CHAPTER 39

MEDICATION USE AND SELF-CARE PRACTICES IN PERSONS WITH DIABETES

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SUMMARY

Individuals diagnosed with diabetes often take medications to control and manage their diabetes and engage in self-care practices. Among adults with diagnosed diabetes in the United States, 88.2% use either oral medications, insulin, or a combination of both to treat and control diabetes. Diabetes treatment patterns differ by demographics, duration since diabetes diagnosis, and glycosylated hemoglobin (A1c) levels. Adults with diabetes often have a number of comorbid conditions that require treatment and medications. An adult with diagnosed diabetes in the United States reports using an average of 5.9 different prescription medications. This number is higher than the average reported by adults with undiagnosed diabetes, prediabetes, or no diabetes (range 2.5–4.3). Diabetes self-care practices are also an important component of diabetes treatment. The majority of adults with diagnosed diabetes report self-care practices, such as receiving a dilated eye exam (62.8%), self-monitoring of blood glucose (63.6%), and receiving a foot exam (67.5%). Report of self-care practices differs by demographics, time since diabetes diagnosis, and geography. Pancreatic transplants and bariatric surgery are sometimes indicated for the treatment of diabetes. However, these procedures are not common and entail a number of additional risks. Describing medication use, treatment patterns, and self-care practices among individuals with diabetes provides information to health care and public health professionals to better understand the multifactorial aspects of diabetes treatment.

INTRODUCTION

Diabetes is a complex disease that often requires a person with diabetes to follow a number of self-care practices, such as taking medications to control and manage their diabetes. In addition, persons with diabetes often have comorbid chronic conditions, including cardiovascular disease (CVD), hypertension, and depression, which often require taking multiple medications. This chapter describes both trends and current medication use and self-care practices among persons with diabetes. The majority of the chapter focuses on previously diagnosed diabetes defined by self-report of diagnosis by a health care professional. To place medication use among adults with diagnosed diabetes in the context of the larger adult population, it also includes data on persons with no diabetes, prediabetes, and undiagnosed diabetes. Persons without diabetes or with prediabetes or undiagnosed diabetes are classified based on glycosylated hemoglobin (A1c) or fasting plasma glucose levels among adults without diagnosed diabetes.

DATA SOURCES, LIMITATIONS

Information on medication use and self-care practices in the U.S. adult population comes from a number of national health surveys: the National Health and Nutrition Examination Surveys (NHANES) 1999–2010, the National Health Interview Surveys (NHIS) 1997–2010, and the Behavioral Risk Factor Surveillance System (BRFSS). The NHANES is a representative sample of the noninstitutionalized population in the United States and includes information collected from in-person interviews, physical examinations, and laboratory tests. In addition, detailed information on prescription medications is collected during home interviews from physical medication containers. Similar to the NHANES, the NHIS is a nationally representative survey of the noninstitutionalized population in the United States; information is collected from in-person interviews. The BRFSS is a telephone survey that collects information on health-related risk behaviors, chronic conditions, and use of preventive services. The BRFSS is conducted in all 50 states, the District of Columbia, and three U.S. territories.

The limitations of these surveys pertaining to diabetes treatment and self-care practices include the lack of information on adherence with prescribed medications, reliance on self-report and lack of supplementary information from medical records, and lack of inclusion of the institutionalized population, which includes nursing home residents (1). Both the NHIS and BRFSS have the additional limitation of not collecting any laboratory or examination data. However, the NHANES, NHIS, and BRFSS all provide valuable information related to the treatment and care of

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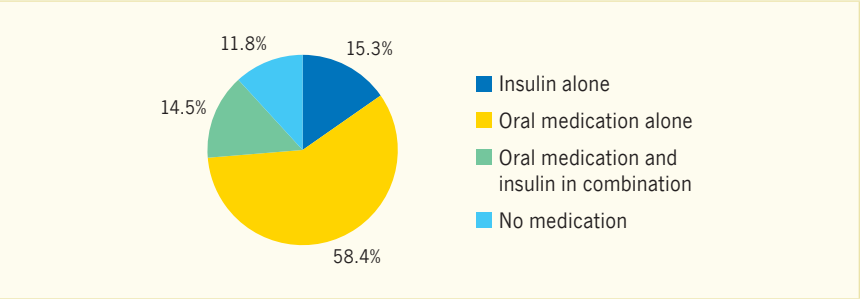
the population with diabetes in the United States.

Data presented in this chapter include new analyses of these national datasets conducted for *Diabetes in America, 3rd edition*, as well as national data published by the Division of Diabetes Translation of the Centers for Disease Control and Prevention. Data presented on pancreas and islet transplantation are based on the International Pancreatic Transplant Registry and the Collaborative Islet Transplant Registry.

DIABETES TREATMENT

Treatment for diabetes often focuses on many different facets of the disease and on controlling and preventing known diabetes complications. The first goal of treatment for diabetes is typically management of blood glucose levels. Glycemic control is associated with reduced risk of both microvascular and macrovascular complications among people with diabetes (2,3). Individuals with diabetes often have a number of comorbid conditions, including hypertension and elevated cholesterol levels, which may require control with medications to reduce the risk of complications (4,5,6).

FIGURE 39.1. Prevalence of Diabetes Treatment Among Adults Age ≥20 Years With Diagnosed Diabetes, U.S., 2007–2010



Diabetes is self-reported. Estimates are weighted to the noninstitutionalized U.S. population.
SOURCE: National Health and Nutrition Examination Surveys 2007–2010

Recommendations on medication use to treat diabetes depend upon the type of diabetes. Individuals with type 1 diabetes make little or no insulin and require daily insulin treatment to control and manage blood sugar levels, while individuals with type 2 diabetes still make insulin and may control blood glucose levels with no medication, oral medications, noninsulin injectable medications (such as glucagon-like peptide [GLP]-1 receptor agonists), insulin, or a combination of these.

In the United States from 2007 to 2010, 88.2% of persons age ≥20 years with diagnosed diabetes were treating their diabetes with insulin and/or oral medications: 58.4% were taking oral medications alone, 15.3% were taking insulin alone, and 14.5% were taking a combination of insulin and oral medications (Figure 39.1, Table 39.1). Patterns of diabetes treatment revealed many similarities and a few differences by demographic groups. Younger adults age <45 years were more likely than older adults to report using insulin alone (28.7%), possibly an indication of the low prevalence of type 2 diabetes and the higher prevalence of type 1 diabetes in this age group. Patterns of diabetes treatment by sex were similar. Patterns of diabetes treatment differed slightly by race/ethnicity. Non-Hispanic whites had the highest prevalence of insulin alone (18.3%) and combination of insulin and oral medication (16.2%). Mexican Americans had the lowest prevalence of use of insulin alone (10.1%), the highest prevalence of using oral medications alone (60.7%), the lowest prevalence of combined use of oral medication and insulin (11.0%), and the highest prevalence of no medication use (18.2%). Differences in patterns of diabetes treatment by demographic factors are shown in Table 39.1.

Management of blood glucose levels is typically monitored by A1c level, an indicator of glycemic levels over the past 3 months. Standards of medical care for diabetes vary by individuals, and for many adults, the recommended A1c is <7.0% (<53 mmol/mol). Adults with higher A1c levels (≥8.0% [≥64 mmol/mol]) are more likely to be taking insulin alone or a combination of insulin and oral medication and least likely to be treating glucose levels with no medication. Duration of diabetes is also associated with diabetes treatment. Adults with duration of diabetes <10 years are most likely to use oral medication alone or no medication to treat diabetes (70.8% and 14.5%, respectively). Adults with duration of diabetes ≥10 years are least likely to use no medication for treatment (8.1%) (Table 39.1).

ORAL DIABETES MEDICATIONS

While 15.3% of adults age ≥20 years with diabetes use insulin alone and 11.8% use no medication, about 70% are using oral medications alone or in combination with insulin. In 2012, the American College of Physicians offered clinical practice guidelines on oral pharmacological treatment for diabetes (7,8). These guidelines provide a systematic review of the different treatment options. Treatment for type 2 diabetes often includes early initiation of multiple drugs (9).

Six different classes of oral medications are approved by the U.S. Food and Drug Administration (FDA) to target lower glucose levels: non-sulfonylureas, sulfonylureas, alpha-glucosidase inhibitors, thiazolidinediones, meglitinides, and dipeptidyl peptidase-4 (DPP-4) inhibitors. Non-sulfonylureas (for example, metformin) are used most commonly by persons age ≥20 years with diagnosed diabetes (49.1%), followed by sulfonylureas (35.7%), thiazolidinediones (19.4%), and other oral diabetes medications (9.0%) (Table 39.2). Information on DPP-4

TABLE 39.1. Prevalence of Diabetes Treatment Among Adults Age ≥20 Years With Diabetes, U.S., 2007–2010

