CHAPTER 16

DIABETES IN OLDER ADULTS

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SUMMARY

Diabetes in older adults is a significant and growing public health problem in the United States. About 40% (39.5%) of the adult diabetic population is age ≥65 years. Approximately 20% (21.4%) of adults age ≥65 years have a known diagnosis of diabetes, and a similar proportion (16%) is unaware that they have diabetes based on glycosylated hemoglobin (A1c), fasting plasma glucose, or oral glucose tolerance testing. From 1997 to 2010, the prevalence of diabetes in older adults increased by 62%.

The geriatric diabetic population is highly heterogeneous in regard to its race/ethnicity, duration of diabetes, comorbidity, and functional status, which complicates the development of standard guidelines for the care of this population. Diagnosed heart disease is prevalent in about one-quarter of older adults with diabetes. Geriatric conditions are also highly prevalent, including chronic pain in over half and at least one functional limitation in two-thirds of older adults with diabetes. Diabetes increases the risk of mortality and cardiovascular and microvascular complications, as well as all known geriatric conditions (cognitive impairment, frailty, unintentional weight loss, polypharmacy, and functional impairment).

The Diabetes Prevention Program showed that a lifestyle intervention may be particularly effective at reducing future diabetes in older adults. Evidence for the benefits of intensive glycemic control among older adults is mixed, and the benefits of intensive control should be weighed carefully against the risks of polypharmacy, falls, and hypoglycemia. Even less evidence is available to guide efforts to prevent the geriatric conditions associated with diabetes. Routine screening for geriatric conditions, including dementia, depression, and falls, as well as hypoglycemia, may be especially important in older adults because of the potential barrier posed by these conditions on diabetes self-management.

In the United States, the costs of diabetes in older adults are largely borne by Medicare, the federal universal health insurance program for older adults. In 2012, the direct medical costs of diabetes care for older adults were estimated to be $104 billion per year largely due to hospital inpatient stays. The additional burden on society of informal caregiving is also significant. The costs of diabetes care in older adults are expected to triple from 2009 to 2034. Future approaches to diabetes care in older adults will likely be guided by recommendations from the American Diabetes Association to provide highly individualized care.

INTRODUCTION

The majority of older adults with diabetes have type 2 diabetes due to a combination of increased insulin resistance and impaired insulin secretion (1). In a study of adults age ≥60 years with diabetes from the Kaiser Permanente Northern California Diabetes Registry (N=6,317) in 2005, 96% had type 2 diabetes (2). Insulin resistance associated with advancing age is believed to be due to a combination of adiposity, sarcopenia (decreased muscle mass), and physical inactivity (3). Additionally, advancing age is associated with declines in pancreatic islet function and islet proliferative capacity, which may impair insulin secretion (4,5,6,7). Increasing insulin resistance is likely a more predominant driver of diabetes than impaired insulin secretion in older adults compared to younger adults. The clinical course of older adults with diabetes is often complicated by concomitant chronic diseases (e.g., hypertension) that can interact with their diabetes and accelerate the progression of diabetic complications (e.g., retinopathy).

DATA SOURCES AND LIMITATIONS

The National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES) were used for original analyses conducted for *Diabetes in America, 3rd edition*, which are presented in the figures, tables, and appendices of this chapter except where noted. These data sets provide cross-sectional snapshots of the nation's health. The NHIS relies on self-report regarding the presence of conditions, and thus, undiagnosed conditions are not available from this data source. For the NHANES, some undiagnosed conditions are available through the collection of biomarkers. Self-reported diabetes includes both type 1 diabetes and type 2 diabetes. For both surveys, the geriatric population is defined as adults age ≥65 years. In some instances, the standard errors for both the NHIS and NHANES estimates were high, in which case the size of relative standard errors was noted in tables and/or figures.

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DEMOGRAPHICS OF THE GERIATRIC DIABETES POPULATION

POPULATION SIZE AND PREVALENCE OF DIABETES

According to new analyses conducted for *Diabetes in America* of NHIS 2009–2010 data, 7.81 million adults age ≥65 years had a self-reported diagnosis of diabetes (Table 16.1). The overall prevalence of diagnosed diabetes in the population age ≥65 years was 20.5%. Compared to adults age 60–69 years and ≥80 years, those age 70–79 years had the highest prevalence of diabetes (22.7%). Men had a higher prevalence of diabetes than women for every age group (e.g., at age ≥80 years, 21.7% for men vs. 15.6% for women). Additional information on prevalence of type 2 diabetes is provided in Chapter 3 *Prevalence and Incidence of Type 2 Diabetes and Prediabetes*.

The high prevalence of diabetes in older adults is a reflection of secular changes in population prevalence. From 1997 to 2010, the prevalence of diagnosed diabetes among older adults age ≥65 years increased from 13.2% to 21.4% in the NHIS, which represents a 62.1% relative increase (Figure 16.1, Appendix 16.1). For each older age group, a similar rise in disease prevalence was observed. Adults age 70–79 years had the greatest relative increase in prevalence (84.1%), while there was a 47.7% relative increase in prevalence among adults age 60–69 years and a 65.8% relative increase among adults age ≥80 years.

In conjunction with rising prevalence rates, the absolute number of older adults living with diabetes in the United States has risen dramatically. Based on the NHIS, from 1997 to 2010, the number of adults age ≥65 years with diagnosed diabetes nearly doubled from an estimated 4.20 million to 8.28 million (Figure 16.2, Appendix 16.2). The relative rate of increase was highest for those age ≥80 years (2.35-fold increase), followed by adults age 60–69 years (2.24-fold increase) and adults age 70–79 years (1.96-fold increase).

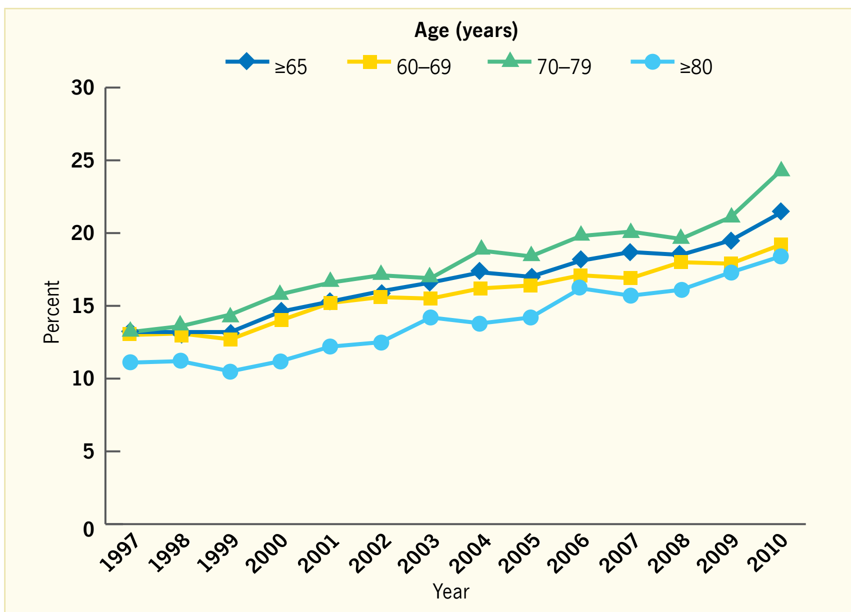
In 2010, adults age ≥65 years represented 39.5% of the U.S. adult diabetic population age ≥18 years (Table 16.2). Based on estimates from the NHIS 1997–2010, the age distribution of the diabetic population has not significantly changed over time, except for an increase in adults age ≥80 years. About one-quarter (23%–27%) of the population is represented by those age 60–69 years, about one-fifth (17%–21%) is represented by those age 70–79 years, and 7%–9% of the adult diabetic population is accounted for by persons age ≥80 years. In 2010, 26.9% of adults with diabetes were age 60–69 years, 19.0% were age 70–79 years, and 8.9% were age ≥80 years.

TABLE 16.1. Prevalence of Diagnosed Diabetes Among Adults Age ≥60 Years, by Age and Sex, U.S., 2009–2010

AGE (YEARS)	N (MILLIONS)*	PERCENT (STANDARD ERROR)
Total		
≥65	7.81	20.5 (0.49)
60–69	5.31	18.6 (0.55)
70–79	3.71	22.7 (0.74)
≥80	1.81	17.9 (0.80)
Men		
≥65	3.89	23.5 (0.76)
60–69	2.79	20.2 (0.85)
70–79	1.90	25.7 (1.19)
≥80	0.82	21.7 (1.52)
Women		
≥65	3.93	18.2 (0.60)
60–69	2.52	17.0 (0.70)
70–79	1.81	20.2 (0.89)
≥80	1.00	15.6 (0.98)

Data are self-reported.
* National Health Interview Survey weighted estimates.
SOURCE: National Health Interview Surveys 2009–2010

FIGURE 16.1. Trends in the Percent of Diagnosed Diabetes Among Adults Age ≥60 Years, by Age, U.S., 1997–2010



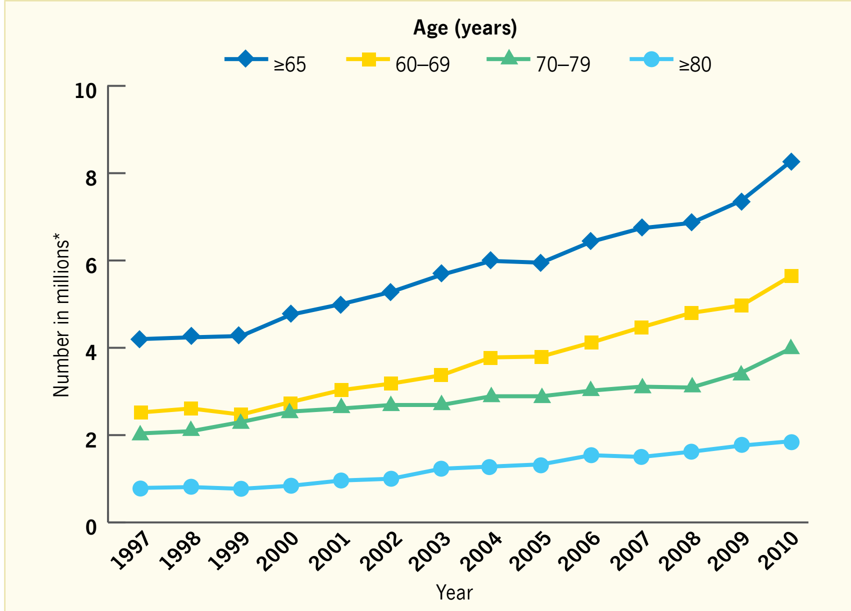
Data are self-reported.
SOURCE: National Health Interview Surveys 1997–2010

Data from the NHANES 2005–2010 were analyzed to provide additional insight into the prevalence of undiagnosed diabetes and prediabetes in older adults (Table 16.3). In 2005–2010, 16.2% of adults age ≥65 years were unaware that they had diabetes, as defined by abnormal laboratory test results (i.e., glycosylated hemoglobin [A1c] ≥6.5% [≥48 mmol/mol], fasting plasma glucose ≥126 mg/dL [≥6.99 mmol/L], or 2-hour plasma glucose from an oral glucose tolerance test ≥200 mg/dL [≥11.10 mmol/L]). The prevalence of undiagnosed diabetes when using A1c and fasting plasma glucose criteria was only 7.8%. Adults age ≥80 years had a higher prevalence of undiagnosed diabetes than adults age 60–69 and 70–79 years based on both abnormal laboratory criteria. Prediabetes, defined by A1c 5.7%–<6.5% (≥39 mmol/mol), fasting plasma glucose 100–<126 mg/dL (≥5.55 mmol/L), or 2-hour plasma glucose 140–199 mg/dL (7.77–11.04 mmol/L), is highly prevalent among older adults; based on the NHANES 2005–2010, 46.4% of older adults had prediabetes. Adults age 60–69 years had a slightly higher prevalence of prediabetes (47.8%) compared to adults age 70–79 years (46.4%) or ≥80 years (45.4%).

RACE/ETHNICITY

Based on new analyses of data from the NHIS 2009–2010, older adults with diabetes were disproportionately non-Hispanic black (13.4%) and Hispanic (11.4%) compared to those without diabetes (7.4% and 6.1%, respectively) (Table 16.4). Among adults age ≥80 years, a slightly greater proportion of adults were non-Hispanic white (74.8%) and smaller proportions were non-Hispanic black (12.1%) and Hispanic (9.2%) compared to adults age 60–69 and 70–79 years. Mexican Americans represented about 60.0% of the geriatric Hispanic population with diabetes (Table 16.5). Because of changing demographics, non-Hispanic blacks and Hispanics are expected to become a larger proportion of the geriatric diabetes population over the next two decades.

FIGURE 16.2. Trend in the Number (in Millions) of Adults Age ≥60 Years With Diabetes, by Age, U.S., 1997–2010



Data are self-reported.
* National Health Interview Survey weighted estimates.
SOURCE: National Health Interview Surveys 1997–2010

TABLE 16.2. Trends in the Percent Distribution of Age Among Adults Age ≥18 Years With Diabetes, U.S., 1997–2010

	PERCENT (STANDARD ERROR)			
	Age (Years)			
YEAR	≥65	60–69	70–79	≥80
1997	41.9 (1.35)	25.2 (1.13)	20.3 (1.00)	7.8 (0.68)
1998	40.8 (1.31)	25.1 (1.15)	20.1 (0.97)	7.9 (0.70)
1999	39.7 (1.31)	23.0 (1.13)	21.4 (1.03)	7.2 (0.61)
2000	40.2 (1.25)	23.2 (1.08)	21.4 (0.97)	7.1 (0.60)
2001	38.5 (1.14)	23.3 (1.03)	20.0 (0.95)	7.4 (0.57)
2002	39.4 (1.14)	23.8 (1.03)	20.1 (0.98)	7.4 (0.58)
2003	40.5 (1.26)	24.0 (1.01)	19.2 (0.88)	8.8 (0.67)
2004	39.6 (1.14)	24.8 (1.00)	19.1 (0.91)	8.5 (0.61)
2005	36.8 (1.12)	23.5 (1.02)	17.8 (0.80)	8.3 (0.57)
2006	37.6 (1.37)	24.1 (1.20)	17.7 (1.04)	9.0 (0.72)
2007	39.1 (1.27)	25.9 (1.20)	18.0 (1.00)	8.7 (0.76)
2008	36.8 (1.34)	25.7 (1.21)	16.6 (0.98)	8.7 (0.68)
2009	36.0 (1.28)	24.3 (1.08)	16.7 (0.87)	8.6 (0.64)
2010	39.5 (1.17)	26.9 (0.93)	19.0 (0.93)	8.9 (0.56)

Data are self-reported.
SOURCE: National Health Interview Surveys 1997–2010

TABLE 16.3. Percent of Undiagnosed Diabetes and Prediabetes Among Adults Age ≥60 Years, by Age, U.S., 2005–2010

AGE (YEARS)	PERCENT (STANDARD ERROR) Undiagnosed Diabetes Based on A1c, FPG, or 2HPG*	Undiagnosed Diabetes Based on A1c or FPG Only*	Prediabetes†
≥65	16.2 (1.07)	7.8 (0.72)	46.4 (1.17)
60–69	11.1 (1.20)	6.6 (0.84)	47.8 (1.63)
70–79	16.1 (1.28)	7.1 (0.90)	46.4 (1.63)
≥80	20.9 (2.20)	8.3 (0.99)	45.4 (2.47)

Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. 2HPG, 2-hour plasma glucose; A1c, glycosylated hemoglobin; FPG, fasting plasma glucose.
* Undiagnosed diabetes is defined as A1c ≥6.5%, FPG ≥126 mg/dL, and/or 2HPG ≥200 mg/dL.
† Prediabetes is defined as A1c 5.7%–<6.5%, FPG 100–<126 mg/dL, or 2HPG 140–199 mg/dL (7.77–11.04 mmol/L).

