (5.5)	43.5 (4.4)	52.1 (2.9)	0.359

Data are expressed as percent (standard error).
P value was derived from multiple logistic regression models after adjusting for age, sex (except sex-specific estimates) and race/ethnicity (except race/ethnicity-specific estimates).
*Estimate should be interpreted with caution as coefficient of variation >0.30.