CHARACTERISTICS	PERCENT (STANDARD ERROR)			
	Insulin Alone	Oral Medication Alone	Combination of Insulin and Oral Medication	No Medication
Overall	15.3 (1.30)	58.4 (2.10)	14.5 (0.92)	11.8 (1.38)
Age (years)				
20–44	28.7 (4.82)	44.3 (4.21)	9.5 (2.89)[1]	17.5 (3.29)
45–64	13.8 (2.02)	59.1 (2.55)	14.8 (1.18)	12.3 (1.90)
65–74	12.0 (2.07)	65.6 (3.86)	14.5 (2.44)	7.9 (1.71)
≥75	14.2 (2.09)	56.3 (3.11)	18.0 (2.31)	11.5 (2.39)
Sex				
Male	19.9 (2.25)	53.4 (2.87)	14.9 (1.81)	11.9 (1.84)
Female	10.9 (1.42)	63.2 (2.31)	14.2 (1.22)	11.7 (1.49)
Race/ethnicity				
Non-Hispanic white	18.3 (1.86)	55.4 (2.84)	16.2 (1.37)	10.1 (1.58)
Non-Hispanic black	13.0 (1.99)	60.5 (3.33)	13.8 (2.20)	12.7 (2.00)
All Hispanic	9.9 (2.16)	61.0 (2.38)	11.5 (1.26)	17.6 (2.07)
Mexican American	10.1 (2.00)	60.7 (2.30)	11.0 (1.50)	18.2 (2.47)
Education				
<High school	10.7 (1.28)	64.7 (2.23)	13.1 (1.58)	11.6 (1.27)
High school	14.3 (2.71)	61.6 (4.16)	14.6 (2.30)	9.7 (2.24)
>High school	19.0 (2.46)	52.4 (3.71)	15.6 (1.56)	13.1 (2.51)
Poverty index ratio				
<100%	11.7 (1.65)	63.2 (2.18)	12.7 (1.98)	12.4 (1.79)
100%–199%	14.2 (2.33)	59.5 (4.03)	15.2 (2.29)	11.1 (1.83)
200%–299%	13.4 (3.29)	55.6 (3.86)	14.6 (3.42)	16.4 (3.00)
300%–399%	26.2 (5.64)	51.2 (7.76)	17.3 (3.97)	5.3 (2.54)[2]
≥400%	13.9 (2.59)	61.8 (5.02)	13.5 (2.09)	10.9 (3.25)
A1c level				
<6.0%	9.0 (3.15)[1]	56.4 (4.86)	2.0 (0.88)[2]	32.7 (4.49)
6.0%–6.9%	8.7 (1.51)	71.5 (2.80)	8.8 (1.13)	11.0 (1.98)
7.0%–7.9%	20.7 (3.22)	54.3 (3.04)	20.1 (1.91)	4.9 (1.39)
≥8.0%	25.6 (3.14)	45.9 (2.94)	23.9 (2.93)	4.6 (1.23)
Diabetes duration				
<10 years	7.5 (1.20)	70.8 (2.95)	7.3 (1.24)	14.5 (1.91)
≥10 years	25.0 (2.71)	43.3 (2.57)	23.7 (1.87)	8.1 (1.31)

Diabetes is self-reported. Estimates are weighted to the noninstitutionalized U.S. population. Conversions for A1c values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin.

[1] Relative standard error >30%–40%

[2] Relative standard error >40%–50%

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

inhibitors is not collected in the NHANES. Patterns of types of oral medications used differ by age group. For example, use of sulfonylureas increases with age, with almost half of adults age ≥75 years reporting use of sulfonylureas compared to less than one-quarter of adults age 20–44 years. Similar patterns were reported by males and females. Hispanics, including Mexican Americans, had a lower prevalence of thiazolidinedione use compared to non-Hispanic whites and somewhat lower prevalence than that in non-Hispanic blacks (Table 39.2).

TRENDS IN DIABETES MEDICATION USE

Trends in medication use for diabetes can be tracked using responses from adults age ≥20 years with diabetes to the NHIS (10). In all groups, the number of adults age ≥20 years with diabetes who report using any diabetes medication has increased from 1997 to 2009, while the numbers of adults age ≥20 years using insulin alone has remained stable (Figure 39.2) (11). Since 1997, there has been a slight increase in the percent of adults age ≥20 years taking a combination of insulin and oral medications or oral medications alone, while the proportion of adults age ≥20 years taking insulin alone has declined slightly; about one-fifth to one-quarter of the population has been taking no medications during this time period (Figure 39.3) (12).

Trends in oral medication use may be influenced by clinical findings of benefit or risk, earlier stage of diagnosis, cost considerations, and new standards of medical care recommendations. Analyses of prescription claims data from 2006–2008 for initiation of monotherapy in a large pharmacy database in the United States provides evidence of practice patterns over time. In the analyses, the authors documented increases in the initial monotherapy of metformin corresponding to 2008 recommendations by the American Diabetes Association and the European Association for the Study of Diabetes (13,14) and declines in the use of thiazolidinediones, which are more expensive and have more adverse effects compared to metformin (15). These findings are consistent with another study of pharmacy data in which the number of metformin prescriptions in the United States increased 97% between 2003 and 2012, while thiazolidinedione prescriptions decreased 64% in that time period and the absolute number of sulfonylurea prescriptions remained constant (16). Among newly introduced medications in that study, the DPP-4 inhibitor sitagliptin was introduced in 2006 and had the biggest increase in usage, including 10.5 million prescriptions (single ingredient or combinations) in 2012 out of a total of 120.9 million non-insulin glucose-lowering prescriptions.

In a survey of ambulatory physician practices in the United States, a similar pattern of increasing metformin use and decreasing thiazolidinedione use was observed among prescription patterns between 1997 and 2012 (17). Metformin was prescribed in 23% of visits in 1997 and 53% of visits in 2012, whereas thiazolidinedione prescriptions peaked in 2005 at 28% of visits and then declined to 16% of visits by 2012. The percentage of visits in which sulfonylureas were prescribed declined

from 61% in 1997 to 22% in 2012. Doctor visits in which multiple compounds were prescribed increased from 41% in 1997 to 58% in 2012, with the average number of compounds prescribed per visit increasing from 1.3 to 1.7 over that time span.

MEDICATION USE FOR COMORBID CONDITIONS

Most patients with diabetes require control and management of comorbid conditions, in addition to control of glycemia. For example, individuals with diabetes have a higher prevalence of hypertension, elevated cholesterol (5,6), depression (18), and arthritis (19). These comorbidities often require separate medication for treatment. According to reports of prescription drugs from the NHANES 2005–2010, the age-standardized average number of prescription drugs in adults age ≥20 years with diabetes was 5.2, which is higher than the number of prescription drugs in those with undiagnosed diabetes (3.7), prediabetes (3.0), and no diabetes (2.6) (Figure 39.4 and Table 39.3, age-standardized; Appendix 39.1; Appendix 39.2, crude estimates).

Hypertension Treatment

Hypertension is highly prevalent in the U.S. population and even more common among adults with diabetes. Overall, among adults age ≥18 years in the United States in 2005–2008, the age-standardized prevalence of hypertension, based on current medication use for hypertension or blood pressure >140/90 mmHg, was 29.9% (20). In 2001–2008, the age-standardized prevalence of hypertension among adults with diagnosed diabetes was 67.3% (21). In 2005–2010, 57.9% of adults with diagnosed diabetes and 40.1% of adults with undiagnosed diabetes self-reported hypertension (Table 39.3, age-standardized; Appendix 39.2, crude estimates). This prevalence was much higher than self-report of hypertension among adults with prediabetes (33.7%) or no diabetes (24.1%) (Table 39.3, age-standardized; Appendix 39.2, crude estimates).

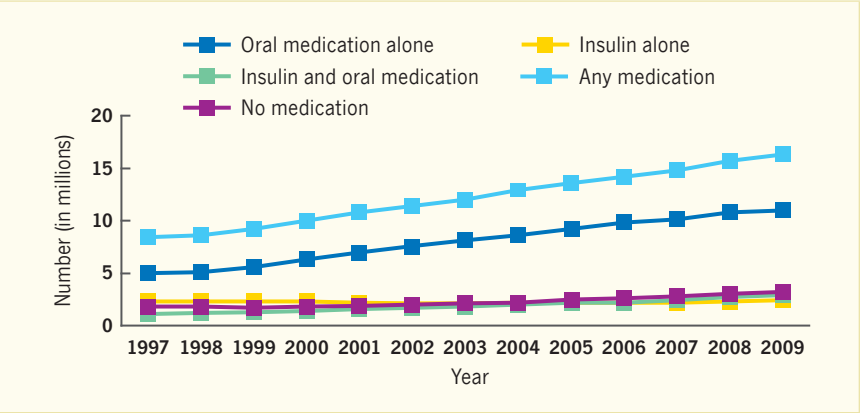
Controlling hypertension is important to prevent CVD events, kidney disease, and retinopathy (4,22,23,24). In 2005–2010

TABLE 39.2. Prevalence of Oral Diabetes Medications Among Adults Age ≥20 Years With Diabetes, U.S., 2005–2010

CHARACTERISTICS	PERCENT (STANDARD ERROR)			
	Sulfonylureas	Non-sulfonylureas	Thiazolidinediones	Other Medications*
Overall	35.7 (1.50)	49.1 (1.75)	19.4 (1.29)	9.0 (0.97)
Age (years)				
20–44	20.4 (3.20)	43.8 (3.35)	12.3 (3.22)	7.2 (2.07)
45–64	34.7 (2.14)	54.3 (2.61)	23.0 (2.21)	10.9 (1.53)
65–74	39.0 (2.34)	51.2 (3.39)	19.6 (2.22)	8.2 (1.46)
≥75	47.5 (2.86)	35.7 (2.85)	15.0 (2.03)	6.1 (1.15)
Sex				
Male	35.6 (2.10)	47.3 (2.45)	20.5 (1.95)	8.2 (1.34)
Female	35.7 (1.96)	50.8 (2.32)	18.3 (1.77)	9.6 (1.33)
Race/ethnicity				
Non-Hispanic white	35.1 (1.76)	50.3 (2.15)	21.1 (1.71)	9.1 (1.58)
Non-Hispanic black	36.3 (1.90)	48.0 (2.80)	17.8 (1.57)	10.5 (1.38)
All Hispanic	36.5 (2.92)	47.0 (2.62)	14.2 (2.27)	9.2 (1.88)
Mexican American	38.0 (2.30)	46.9 (2.83)	12.3 (2.08)	11.0 (2.62)