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

TABLE 16.4. Race/Ethnicity Distribution Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2009–2010

RACE/ETHNICITY	PERCENT (STANDARD ERROR) Diabetes	No Diabetes
Non-Hispanic white	71.0 (1.03)	83.1 (0.51)
Non-Hispanic black	13.4 (0.77)	7.4 (0.35)
Hispanic	11.4 (0.65)	6.1 (0.27)
Mexican American	6.8 (0.51)	3.0 (0.23)
Other Hispanic	4.7 (0.45)	3.1 (0.15)
Non-Hispanic Asian	4.2 (0.44)	3.4 (0.20)

Diabetes status is self-reported.

SOURCE: National Health Interview Surveys 2009–2010

TABLE 16.5. Race/Ethnicity Distribution of Diabetes Among Adults Age ≥60 Years, by Age, U.S., 2009–2010

RACE/ETHNICITY	PERCENT (STANDARD ERROR) Age (Years) 60–69	70–79	≥80
Non-Hispanic white	70.1 (1.29)	70.5 (1.65)	74.8 (1.90)
Non-Hispanic black	14.2 (0.89)	13.3 (1.17)	12.1 (1.30)
Hispanic	12.1 (0.97)	12.0 (1.24)	9.2 (1.09)
Mexican American	7.7 (0.77)	7.0 (1.02)	5.2 (0.88)
Other Hispanic	4.4 (0.61)	5.0 (0.77)	4.0 (0.70)
Non-Hispanic Asian	3.6 (0.53)	4.2 (0.62)	3.9 (0.80)

Diabetes status is self-reported.

SOURCE: National Health Interview Surveys 2009–2010

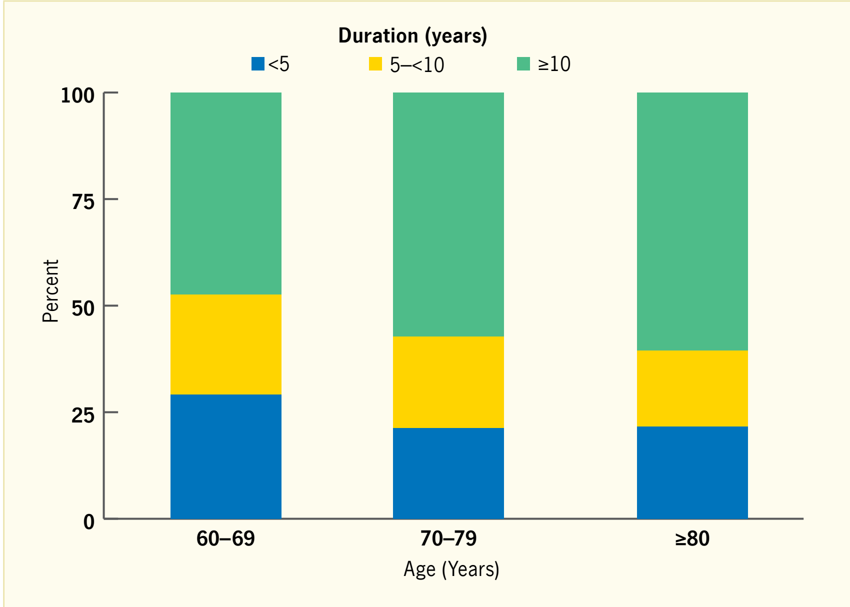
POPULATION SIZE AND PREVALENCE OF DIABETES IN NURSING HOMES

The nursing home population has a high prevalence of diabetes. Based on the National Nursing Home Surveys, in 2004, an estimated 23.4% of nursing home residents age ≥55 years had diabetes, approximately 329,000 individuals (8). Between 1995 and 2004, there was a significant 7% relative increase in diabetes prevalence in nursing home residents, which was also observed for many nursing home subgroups (men age 65–74 years, 75–84 years, and ≥85 years; women age ≥85 years; non-Hispanic whites; non-Hispanic black women; and Hispanic women). For more details regarding diabetes in nursing homes please see Chapter 40 *Health Care Utilization and Costs of Diabetes.*

DURATION OF DIABETES

Older adults with diabetes vary greatly with regard to the duration of their diabetes. In the NHIS 2009–2010, the average duration of diabetes in the U.S. geriatric population was 14.7 years; 23% of older adults had diabetes for <5 years, 20.4% had diabetes for 5–<10 years, and over half (56.6%) had diabetes for ≥10 years (Figure 16.3, Appendix 16.3). Differences in duration of diabetes translate into different degrees of risk for diabetic complications, which add to the heterogeneity of this population.

FIGURE 16.3. Duration of Diabetes Among Adults Age ≥60 Years, by Age, U.S., 2009–2010



Data are self-reported.

SOURCE: National Health Interview Surveys 2009–2010

COMORBIDITIES OF DIABETES

Older adults with diabetes are at elevated risk for concomitant cardiovascular risk factors, diabetic complications, geriatric conditions, and comorbid diseases. Compared to the nondiabetic population, older adults with diabetes have a higher risk of blindness, renal failure, coronary heart disease, and stroke (9,10). Additionally, the geriatric diabetic population is at higher risk for geriatric conditions, including falls (11), osteoporosis, urinary incontinence (12), chronic pain (13), depression (14), dementia (15), frailty/sarcopenia, and polypharmacy (16). Geriatric conditions are important considerations for older diabetes patients because they can have a devastating effect on quality of life. In many cases, a patient's experience with geriatric conditions may have a greater bearing on immediate symptomatology than the prevention of long-term diabetic complications. In addition, older adults with diabetes frequently have several comorbid diseases, which increase the risks of polypharmacy and multi-drug interactions. A description of these comorbidities is provided below. The reader may obtain additional information in Chapter 9 *Physical and Metabolic Characteristics of Persons With Diabetes and Prediabetes*, Chapter 10 *Lifestyle Characteristics Among Persons With Diabetes and Prediabetes*, and the chapters related to various diabetic complications (Chapters 17–36).

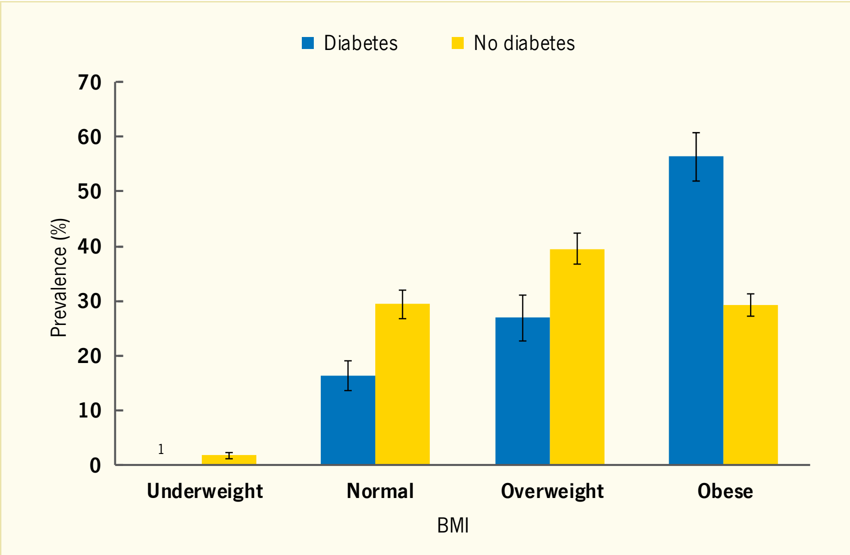
Rates of complications and mortality were compared in a 7-year cohort study from Kaiser Permanente Northern California using data from 2004–2010 among adults age ≥60 years (17). This study found that cardiovascular complications and hypoglycemia were the most common nonfatal complications. Duration of diabetes and advancing age were independently predictive of diabetic complications and mortality rates. Detailed sex- and race-adjusted incidence rates among older adults by age cohort (60–69, 70–79, and ≥80 years) and duration of diabetes (<10 and ≥10 years) were reported. For example, among adults age 70–79 years with duration of diabetes ≥10 years, the sex- and race-adjusted incidences of congestive heart failure, coronary artery disease, and cerebrovascular disease were 23.86, 18.98, and 14.62 events per 1,000 person-years, respectively. In this subpopulation, acute hypoglycemic events occurred at a sex- and race-adjusted incidence of 15.88 events per 1,000 person-years. Acute hyperglycemic events were rare at 1.76 events per 1,000 person-years among adults age 70–79 years with duration of diabetes ≥10 years.

CARDIOVASCULAR RISK FACTORS

Overweight and Obesity

Older adults with diabetes have a much higher prevalence of overweight, defined by a body mass index ≥25 kg/m^2, or obesity, defined by a body mass index ≥30 kg/m^2, than those without diabetes, according to new analyses for *Diabetes in America*. NHANES data from 2007–2010 showed that 83.3% of adults age ≥65 years with diabetes were overweight or obese compared to 68.8% of adults age ≥65 years without diabetes (p<0.001) (Figure 16.4, Appendix 16.4). According to the NHIS 2009–2010, the proportion of overweight or obese individuals decreased with increasing age, with 89.1% of adults

FIGURE 16.4. Body Mass Index Distribution Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2007–2010

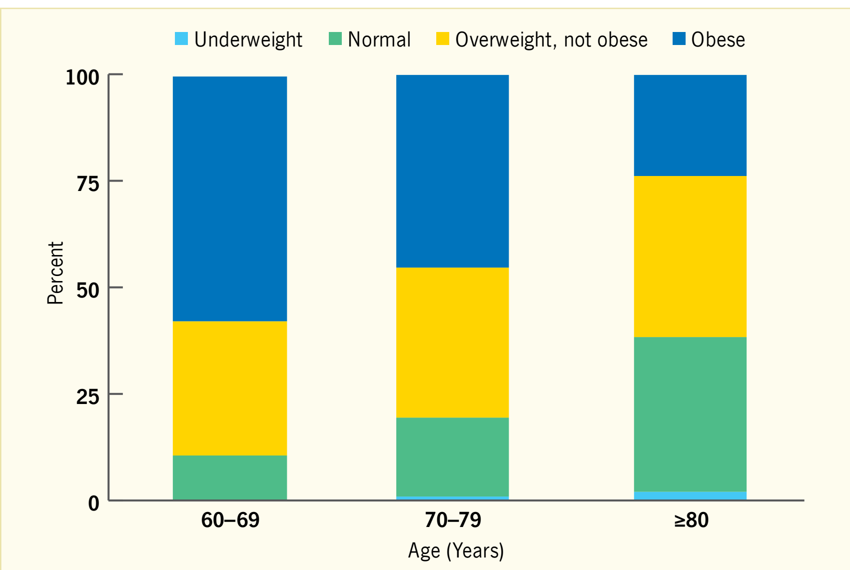


BMI is calculated based on measured height and weight. Underweight, BMI <18.5 kg/m²; normal, BMI 18.5–<25 kg/m²; overweight BMI 25–<30 kg/m²; obese, BMI ≥30 kg/m². Diabetes status is self-reported. Error bars represent 95% confidence intervals. BMI, body mass index.

[1] Estimate is too unreliable to present; ≤1 case or relative standard error >50%.

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

FIGURE 16.5. Body Mass Index Distribution Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010



BMI is calculated based on self-reported height and weight. Underweight, BMI <18.5 kg/m²; normal, BMI 18.5–<25 kg/m²; overweight, 25–<30 kg/m²; obese, ≥30 kg/m²; overweight or obese, ≥25 kg/m². Diabetes status is self-reported. BMI, body mass index.

SOURCE: National Health Interview Surveys 2009–2010

age 60–69 years being overweight or obese compared to 80.6% of those age 70–79 years and 61.7% of adults age ≥80 years (Figure 16.5, Appendix 16.5).

Hypertension

Older adults with diabetes had a prevalence of hypertension that was about 1.5 times as great as that found in the nondiabetic population (74.8% vs. 51.1%) in the NHIS 2009–2010. A slightly larger percentage (76.3%) of adults age 70–79 years had hypertension compared to those age 60–69 years (73.5%) and ≥80 years (70.9%). According to data from the NHANES 2007–2010, blood pressure averaged 135.0/62.5 mmHg in adults with diabetes age ≥65 years (Table 16.6). Over 10% (12.6%) of the geriatric diabetic population had systolic blood pressure (SBP) levels ≥160 mmHg, and a small percentage (2.3%) had diastolic blood pressure levels ≥90 mmHg.

Hyperlipidemia

In a departure from the patterns observed in overweight/obesity and hypertension, the prevalence of hyperlipidemia is about equal in the geriatric diabetic and nondiabetic populations (18). According to new analysis of data from the NHANES 2007–2010, low-density lipoprotein (LDL) cholesterol levels averaged 93.3 mg/dL (2.42 mmol/L) in adults age ≥65 years with diabetes (Table 16.6). About 5% (5.1%) of the geriatric diabetic population had LDL cholesterol levels ≥160 mg/dL (≥4.14 mmol/L).

Smoking

Among adults age ≥65 years, a slightly lower proportion of the diabetic population (8.2%) smoked compared with the nondiabetic population (9.8%) according to a new analysis of NHIS 2009–2010 data conducted for *Diabetes in America.* The prevalence of smoking among older adults with diabetes was greatest among the youngest age group and decreased with advancing age (60–69 years, 13.9%; 70–79 years, 8.5%; ≥80 years, 3.0%). The observation that the rates of obesity and current smoking decline with advancing age may be due to differences in survivorship associated with these cardiovascular risk factors.

CARDIOVASCULAR COMPLICATIONS

Diabetes increases the risk of cardiovascular complications in adults, especially among older adults, as described in Chapter 18 *Heart Disease and Diabetes* and Chapter 19 *Stroke and Diabetes*. In new analyses of the NHANES 2007–2010, the prevalences of all forms of cardiovascular complications (e.g., congestive heart failure, coronary heart disease,

TABLE 16.6. Blood Pressure and LDL Cholesterol Levels Among Adults Age ≥65 Years With Diabetes, U.S., 2007–2010

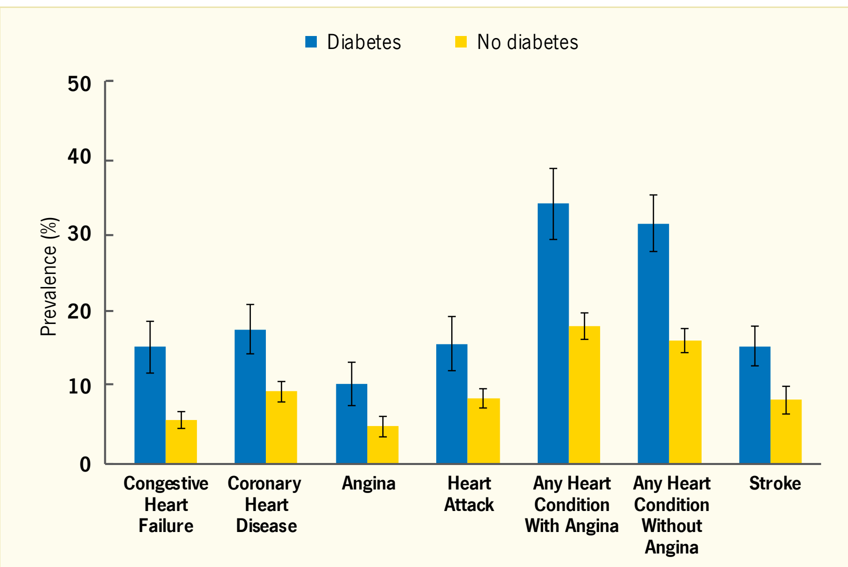
	MEAN (SE)	PERCENT (SE)
Blood pressure (mmHg)		
Systolic	135.0 (1.25)	
<130		44.5 (2.33)
130–139		19.4 (1.83)
140–159		23.6 (1.66)
≥160		12.6 (1.64)
Diastolic	62.5 (0.80)	
<70		72.6 (2.13)
70–79		20.6 (1.71)
80–89		4.6 (0.98)
≥90		2.3 (0.91)[1]
LDL cholesterol (mg/dL)	93.3 (2.52)	
<70		26.3 (2.71)
70–99		36.9 (3.98)
100–129		21.8 (3.00)
130–159		10.0 (2.81)
≥160		5.1 (1.61)

Diabetes status is self-reported. Conversions for LDL cholesterol values are provided in *Diabetes in America Appendix 1 Conversions*. LDL, low density lipoprotein; SE, standard error.