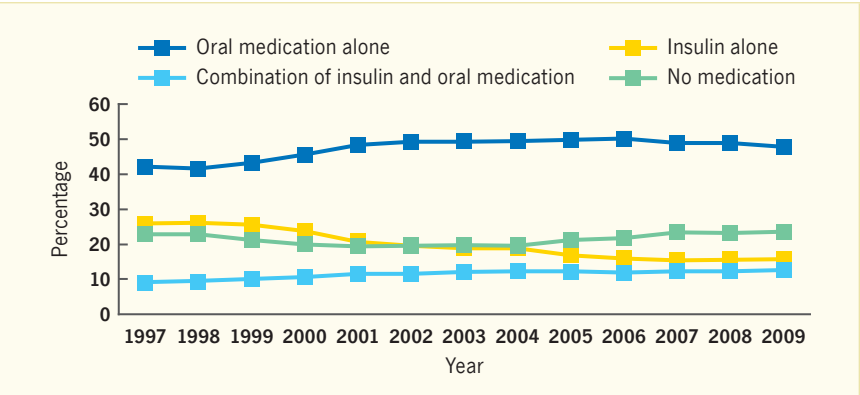
Diabetes is self-reported. Estimates are weighted to the noninstitutionalized U.S. population.
* Includes exenatide, pramlintide, meglitinides, and alpha-glucosidase inhibitors. Information on dipeptidyl peptidase-4 inhibitors is not collected in the National Health and Nutrition Examination Survey.
SOURCE: National Health and Nutrition Examination Surveys 2005–2010

FIGURE 39.2. Number in Millions of Adults Age ≥20 Years With Diabetes, by Diabetes Medication Status, U.S., 1997–2009



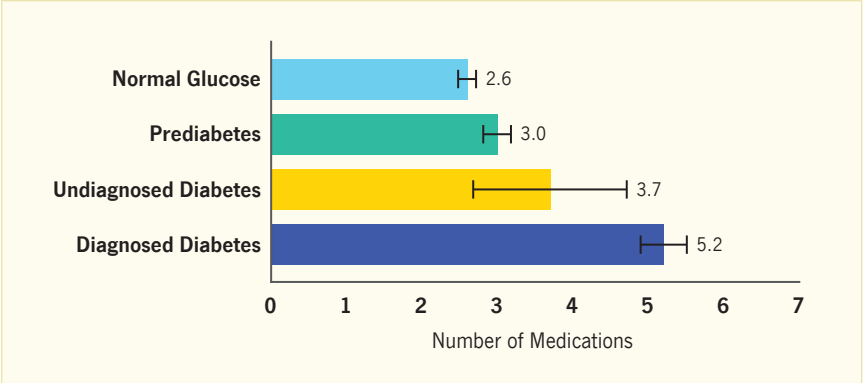
Diabetes is self-reported. Estimates are weighted to the noninstitutionalized U.S. population.
SOURCE: Reference 11

FIGURE 39.3. Age-Standardized Percentage of Adults Age ≥20 Years With Diabetes Using Diabetes Medication, by Type of Medication, U.S., 1997–2009



Diabetes is self reported. Data are age-standardized to the 2000 U.S. Standard Population. Estimates are weighted to the noninstitutionalized U.S. population.
SOURCE: Reference 12

FIGURE 39.4. Age-Standardized Mean Number of Medications Among Adults Age ≥20 Years, by Diabetes Status, U.S., 2005–2010



Data are standardized to the age distribution (20–44, 45–64, ≥65 years) of the National Health Interview Survey 2010 overall population. Diagnosed diabetes is based on self-report. Undiagnosed diabetes is based on A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL; prediabetes is based on A1c 5.7%–6.4% or fasting plasma glucose 100–125 mg/dL; and normal glucose is based on A1c <5.7% and fasting plasma glucose <100 mg/dL. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions.* A1c, glycosylated hemoglobin.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

TABLE 39.3. Age-Standardized Prevalence of Diabetes Comorbidities and Associated Medication Use Among Adults Age ≥20 Years, by Diabetes Status, U.S., 2005–2010

MEDICATION*	DIAGNOSED DIABETES†	UNDIAGNOSED DIABETES‡	PREDIABETES‡	NORMAL GLUCOSE‡
Mean number of medications (standard error)	5.2 (0.15)	3.7 (0.50)	3.0 (0.09)	2.6 (0.06)
Percent (standard error)				
Self-report hypertension	57.9 (2.39)	40.1 (4.30)	33.7 (1.30)	24.1 (0.99)
Any hypertension medication	60.4 (2.01)	34.9 (3.15)	29.3 (1.00)	17.9 (0.76)
Diuretics	25.3 (1.72)	22.3 (3.34)	13.2 (0.64)	7.7 (0.62)
ARBs	12.7 (1.24)	9.1 (1.69)	6.9 (0.76)	4.0 (0.42)
CCBs	13.2 (1.35)	8.5 (1.41)	7.0 (0.55)	4.4 (0.43)
Beta blockers	20.9 (1.53)	14.8 (2.37)	11.5 (0.55)	6.5 (0.66)
ACE inhibitors	36.3 (2.08)	10.3 (0.97)	11.6 (0.66)	5.5 (0.52)
Other	18.2 (1.52)	15.0 (2.61)	9.8 (0.74)	5.2 (0.53)
Self-report high cholesterol	54.1 (1.75)	31.0 (2.94)	31.4 (1.05)	25.4 (0.97)
Any cholesterol medication	45.1 (2.17)	21.1 (1.87)	16.7 (0.87)	9.8 (0.70)
Statins	41.8 (2.08)	18.9 (2.01)	15.6 (0.89)	8.9 (0.64)
Central nervous system medications	32.2 (2.25)	22.3 (3.45)	20.4 (1.24)	17.5 (0.78)
Psychotherapeutics	19.6 (1.99)	8.7 (2.80)[1]	10.1 (0.87)	12.2 (0.75)
Depression	19.0 (1.99)	8.6 (2.84)[1]	9.6 (0.86)	11.6 (0.80)
Respiratory	18.0 (2.00)	15.5 (2.83)	12.7 (0.99)	11.1 (0.70)
Gastrointestinal	22.4 (2.16)	11.8 (2.61)	12.6 (0.82)	10.3 (0.73)
Hormones	21.5 (1.91)	7.2 (1.62)	12.7 (0.72)	15.2 (1.02)

Data are standardized to the age distribution (20–44, 45–64, ≥65 years) of the National Health Interview Survey 2010 overall population. Estimates are weighted to the noninstitutionalized U.S. population. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions.* A1c, glycosylated hemoglobin; ACE inhibitor, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; CCB, calcium channel blocker.

* A detailed list of medications included in each category is available in Appendix 39.1.

† Diagnosed diabetes is based on self-report.

‡ Undiagnosed diabetes is based on A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL; prediabetes is based on A1c 5.7%–6.4% or fasting plasma glucose 100–125 mg/dL; and normal glucose is based on A1c <5.7% and fasting plasma glucose <100 mg/dL.

[1] Relative standard error >30%–40%

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

among adults age ≥20 years with diagnosed diabetes, 60.4% reported taking any medication typically prescribed for hypertension (Table 39.3, age-standardized; Appendix 39.2, crude estimates). Prevalence of hypertension medication use, based on a survey of prescription medications in the NHANES, increased across the spectrum of diabetes status, as defined by increasing glucose levels from no diabetes to undiagnosed diabetes. Adults age ≥20 years with no diabetes had the lowest hypertension medication use (17.9%), followed by adults with prediabetes (29.3%). Adults with undiagnosed diabetes, as defined by not self-reporting diagnosis but having blood glucose levels that indicated diabetes, also had a high prevalence of any hypertension medication use (34.9%) (Table 39.3, age-standardized; Appendix 39.2, crude estimates).

A number of different prescription medications are typically used to control blood pressure: thiazide diuretics, beta blockers, angiotensin-converting enzyme (ACE) inhibitors, angiotensin II receptor blockers (ARBs), calcium channel blockers (CCBs), and renin inhibitors (25). The most common hypertension medications taken by diabetic patients are ACE inhibitors, followed by diuretics, beta blockers, CCBs, and ARBs.

Cholesterol Treatment

In 2005–2010, over half of adults age ≥20 years with diagnosed diabetes self-reported high cholesterol (54.1%) (Table 39.3, age-standardized; Appendix 39.2, crude estimates). The prevalence of self-reported high cholesterol was also high among adults with undiagnosed diabetes (31.0%) and prediabetes (31.4%), and lowest among adults with no diabetes (25.4%).

Control of cholesterol levels is recommended both for adults with and without diabetes (5,26). Control of cholesterol levels among adults with diabetes is associated with lower risk of CVD events (27,28,29). Almost half of adults with diabetes (45.1%) used some type of cholesterol-lowering medication (Table 39.3, age-standardized; Appendix 39.2, crude

estimates). Similar to hypertension medications, the prevalence of use was lowest among adults with no diabetes (9.8%), followed by prediabetes (16.7%), and undiagnosed diabetes (21.1%). Statins were the most commonly used cholesterol-lowering medication regardless of diabetes status.

Other Prescribed Medications

In addition to medications for hypertension and high cholesterol, adults with diagnosed diabetes might also take medications related to the central nervous system; respiratory agents; gastrointestinal agents; hormones; and psychotherapeutic medications, including those for depression (see the detailed list of medications from the NHANES 2005–2010 in Appendix 39.1) (Table 39.3, age-standardized; Appendix 39.2 crude estimates). In general, the proportion of adults taking these medications in 2005–2010 was highest among those with diagnosed diabetes. Many conditions associated with these medications occur at a higher prevalence among adults with diabetes compared to the general population. For example, thyroid dysfunction commonly occurs in patients with type 1 diabetes, as autoimmune disease in one endocrine organ increases the predisposition for other autoimmune endocrine disorders. The prevalence of hypothyroidism among people with diabetes was 10% compared to 6.6% among the general population (30).

The relationship between diabetes and depression is complex, with some studies showing that diabetes may lead to depression and other studies showing that depression may lead to diabetes (18,31,32,33). The association of diabetes and depression is described in Chapter 33 *Psychiatric and Psychosocial Issues Among Individuals Living With Diabetes*. Regardless of the direction of causality, the age-standardized prevalence of antidepressant use in 2005–2010 was 19.0% or almost 1 in 5 adults with diabetes (Table 39.3, age-standardized; Appendix 39.2, crude estimates). This was higher than the prevalence for adults with undiagnosed diabetes (8.6%), prediabetes (9.6%), and no diabetes (11.6%).

TABLE 39.4. Prevalence of Low-Dose Aspirin Usage Among Adults Age ≥40 Years With Diagnosed Diabetes, U.S., 2012

CHARACTERISTICS	PERCENT (STANDARD ERROR)		
	Medically Advised To Take Low-Dose Aspirin	Medically Advised To Take Low-Dose Aspirin and Currently Following Advice	Currently Taking Low-Dose Aspirin on Own*
Overall	61.3 (1.13)	52.2 (1.18)	10.8 (1.24)
Age (years)			
40–64	54.3 (1.52)	45.8 (1.63)	9.6 (1.47)
65–74	70.6 (2.03)	61.1 (2.12)	13.9 (2.78)
≥75	71.2 (2.23)	60.8 (2.47)	12.6 (3.55)
Sex			
Male	62.7 (1.70)	54.6 (1.76)	13.2 (2.00)
Female	60.0 (1.43)	50.0 (1.54)	8.7 (1.57)
Race/ethnicity			
Non-Hispanic white	65.4 (1.42)	55.0 (1.50)	13.5 (1.91)
Non-Hispanic black	55.3 (2.32)	48.5 (2.24)	9.0 (2.19)
All Hispanic	54.1 (2.60)	47.3 (2.75)	6.1 (1.86)[1]
Education			
<High school	58.9 (2.22)	50.8 (2.25)	6.6 (1.83)
High school	61.4 (1.99)	51.4 (2.11)	9.2 (1.77)
>High school	62.5 (1.71)	53.4 (1.81)	14.0 (2.08)
Diabetes duration			
<10 years	57.4 (1.68)	48.7 (1.70)	9.3 (1.50)
≥10 years	66.2 (1.52)	56.8 (1.63)	13.2 (2.05)
History of CVD			
Yes	83.7 (1.81)	76.2 (2.04)	14.6 (4.36)
No	54.3 (1.33)	44.8 (1.31)	10.3 (1.27)

Diabetes is self-reported. CVD, cardiovascular disease.
* Among those not advised to take aspirin.
[1] Relative standard error >30%–40%
SOURCE: National Health Interview Survey 2012

Prophylactic Aspirin Use

The use of prophylactic aspirin to prevent CVD among individuals with diabetes is recommended for individuals at higher risk of CVD, defined as being age ≥40 years or with additional risk factors (5,6). However, potential benefits of primary or secondary CVD reduction must also be balanced by potential risks, such as bleeding and gastrointestinal symptoms (34,35).

Almost two-thirds of adults age ≥40 years with diagnosed diabetes reported being medically advised to take low-dose aspirin as a prophylactic for CVD (61.3%) (Table 39.4). Adults with diagnosed diabetes who reported being advised to take aspirin tended to be age ≥75 years, non-Hispanic white, had longer duration of diabetes, and had a history of CVD. However, only 52.2% of adults age ≥40 years with diagnosed diabetes who received this advice reported currently following it. Adults with diabetes and a history of CVD were most likely to report currently taking aspirin after being advised to (76.2%). There was a small percentage of adults age ≥40 years with diagnosed diabetes who were not advised to take a low dose of aspirin who report taking it on their own (10.8%). This was somewhat more common among individuals age ≥65 years, men, non-Hispanic whites, high school graduates, and those with diabetes duration ≥10 years.

SELF-CARE PRACTICES

Diabetes self-care practices are important for preventing diabetes complications by improving glycemic control, increasing awareness and knowledge of the complication, and identifying early symptoms (36,37). One of the first studies to look specifically at these questions in the United States found that few adults with diabetes in 1989 attended a diabetes education class (35%), reported having their eyes checked (49%), or monitored their glucose daily (39.5% among adults type 1 diabetes and 5.3% among adults with type 2 diabetes and not taking insulin) (38). Estimates of diabetes self-care practices are derived from the BRFSS 2010. These practices include diabetes education, self-monitoring of glucose levels, receiving a foot exam by a health professional, self-foot exams, dilated eye exam, annual influenza vaccine, and ever receiving the pneumococcal vaccine (Table 39.5) (39). More than half of adults with diagnosed diabetes report ever taking a course or class in diabetes self-management (57.4%). In 2010, the majority of adults with diagnosed diabetes reported receiving a dilated eye exam in the last year (62.8%), daily self-monitoring for blood glucose (63.6%), and receiving a foot exam by a health care professional in the last year (67.5%). Half of adults with diagnosed diabetes reported receiving an annual influenza vaccination (50.1%), but only 42% reported ever receiving the pneumococcal vaccine.

Diabetes duration likely impacts diabetes self-care practices (Table 39.6) (39). In 2010, adults who reported diabetes duration of ≥10 years were more likely to have completed some type of diabetes education (61.7%), whereas only half of adults with diabetes <10 years reported completing diabetes education (50.0%). Adults who reported diabetes duration of ≥10 years were more likely to report daily (69.7%) and weekly (86.2%) self-foot exams compared to adults with diabetes duration <10 years (63.0% daily and 79.2% weekly). Self-monitoring of glucose is considered standard established practice for patients with type 1 diabetes and recommended for patients with type 2 diabetes (40,41,42). Self-monitoring of glucose was more common among adults with longer duration of diabetes (72.3% for duration ≥10 years vs. 57.3% for duration <10 years) (Table 39.6). Analyses of the BRFSS 2006 found that self-monitoring of glucose was lower among men, those with less than a high school education, those with no health insurance coverage, report of taking no medication or oral medication only, having two or fewer doctor visits annually, and not attending a diabetes education course. Self-monitoring of glucose also differs by state. During 2006, the state-specific rates of self-monitoring of glucose among adults with diabetes ranged from 47.1% to 78.2% (43).

TRENDS IN SELF-CARE PRACTICES

Overall, the percentage of adults with diabetes who reported self-care practices of glucose monitoring and received a foot exam from a health care professional increased from 2000 to 2010 based on the BRFSS (Figure 39.5) (39). For example, the percentage of adults who reported

TABLE 39.5. Prevalence of Preventive Care Practices Among Adults Age ≥18 Years With Diagnosed Diabetes, U.S., 2010

	PERCENT (STANDARD ERROR)								
CHARACTERISTICS	Received Dilated Eye Exam in Past Year	Performed Daily Self-Monitoring of Blood Glucose	Received a Foot Exam in the Past Year	Visited a Doctor for Diabetes at Least Once in the Past Year	Performed Daily Self-Exam of Feet	Had Two or More A1c Tests in the Last Year	Ever Attended a Diabetes Self-Management Class	Received an Influenza Vaccine in the Past Year	Ever Received Pneumococcal Vaccine
Overall	62.8 (1.1)	63.6 (1.1)	67.5 (1.1)	84.9 (0.01)	61.1 (1.1)	68.5 (1.1)	57.4 (1.0)	50.1 (0.8)	42.5 (0.8)
Age (years)									
18–44	56.5 (1.9)	63.8 (1.9)	62.5 (1.9)	81.6 (1.7)	56.8 (2.0)	63.5 (2.0)	60.3 (1.9)	40.9 (1.4)	29.8 (1.4)
45–64	65.7 (0.7)	62.2 (0.7)	72.8 (0.7)	89.2 (0.5)	66.8 (0.7)	72.4 (0.7)	56.0 (0.8)	54.6 (0.6)	47.0 (0.6)
65–74	74.8 (0.8)	65.2 (0.9)	74.9 (0.8)	89.4 (0.5)	66.7 (0.9)	78.2 (0.8)	55.0 (0.9)	67.7 (0.7)	69.1 (0.7)
≥75	80.3 (0.8)	65.7 (0.9)	72.1 (0.9)	86.2 (0.7)	62.6 (1.0)	75.7 (0.9)	46.8 (1.0)	74.7 (0.7)	79.5 (0.6)
Sex									
Male	64.8 (1.6)	59.6 (1.7)	66.8 (1.7)	83.1 (1.5)	59.1 (1.7)	67.5 (1.7)	56.5 (1.6)	48.5 (1.2)	42.0 (1.2)
Female	60.7 (1.3)	67.8 (1.2)	68.1 (1.2)	86.9 (1.0)	63.2 (1.3)	69.5 (1.3)	58.3 (1.3)	51.8 (1.0)	43.1 (0.9)
Race/ethnicity									
Non-Hispanic white	63.6 (1.3)	63.5 (1.3)	66.6 (1.4)	84.3 (1.2)	60.2 (1.4)	68.9 (1.4)	58.7 (1.3)	50.9 (0.9)	43.7 (0.9)
Non-Hispanic black	63.5 (1.2)	69.8 (2.2)	73.8 (2.1)	89.0 (1.8)	68.6 (2.1)	71.1 (2.2)	57.8 (2.1)	47.7 (1.8)	41.1 (1.8)
Hispanic	55.4 (3.0)	56.9 (3.0)	55.7 (3.0)	82.8 (2.7)	59.5 (3.0)	59.1 (3.1)	45.8 (3.0)	39.3 (1.7)	30.5 (1.8)
Education									
<High school	50.6 (3.1)	59.6 (3.3)	59.1 (3.2)	77.3 (3.4)	59.7 (3.3)	54.4 (3.2)	41.1 (3.1)	40.9 (2.0)	35.6 (2.1)
High school	60.3 (1.8)	66.2 (1.7)	67.8 (1.7)	85.4 (1.5)	64.3 (1.7)	67.5 (1.8)	56.0 (1.7)	47.6 (1.4)	40.4 (1.3)
>High school	67.8 (1.3)	63.4 (1.3)	70.0 (1.4)	87.0 (0.9)	60.0 (1.4)	72.8 (1.3)	63.2 (1.3)	54.1 (1.0)	45.7 (1.0)