[1] Relative standard error >30%–40%

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

FIGURE 16.6. Cardiovascular Complications Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2007–2010



Data are self-reported. Error bars represent 95% confidence intervals.

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

and stroke) were nearly double for older adults with diabetes compared to those without diabetes (Figure 16.6, Appendix 16.6). The increased rate of cardiovascular complications was most pronounced for congestive heart failure, which was nearly three times more prevalent among the geriatric diabetic population compared to the nondiabetic population (15.3% vs. 5.7%). According to NHIS 2009–2010 data analyzed for *Diabetes in America*, coronary heart disease was present in about 24.3% of older adults with diabetes, followed by myocardial infarction (16.3%), stroke (13.0%), and angina (10.4%) (Figure 16.7, Appendix 16.7). The prevalences of most cardiovascular complications increased by age, with adults age ≥80 years having the highest prevalences of coronary heart disease, angina, other heart conditions or diseases, and stroke.

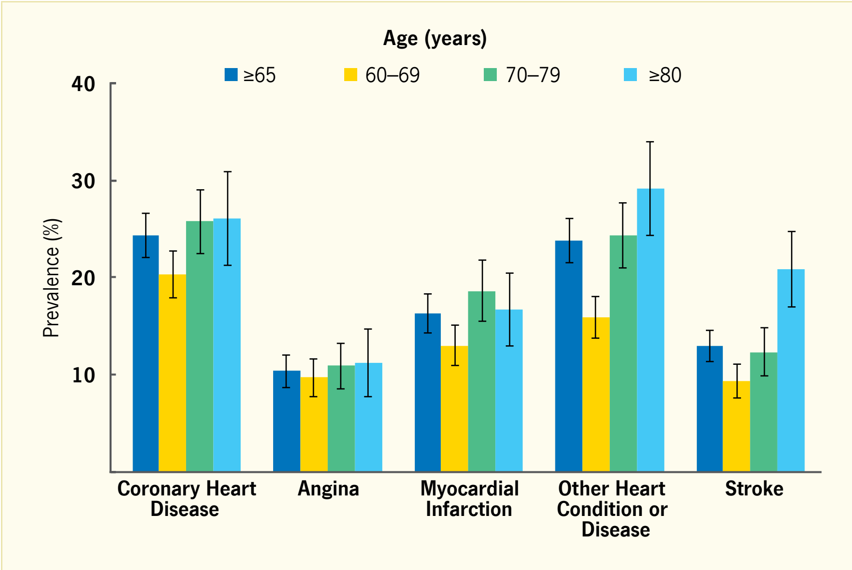
The presence of cardiovascular complications may increase the risk of other complications of diabetes. In a study of patients with diabetes age ≥65 years using Medicare claims from 1994–1999, metabolic complications of diabetes (hypoglycemia, hyperosmolar coma, ketoacidosis), ischemic heart disease, nephropathy, and peripheral vascular disease increased the 5-year incidence of heart failure by 23%, 74%, 55%, and 35%, respectively (19).

MICROVASCULAR COMPLICATIONS

Microvascular complications are more prevalent among older adults with diabetes compared to those without diabetes, according to new analyses of national data for *Diabetes in America*. In the NHANES 2005–2008, older adults with diabetes had a fourfold higher prevalence of retinopathy, as detected by non-mydriatric digital fundus photography, compared to those without diabetes (Figure 16.8, Table 16.7). For comparison, in the NHIS 2009–2010, 18.5% of the geriatric diabetes population reported trouble seeing compared to 12.3% of the nondiabetic population (Appendix 16.8). Increasing age was associated with higher rates of trouble seeing and blindness (Figure 16.9, Appendix 16.8).

Microalbuminuria, defined by an albumin-to-creatinine ratio 30–300 mg/g, was nearly twice as likely among older adults with diabetes versus those without diabetes in the NHANES 2007–2010 (Figure 16.8, Table 16.7). Decreased kidney function, based on the Chronic Kidney Disease Epidemiology Collaboration equation and serum creatinine, was 45% more prevalent among the older adult diabetic population compared to the nondiabetic population (39.7% vs. 27.3%, respectively). Nine percent of the geriatric diabetic population reported having weak/failing kidneys in the NHIS 2009–2010 (Figure 16.9, Appendix 16.8). Increasing age was associated with higher rates of weak/failing kidneys among the

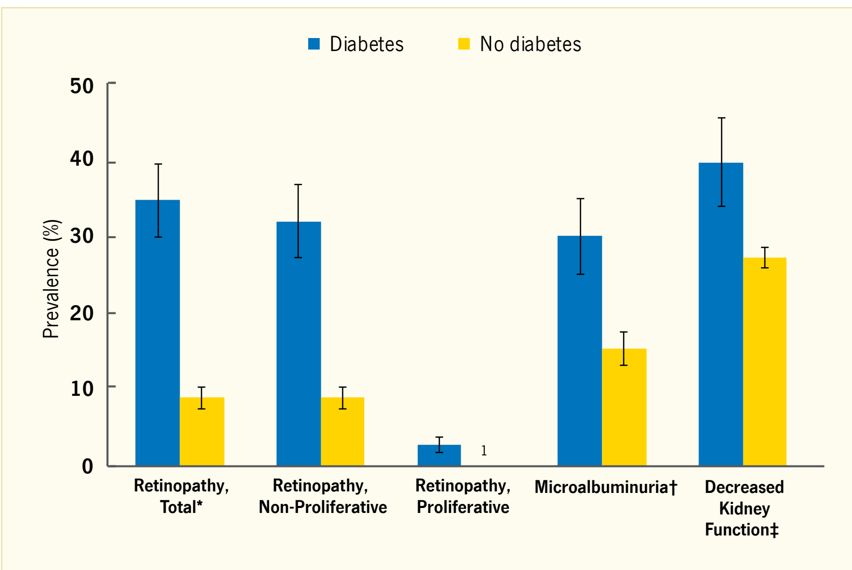
FIGURE 16.7. Cardiovascular Complications Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010



Data are self-reported. Error bars represent 95% confidence intervals.

SOURCE: National Health Interview Surveys 2009–2010

FIGURE 16.8. Microvascular Complications Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2005–2010



Diabetes status is self-reported. Error bars represent 95% confidence intervals.
* Retinopathy detected by non-mydriatic digital fundus photography. Based on 2005–2008 data.
† Microalbuminuria defined as albumin-to-creatinine ratio 30–300 mg/g. Based on 2007–2010 data.
‡ Decreased kidney function based on estimated glomular filtration rate (eGFR) <60 mL/min/1.73 m^2 determined using the CKD-EPI equation and serum creatinine.
[1] Estimate is too unreliable to present; ≤1 case or relative standard error >50%.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

geriatric diabetic population in the NHIS 2009–2010 (Figure 16.9, Appendix 16.8).

According to the National Hospital Discharge Survey and the NHIS, in 2008, diabetes-related nontraumatic lower extremity amputation rates were highest among adults age ≥75 years compared to adults age 40–64 years and 65–74 years (6.2 vs. 3.2 and 4.9, respectively, per 1,000 persons with diabetes) (20). From 1996 to 2008, the rates of amputation declined significantly among the U.S. diabetic population, especially for those age ≥75 years (20).

GERIATRIC CONDITIONS

In addition to the traditional cardiovascular and microvascular complications, the presence of diabetes increases the risk of many geriatric conditions. Much of the previously published data on geriatric conditions in this section are from the Study of Osteoporotic Fractures, a multicenter, longitudinal observational study of 9,654 older community-dwelling women that began in 1986. This cohort was established to collect prospective data on osteoporosis and collected data every 2 years for 20 years. The remaining data in this section come from new analyses for *Diabetes in America*. Prevalence estimates of geriatric conditions are likely underestimated since they may not fully account for conditions that are difficult to measure, such as cognitive dysfunction, depression, and functionality.

Falls

Risk for injurious falls is greater among older women with diabetes compared to their nondiabetic counterparts. Previous research found that women with diabetes had a higher risk of falls (odds ratio [OR] 1.38, 95% confidence interval [CI] 1.04–1.81) and multiple falls (OR 1.69, 95% CI 1.18–2.43) compared to women without diabetes (21). This increased risk of falls is associated with increased rates of fractures. In the Study of Osteoporotic Fractures, diabetes was associated with an 82% increased risk of hip fracture and a 94% increased risk of proximal humerus fracture. Treatment with insulin was associated with a two times greater risk of foot fractures (22), likely because insulin treatment indicated more advanced diabetes. Reduced vibration perception, as a measure of peripheral neuropathy, has been suggested to be an important risk factor for falling (23). It has not been established whether older men with diabetes also have a greater risk of falls. More information about falls and fractures among persons with diabetes is provided in Chapter 32 *Bone and Joint Complications in Diabetes.*

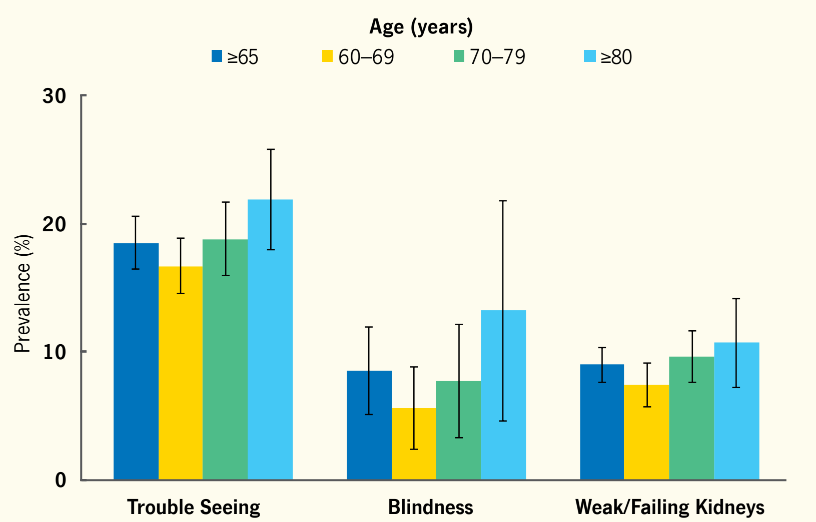
TABLE 16.7. Microvascular Complications Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2005–2010

MICROVASCULAR COMPLICATIONS	PERCENT (STANDARD ERROR)	
	Diabetes	No Diabetes
Retinopathy*	34.7 (2.40)	8.9 (0.75)
Non-proliferative	32.0 (2.45)	8.9 (0.75)
Proliferative	2.7 (0.52)	[1]
Microalbuminuria†	30.0 (2.51)	15.3 (1.12)
Decreased kidney function‡	39.7 (2.94)	27.3 (0.69)

Diabetes status is self-reported.
* Retinopathy detected by non-mydriatric digital fundus photography. Based on 2005–2008 data.
† Microalbuminuria defined as albumin-to-creatinine ratio 30–300 mg/g. Based on 2007–2010 data.
‡ Decreased kidney function based on estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m^2 determined using the Chronic Kidney Disease Epidemiology Collaboration equation and serum creatinine.
[1] Estimate is too unreliable to present; ≥1 case or relative standard error >50%.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

FIGURE 16.9. Microvascular Complications Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010



Data are self-reported. Error bars represent 95% confidence intervals.

SOURCE: National Health Interview Surveys 2009–2010

TABLE 16.8. Urinary Incontinence Among Adults Age ≥60 Years, by Diabetes Status, U.S., 2007–2010

	DIABETES		NO DIABETES	
	N	Percent (SE)	N	Percent (SE)
Urinary incontinence	545	31.7 (2.09)	1,847	21.5 (1.31)

Urinary incontinence is defined as self-reported leakage ≥1 time per week. Diabetes status is self-reported. SE, standard error.

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

TABLE 16.9. Urinary Incontinence Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2007–2010

	AGE (YEARS)					
	60–69		70–79		≥80	
	N	Percent (SE)	N	Percent (SE)	N	Percent (SE)
Urinary incontinence	282	27.3 (3.60)	180	34.7 (4.51)	83	41.4 (6.30)

Urinary incontinence is defined as self-reported leakage ≥1 time per week. Diabetes status is self-reported. SE, standard error.

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

Urinary Incontinence

According to *Diabetes in America* analysis of NHANES 2007–2010 data, urinary incontinence, defined by self-reported leakage at least once per week, was more prevalent in adults age ≥60 years with diabetes in comparison with those without diabetes (31.7% vs. 21.5%) (Table 16.8). The prevalence of urinary incontinence increases with age among persons with diabetes (Table 16.9).

Chronic Pain

Among geriatric conditions, chronic pain is highly prevalent and seriously impacts health-related quality of life in older adults with diabetes (2). Additionally, older adults with diabetes are at higher risk for chronic pain compared to older nondiabetic adults, possibly due to their increased risk of peripheral neuropathy (13,24) and a decrease in pain tolerance from hyperglycemia (25). According to new *Diabetes in America* analyses of data from the NHIS 2009–2010, chronic pain was reported more frequently by adults age ≥65 years with diabetes compared to those without diabetes (Table 16.10). Chronic pain was reported in 4.5%–56.9% of older adults with diabetes, depending on the site of pain. For example, joint pain within the past 30 days was present in 56.9% of older adults with diabetes, and lower back pain within the past 3 months was present in 38.4%. The prevalence of chronic pain was higher among adults age 60–69 years compared to those age 70–79 years and ≥80 years (Figure 16.10, Appendix 16.9).