Diabetes is self-reported. Data are age-standardized to the 2000 U.S. Standard Population. Age-specific estimates are not age-standardized. Estimates are weighted to the non-institutionalized U.S. population. A1c, glycosylated hemoglobin.

SOURCE: Reference 39

daily self-monitoring of glucose increased from 48.4% in 2000 to 63.6% in 2010. Over the same period, the prevalence of receiving a foot exam by a health care professional within the last year also increased (61.3% to 67.5%). However, other self-care practices, such as annual dilated eye exams, ever attending a diabetes self-management class, annual visits to the doctor, and daily self-exam of feet, remained relatively stable from 2000 to 2010 (Figure 39.5) (39). The 2014 American Diabetes Association Standards of Care recommend an annual eye exam only for individuals with type 1 diabetes and for individuals with type 2 diabetes with retinopathy (5).

BARRIERS TO SELF-CARE

Many barriers to diabetes self-care have been identified, including caring for young children, dependent adults, and/or workplace responsibilities. The Translating Research into Action for Diabetes (TRIAD) is a national, multicenter prospective study that provides useful information about effective treatments and better care for people with diabetes in managed care settings (44). Researchers for the TRIAD study asked study participants about these competing demands and examined how they affected diabetes care (45). Participants were grouped by whether they had other caregiving responsibilities (i.e., young children or dependent adults) or workplace responsibilities, had both, or had neither. Among women, those who had any caregiving responsibilities with or without employment responsibilities had higher A1c levels (average A1c, 8.2% [66 mmol/mol]) than women with no caregiving responsibilities (average A1c, 7.9% [63 mmol/mol]). Among men, any additional demands as a caregiver were associated with higher A1c levels (average A1c, 8.0%–8.3% [64–67 mmol/mol]) compared to those with no additional demands as a caregiver (average A1c, 7.8% [62 mmol/mol]). There was no significant association of additional demands with blood pressure or cholesterol levels. In general, having both caregiving and employment responsibilities was associated with lower levels of diabetes self-management. An additional aspect of barriers to diabetes self-care practices is the residential or neighborhood environment. A study of TRIAD participants found that neighborhoods where the participants perceived more problems, as defined by higher crime and less access to exercise facilities and supermarkets, were more likely to be associated with higher blood pressure and current smoking (46).

National surveys of adults with diabetes may not always capture differences in diabetes care practices. The quality of diabetes care may also differ by type of health care organization (47,48,49). In addition, socioeconomic disparities are associated with diabetes self-care activities. For 44,181 patients with diabetes in managed care, TRIAD investigators found that lower education levels were associated with being a current smoker, getting less regular exercise, and being less likely to engage in health-seeking behavior. No significant differences by educational level for foot exams or daily self-blood glucose monitoring were observed (50).

An analysis of the NHANES 2007–2008 examined the proportion of adults with diabetes, defined by either self-reported diagnosis or by A1c ≥6.5% (≥48 mmol/mol), who were asked whether they received medical advice to control or lose

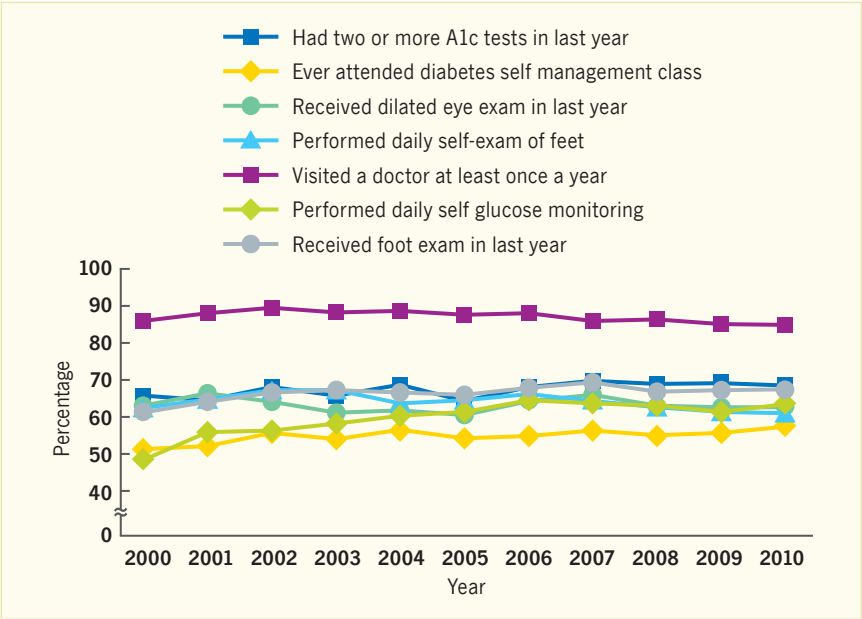
TABLE 39.6. Prevalence of Self-Care Practices Among Adults Age ≥18 Years, by Diabetes Duration, U.S., 2010

SELF-CARE PRACTICE	PERCENT (STANDARD ERROR)	
	<10 Years Diabetes Duration	≥10 Years Diabetes Duration
Ever attended a diabetes self-management class	50.0 (0.7)	61.7 (0.7)
Foot self-exam		
≥1/day	63.0 (0.7)	69.7 (0.7)
≥1/week	79.2 (0.6)	86.2 (0.5)
Self-monitoring of glucose ≥1/day	57.3 (0.7)	72.3 (0.7)

Estimates are weighted to the noninstitutionalized U.S. population.

SOURCE: Reference 39

FIGURE 39.5. Self-Care Practices Among Adults Age ≥18 Years With Diagnosed Diabetes, U.S., 2000–2010



Diabetes is self-reported. Data are age-standardized to the 2000 U.S. Standard Population. Estimates are weighted to the non-institutionalized U.S. population. A1c, glycosylated hemoglobin.

SOURCE: Reference 39

weight, exercise, or reduce calories from fats. One-third of adults with diabetes reported not receiving any advice on diet, exercise or weight management (51). The study also found differences in advice received according to body mass index (BMI). For example, 33.5% of adults with diabetes and a BMI in the highest quartile reported receiving advice to control weight compared to 29.1% of adults with BMI in the lowest quartile. Those who did receive advice on how to control or lose weight, exercise, or reduce calories from fat, were 4–8 times more likely to report practicing these behaviors compared to those who did not receive this advice (51).

MEDICATION ADHERENCE

An additional aspect of diabetes self-care practices is medication adherence. Medication adherence is typically defined as whether or not a patient takes his or her medication as prescribed in terms of dosage, length of time, and frequency (52,53). Medication adherence or nonadherence among individuals with diabetes is likely influenced by a number of factors, including cost, comorbidities, number of medications, and health literacy (54). In a study of patients with diabetes in a managed care organization, medication nonadherence was associated with increased risk for adverse outcomes, including higher hospitalization rates. Medication nonadherence is also associated with emergency room visits. Analysis of the National Hospital Ambulatory Care Surveys 2006–2007 found that 0.13% of all emergency room visits were due to medication nonadherence. Diabetes was the primary diagnosis for 5.95% (or 25,395 visits) of all emergency room visits related to medication nonadherence (55). Just as medication nonadherence is associated with increased risk of adverse outcomes, medication adherence is associated with improved outcomes. One study found that individuals who practiced diabetes self-care practices were also more likely to have high medication adherence (56).

PANCREAS AND ISLET CELL TRANSPLANTS

Pancreas transplants are sometimes indicated for individuals who have type 1 diabetes and in rare cases for individuals with type 2 diabetes. No data are available on the intensity of multiple daily insulin injections for individuals prior to considering a pancreas transplant. The overall goal of pancreas transplants is to restore normoglycemia by replacing part of the lost beta cell mass. A pancreatic transplant involves considerable risk, since it requires immunosuppression medications and can be rejected by the recipient (57). This procedure is primarily indicated for individuals with type 1 diabetes whose beta cells have been permanently destroyed (58). The pancreas in those with type 1 diabetes no longer produces insulin, whereas in people with type 2 diabetes, insulin production by the pancreas may still be possible. When successful, pancreatic transplants often mean that the patients no longer need daily insulin treatment.

TABLE 39.7. Selected Characteristics of Patients Who Underwent a Primary Pancreas Transplant Using a Deceased Donor, 2004–2008

CHARACTERISTICS	SIMULTANEOUS PANCREAS-KIDNEY	PANCREAS AFTER KIDNEY	PANCREAS TRANSPLANT ALONE
Number primary transplants (%)	4,320 (73)	1,148 (19)	494 (8)
Recipient age (years, %)			
15–29	7	5	15
30–44	56	55	48
45–59	36	39	34
≥60	1	1	3
Male (%)	63	58	41
Race (%)			
White	73	85	94
African American	15	8	3
Hispanic	7	3	1
Asian	1	0	0
American Indian	1	0	0
Type of diabetes (%)			
Type 1	91	94	93
Type 2	7	4	3
Other	1	1	3
Diabetes duration (years, %)			
0–19	20	13	33
20–39	72	77	55
40–59	8	10	12

SOURCE: Reference 57, copyright © 2010 Wolters Kluwer Health, reprinted with permission

In the United States, the rate of pancreas transplants has increased from fewer than 200 per year in the 1970s and 1980s to more than 1,200 in 2009. The majority of patients who underwent pancreas transplant were age 30–59 years, were white, and had type 1 diabetes (Table 39.7) (57). Data on pancreatic transplants are reported to the International Pancreatic Transplant Registry, which is maintained by the University of Arizona (57). There are three types of pancreatic transplants: simultaneous pancreas-kidney transplant, pancreas after kidney transplant (PAK), and pancreas transplant alone (PTA). From 2004 to 2008, more than 90% of pancreas transplant recipients had type 1 diabetes. The majority of individuals having a transplant had duration of diabetes 20–39 years, followed by individuals with duration <20 years, and those with duration 40–59 years. The characteristics of individuals who have a pancreatic transplant differ by the type of transplant, with significantly more whites than nonwhites undergoing PAK or PTA transplants (57,59).

Pancreatic islet cell transplants are another type of transplant option for individuals with type 1 diabetes. During the procedure, islets from the pancreas of a deceased organ donor are purified, processed, and transferred into another person. As of 2013, the procedures were still considered experimental by the FDA and performed at hospitals receiving approval from the FDA (60,61,62).

Pancreatic islet cell transplants are tracked through the Collaborative Islet Transplant Registry. There were 571 transplants from 1999 to 2009 (60).

BARIATRIC SURGERY TO TREAT DIABETES

Bariatric surgery may be appropriate in some cases to treat type 2 diabetes (63,64,65). Clinical trials have found remission of type 2 diabetes among morbidly obese patients with type 2 diabetes who underwent bariatric surgery (66,67,68). Less is known on the effectiveness of bariatric surgery to treat diabetes among those who are nonmorbidly obese (69,70). How common this procedure is among obese U.S. residents with diabetes is unknown. Overall in 2002–2004, it was estimated that more than 60,000 bariatric procedures were performed among adults age 18–44 years and more than 40,000 among those age 45–64 years (Table 39.8). Among obese adults with diagnosed diabetes, there were over 20,000 procedures performed from 2002–2004. Bariatric procedures may be performed in inpatient or outpatient settings. These estimates include only inpatient procedures based on the National Hospital Discharge Survey, and the total number of bariatric procedures performed is likely to be greater than these estimates (71,72).

TABLE 39.8. Number of Obese People Age 18–64 Years Who Had Bariatric Surgery, by Diagnosed Diabetes and Age Group, 2002–2004

	OVERALL	DIABETES	NO DIABETES
Overall	106,242	22,756	83,486
Age (years)			
18–44	63,602	9,572	54,030
45–64	42,640	13,184	29,456

Obesity is defined as ICD-9 codes 278.00 and 278.01. Diabetes is defined as ICD-9 codes 250, 357.2, 362.0, 366.41, 648.0, and 775.1. Bariatric surgery is defined as ICD-9 procedure codes 43.7, 43.89, 44.31, 44.39, 44.68, 44.69, and 44.95–44.98. ICD-9, International Classification of Diseases, Ninth Revision.

SOURCE: National Hospital Discharge Surveys 2002–2004

LIST OF ABBREVIATIONS

A1c. . . . . .glycosylated hemoglobin
ACE . . . . . .angiotensin-converting enzyme
ARB . . . . . .angiotensin II receptor blocker
BMI . . . . . .body mass index
BRFSS . . . . . .Behavioral Risk Factor Surveillance System
CCB . . . . . .calcium channel blocker
CVD . . . . . .cardiovascular disease
DPP-4 . . . . . .dipeptidyl peptidase-4
FDA . . . . . .Food and Drug Administration
NHANES . . . . .National Health and Nutrition Examination Survey
NHIS . . . . . .National Health Interview Survey
PAK . . . . . .pancreas after kidney transplant
PTA . . . . . .pancreas transplant alone
TRIAD. . . . . .Translating Research into Action for Diabetes study

CONVERSIONS

Conversions for A1c values are provided in *Diabetes in America Appendix 1 Conversions*.

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DUALITY OF INTEREST

Dr. Saydah reported no conflicts of interest.

REFERENCES

1. National health and nutrition examination survey [article online], 2012. Available from *http://www.cdc.gov/nchs/nhanes.htm*. Accessed 19 June 2012
2. Diabetes Control and Complications Trial Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 329:977–986, 1993
3. Stratton IM, Adler AI, Neil HA, Matthews DR, Manley SE, Cull CA, Hadden D, Turner RC, Holman RR: Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 321:405–412, 2000
4. Adler AI, Stratton IM, Neil HA, Yudkin JS, Matthews DR, Cull CA, Wright AD, Turner RC, Holman RR: Association of systolic blood pressure with macrovascular and microvascular complications of type 2 diabetes (UKPDS 36): prospective observational study. *BMJ* 321:412–419, 2000
5. American Diabetes Association: Standards of medical care in diabetes—2014. *Diabetes Care* 37:S14–S80, 2014
6. Buse JB, Ginsberg HN, Bakris GL, Clark NG, Costa F, Eckel R, Fonseca V, Gerstein HC, Grundy S, Nesto RW, Pignone MP, Plutzky J, Porte D, Redberg R, Stitzel KF, Stone NJ; American Heart Association; American Diabetes Association: Primary prevention of cardiovascular diseases in people with diabetes mellitus: a scientific statement from the American Heart Association and the American Diabetes Association. *Diabetes Care* 30:162–172, 2007
7. Qaseem A, Humphrey LL, Sweet DE, Starkey M, Shekelle P; Clinical Guidelines Committee of the American College of Physicians: Oral pharmacologic treatment of type 2 diabetes mellitus: a clinical practice guideline from the American College of Physicians. *Ann Intern Med* 156:218–231, 2012
8. Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, Peters AL, Tsapas A, Wender R, Matthews DR: Management of hyperglycemia in type 2 diabetes: a patient-centered approach: position statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 35:1364–1379, 2012
9. DeFronzo RA: Current issues in the treatment of type 2 diabetes. Overview of newer agents: where treatment is going. *Am J Med* 123(3 Suppl):S38–S48, 2010
10. Design and estimation for the National Health Interview Survey, 1995–2004. *Vital Health Stat* 2:1–31, 2000
11. Diabetes Public Health Resource: Number (in millions) of adults with diabetes by diabetes medication status, United States, 1997–2011 [article online], 2012. Available from *http://www.cdc.gov/diabetes/statistics/meduse/fig1.htm*. Accessed 29 April 2015
12. Diabetes Public Health Resource: Crude and age-adjusted percentage of adults with diabetes using diabetes medication, by type of medication, United States, 1997–2011 [article online], available from *http://www.cdc.gov/diabetes/statistics/meduse/dtltable2.htm*. Accessed 29 April 2015
13. Nathan DM, Buse JB, Davidson MB, Ferrannini E, Holman RR, Sherwin R, Zinman B: Medical management of hyperglycemia in type 2 diabetes: a consensus algorithm for the initiation and adjustment of therapy: a consensus statement of the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 32:193–203, 2009
14. Nathan DM, Buse JB, Davidson MB, Heine, RJ, Holman RR, Sherwin R, Zinman B: Management of hyperglycemia in type 2 diabetes: A consensus algorithm for the initiation and adjustment of therapy: a consensus statement from the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 29:1963–1972, 2006
15. Desai NR, Shrank WH, Fischer MA, Avorn J, Liberman JN, Schneeweiss S, Pakes J, Brennan TA, Choudhry NK: Patterns of medication initiation in newly diagnosed diabetes mellitus: quality and cost implications. *Am J Med* 125:302.e1–7, 2012
16. Hampp C, Borders-Hemphill V, Moeny DG, Wysowski DK: Use of antidiabetic drugs in the U.S., 2003–2012. *Diabetes Care* 37:1367–1374, 2014
17. Turner LW, Nartey D, Stafford RS, Singh S, Alexander GC: Ambulatory treatment of type 2 diabetes mellitus in the U.S., 1997–2012. *Diabetes Care* 37:985–992, 2014
18. Egede LE, Dismuke CE: Serious psychological distress and diabetes: a review of the literature. *Curr Psychiatry Rep* 14:15–22, 2012
19. Cheng YJ, Imperatore G, Caspersen CJ, Gregg EW, Albright AL, Helmick CG: Prevalence of diagnosed arthritis and arthritis-attributable activity limitation among adults with and without diagnosed diabetes: United States, 2008–2010. *Diabetes Care* 35:1686–1691, 2012
20. Keenan N, Rosendorf K: Prevalence of hypertension and controlled hypertension—United States, 2005–2008. *MMWR Surveill Summ* 60:94–97, 2011
21. Wang J, Geiss LS, Cheng YJ, Imperatore G, Saydah SH, James C, Gregg EW: Long-term and recent progress in blood pressure levels among U.S. adults with diagnosed diabetes, 1988–2008. *Diabetes Care* 34:1579–1581, 2011
22. Hansson L, Zanchetti A, Carruthers SG, Dahlöf B, Elmfeldt D, Julius S, Ménard J, Rahn KH, Wedel H, Westerling S; HOT Study Group: Effects of intensive blood-pressure lowering and low-dose aspirin in patients with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomised trial. *Lancet* 351:1755–1762, 1998
23. UK Prospective Diabetes Study (UKPDS) Group: Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 352:837–853, 1998
24. UK Prospective Diabetes Study (UKPDS) Group: Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ* 317:703–713, 1998
25. High blood pressure: treatment and medication [article online], 2012. Available from *http://www.mayoclinic.com/health/high-blood-pressure/DS00100/DSECTION=treatments-and-drugs*. Accessed 19 June 2012
26. Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation and treatment of high cholesterol in adults (Adult Treatment Panel III) final report. *Circulation* 106:3143–3421, 2002
27. Sacks FM, Moye LA, Davis BR, Cole TG, Rouleau JL, Nash DT, Pfeffer MA, Braunwald E: Relationship between plasma LDL concentrations during treatment with pravastatin and recurrent coronary events in the Cholesterol and Recurrent Events trial. *Circulation* 97:1446–1452, 1998

28. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). *Lancet* 344:1383–1389, 1994
29. Downs JR, Clearfield M, Weis S, Whitney E, Shapiro DR, Beere PA, Langendorfer A, Stein EA, Kruyer W, Gotto AM, Jr.: Primary prevention of acute coronary events with lovastatin in men and women with average cholesterol levels: results of AFCAPS/TexCAPS. Air Force/Texas Coronary Atherosclerosis Prevention Study. *JAMA* 279:1615–1622, 1998
30. Wu P: Thyroid disorders and diabetes. It is common for a person to be affected by both thyroid disease and diabetes. *Diabetes Self Manag* 24:80–82, 85–87, 2007
31. Saydah SH, Brancati FL, Golden SH, Fradkin J, Harris MI: Depressive symptoms and the risk of type 2 diabetes mellitus in a US sample. *Diabetes Metab Res Rev* 19:202–208, 2003
32. Clouse RE, Lustman PJ, Freedland KE, Griffith LS, McGill JB, Carney RM: Depression and coronary heart disease in women with diabetes. *Psychosom Med* 65:376–383, 2003
33. Mezuk B, Eaton WW, Albrecht S, Golden SH: Depression and type 2 diabetes over the lifespan: a meta-analysis. *Diabetes Care* 31:2383–2390, 2008
34. Butalia S, Leung AA, Ghali WA, Rabi DM: Aspirin effect on the incidence of major adverse cardiovascular events in patients with diabetes mellitus: a systematic review and meta-analysis. *Cardiovasc Diabetol* 10:25, 2011
35. Sutcliffe P, Connock M, Gurung T, Freeman K, Johnson S, Kandala NB, Grove A, Gurung B, Morrow S, Clarke A: Aspirin for prophylactic use in the primary prevention of cardiovascular disease and cancer: a systematic review and overview of reviews. *Health Technol Assess* 17:1–253, 2013
36. Blonde L: Best practices in diabetes management: getting more patients to goal. *Am J Manag Care* 11(5 Suppl):S186–S188, 2005
37. Blonde L, Karter AJ: Current evidence regarding the value of self-monitored blood glucose testing. *Am J Med* 118(Suppl 9A):20S–26S, 2005
38. Harris MI: Medical care for patients with diabetes. Epidemiologic aspects. *Ann Intern Med* 124:117–122, 1996
39. Preventive care practices [article online], 2013. Available from *http://www.cdc.gov/diabetes/statistics/preventive_national.htm*. Accessed 29 April, 2015
40. Klonoff DC, Blonde L, Cembrowski G, Chacra AR, Charpentier G, Colagiuri S, Dailey G, Gabbay RA, Heinemann L, Kerr D, Nicolucci A, Polonsky W, Schnell O, Vigersky R, Yale JF: Consensus report: the current role of self-monitoring of blood glucose in non-insulin-treated type 2 diabetes. *J Diabetes Sci Technol* 5:1529–1548, 2011
41. Malanda UL, Bot SD, Nijpels G: Self-monitoring of blood glucose in noninsulin-using type 2 diabetic patients: it is time to face the evidence. *Diabetes Care* 36:176–178, 2013
42. Polonsky WH, Fisher L: Self-monitoring of blood glucose in noninsulin-using type 2 diabetic patients: right answer, but wrong question: self-monitoring of blood glucose can be clinically valuable for noninsulin users. *Diabetes Care* 36:179–182, 2013
43. Centers for Disease Control and Prevention: Self monitoring of blood glucose among adults with diabetes—United States 1997–2006. *MMWR Morb Mortal Wkly Rep* 56:1133–1137, 2007
44. Translating research into action for diabetes (TRIAD) fact sheet, 2009 [article online], 2009. Available from *http://www.cdc.gov/diabetes/projects/pdfs/triad_fact_sheet.pdf*. Accessed 31 May 2012
45. McEwen LN, Kim C, Ettner SL, Herman WH, Karter AJ, Beckles GL, Brown AF: Competing demands for time and self-care behaviors, processes of care, and intermediate outcomes among people with diabetes: Translating Research Into Action for Diabetes (TRIAD). *Diabetes Care* 34:1180–1182, 2011
46. Gary TL, Safford MM, Gerzoff RB, Ettner SL, Karter AJ, Beckles GL, Brown AF: Perception of neighborhood problems, health behaviors, and diabetes outcomes among adults with diabetes in managed care: the Translating Research Into Action for Diabetes (TRIAD) study. *Diabetes Care* 31:273–278, 2008
47. Kerr EA: Clinical management strategies and diabetes quality: what can we learn from observational studies? *Med Care* 42:825–828, 2004
48. Kerr EA, Gerzoff RB, Krein SL, Selby JV, Piette JD, Curb JD, Herman WH, Marrero DG, Narayan KM, Safford MM, Thompson T, Mangione CM: Diabetes care quality in the Veterans Affairs Health Care System and commercial managed care: the TRIAD study. *Ann Intern Med* 141:272–281, 2004
49. Asch SM, McGlynn EA, Hogan MM, Hayward RA, Shekelle P, Rubenstein L, Keesey J, Adams J, Kerr EA: Comparison of quality of care for patients in the Veterans Health Administration and patients in a national sample. *Ann Intern Med* 141:938–945, 2004
50. Karter AJ, Stevens MR, Brown AF, Duru OK, Gregg EW, Gary TL, Beckles GL, Tseng CW, Marrero DG, Waitzfelder B, Herman WH, Piette JD, Safford MM, Ettner SL: Educational disparities in health behaviors among patients with diabetes: the Translating Research Into Action for Diabetes (TRIAD) Study. *BMC Public Health* 7:308, 2007
51. Vaccaro JA, Feaster DJ, Lobar SL, Baum MK, Magnus M, Huffman FG: Medical advice and diabetes self-management reported by Mexican-American, black- and white-non-Hispanic adults across the United States. *BMC Public Health* 12:185, 2012
52. Ho PM, Bryson CL, Rumsfeld JS: Medication adherence: its importance in cardiovascular outcomes. *Circulation* 119:3028–3035, 2009
53. Viswanathan M, Golin CE, Jones CD, Ashok M, Blalock SJ, Wines RC, Coker-Schwimmer EJ, Rosen DL, Sista P, Lohr KN: Interventions to improve adherence to self-administered medications for chronic diseases in the United States: a systematic review. *Ann Intern Med* 157:785–795, 2012
54. Garcia-Perez LE, Alvarez M, Dilla T, Gil-Guillen V, Orozco-Beltran D: Adherence to therapies in patients with type 2 diabetes. *Diabetes Ther* 4:175–194, 2013
55. Heaton PC, Tundia NL, Luder HR: U.S. emergency departments visits resulting from poor medication adherence: 2005–07. *J Am Pharm Assoc* (2003) 53:513–519, 2013
56. Coyle ME, Francis K, Chapman Y: Self-management activities in diabetes care: a systematic review. *Aust Health Rev* 37:513–522, 2013
57. Gruessner AC, Sutherland DE, Gruessner RW: Pancreas transplantation in the United States: a review. *Curr Opin Organ Transplant* 15:93–101, 2010
58. Han DJ, Sutherland DE: Pancreas transplantation. *Gut Liver* 4:450–465, 2010
59. International Pancreatic Transplant Registry [article online], 2012. Available from *http://surgery.arizona.edu/sites/surgery.arizona.edu/files/imagecache/Page_SS_teaser/AZ_2011_Patient_Characteristics.pdf*. Accessed 7 May 2012
60. Collaborative Islet Transplant Registry seventh annual report [article online], 2012. Available from *https://web.emmes.com/study/isl//reports/01062012_7th-AnnualReport.pdf*. Accessed 4 December 2013