Depression

Depression is highly prevalent among the geriatric diabetic population (14,26,27). The Study of Osteoporotic Fractures found that diabetes increased the odds of a trajectory of persistently high depressive symptoms by threefold (28). Depressive symptoms, defined based on the K6+ questionnaire, were 73% more frequent in adults age ≥65 years with diabetes compared to those without diabetes (3.3% vs. 1.9%) in a new analysis of NHIS 2009–2010 data. The prevalence of depressive symptoms decreased with age and was twice as great among adults with diabetes

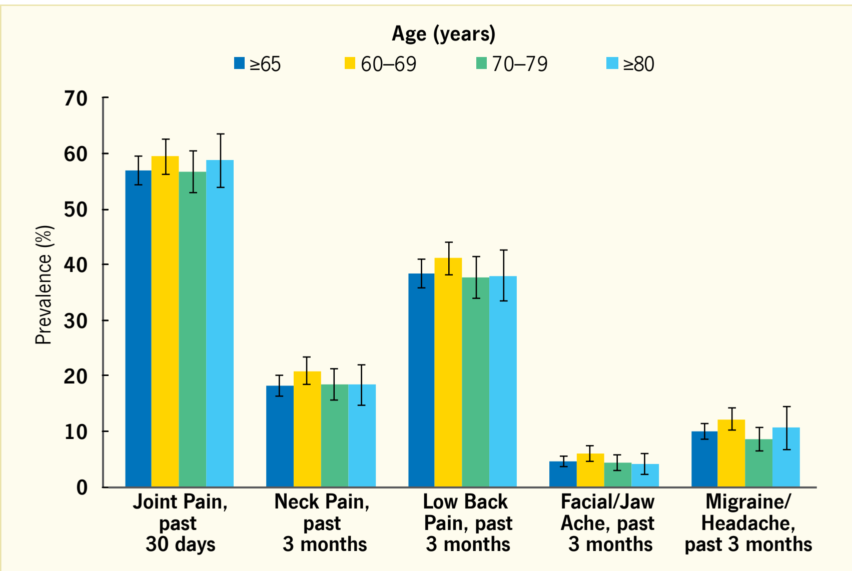
TABLE 16.10. Chronic Pain Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2009–2010

SITE OF CHRONIC PAIN	PERCENT (STANDARD ERROR)	
	Diabetes	No Diabetes
Joint pain, past 30 days	56.9 (1.35)	48.4 (0.68)
Pain in neck, past 3 months	18.2 (0.97)	13.8 (0.45)
Lower back pain, past 3 months	38.4 (1.33)	30.1 (0.66)
Facial/jaw ache, past 3 months	4.5 (0.48)	3.1 (0.23)
Migraine/headache, past 3 months	10.0 (0.76)	5.4 (0.30)

Data are self-reported.

SOURCE: National Health Interview Surveys 2009–2010

FIGURE 16.10. Chronic Pain Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010



Data are self-reported. Error bars represent 95% confidence intervals.

SOURCE: National Health Interview Surveys 2009–2010

TABLE 16.11. Depression Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010

	PERCENT (STANDARD ERROR)		
	Age (Years)		
	60–69	70–79	≥80
Depression	6.2 (0.81)	3.6 (0.72)	3.1 (0.84)

Depression is based on the K6+ questionnaire (cutpoint at 12 [range 0–24]). Diabetes status is self-reported.

SOURCE: National Health Interview Surveys 2009–2010

age 60–69 years (6.2%) compared to adults with diabetes age ≥80 years (3.1%) (Table 16.11). The relationship between diabetes and depression is discussed in Chapter 33 *Psychiatric and Psychosocial Issues Among Individuals Living With Diabetes.*

Cognitive Impairment

Diabetes is associated with cognitive impairment in older adults (29,30,31), as described in Chapter 24 *Diabetes and Cognitive Impairment*. In the Study of Osteoporotic Fractures, older women with diabetes performed significantly worse on cognitive function tests compared to older women without diabetes (32). Further, after 3–6 years of follow-up, they experienced accelerated cognitive decline and had increased odds of major cognitive decline. Women with diabetes duration >15 years had a 57%–114% greater risk of major cognitive decline compared to women without diabetes.

Sarcopenia and Frailty

Sarcopenia describes the age-associated declines in lean body mass commonly seen in older adults. Frailty is a broader term that encompasses sarcopenia, as well as age-associated declines in strength, endurance, balance, walking performance, and activity (33). Older adults with diabetes have a greater risk of sarcopenia (34) and frailty (33) than those without diabetes. A study of community-dwelling older women found that diabetes was associated with an increased risk of being prefrail and frail (35). Unintentional weight loss in older adults is associated with increased risk of morbidity and mortality (36). The association between weight loss and mortality is more pronounced in the diabetic population. In the Rancho Bernardo Study of >1,000 older men and women from 1972–1987, weight loss of ≥10 pounds over a 10-year period was associated with 3.66 and 1.65 times greater risks of death in men and women with diabetes compared to 1.38 and 1.76 times greater risks of death among men and women without diabetes, respectively (37).

Polypharmacy

Polypharmacy is a particularly challenging aspect of caring for older adults with diabetes, since they often require multiple medications to optimally manage their diabetes and associated conditions. Although multiple medications are unavoidable in some patients to achieve glycemic control and to adequately control cardiovascular risk factors, a focus on appropriate prescribing, interventions to increase regimen adherence, and assessment of financial feasibility are crucial to successful care in this population. On average, patients with diabetes are prescribed four diabetes-related medications (38). Older adults with diabetes are at greater risk for drug side effects and drug-drug interactions. For example, polypharmacy is associated with an increased risk of falls in the geriatric diabetes population, ranging from 1.22 to 1.59 times increased risk, compared to when patients are prescribed zero or one medication (39). Chapter 39 *Medication Use and Self-Care Practices in Persons With Diabetes* provides more information on the use of medications to treat diabetes and associated complications.

COMORBID DISEASES

Diabetes frequently co-occurs with other medical conditions, including those that represent complications of the disease. According to U.S. Medicare data, in 1999, nearly 60% of older adults with diabetes had at least one comorbid chronic disease (40,41), and as many as 40% had four or more comorbid diseases (42). A study using data from the NHANES 1999–2004 described the comorbid prevalence of five major chronic diseases (arthritis, coronary heart disease, chronic lower respiratory tract disease, cerebrovascular accident, and diabetes) in older men and women (Table 16.12) (43,44). In 39% of men and 38% of women, diabetes occurred with one comorbid disease. In 18% of men and 27% of women, diabetes occurred with two comorbid diseases; diabetes occurred with three comorbid conditions in 3% of men and 10% of women. Eight different combinations of diabetes and comorbid conditions were identified among the five chronic diseases studied.

TABLE 16.12. Prevalence of Comorbid Disease Patterns in Adults Age ≥65 Years With Diabetes, by Sex, U.S., 1999–2004

COMORBID DISEASE	PERCENT (WEIGHTED N)	
	Men (Weighted N=2,592,800)	Women (Weighted N=3,426,500)
Diabetes only	27 (703,120)	17 (585,280)
One comorbid condition		
Arthritis	21 (545,260)	31 (1,049,700)
CHD	11 (285,080)	4 (135,540)
CLRT	4 (110,890)	3 (97,480)
CVA	3 (82,780)	0
Two comorbid conditions		
Arthritis and CHD	12 (313,310)	13 (454,630)
Arthritis and CLRT	3 (83,450)	11 (369,870)
Arthritis and CVA	3 (79,260)	3 (98,590)
Three comorbid conditions		
Arthritis, CHD, and CVA	3 (79,420)	4 (123,310)
Arthritis, CHD, and CLRT	0	6 (192,380)

Data are self-reported. CHD, coronary heart disease; CLRT, chronic lower respiratory tract disease; CVA, cerebrovascular accident

SOURCE: Reference 43

MORTALITY RATES

According to data from the NHANES I 1971–1975, adults age 65–74 years with diabetes had a 50% higher mortality rate than those without diabetes during a 22-year follow-up (45). Diabetes also increases the risk of cardiovascular mortality. Data from the Nurses' Health Study, a longitudinal cohort of 121,700 registered nurses established in 1976, found that diabetes was associated with about a fivefold increased risk of coronary heart disease death among women age ≥65 years. Additionally, in this study, women with diabetes and coronary heart disease had an 18-fold increased risk of coronary heart disease death among women age ≥65 years. Mortality rates for older adults with diabetes have declined over time. Comparing the NHIS data from 1997–1998 and 2003–2004, rates of death from cardiovascular disease (CVD) have declined by 19.7 deaths per 1,000 person years (multivariate hazard risk ratio [HRR] 0.57, 95% CI 0.44–0.76), and rates of death from all-cause mortality have declined by 33.0 deaths per 1,000 person years (HRR 0.77, 95% CI 0.65–0.90) (both $p<0.001$) among older adults with diabetes (46).

QUALITY OF LIFE

Among older adults with diabetes, quality of life is a particularly important outcome because many of these patients may not survive the approximately 10 years necessary to benefit from intensive glycemic control (47). Diabetes is associated with lower quality of life among all adults, including older adults (48). For example, among older Mexican Americans, diabetes was associated with lower physical health-related quality of life but not mental health-related quality of life (49). Quality of life is affected to similar degrees by geriatric conditions as by diabetic complications in older adults with diabetes (2).

FUNCTIONAL STATUS

Diabetes substantially increases the risks of functional impairment, as described in Chapter 34 *Diabetes and Disability,* which is a particularly prominent issue among older adults (50,51). In the NHANES III, among 6,588 community-dwelling adults age ≥60 years, diabetes was associated with twofold to threefold increased odds of functional disability, such as not being able to walk one-fourth of a mile, climb stairs, or do housework, and a 3.6-fold increased risk of not being able to do all three tasks (52). In the NHIS 2009–2010, functional status was measured by asking whether participants needed help with Instrumental Activities of Daily Living (IADLs), such as household chores, shopping, doing necessary business, or getting around for other purposes for routine activities, and by asking how difficult specific activities were. In new analyses of these data for *Diabetes in America,* adults age ≥65 years with diabetes reported that they needed help with IADLs 60% more often than those without diabetes (Table 16.13). About two-thirds (66.7%) of the U.S. geriatric diabetes population in the NHIS 2009–2010 reported difficulty with at least one functional status activity (e.g., walking, climbing, stooping) compared to 59.7% of those without diabetes. Among women, diabetes has been associated with significantly more difficulty with most IADLs and Activities of Daily Living (e.g., bathing, toileting, transferring, etc.), including walking two to three blocks, lifting 10 pounds, using the telephone, and bathing (range of OR 1.5–2.8, all

TABLE 16.13. Functional Status of Adults Age ≥65 Years, by Diabetes Status, U.S., 2009–2010

FUNCTIONAL STATUS	PERCENT (STANDARD ERROR)	
	Diabetes	No Diabetes
Difficulty with IADLs*	18.1 (0.95)	11.0 (0.95)
Difficulty ≥1 functional status†	66.7 (1.25)	59.7 (1.58)
Difficulty walking	40.8 (1.33)	35.6 (1.67)
Difficulty climbing	32.3 (1.23)	28.2 (1.53)
Difficulty standing	44.9 (1.31)	41.2 (1.61)
Difficulty sitting	12.8 (0.81)	16.4 (1.18)
Difficulty stooping	48.1 (1.20)	44.1 (1.61)
Difficulty reaching	17.3 (1.02)	16.0 (1.10)
Difficulty grasping	13.9 (0.92)	14.4 (1.14)
Difficulty carrying 10 lbs	25.0 (1.19)	21.3 (1.29)
Difficulty pushing heavy objects	30.1 (1.23)	26.6 (1.53)
Difficulty shopping	21.4 (1.05)	19.7 (1.38)
Difficulty engaging in social activities	17.2 (1.00)	13.9 (1.11)
Difficulty relaxing	5.2 (0.57)	5.3 (0.67)

Diabetes status is self-reported. IADL, Instrumental Activity of Daily Living.

* Difficulty with IADL: self-reported need for help with routine needs, such as household chores, shopping, doing necessary business, or getting around for other purposes.

† Functional status: limitation is defined as a report of the activity being somewhat difficult, very difficult, or cannot do at all.

SOURCE: National Health Interview Surveys 2009–2010

TABLE 16.14. Functional Status of Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010

FUNCTIONAL STATUS	PERCENT (STANDARD ERROR) Age (Years)		
	60–69	70–79	≥80
Difficulty with IADLs*	11.0 (0.95)	14.5 (1.29)	32.7 (2.40)
Difficulty ≥1 functional status†	59.7 (1.58)	66.6 (1.75)	76.5 (2.04)
Difficulty walking	35.6 (1.67)	38.8 (1.82)	54.0 (2.61)
Difficulty climbing	28.2 (1.53)	30.4 (1.75)	43.2 (2.64)
Difficulty standing	41.2 (1.61)	41.6 (1.86)	57.9 (2.78)
Difficulty sitting	16.4 (1.18)	12.3 (1.10)	13.6 (1.82)
Difficulty stooping	44.1 (1.61)	47.9 (1.83)	54.6 (2.56)
Difficulty reaching	16.0 (1.10)	16.5 (1.43)	23.7 (2.23)
Difficulty grasping	14.4 (1.14)	13.1 (1.43)	17.6 (1.66)
Difficulty carrying 10 lbs	21.3 (1.29)	21.4 (1.57)	38.5 (2.54)
Difficulty pushing heavy objects	26.6 (1.53)	28.0 (1.78)	42.0 (2.43)
Difficulty shopping	19.7 (1.38)	18.3 (1.46)	32.9 (2.36)
Difficulty engaging in social activities	13.9 (1.11)	15.5 (1.36)	26.0 (2.48)
Difficulty relaxing	5.3 (0.67)	5.1 (0.85)	7.5 (1.46)

Diabetes status is self-reported. IADL, Instrumental Activity of Daily Living.

* IADL: self-reported need for help with routine needs, such as household chores, shopping, doing necessary business, or getting around for other purposes.

† Functional status: limitation is defined as a report of the activity being somewhat difficult, very difficult, or cannot do at all.

SOURCE: National Health Interview Surveys 2009–2010

p<0.01). The relationships between diabetes and disability may possibly be mediated by neuropathy and peripheral vascular disease (53). Functional disability may occur with the same frequency between older and middle-aged adults with diabetes (54).

Functional impairment varies greatly by type of activity. The percentage reporting difficulties varies widely depending on the activity; for example, only 5.2% reported difficulty relaxing, while 48.1% reported difficulty stooping. Functional impairment also varies by age group, with the oldest patients having the highest prevalence of impairment. Nearly one-third (32.7%) of adults with diabetes age ≥80 years had difficulty with one IADL, and over three-quarters (76.5%) had difficulty with at least one functional status activity (Table 16.14). Up to 85% of the excess odds of disability associated with diabetes have been attributed to comorbidities, especially CVD and obesity, and poor glycemic control (A1c ≥8.0% [≥64 mmol/mol]). The associations of diabetes with disability in the geriatric diabetes population are fully attenuated by adjustment for comorbidities, A1c, and diabetes duration (55).

PREVENTING DIABETES

In addition to the high rates of diabetes in the older adult population, nearly half of the geriatric population met criteria for prediabetes (Table 16.3). Because of the size of the older adult prediabetic population, the importance of preventing the progression of diabetes in the older adult population is paramount.

The Diabetes Prevention Program (DPP) is the largest trial that has evaluated the role of lifestyle interventions and medications in preventing diabetes. The overall study enrolled >3,000 adults, about 20% of whom were age ≥60 years (56). The mean age of adults age ≥60 years in the DPP was 66.4 years and ranged from 60 to 85 years. The study population had good representation among older adults in their mid-sixties but far less participation from adults age ≥70 years. This study found reductions in the incidence of diabetes with the lifestyle intervention and metformin treatment after 2.8 years of follow-up. The reductions with the lifestyle intervention were largest for adults age ≥60 years compared to adults age 25–44 years and 45–59 years (71% vs. 48% and 59%, respectively). Interestingly, the oldest adults did not experience reductions in diabetes incidence with metformin, while younger subjects did (57). Ten-year follow-up data from the DPP provided evidence for the persistent benefits of the lifestyle intervention compared to drug therapy in older adults (58), as well as secondary benefits of the lifestyle intervention, including reductions in urinary incontinence (59) and improvements in quality of life (60).

The reader may obtain additional information on this topic in Chapter 38 *Prevention of Type 2 Diabetes*.

PREVENTING COMPLICATIONS OF DIABETES

PREVENTING CARDIOVASCULAR AND MICROVASCULAR COMPLICATIONS

Glucose Control

In the past, clinical trials of diabetes therapies, such as the United Kingdom Prospective Diabetes Study (UKPDS), systematically excluded adults age >65 years. Subsequent major clinical trials, such as ACCORD (Action to Control Cardiovascular Risk in Diabetes), ADVANCE (Action in Diabetes and Vascular Disease: Preterax and Diamicron MR Controlled Evaluation), and VADT (Veterans Affairs Diabetes Trial), included adults age ≥65 years but did not include significant numbers of participants age >75 years. In addition, these clinical trials excluded older adults with significant functional impairment or comorbid illnesses.

The UKPDS provided valuable evidence for the benefits of glycemic control on reducing the risk of microvascular complications; however, the study enrolled middle-aged subjects with newly diagnosed type 2 diabetes and excluded those age >65 years at the time of enrollment (47,61). During the post-trial follow-up, as participants entered the geriatric age range, the benefits of intensive glycemic control on microvascular complications persisted, and benefits for reducing mortality and myocardial infarctions emerged (62).

Following the UKPDS, the ACCORD, ADVANCE, and VADT trials studied glycemic control for preventing CVD events in high-risk middle-aged and older adults with type 2 diabetes. The ACCORD trial enrolled subjects with diabetes age 40–79 years and randomly assigned them to intensive glucose control therapy (A1c <6.0% [<42 mmol/mol]) or standard therapy (A1c 7.0%–7.9% [53–63 mmol/mol]) (63). The mean age was 62 years, and median duration of diabetes was 10 years. The intensive therapy group achieved a median A1c level of 6.4% (46 mmol/mol), and the standard therapy group achieved a median A1c level of 7.5% (58 mmol/mol). The trial was ended after a mean follow-up of 3.5 years, because the intensive therapy group had a higher mortality rate than the standard therapy group (hazard ratio [HR] 1.22, 95% CI 1.01–1.46). Subjects age ≥65 years had no higher risk of cardiovascular events or overall mortality than subjects age <65 years. In prespecified subgroup analyses, increased age was significantly associated with a higher risk of severe hypoglycemia (64).

In contrast to the ACCORD trial, the ADVANCE study did not show excessive deaths due to intensive glycemic control and showed some reduction in microvascular disease from intensive glucose control (65). ADVANCE included participants with type 2 diabetes age ≥55 years and randomized them to intensive glucose control (A1c <6.5%) or standard glucose control. Participants were required to have a history of major macrovascular or microvascular disease or at least one risk factor for vascular disease. Their mean age was 66 years, and median duration of diabetes was about 8 years. The intensive therapy and standard therapy groups in ADVANCE achieved mean A1c levels of 6.5% and 7.3% (56 mmol/mol), respectively, at 5 years of follow-up. The intensive glucose therapy group had a 10% relative reduction in the combined outcome of major macrovascular and microvascular events, mostly due to a 21% relative reduction in nephropathy. In prespecified subgroup analyses, no difference in major macrovascular and microvascular events was observed between participants age <65 years and those age ≥65 years.

While the ADVANCE study suggested benefit of intensive glucose control on microvascular events, the VADT showed no benefits from intensive glucose control. The VADT randomized 1,791 veterans to intensive glucose control (to achieve an absolute reduction of 1.5% in A1c) versus standard control (66). Participants' mean age was 60.4 years and mean duration of diabetes was 11.5 years; 40% had a history of CVD. The intensive therapy group achieved a median A1c of 6.9% (52 mmol/mol), and the standard therapy group achieved a median A1c of 8.4% (68 mmol/mol). The VADT found no significant differences in major cardiovascular events, death, or microvascular events between the two groups after a median follow-up of 5.6 years. In *post hoc* analyses, adults with diabetes duration >20 years had an increased risk for cardiovascular events with intensive therapy (67).

Since the geriatric diabetic population has been largely excluded from trials, data from epidemiologic studies on the relationship between glycemic control and complications are relevant. In adults age ≥50 years with type 2 diabetes from the U.K. General Practice Research Database, both low and high A1c values were associated with increased all-cause mortality and cardiac events (68). In a large retrospective cohort study of 71,092 patients with type 2 diabetes age ≥60 years, the risk of any nonfatal complication rose linearly for A1c >6.0%, but mortality had a U-shaped relationship with A1c. Mortality risk was lower for A1c levels between 6.0% and 9.0% (75 mmol/mol) (adjusted HR 0.83) and higher for A1c levels ≥11.0% (≥97 mmol/mol) (adjusted HR 1.31) compared to those with A1c <6.0%. Age did not affect this U-shaped relationship between mortality and A1c (69).

Based on a new analysis of NHANES 2005–2008 data conducted for *Diabetes in America*, sulfonylureas (41.2%) and non-sulfonylureas (i.e., metformin) (43.4%) were the oral agents most commonly used for glucose control among older adults with diabetes (Table 16.15). A smaller but substantial proportion of older adults with diabetes used alpha-glucosidase inhibitors (18.5%) and thiazolidinediones (20.5%). More information on medication use for diabetes is provided in Chapter 39.

TABLE 16.15. Oral Diabetes Medication Use Among Adults Age ≥65 Years With Diabetes, U.S., 2005–2008

ORAL DIABETES MEDICATION	PERCENT (STANDARD ERROR)
Sulfonylureas	41.2 (2.28)
Non-sulfonylureas	43.4 (3.50)
Alpha-glucosidase inhibitors	18.5 (2.11)
Thiazolidinediones	20.5 (1.95)
Miscellaneous*	1.6 (0.56)[1]
Combinations	5.5 (1.10)

Data are self-reported.
* Miscellaneous includes meglitinides, exenatide, pramlintide.
[1] Relative standard error >30%–40%
SOURCE: National Health and Nutrition Examination Surveys 2005–2008

Blood Pressure Control

Multiple trials have studied the importance of blood pressure control in patients with diabetes. Evidence is consistent for the benefits of lowering SBP to <150 mmHg for older adults with diabetes (70). However, evidence for lower blood pressure targets is less clear. The UKPDS aimed to lower blood pressure to <150/85 mmHg versus <180/105 mmHg (71). The intervention group achieved a mean blood pressure of 144/82 mmHg compared to 154/87 mmHg in the control group and had a decreased risk of microvascular disease, mostly due to reductions in risks for retinal photocoagulation and aggregate macrovascular endpoints (e.g., 44% reduction in stroke and 49% reduction in peripheral vascular disease). The Systolic Hypertension in the Elderly Program (SHEP) evaluated the effectiveness of stepwise hypertension management in adults age ≥60 years to a goal of <160 mmHg, if their baseline SBP was ≥180 mmHg, or a goal of decreasing SBP by ≥20 mmHg (70). Older adults with type 2 diabetes in the intervention arm had a lower blood pressure on average (-9.8/2.2 mmHg) and had a 34% reduction in 5-year major CVD events compared to the placebo arm.

Studies subsequent to the UKPDS and SHEP evaluated the effectiveness of lower blood pressure goals, but have been conflicting. The ADVANCE study randomized participants to a fixed combination of perindopril and indapamide or placebo. Initial blood pressure levels were 145/81 mmHg in both study arms (72). After a mean follow-up of 4.3 years, the intervention arm had a mean reduction in blood pressure by 5.6/2.2 mmHg compared to placebo and a relative risk of major macrovascular or microvascular events by 9%. Studies that have evaluated even lower blood pressure targets have not shown benefits of control at <130/80 mmHg. A subgroup analysis of the INVEST trial (International Verapamil SR-Trandolapril Study), which included adults age ≥50 years with diabetes and coronary artery disease, found that tight SBP control (SBP <130 mmHg) was not associated with improved cardiovascular outcomes compared with usual control (SBP 130–140 mmHg) (73). The ACCORD-BP trial did not show benefits from lowering to SBP <120 mmHg compared to <140 mmHg for major adverse cardiovascular events (74). Additionally, results from the VADT trial suggested that diastolic blood pressure <70 mmHg may be associated with an increase in cardiovascular events (75).

Lipid Control

Several studies in middle- and older-aged adults with and without diabetes have established the benefits of statin therapy in older adults with diabetes. In a clinical trial of adults age 70–82 years with a history of or high risk for vascular disease, participants were randomized to pravastatin or placebo and followed for about 3 years. Participants who received pravastatin had a 34% reduction in their LDL cholesterol levels and a 15% decreased risk of CVD events (76). A meta-analysis of 18,686 subjects with diabetes from 14 trials of statin therapy for primary prevention found similar 20% reductions in major vascular events from a 1.0 mmol/L reduction in LDL cholesterol among adult age groups (<65, 65–75, and >75 years) (77). Additionally, the Heart Protection Study found that simvastatin therapy was associated with a highly significant 33% proportional reduction in first major vascular events, regardless of diabetes status or age <65 or ≥65 years (78).

In contrast to the strong evidence for statin therapy, other agents, like fenofibrate, have no evidence of benefit. In the ACCORD lipid trial, adding fenofibrate to statin therapy had no cardiovascular benefits for adults age <65 or ≥65 years (79). Also, the Fenofibrate Intervention and Event Lowering in Diabetes study of adults age 50–75 years with type 2 diabetes reported reductions in total cardiovascular events overall, but no benefits were seen in adults age ≥65 years (80).

Multifactorial Control

Evidence exists for the benefits of a target-driven approach to reducing cardiovascular morbidity in patients with type 2 diabetes. The Steno-2 Study compared the effects of intensive stepwise treatment of hyperglycemia, hypertension, dyslipidemia, and microalbuminuria and secondary prevention of CVD with aspirin compared to usual care (81). The mean age of patients was 55.1 years and mean follow-up was 7.8 years. Patients with intensive therapy had a significantly lower risk of CVD, nephropathy, retinopathy, autonomic neuropathy, and mortality. It is unknown whether such a multifactorial approach has similar benefits in older adults with diabetes.

PREVENTING GERIATRIC CONDITIONS

While several studies have examined strategies to prevent macrovascular and microvascular complications of diabetes, fewer studies have addressed the prevention of geriatric conditions in older adults with diabetes.

Falls

The increased risk of falls in older adults with diabetes is attributable to a combination of factors, such as frailty/sarcopenia, gait/balance abnormalities, loss of vision and/or hearing, and osteoarthritis, along with the diabetes-related complications of neuropathy, retinopathy, polypharmacy (four or more prescription medications), and hypoglycemia (39). While good glycemic control prevents progression of neuropathy and retinopathy, the trade-off of polypharmacy or hypoglycemia may increase the risk of falls. Therefore, regular assessments of fall-risk in older patients with diabetes are important. Several strategies for preventing falls have proven effective, including vitamin D therapy (82) and gait- and balance-focused exercise programs (83,84).

Depression

Depression has a significant impact on the mortality and quality of life in older adults with diabetes and is associated with significant societal health care costs (85,86,87). Depression is associated with poor diabetes self-care, including deficits in healthy eating, exercise, and medication adherence (88,89,90). Additionally, depression is associated with an increased risk of poor glycemic control (91), dementia (92,93), and mortality (94,95,96) in diabetic patients. Because of the prevalence of depression in older adults with diabetes (87,97) and the great burden of depression (2), routine screening for depression should be considered in older adults (98). Since depression can present atypically in older adults, using geriatric-specific screening tools, like the Geriatric Depression Scale, may enhance screening and allow earlier identification and subsequent treatment of depression (99).

Dementia

Dementia or cognitive impairment is a sentinel condition for diabetes because it affects background mortality and changes the extent to which patients are able to care for themselves (100), as discussed in Chapter 24. While dementia poses a significant challenge to self-management, evidence for how to prevent dementia is scant. A major study on diabetes and dementia, the ACCORD-MIND trial, found no benefits from intensive glucose control or blood pressure control on improving cognitive outcomes compared to standard therapy (101). However, the harms from cognitive dysfunction in older adults with diabetes are well known. Cognitive impairment is associated with poor glycemic control (102). The relationship between hypoglycemia and cognitive dysfunction may be bidirectional, with cognitive impairment increasing the risk for future hypoglycemia (103) and past severe hypoglycemia increasing the incidence of dementia (104,105). Additionally, the development of dementia is significantly associated with the presence of diabetes (92,93). A high index of suspicion for cognitive impairment should be present when evaluating older adults with diabetes. Worsening cognitive function should be suspected in older patients who develop nonadherence, frequent hypoglycemia, or sudden deterioration of glycemic control. Screening for cognitive dysfunction with practical clinical tools, such as the Mini-cog, is recommended for all older patients with diabetes (106).

Polypharmacy

The older adult diabetes population is at high risk for polypharmacy and has increased susceptibility to the side effects of medications. For example, the risk of hypoglycemia among adults age ≥65 years using insulin or sulfonylurea was highest among adults age >80 years (relative risk 1.8, 95% CI 1.4–2.3) compared with adults age 65–70 years (107). However, comprehensive diabetes care is strongly tied to increasing prescription medications, as diabetes and its complications progress over time (108). Thus, the trade-offs between the potential benefits and risks of adding new diabetes-related and other medications for older patients with diabetes should be carefully weighed.

Intensive Control in Older Adults With Functional Impairment and/or Comorbidity

The geriatric diabetes population is at greater risk for death due to diabetes and comorbidity, and this increased risk affects the potential benefit of intensive glycemic control. A decision analytic study compared the projected health benefits of moderate glucose control (A1c <7.9%) and intensive glucose control (A1c <7.0%) for hypothetical older patients of varying ages, durations of diabetes, and risks of mortality (109). Risk for mortality in 4 years was estimated based on functional impairment and comorbid illness (110). This study found that the estimated benefits of glucose control steadily declined as the 4-year mortality risk increased, highlighting the importance of competing mortality and life expectancy estimates in the care of older patients with diabetes. An observational study of 3,074 patients with type 2 diabetes confirmed these results (111). These patients were categorized into high and low-to-moderate comorbidity groups at baseline and observed for 5 years. During follow-up, only patients in the low-to-moderate comorbidity group with baseline A1c levels ≤6.5% had a lower 5-year incidence of cardiovascular events (adjusted HR 0.60, 95% CI 0.42–0.85, p=0.005), while patients in the high comorbidity group experienced no significant benefit from A1c levels ≤6.5%. Similarly, only the low-to-moderate comorbidity group had fewer cardiovascular events after attaining an A1c level ≤7.0% (adjusted HR 0.61, 95% CI 0.44–0.83, p=0.001). These studies suggest that moderate glucose targets may be reasonable in older patients with diabetes and limited life expectancy due to functional impairment and comorbidity.

HYPOGLYCEMIA

Avoidance of hypoglycemia should be an important consideration before choosing therapeutic agents and establishing glycemic goals in older adults. Older frail adults are at high risk for severe sequelae of hypoglycemia, even if the hypoglycemia is mild (104,112,113). Older adults have more neuroglycopenic manifestations of hypoglycemia (dizziness, weakness, delirium, confusion) rather than adrenergic manifestations (tremors, sweating) typical of middle-aged adults.