61. Pancreatic islet transplant [article online], 2013. Available from *http://diabetes.niddk.nih.gov/dm/pubs/pancreaticislet*. Accessed 4 December 2013
62. Zinger A, Leibowitz G: Islet transplantation in type 1 diabetes: hype, hope and reality—a clinician's perspective. *Diabetes Metab Res Rev* 30:83–87, 2013
63. Dixon JB, Zimmet P, Alberti KG, Mbanya JC, Rubino F; International Diabetes Federation Taskforce on Epidemiology Prevention: Bariatric surgery for diabetes: the International Diabetes Federation takes a position. *J Diabetes* 3:261–264, 2011
64. Dixon JB, Zimmet P, Alberti KG, Rubino F; International Diabetes Federation Taskforce on Epidemiology Prevention: Bariatric surgery: an IDF statement for obese type 2 diabetes. *Surg Obes Relat Dis* 7:433–447, 2011
65. Zimmet P, Alberti KG, Rubino F, Dixon JB: IDF's view of bariatric surgery in type 2 diabetes. *Lancet* 378:108–110, 2011
66. Mingrone G, Panunzi S, De Gaetano A, Guidone C, Iaconelli A, Leccesi L, Nanni G, Pomp A, Castagneto M, Ghirlanda G, Rubino F: Bariatric surgery versus conventional medical therapy for type 2 diabetes. *N Engl J Med* 366:1577–1585, 2012
67. Brethauer SA, Aminian A, Romero-Talamas H, Batayyah E, Mackey J, Kennedy L, Kashyap SR, Kirwan JP, Rogula T, Kroh M, Chand B, Schauer PR: Can diabetes be surgically cured? Long-term metabolic effects of bariatric surgery in obese patients with type 2 diabetes mellitus. *Ann Surg* 258:628–636; discussion 636–637, 2013
68. Yip S, Plank LD, Murphy R: Gastric bypass and sleeve gastrectomy for type 2 diabetes: a systematic review and meta-analysis of outcomes. *Obes Surg* 23:1994–2003, 2013
69. Kenngott HG, Clemens G, Gondan M, Senft J, Diener MK, Rudofsky G, Nawroth PP, Buchler MW, Fischer L, Muller-Stich BP: DiaSurg 2 trial—surgical vs. medical treatment of insulin-dependent type 2 diabetes mellitus in patients with a body mass index between 26 and 35 kg/m2: study protocol of a randomized controlled multicenter trial—DRKS00004550. *Trials* 14:183, 2013
70. Maggard-Gibbons M, Maglione M, Livhits M, Ewing B, Maher AR, Hu J, Li Z, Shekelle PG: Bariatric surgery for weight loss and glycemic control in nonmorbidly obese adults with diabetes: a systematic review. *JAMA* 309:2250–2261, 2013
71. National Center for Health Statistics: Health, United States, 2006, With Chartbook on Trends in the Health of Americans. Hyattsville, MD: 2006
72. Livingston EH: The incidence of bariatric surgery has plateaued in the U.S. *Am J Surg* 200:378–385, 2010

APPENDICES

APPENDIX 39.1. Classes and Subgroups of Medications, NHANES, 2005–2010

CLASS	SUBGROUP		
Diuretics	loop diuretics potassium-sparing diuretics	thiazide diuretics carbonic anhydrase inhibitors	
ARBs	angiotensin II inhibitors or angiotensin receptor blockers		
CCBs	calcium channel blocking agents		
Beta blockers	cardioselective beta blockers	noncardioselective beta blockers	
ACEs	angiotensin converting enzyme inhibitors		
Other hypertension	antiadrenergic agents, peripherally acting antiadrenergic agents, centrally acting peripheral vasodilators	vasodilators antihypertensive combinations aldosterone receptor antagonists	renin inhibitors
Any cholesterol	HMG-CoA reductase inhibitors miscellaneous antihyperlipidemic agents	fibric acid derivatives bile acid sequestrants	cholesterol absorption inhibitors antihyperlipidemic combinations
Statins	HMG-CoA reductase inhibitors		
Central nervous system (CNS)	miscellaneous analgesics narcotic analgesics nonsteroidal anti-inflammatory agents salicylates analgesic combinations narcotic analgesic combinations antimigraine agents Cox-2 inhibitors hydantoin anticonvulsants succinimide anticonvulsants barbiturate anticonvulsants benzodiazepine anticonvulsants miscellaneous anticonvulsants dibenzazepine anticonvulsants	fatty acid derivative anticonvulsants gamma-aminobutyric acid reuptake inhibitors gamma-aminobutyric acid analogs triazine anticonvulsants pyrrolidine anticonvulsants carbonic anhydrase inhibitor anticonvulsants 5-HT3 receptor antagonists phenothiazine antiemetics anticholinergic antiemetics miscellaneous antiemetics anticholinergic antiparkinson agents dopaminergic antiparkinsonism agents	barbiturates benzodiazepines miscellaneous anxiolytics, sedatives, and hypnotics CNS stimulants skeletal muscle relaxants skeletal muscle relaxant combinations miscellaneous CNS agents anorexiants cholinergic agonists cholinesterase inhibitors drugs used in alcohol dependence
Psychotherapeutics	miscellaneous antidepressants SSRI antidepressants tricyclic antidepressants monoamine oxidase inhibitors	phenylpiperazine antidepressants tetracyclic antidepressants SSNRI antidepressants miscellaneous antipsychotic agents	psychotherapeutic combinations phenothiazine antipsychotics thioxanthenes atypical antipsychotics

Appendix 39.1 continues on the next page.

APPENDIX 39.1. (continued)

CLASS	SUBGROUP		
Depression	miscellaneous antidepressants SSRI antidepressants tricyclic antidepressants	monoamine oxidase inhibitors phenylpiperazine antidepressants tetracyclic antidepressants	SSNRI antidepressants
Respiratory	antihistamines antitussives methylxanthines adrenergic bronchodilators bronchodilator combinations anticholinergic bronchodilators	decongestants expectorants miscellaneous respiratory agents inhaled corticosteroids mucolytics mast cell stabilizers	inhaled anti-infectives antiasthmatic combinations upper respiratory combinations leukotriene modifiers
Gastrointestinal (GI)	antacids antidiarrheals digestive enzymes gallstone solubilizing agents GI stimulants	H2 antagonists laxatives miscellaneous GI agents proton pump inhibitors 5-aminosalicylates	*H. pylori* eradication agents anticholinergics/antispasmodics serotoninergic neuroenteric modulators chloride channel activators
Hormones	glucocorticoids mineralocorticoids contraceptives androgens and anabolic steroids estrogens progestins sex hormone combinations miscellaneous sex hormones	gonadotropin-releasing hormone and analogs thyroid hormones 5-alpha-reductase inhibitors growth hormones prolactin inhibitors calcitonin antigonadotropic agents	antidiuretic hormones somatostatin and somatostatin analogs selective estrogen receptor modulators parathyroid hormone and analogs antiandrogens antithyroid agents aromatase inhibitors synthetic ovulation stimulants

CNS, central nervous system; GI, gastrointestinal; SSNRI, selective serotonin norepinephrine re-uptake inhibitor; SSRI, selective serotonin re-uptake inhibitor.

SOURCE: National Health and Nutrition Examination Surveys (NHANES) 2005–2010

APPENDIX 39.2. Crude Prevalence of Diabetes Comorbidities and Associated Medication Use Among Adults Age ≥20 Years, by Diabetes Status, U.S., 2005–2010

MEDICATION*	DIAGNOSED DIABETES†	UNDIAGNOSED DIABETES‡	PREDIABETES‡	NORMAL GLUCOSE‡
Mean number of medications (standard error)	5.9 (0.11)	4.3 (0.22)	3.3 (0.07)	2.5 (0.07)
Percent (standard error)				
Self-report hypertension	66.8 (1.66)	57.1 (3.90)	39.3 (1.49)	18.8 (1.00)
Any hypertension medication	73.1 (1.55)	57.0 (3.55)	35.3 (1.14)	11.6 (0.69)
Diuretics	33.7 (1.55)	36.5 (3.94)	16.0 (0.78)	4.7 (0.43)
ARBs	17.6 (1.21)	15.5 (2.52)	8.3 (0.80)	2.5 (0.29)
CCBs	18.8 (1.12)	16.1 (2.34)	8.5 (0.66)	2.9 (0.31)
Beta blockers	29.9 (1.32)	27.7 (3.70)	14.3 (0.65)	4.0 (0.46)
ACE inhibitors	40.7 (1.37)	18.5 (1.79)	14.0 (0.83)	3.6 (0.37)
Other	23.9 (1.37)	23.0 (3.14)	12.0 (0.88)	3.3 (0.36)
Self-report high cholesterol	60.0 (1.62)	45.4 (2.98)	36.6 (1.18)	20.9 (0.87)
Any cholesterol medication	55.0 (1.37)	37.7 (2.89)	20.7 (0.98)	6.1 (0.54)
Statins	50.6 (1.28)	33.7 (2.97)	19.4 (0.97)	5.6 (0.47)
Central nervous system medications	34.1 (1.75)	28.5 (3.11)	22.1 (1.24)	15.4 (0.76)
Psychotherapeutics	19.6 (1.27)	10.9 (2.34)	11.0 (0.91)	11.0 (0.75)
Depression	19.1 (1.33)	10.6 (2.46)	10.4 (0.88)	10.4 (0.79)
Respiratory	18.1 (1.38)	16.3 (2.80)	13.4 (1.04)	10.7 (0.61)
Gastrointestinal	25.9 (1.51)	17.5 (2.91)	14.7 (0.98)	8.0 (0.55)
Hormones	21.8 (1.28)	12.3 (2.26)	14.2 (0.76)	13.8 (0.89)

Estimates are weighted to the noninstitutionalized U.S. population. These data represent crude estimates. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions.* A1c, glycosylated hemoglobin; ACE inhibitor, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; CCB, calcium channel blocker.

* A detailed list of medications included in each category is available in Appendix 39.1.

† Diagnosed diabetes is based on self-report.

‡ Undiagnosed diabetes is based on A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL; prediabetes is based on A1c 5.7%–6.4% or fasting plasma glucose 100–125 mg/dL; and normal glucose is based on A1c <5.7% and fasting plasma glucose <100 mg/dL.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010