Despite the clinical importance of hypoglycemia in older adults, several studies suggest that many older adults may be receiving intensive glucose-lowering treatments that increase the risk of hypoglycemia. A study of Medicare claims from 1999 to 2011 revealed that the risk of hospitalization due to acute hyperglycemia has declined, but that the risk of hospitalization due to hypoglycemia increased by 11.7% (from 94 to 105 admissions per 100,000 person-years) (114). These findings suggest that treatments may be becoming overly aggressive over time. A separate study within the Veterans Health Administration specifically examined the prescribing of agents that increase the risk of hypoglycemia, namely insulin secretagogues, such as sulfonylureas and meglitinides, and all insulins in 2009. The investigators identified instances of overtreatment as the use of any of these agents in patients with A1c levels below specific thresholds (e.g., <7.0%). Among adults age ≥75 years who had a serum creatinine value ≥2.0 mg/dL or a diagnosis of cognitive impairment or dementia receiving insulin and/or sulfonylureas in 2009, rates of overtreatment were 11.3% for A1c <6.0%, 28.6% for <6.5%, and 50.0% for <7.0% (115). Despite the lack of clinical trial data in support of intensive treatment and despite care guidelines recommending less intensive goals, it has been repeatedly found that the oldest patients with diabetes continue to receive intensive glucose-lowering treatments, irrespective of health status. Within the NHANES 2001–2010, 54.9% of adults age ≥65 years with A1c <7.0% were treated with either insulin or sulfonylureas, and this proportion was similar across health status categories (116).

QUALITY OF CARE STANDARDS

Care of older diabetes patients will likely be influenced by concepts introduced in care guidelines during the early 2000s. In 2003, the California Healthcare Foundation/American Geriatrics Society panel published guidelines for improving the care of older adults with diabetes (112). A significant proportion of the recommendations concern geriatric conditions. Highlights of diabetes-specific recommendations include A1c targets of <7.0% in "relatively healthy adults," while for those who are frail or with life expectancy <5 years, a less stringent target, such as 8.0%, is considered appropriate. The Department of Veterans Affairs and Department of Defense diabetes guideline was updated in 2010 (117). This guideline highlighted the frequency of comorbid conditions in patients with diabetes and recommended stratification of glycemic goals based on comorbidity and life expectancy. The European Diabetes Working Party for Older People in 2011 published guidelines for treating people with diabetes age >70 years (118). These guidelines recommended that treatments be based on the benefit/risk ratio of the intervention for the individual patient with consideration for hypoglycemia, self-management, cognitive status, and life expectancy. In 2012, the American Diabetes Association released a consensus report on the care of older patients with diabetes (119), which summarized diabetes epidemiology and pathogenesis in older adults, evidence for prevention and treating comorbidities, guidelines for older adults, individualizing treatment regimens, consensus recommendations for treatment, and how gaps in evidence can be filled.

A consistent theme of these guidelines is the recommendation to pursue an individualized approach to diabetes care, focusing on clinical and functional heterogeneity and comorbidities and weighing the expected timeframe of benefit of interventions against life expectancy.

ECONOMIC CONSEQUENCES OF DIABETES

MEDICARE

In the United States, the vast majority of adults age ≥65 years have universal health insurance through the Medicare program, which was established by the federal government in 1965. The Medicare program has two major components: (1) the hospital benefit under Part A and (2) outpatient medical services under Part B. Patients have the option of an open-network single payer health care plan (traditional Medicare) or a network plan (Medicare Advantage or Medicare Part C) where the federal government pays for private health coverage. Lastly, Part D is an outpatient prescription drug plan. In 1972, the Social Security Amendments of 1972 extended Medicare coverage to individuals with end-stage renal disease in order to provide coverage for outpatient dialysis. In 1997, the Balanced Budget Act provided coverage for blood glucose monitors and testing strips, in addition to outpatient diabetes self-management training (120).

COSTS OF DIABETES

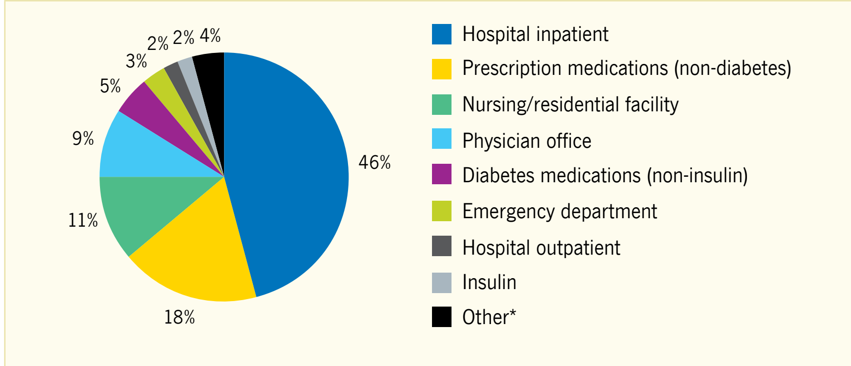
Diabetes accounts for an estimated 32% of all Medicare spending. The total national cost of diabetes in the United States was estimated at $245 billion in 2012 based on national public and private data sources (121), as described in depth in Chapter 40. Government insurance, including Medicare, Medicaid, and the military, covered an estimated 62.4% of diabetes care in 2012. Of this total, an estimated $104 billion was due to direct medical costs in adults age ≥65 years. Approximately 85% of these direct medical costs were due to hospital inpatient stays ($48 billion), prescription medications (excluding diabetes medications) ($19 billion), nursing/residential facility stays ($12 billion), and physician's office visits ($9 billion) (Figure 16.11).

Aside from the direct costs of diabetes in older adults, indirect costs for diabetes and diabetic complications among older adults are significant. A nationally representative survey of adults age ≥70 years estimated the costs associated with informal caregiving for community-dwelling older individuals with and without diabetes (122). This study found that older adults with diabetes required an average of 10.5–14.4 hours of informal caregiving per week, compared to only 6.1 hours per week for those without diabetes ($p<0.01$). This time was estimated to be equivalent to a total cost of $3–$6 billion per year in the United States.

ANTICIPATED GROWTH IN SPENDING OVER TIME

As a result of the aging of the U.S. population and the increasing prevalence of obesity, health care costs associated with diabetes have been anticipated to grow significantly. Forecasting studies have projected that the number of older individuals with diagnosed diabetes will rise from 6.5 million in 2009 to 14.1 million in 2034 (123). Medicare spending on diabetes care has been estimated to triple over the 25-year period, from $45 billion in 2009 to $171 billion in 2034.

FIGURE 16.11. Proportion of Health Care Expenditures Attributed to Diabetes Among Adults Age ≥65 Years, by Service, U.S., 2012



* Includes home health, diabetic supplies, other equipment and supplies, podiatry, hospice, and ambulance services.

SOURCE: Reference 121

EFFORTS TO IMPROVE CARE AND CURB SPENDING

Several national efforts are underway with the dual purpose of improving care and curbing spending; however, evidence from these large-scale experiments is inconclusive. Past and ongoing experiments by Medicare have included disease management programs, as well as payment innovation models, such as Accountable Care Organizations and the Patient Centered Medical Home (124,125,126).

LIST OF ABBREVIATIONS

A1c . . . . .glycosylated hemoglobin
ACCORD . . . . .Action to Control Cardiovascular Risk in Diabetes
ADVANCE . . . .Action in Diabetes and Vascular Disease: Preterax and Diamicron MR Controlled Evaluation
CI . . . . .confidence interval
CVD . . . . .cardiovascular disease
DPP . . . . .Diabetes Prevention Program
HR . . . . .hazard ratio
HRR . . . . .hazard risk ratio
IADL. . . . . .Instrumental Activity of Daily Living
INVEST . . . . . .International Verapamil SR-Trandolapril Study
LDL . . . . .low-density lipoprotein
NHANES . . . . .National Health and Nutrition Examination Survey
NHIS . . . . .National Health Interview Survey
OR . . . . .odds ratio
SBP . . . . .systolic blood pressure
SHEP . . . . .Systolic Hypertension in the Elderly Program (SHEP)
UKPDS. . . . . . .United Kingdom Prospective Diabetes Study
VADT . . . . .Veterans Affairs Diabetes Trial

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CONVERSIONS

Conversions for A1c, glucose, and LDL cholesterol values are provided in *Diabetes in America Appendix 1 Conversions*.

DUALITY OF INTEREST

Drs. Laiteerapong and Huang reported no conflicts of interest.

REFERENCES

1. Morley JE: The elderly type 2 diabetic patient: special considerations. *Diabet Med* 15(Suppl 4):S41–S46, 1998
2. Laiteerapong N, Karter AJ, Liu JY, Moffet HH, Sudore R, Schillinger D, John PM, Huang ES: Correlates of quality of life in older adults with diabetes: the Diabetes & Aging Study. *Diabetes Care* 34:1749–1753, 2011
3. Amati F, Dube JJ, Coen PM, Stefanovic-Racic M, Toledo FG, Goodpaster BH: Physical inactivity and obesity underlie the insulin resistance of aging. *Diabetes Care* 32:1547–1549, 2009
4. Chang AM, Halter JB: Aging and insulin secretion. *Am J Physiol Endocrinol Metab* 284:E7–E12, 2003
5. Reers C, Erbel S, Esposito I, Schmied B, Buchler MW, Nawroth PP, Ritzel RA: Impaired islet turnover in human donor pancreata with aging. *Eur J Endocrinol* 160:185–191, 2009
6. Maedler K, Schumann DM, Schulthess F, Oberholzer J, Bosco D, Berney T, Donath MY: Aging correlates with decreased beta-cell proliferative capacity and enhanced sensitivity to apoptosis: a potential role for Fas and pancreatic duodenal homeobox-1. *Diabetes* 55:2455–2462, 2006
7. Rankin MM, Kushner JA: Adaptive beta-cell proliferation is severely restricted with advanced age. *Diabetes* 58:1365–1372, 2009
8. Zhang X, Decker FH, Luo H, Geiss LS, Pearson WS, Saaddine JB, Gregg EW, Albright A: Trends in the prevalence and comorbidities of diabetes mellitus in nursing home residents in the United States: 1995–2004. *J Am Geriatr Soc* 58:724–730, 2010
9. Nathan DM, Meigs J, Singer DE: The epidemiology of cardiovascular disease in type 2 diabetes mellitus: how sweet it is ... or is it? *Lancet* 350(Suppl 1):SI4–S19, 1997
10. Nathan DM, Singer DE, Godine JE, Harrington CH, Perlmuter LC: Retinopathy in older type II diabetics. Association with glucose control. *Diabetes* 35:797–801, 1986
11. Tinetti ME: Clinical practice. Preventing falls in elderly persons. *N Engl J Med* 348:42–49, 2003
12. Brown JS, Seeley DG, Fong J, Black DM, Ensrud KE, Grady D; Study of Osteoporotic Fractures Research Group: Urinary incontinence in older women: who is at risk? *Obstet Gynecol* 87:715–721, 1996
13. Greene DA, Stevens MJ, Feldman EL: Diabetic neuropathy: scope of the syndrome. *Am J Med* 107:2S–8S, 1999
14. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ: The prevalence of comorbid depression in adults with diabetes: a meta-analysis. *Diabetes Care* 24:1069–1078, 2001
15. Stewart R, Liolitsa D: Type 2 diabetes mellitus, cognitive impairment and dementia. *Diabet Med* 16:93–112, 1999
16. Murray MD, Kroenke K: Polypharmacy and medication adherence: small steps on a long road. *J Gen Intern Med* 16:137–139, 2001
17. Huang ES, Laiteerapong N, Liu JY, John PM, Moffet HH, Karter AJ: Rates of complications and mortality in older patients with diabetes mellitus: the Diabetes and Aging Study. *JAMA Intern Med* 174:251–258, 2014
18. Harris MI: Hypercholesterolemia in diabetes and glucose intolerance in the U.S. population. *Diabetes Care* 14:366–374, 1991
19. Bertoni AG, Hundley WG, Massing MW, Bonds DE, Burke GL, Goff DC, Jr.: Heart failure prevalence, incidence, and mortality in the elderly with diabetes. *Diabetes Care* 27:699–703, 2004
20. Li Y, Burrows NR, Gregg EW, Albright A, Geiss LS: Declining rates of hospitalization for nontraumatic lower-extremity amputation in the diabetic population aged 40 years or older: U.S., 1988–2008. *Diabetes Care* 35:273–277, 2012
21. Volpato S, Leveille SG, Blaum C, Fried LP, Guralnik JM: Risk factors for falls in older disabled women with diabetes: the Women's Health and Aging Study. *J Gerontol A Biol Sci Med Sci* 60:1539–1545, 2005
22. Schwartz AV, Sellmeyer DE, Ensrud KE, Cauley JA, Tabor HK, Schreiner PJ, Jamal SA, Black DM, Cummings SR; Study of Osteoporotic Features Research Group: Older women with diabetes have an increased risk of fracture: a prospective study. *J Clin Endocrinol Metab* 86:32–38, 2001
23. Patel S, Hyer S, Tweed K, Kerry S, Allan K, Rodin A, Barron J: Risk factors for fractures and falls in older women with type 2 diabetes mellitus. *Calcif Tissue Int* 82:87–91, 2008
24. Vinik AI: Diabetic neuropathy: pathogenesis and therapy. *Am J Med* 107:17S–26S, 1999
25. Morley GK, Mooradian AD, Levine AS, Morley JE: Mechanism of pain in diabetic peripheral neuropathy. Effect of glucose on pain perception in humans. *Am J Med* 77:79–82, 1984
26. Gavard JA, Lustman PJ, Clouse RE: Prevalence of depression in adults with diabetes. An epidemiological evaluation. *Diabetes Care* 16:1167–1178, 1993
27. Peyrot M, Rubin RR: Levels and risks of depression and anxiety symptomatology among diabetic adults. *Diabetes Care* 20:585–590, 1997
28. Byers AL, Vittinghoff E, Lui LY, Hoang T, Blazer DG, Covinsky KE, Ensrud KE, Cauley JA, Hillier TA, Fredman L, Yaffe K: Twenty-year depressive trajectories among older women. *Arch Gen Psychiatry* 69:1073–1079, 2012
29. Strachan MW, Deary IJ, Ewing FM, Frier BM: Is type II diabetes associated with an increased risk of cognitive dysfunction? A critical review of published studies. *Diabetes Care* 20:438–445, 1997
30. Helkala EL, Niskanen L, Viinamaki H, Partanen J, Uusitupa M: Short-term and long-term memory in elderly patients with NIDDM. *Diabetes Care* 18:681–685, 1995

31. Mooradian AD, Perryman K, Fitten J, Kavonian GD, Morley JE: Cortical function in elderly non-insulin dependent diabetic patients. Behavioral and electrophysiologic studies. *Arch Intern Med* 148:2369–2372, 1988
32. Gregg EW, Yaffe K, Cauley JA, Rolka DB, Blackwell TL, Narayan KM, Cummings SR: Is diabetes associated with cognitive impairment and cognitive decline among older women? Study of Osteoporotic Fractures Research Group. *Arch Intern Med* 160:174–180, 2000
33. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA: Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 56:M146–M156, 2001
34. Park SW, Goodpaster BH, Strotmeyer ES, de Rekeneire N, Harris TB, Schwartz AV, Tylavsky FA, Newman AB: Decreased muscle strength and quality in older adults with type 2 diabetes: the Health, Aging, and Body Composition Study. *Diabetes* 55:1813–1818, 2006
35. Blaum CS, Xue QL, Michelon E, Semba RD, Fried LP: The association between obesity and the frailty syndrome in older women: the Women's Health and Aging Studies. *J Am Geriatr Soc* 53:927–934, 2005
36. Newman AB, Yanez D, Harris T, Duxbury A, Enright PL, Fried LP: Weight change in old age and its association with mortality. *J Am Geriatr Soc* 49:1309–1318, 2001
37. Wedick NM, Barrett-Connor E, Knoke JD, Wingard DL: The relationship between weight loss and all-cause mortality in older men and women with and without diabetes mellitus: the Rancho Bernardo study. *J Am Geriatr Soc* 50:1810–1815, 2002
38. Huang ES, Basu A, Finch M, Frytak J, Manning W: The complexity of medication regimens and test ordering for patients with diabetes from 1995 to 2003. *Curr Med Res Opin* 23:1423–1430, 2007
39. Huang ES, Karter AJ, Danielson KK, Warton EM, Ahmed AT: The association between the number of prescription medications and incident falls in a multi-ethnic population of adult type-2 diabetes patients: the Diabetes and Aging Study. *J Gen Intern Med* 25:141–146, 2010
40. Lee PG, Cigolle C, Blaum C: The co-occurrence of chronic diseases and geriatric syndromes: the Health and Retirement Study. *J Am Geriatr Soc* 57:511–516, 2009
41. Schneider KM, O'Donnell BE, Dean D: Prevalence of multiple chronic conditions in the United States' Medicare population. *Health Qual Life Outcomes* 7:82, 2009
42. Wolff JL, Starfield B, Anderson G: Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. *Arch Intern Med* 162:2269–2276, 2002
43. Weiss CO, Boyd CM, Yu Q, Wolff JL, Leff B: Patterns of prevalent major chronic disease among older adults in the United States. *JAMA* 298:1160–1162, 2007
44. Laiteerapong N, Huang ES, Chin MH: Prioritization of care in adults with diabetes and comorbidity. *Ann N Y Acad Sci* 1243:69–87, 2011
45. Gu K, Cowie CC, Harris MI: Mortality in adults with and without diabetes in a national cohort of the U.S. population, 1971–1993. *Diabetes Care* 21:1138–1145, 1998
46. Gregg EW, Cheng YJ, Saydah S, Cowie C, Garfield S, Geiss L, Barker L: Trends in death rates among U.S. adults with and without diabetes between 1997 and 2006: findings from the National Health Interview Survey. *Diabetes Care* 35:1252–1257, 2012
47. UK Prospective Diabetes Study (UKPDS) Group: Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet* 352:854–865, 1998
48. Banegas JR, Lopez-Garcia E, Graciani A, Guallar-Castillon P, Gutierrez-Fisac JL, Alonso J, Rodriguez-Artalejo F: Relationship between obesity, hypertension and diabetes, and health-related quality of life among the elderly. *Eur J Cardiovasc Prev Rehabil* 14:456–462, 2007
49. Graham JE, Stoebner-May DG, Ostir GV, Al Snih S, Peek MK, Markides K, Ottenbacher KJ: Health related quality of life in older Mexican Americans with diabetes: a cross-sectional study. *Health Qual Life Outcomes* 5:39, 2007
50. Volpato S, Ferrucci L, Blaum C, Ostir G, Cappola A, Fried LP, Fellin R, Guralnik JM: Progression of lower-extremity disability in older women with diabetes: the Women's Health and Aging Study. *Diabetes Care* 26:70–75, 2003
51. Volpato S, Blaum C, Resnick H, Ferrucci L, Fried LP, Guralnik JM: Comorbidities and impairments explaining the association between diabetes and lower extremity disability: the Women's Health and Aging Study. *Diabetes Care* 25:678–683, 2002
52. Gregg EW, Beckles GL, Williamson DF, Leveille SG, Langlois JA, Engelgau MM, Narayan KM: Diabetes and physical disability among older U.S. adults. *Diabetes Care* 23:1272–1277, 2000
53. Maty SC, Fried LP, Volpato S, Williamson J, Brancati FL, Blaum CS: Patterns of disability related to diabetes mellitus in older women. *J Gerontol A Biol Sci Med Sci* 59:148–153, 2004
54. Wray LA, Ofstedal MB, Langa KM, Blaum CS: The effect of diabetes on disability in middle-aged and older adults. *J Gerontol A Biol Sci Med Sci* 60:1206–1211, 2005
55. Kalyani RR, Saudek CD, Brancati FL, Selvin E: Association of diabetes, comorbidities, and A1C with functional disability in older adults: results from the National Health and Nutrition Examination Survey (NHANES), 1999–2006. *Diabetes Care* 33:1055–1060, 2010
56. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM; Diabetes Prevention Program Research Group: Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 346:393–403, 2002
57. Crandall J, Schade D, Ma Y, Fujimoto WY, Barrett-Connor E, Fowler S, Dagogo-Jack S, Andres R; Diabetes Prevention Program Research Group: The influence of age on the effects of lifestyle modification and metformin in prevention of diabetes. *J Gerontol A Biol Sci Med Sci* 61:1075–1081, 2006
58. Knowler WC, Fowler SE, Hamman RF, Christophi CA, Hoffman HJ, Brenneman AT, Brown-Friday JO, Goldberg R, Venditti E, Nathan DM; Diabetes Prevention Program Research Group: 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 374:1677–1686, 2009
59. Brown JS, Wing R, Barrett-Connor E, Nyberg LM, Kusek JW, Orchard TJ, Ma Y, Vittinghoff E, Kanaya AM; Diabetes Prevention Program Research Group: Lifestyle intervention is associated with lower prevalence of urinary incontinence: the Diabetes Prevention Program. *Diabetes Care* 29:385–390, 2006
60. Florez H, Pan Q, Ackermann RT, Marrero DG, Barrett-Connor E, Delahanty L, Kriska A, Saudek CD, Goldberg RB, Rubin RR: Impact of lifestyle intervention and metformin on health-related quality of life: the Diabetes Prevention Program randomized trial. *J Gen Intern Med* 27:1594–1601
61. 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

62. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HA: 10-year follow-up of intensive glucose control in type 2 diabetes. *N Engl J Med* 359:1577–1589, 2008
63. Gerstein HC, Miller ME, Byington RP, Goff DC, Jr., Bigger JT, Buse JB, Cushman WC, Genuth S, Ismail-Beigi F, Grimm RH, Jr., Probstfield JL, Simons-Morton DG, Friedewald WT; Action to Control Cardiovascular Risk in Diabetes Study Group: Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med* 358:2545–2559, 2008
64. Miller ME, Bonds DE, Gerstein HC, Seaquist ER, Bergenstal RM, Calles-Escandon J, Childress RD, Craven TE, Cuddihy RM, Dailey G, Feinglos MN, Ismail-Beigi F, Largay JF, O'Connor PJ, Paul T, Savage PJ, Schubart UK, Sood A, Genuth S; ACCORD investigators: The effects of baseline characteristics, glycaemia treatment approach, and glycated haemoglobin concentration on the risk of severe hypoglycaemia: post hoc epidemiological analysis of the ACCORD study. *BMJ* 340:b5444, 2010
65. Patel A, MacMahon S, Chalmers J, Neal B, Billot L, Woodward M, Marre M, Cooper M, Glasziou P, Grobbee D, Hamet P, Harrap S, Heller S, Liu L, Mancia G, Mogensen CE, Pan C, Poulter N, Rodgers A, Williams B, Bompoint S, de Galan BE, Joshi R, Travert F; ADVANCE Collaborative Group: Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 358:2560–2572, 2008
66. Duckworth W, Abraira C, Moritz T, Reda D, Emanuele N, Reaven PD, Zieve FJ, Marks J, Davis SN, Hayward R, Warren SR, Goldman S, McCarren M, Vitek ME, Henderson WG, Huang GD; VADT investigators: Glucose control and vascular complications in veterans with type 2 diabetes. *N Engl J Med* 360:129–139, 2009
67. Duckworth WC, Abraira C, Moritz TE, Davis SN, Emanuele N, Goldman S, Hayward R, Huang GD, Marks JB, Reaven PD, Reda DJ, Warren SR, Zieve FJ: The duration of diabetes affects the response to intensive glucose control in type 2 subjects: the VA Diabetes Trial. *J Diabetes Complications* 25:355–361, 2011
68. Currie CJ, Peters JR, Tynan A, Evans M, Heine RJ, Bracco OL, Zagar T, Poole CD: Survival as a function of HbA(1c) in people with type 2 diabetes: a retrospective cohort study. Lancet 375:481–489, 2010
69. Huang ES, Liu JY, Moffet HH, John PM, Karter AJ: Glycemic control, complications, and death in older diabetic patients: the Diabetes and Aging Study. *Diabetes Care* 34:1329–1336, 2011
70. Curb JD, Pressel SL, Cutler JA, Savage PJ, Applegate WB, Black H, Camel G, Davis BR, Frost PH, Gonzalez N, Guthrie G, Oberman A, Rutan GH, Stamler J; Systolic Hypertension in the Elderly Program Cooperative Research Group: Effect of diuretic-based antihypertensive treatment on cardiovascular disease risk in older diabetic patients with isolated systolic hypertension. *JAMA* 276:1886–1892, 1996
71. 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
72. Patel A, MacMahon S, Chalmers J, Neal B, Woodward M, Billot L, Harrap S, Poulter N, Marre M, Cooper M, Glasziou P, Grobbee DE, Hamet P, Heller S, Liu LS, Mancia G, Mogensen CE, Pan CY, Rodgers A, Williams B; ADVANCE Collaborative Group: Effects of a fixed combination of perindopril and indapamide on macrovascular and microvascular outcomes in patients with type 2 diabetes mellitus (the ADVANCE trial): a randomised controlled trial. *Lancet* 370:829–840, 2007
73. Cooper-DeHoff RM, Gong Y, Handberg EM, Bavry AA, Denardo SJ, Bakris GL, Pepine CJ: Tight blood pressure control and cardiovascular outcomes among hypertensive patients with diabetes and coronary artery disease. *JAMA* 304:61–68, 2010
74. Cushman WC, Evans GW, Byington RP, Goff DC, Jr., Grimm RH, Jr., Cutler JA, Simons-Morton DG, Basile JN, Corson MA, Probstfield JL, Katz L, Peterson KA, Friedewald WT, Buse JB, Bigger JT, Gerstein HC, Ismail-Beigi F: Effects of intensive blood-pressure control in type 2 diabetes mellitus. *N Engl J Med* 362:1575–1585, 2010
75. Anderson RJ, Bahn GD, Moritz TE, Kaufman D, Abraira C, Duckworth W: Blood pressure and cardiovascular disease risk in the Veterans Affairs Diabetes Trial. *Diabetes Care* 34:34–38, 2011
76. Shepherd J, Blauw GJ, Murphy MB, Bollen EL, Buckley BM, Cobbe SM, Ford I, Gaw A, Hyland M, Jukema JW, Kamper AM, Macfarlane PW, Meinders AE, Norrie J, Packard CJ, Perry IJ, Stott DJ, Sweeney BJ, Twomey C, Westendorp RG; PROSPER Study Group: Pravastatin in elderly individuals at risk of vascular disease (PROSPER): a randomised controlled trial. *Lancet* 360:1623–1630, 2002
77. Baigent C, Blackwell L, Emberson J, Holland LE, Reith C, Bhala N, Peto R, Barnes EH, Keech A, Simes J, Collins R; Cholesterol Treatment Trialists' (CTT) Collaboration: Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet* 376:1670–1681, 2010
78. Collins R, Armitage J, Parish S, Sleigh P, Peto R; Heart Protection Study Collaborative Group: MRC/BHF Heart Protection Study of cholesterol-lowering with simvastatin in 5963 people with diabetes: a randomised placebo-controlled trial. *Lancet* 361:2005–2016, 2003
79. Ginsberg HN, Elam MB, Lovato LC, Crouse JR, 3rd, Leiter LA, Linz P, Friedewald WT, Buse JB, Gerstein HC, Probstfield J, Grimm RH, Ismail-Beigi F, Bigger JT, Goff DC, Jr., Cushman WC, Simons-Morton DG, Byington RP; ACCORD Study Group: Effects of combination lipid therapy in type 2 diabetes mellitus. *N Engl J Med* 362:1563–1574, 2010
80. Keech A, Simes RJ, Barter P, Best J, Scott R, Taskinen MR, Forder P, Pillai A, Davis T, Glasziou P, Drury P, Kesaniemi YA, Sullivan D, Hunt D, Colman P, d'Emden M, Whiting M, Ehnholm C, Laakso M; FIELD study investigators: Effects of long-term fenofibrate therapy on cardiovascular events in 9795 people with type 2 diabetes mellitus (the FIELD study): randomised controlled trial. *Lancet* 366:1849–1861, 2005
81. Gaede P, Vedel P, Larsen N, Jensen GV, Parving HH, Pedersen O: Multifactorial intervention and cardiovascular disease in patients with type 2 diabetes. *N Engl J Med* 348:383–393, 2003
82. Bischoff-Ferrari HA, Dawson-Hughes B, Staehelin HB, Orav JE, Stuck AE, Theiler R, Wong JB, Egli A, Kiel DP, Henschkowski J: Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials. *BMJ* 339:b3692, 2009
83. Trombetti A, Hars M, Herrmann FR, Kressig RW, Ferrari S, Rizzoli R: Effect of music-based multitask training on gait, balance, and fall risk in elderly people: a randomized controlled trial. *Arch Intern Med* 171:525–533, 2011

84. Moyer VA: Prevention of falls in community-dwelling older adults: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med* 157:197–204, 2012
85. Katon WJ, Rutter C, Simon G, Lin EH, Ludman E, Ciechanowski P, Kinder L, Young B, Von Korff M: The association of comorbid depression with mortality in patients with type 2 diabetes. *Diabetes Care* 28:2668–2672, 2005
86. Goldney RD, Phillips PJ, Fisher LJ, Wilson DH: Diabetes, depression, and quality of life: a population study. *Diabetes Care* 27:1066–1070, 2004
87. Finkelstein EA, Bray JW, Chen H, Larson MJ, Miller K, Tompkins C, Keme A, Manderscheid R: Prevalence and costs of major depression among elderly claimants with diabetes. *Diabetes Care* 26:415–420, 2003
88. Lin EH, Katon W, Von Korff M, Rutter C, Simon GE, Oliver M, Ciechanowski P, Ludman EJ, Bush T, Young B: Relationship of depression and diabetes self-care, medication adherence, and preventive care. *Diabetes Care* 27:2154–2160, 2004
89. Katon W, Russo J, Lin EH, Heckbert SR, Karter AJ, Williams LH, Ciechanowski P, Ludman E, Von Korff M: Diabetes and poor disease control: is comorbid depression associated with poor medication adherence or lack of treatment intensification? *Psychosom Med* 71:965–972, 2009
90. Ciechanowski PS, Katon WJ, Russo JE: Depression and diabetes: impact of depressive symptoms on adherence, function, and costs. *Arch Intern Med* 160:3278–3285, 2000
91. Lustman PJ, Anderson RJ, Freedland KE, de Groot M, Carney RM, Clouse RE: Depression and poor glycemic control: a meta-analytic review of the literature. *Diabetes Care* 23:934–942, 2000
92. Katon W, Lyles CR, Parker MM, Karter AJ, Huang ES, Whitmer RA: Association of depression with increased risk of dementia in patients with type 2 diabetes: the Diabetes and Aging Study. *Arch Gen Psychiatry* 69:410–417, 2011
93. Katon WJ, Lin EH, Williams LH, Ciechanowski P, Heckbert SR, Ludman E, Rutter C, Crane PK, Oliver M, Von Korff M: Comorbid depression is associated with an increased risk of dementia diagnosis in patients with diabetes: a prospective cohort study. *J Gen Intern Med* 25:423–429, 2010
94. Pan A, Lucas M, Sun Q, van Dam RM, Franco OH, Willett WC, Manson JE, Rexrode KM, Ascherio A, Hu FB: Increased mortality risk in women with depression and diabetes mellitus. *Arch Gen Psychiatry* 68:42–50, 2011
95. Katon W, Fan MY, Unutzer J, Taylor J, Pincus H, Schoenbaum M: Depression and diabetes: a potentially lethal combination. *J Gen Intern Med* 23:1571–1575, 2008
96. Egede LE, Nietert PJ, Zheng D: Depression and all-cause and coronary heart disease mortality among adults with and without diabetes. *Diabetes Care* 28:1339–1345, 2005
97. Bell RA, Smith SL, Arcury TA, Snively BM, Stafford JM, Quandt SA: Prevalence and correlates of depressive symptoms among rural older African Americans, Native Americans, and whites with diabetes. *Diabetes Care* 28:823–829, 2005
98. American Diabetes Association: Standards of medical care in diabetes—2012. *Diabetes Care* 35(Suppl 1):S11–S63, 2012
99. Rinaldi P, Mecocci P, Benedetti C, Ercolani S, Bregnocchi M, Menculini G, Catani M, Senin U, Cherubini A: Validation of the five-item geriatric depression scale in elderly subjects in three different settings. *J Am Geriatr Soc* 51:694–698, 2003
100. Brauner DJ, Muir JC, Sachs GA: Treating nondementia illnesses in patients with dementia. *JAMA* 283:3230–3235, 2000
101. Launer LJ, Miller ME, Williamson JD, Lazar RM, Gerstein HC, Murray AM, Sullivan M, Horowitz KR, Ding J, Marcovina S, Lovato LC, Lovato J, Margolis KL, O'Connor P, Lipkin EW, Hirsch J, Coker L, Maldjian J, Sunshine JL, Truwit C, Davatzikos C, Bryan RN; ACCORD MIND investigators: Effects of intensive glucose lowering on brain structure and function in people with type 2 diabetes (ACCORD MIND): a randomised open-label substudy. *Lancet Neurol* 10:969–977, 2011
102. Munshi M, Grande L, Hayes M, Ayres D, Suhl E, Capelson R, Lin S, Milberg W, Weinger K: Cognitive dysfunction is associated with poor diabetes control in older adults. *Diabetes Care* 29:1794–1799, 2006
103. Punthakee Z, Miller ME, Launer LJ, Williamson JD, Lazar RM, Cukierman-Yaffee T, Seaquist ER, Ismail-Beigi F, Sullivan MD, Lovato LC, Bergenstal RM, Gerstein HC; ACCORD group of investigators; ACCORD MIND investigators: Poor cognitive function and risk of severe hypoglycemia in type 2 diabetes: post hoc epidemiologic analysis of the ACCORD trial. *Diabetes Care* 35:787–793, 2012
104. Whitmer RA, Karter AJ, Yaffe K, Quesenberry CP, Jr., Selby JV: Hypoglycemic episodes and risk of dementia in older patients with type 2 diabetes mellitus. *JAMA* 301:1565–1572, 2009
105. Yaffe K, Falvey CM, Hamilton N, Harris TB, Simonsick EM, Strotmeyer ES, Shorr RI, Metti A, Schwartz AV; Health ABC Study: Association between hypoglycemia and dementia in a biracial cohort of older adults with diabetes mellitus. *JAMA Intern Med* 173:1300–1306, 2013
106. Borson S, Scanlan JM, Chen P, Ganguli M: The Mini-Cog as a screen for dementia: validation in a population-based sample. *J Am Geriatr Soc* 51:1451–1454, 2003
107. Shorr RI, Ray WA, Daugherty JR, Griffin MR: Incidence and risk factors for serious hypoglycemia in older persons using insulin or sulfonylureas. *Arch Intern Med* 157:1681–1686, 1997
108. Turner RC, Cull CA, Frighi V, Holman RR; UK Prospective Diabetes Study (UKPDS) Group: Glycemic control with diet, sulfonylurea, metformin, or insulin in patients with type 2 diabetes mellitus: progressive requirement for multiple therapies (UKPDS 49). *JAMA* 281:2005–2012, 1999
109. Huang ES, Zhang Q, Gandra N, Chin MH, Meltzer DO: The effect of comorbid illness and functional status on the expected benefits of intensive glucose control in older patients with type 2 diabetes: a decision analysis. *Ann Intern Med* 149:11–19, 2008
110. Lee SJ, Lindquist K, Segal MR, Covinsky KE: Development and validation of a prognostic index for 4-year mortality in older adults. *JAMA* 295:801–808, 2006
111. Greenfield S, Billimek J, Pellegrini F, Franciosi M, De Berardis G, Nicolucci A, Kaplan SH: Comorbidity affects the relationship between glycemic control and cardiovascular outcomes in diabetes: a cohort study. *Ann Intern Med* 151:854–860, 2009
112. Brown AF, Mangione CM, Saliba D, Sarkisian CA; California Healthcare Foundation/American Geriatrics Society Panel on Improving Care for Elders with Diabetes: Guidelines for improving the care of the older person with diabetes mellitus. *J Am Geriatr Soc* 51:S265–S280, 2003
113. Bonds DE, Miller ME, Bergenstal RM, Buse JB, Byington RP, Cutler JA, Dudl RJ, Ismail-Beigi F, Kimel AR, Hoogwerf B, Horowitz KR, Savage PJ, Seaquist ER, Simmons DL, Sivitz WI, Speril-Hillen JM, Sweeney ME: The association between symptomatic, severe hypoglycaemia and

mortality in type 2 diabetes: retrospective epidemiological analysis of the ACCORD study. *BMJ* 340:b4909, 2010

114. Lipska KJ, Ross JS, Wang Y, Inzucchi SE, Minges K, Karter AJ, Huang ES, Desai MM, Gill TM, Krumholz HM: National trends in US hospital admissions for hyperglycemia and hypoglycemia among Medicare beneficiaries, 1999 to 2011. *JAMA Intern Med* 174:1116–1124, 2014
115. Tseng CL, Soroka O, Maney M, Aron DC, Pogach LM: Assessing potential glycemic overtreatment in persons at hypoglycemic risk. *JAMA Intern Med* 174:259–268, 2014
116. Lipska KJ, Ross JS, Miao Y, Shah ND, Lee SJ, Steinman MA: Potential overtreatment of diabetes mellitus in older adults with tight glycemic control. *JAMA Intern Med* 175:356–362, 2015
117. Management of Diabetes Mellitus Update Working Group: *VA/DoD Clinical Practice Guideline for the Management of Diabetes Mellitus*, version 4.0. Washington, DC: Veterans Health Administration and Department of Defense, 2010
118. Sinclair AJ, Paolisso G, Castro M, Bourdel-Marchasson I, Gadsby R, Rodriguez Manas L; European Diabetes Working Party for Older People: European Diabetes Working Party for Older People 2011 clinical guidelines for type 2 diabetes mellitus. Executive summary. *Diabetes Metab* 37(Suppl 3):S27–S38, 2011
119. Kirkman MS, Briscoe VJ, Clark N, Florez H, Haas LB, Halter JB, Huang ES, Korytkowski MT, Munshi MN, Odegard PS, Pratley RE, Swift CS: Diabetes in older adults. *Diabetes Care* 35:2650–2664, 2012
120. Ashkenazy R, Abrahamson MJ: Medicare coverage for patients with diabetes. A national plan with individual consequences. *J Gen Intern Med* 21:386–392, 2006
121. American Diabetes Association: Economic costs of diabetes in the U.S. in 2012. *Diabetes Care* 36:1033–1046, 2013
122. Langa KM, Vijan S, Hayward RA, Chernew ME, Blaum CS, Kabeto MU, Weir DR, Katz SJ, Willis RJ, Fendrick AM: Informal caregiving for diabetes and diabetic complications among elderly Americans. *J Gerontol B Psychol Sci Soc Sci* 57:S177–186, 2002
123. Huang ES, Basu A, O'Grady M, Capretta JC: Projecting the future diabetes population size and related costs for the U.S. *Diabetes Care* 32:2225–2229, 2009
124. Berwick DM: Making good on ACOs' promise—the final rule for the Medicare shared savings program. *N Engl J Med* 365:1753–1756, 2011
125. Jaen CR, Ferrer RL, Miller WL, Palmer RF, Wood R, Davila M, Stewart EE, Crabtree BF, Nutting PA, Stange KC: Patient outcomes at 26 months in the patient-centered medical home National Demonstration Project. *Ann Fam Med* 8(Suppl 1):S57–S67; S92, 2010
126. Rittenhouse DR, Shortell SM: The patient-centered medical home: will it stand the test of health reform? *JAMA* 301:2038–2040, 2009

APPENDICES

APPENDIX 16.1. Trends in the Percent of Diagnosed Diabetes Among Adults Age ≥60 Years, by Age, U.S., 1997–2010

YEAR	PERCENT (STANDARD ERROR) Age (Years) ≥65	60–69	70–79	≥80
1997	13.2 (0.50)	13.0 (0.65)	13.2 (0.70)	11.1 (0.88)
1998	13.2 (0.50)	13.1 (0.65)	13.6 (0.66)	11.2 (0.98)
1999	13.2 (0.50)	12.7 (0.65)	14.4 (0.69)	10.5 (0.89)
2000	14.6 (0.52)	14.0 (0.70)	15.8 (0.74)	11.2 (0.92)
2001	15.3 (0.51)	15.2 (0.73)	16.6 (0.81)	12.2 (0.89)
2002	16.0 (0.54)	15.6 (0.68)	17.1 (0.81)	12.5 (0.95)
2003	16.6 (0.62)	15.5 (0.73)	16.9 (0.83)	14.2 (1.06)
2004	17.3 (0.59)	16.2 (0.69)	18.8 (0.91)	13.8 (0.92)
2005	17.0 (0.54)	16.4 (0.72)	18.4 (0.81)	14.2 (0.91)
2006	18.1 (0.72)	17.1 (0.91)	19.8 (1.14)	16.2 (1.22)
2007	18.7 (0.67)	16.9 (0.76)	20.1 (1.09)	15.7 (1.28)
2008	18.5 (0.68)	18.0 (0.87)	19.6 (1.09)	16.1 (1.17)
2009	19.5 (0.71)	17.9 (0.79)	21.1 (1.09)	17.3 (1.21)
2010	21.4 (0.67)	19.2 (0.75)	24.3 (1.09)	18.4 (1.10)

Data are self-reported.

SOURCE: National Health Interview Surveys 1997–2010

APPENDIX 16.2. Trends in the Number (in Millions) of Adults Age ≥60 Years With Diagnosed Diabetes, by Age, U.S., 1997–2010

YEAR	NUMBER (IN MILLIONS)* Age (Years) ≥65	60–69	70–79	≥80
1997	4.20	2.52	2.04	0.79
1998	4.24	2.61	2.09	0.81
1999	4.27	2.47	2.30	0.77
2000	4.76	2.76	2.54	0.84
2001	5.00	3.03	2.61	0.96
2002	5.28	3.18	2.69	1.00
2003	5.67	3.37	2.69	1.23
2004	5.99	3.78	2.89	1.28
2005	5.95	3.80	2.89	1.33
2006	6.43	4.12	3.02	1.54
2007	6.74	4.47	3.11	1.50
2008	6.86	4.80	3.09	1.62
2009	7.37	4.97	3.43	1.76
2010	8.28	5.65	3.99	1.86

Data are self-reported.
* National Health Interview Survey weighted estimates.

SOURCE: National Health Interview Surveys 1997–2010

APPENDIX 16.3. Duration of Diabetes Among Adults Age ≥60 Years, by Age, U.S., 2009–2010

DURATION	AGE (YEARS)			
	≥65	60–69	70–79	≥80
Mean years (SE)	14.7 (0.32)	11.6 (0.36)	14.8 (0.43)	17.0 (0.87)
Percent (SE)				
<5 years	23.0 (1.05)	29.1 (1.43)	21.3 (1.44)	21.6 (2.25)
5–<10 years	20.4 (1.13)	23.5 (1.06)	21.4 (1.60)	17.9 (2.22)
≥10 years	56.6 (1.25)	47.4 (1.59)	57.3 (1.68)	60.5 (2.51)

Data are self-reported. SE, standard error.

SOURCE: National Health Interview Surveys 2009–2010

APPENDIX 16.4. Body Mass Index Distribution in Adults Age ≥65 Years, by Diabetes Status, U.S., 2007–2010

BMI*	PERCENT (STANDARD ERROR)	
	Diabetes	No Diabetes
Underweight	[1]	1.8 (0.29)
Normal	16.3 (1.42)	29.4 (1.32)
Overweight, not obese	26.9 (2.18)	39.5 (1.45)
Obese	56.4 (2.24)	29.3 (1.06)

Diabetes status is self-reported. BMI, body mass index.

* BMI is calculated based on measured height and weight. Underweight, BMI <18.5 kg/m^2; normal, BMI 18.5–<25 kg/m^2; overweight BMI 25–<30 kg/m^2; obese, BMI ≥30 kg/m^2.

[1] Estimate is too unreliable to present; ≥1 case or relative standard error >50%.

SOURCE: National Health Interview Surveys 2009–2010

APPENDIX 16.5. Body Mass Index Distribution Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010

BMI*	PERCENT (STANDARD ERROR) Age (Years)		
	60–69	70–79	≥80
Underweight	[2]	0.7 (0.25)[1]	2.1 (0.67)[1]
Normal	10.7 (0.91)	18.7 (1.42)	36.2 (2.18)
Overweight, not obese	31.4 (1.64)	35.5 (1.62)	38.0 (2.25)
Obese	57.7 (1.73)	45.1 (1.77)	23.7 (1.96)
Overweight or Obese	89.1 (0.92)	80.6 (1.44)	61.7 (2.13)

Diabetes is self-reported. BMI, body mass index.

* BMI is calculated based on self-reported height and weight. Underweight, BMI <18.5 kg/m^2; normal, BMI 18.5–<25 kg/m^2; overweight, 25–<30 kg/m^2; obese, ≥30 kg/m^2; overweight or obese, ≥25 kg/m^2.

[1] Relative standard error >30%–40%

[2] Estimate is too unreliable to present; ≤1 case or relative standard error >50%.

SOURCE: National Health Interview Surveys 2009–2010

APPENDIX 16.6. Cardiovascular Complications Among Adults Age ≥65 Years, by Diabetes Status, U.S., 2007–2010

CARDIOVASCULAR COMPLICATIONS	PERCENT (STANDARD ERROR)	
	Diabetes	No Diabetes
Congestive heart failure	15.3 (1.75)	5.7 (0.56)
Coronary heart disease	17.6 (1.65)	9.4 (0.68)
Angina	10.4 (1.45)	4.8 (0.67)
Heart attack	15.7 (1.81)	8.5 (0.61)
Any heart condition with angina	34.2 (2.38)	18.0 (0.90)
Any heart condition without angina	31.6 (1.87)	16.1 (0.83)
Stroke	15.4 (1.34)	8.3 (0.93)

Data are self-reported.

SOURCE: National Health and Nutrition Examination Surveys 2007–2010

APPENDIX 16.7. Cardiovascular Complications Among Adults Age ≥60 Years, by Age, U.S., 2009–2010

CARDIOVASCULAR COMPLICATIONS	PERCENT (STANDARD ERROR)			
	Age (Years)			
	≥65	60–69	70–79	≥80
Coronary heart disease	24.3 (1.16)	20.3 (1.24)	25.8 (1.67)	26.1 (2.44)
Angina	10.4 (0.86)	9.7 (0.99)	10.9 (1.19)	11.2 (1.78)
Myocardial infarction	16.3 (1.00)	13.0 (1.07)	18.6 (1.61)	16.7 (1.92)
Other heart condition or disease	23.8 (1.17)	15.9 (1.11)	24.4 (1.71)	29.2 (2.44)
Stroke	13.0 (0.82)	9.3 (0.88)	12.3 (1.27)	20.9 (2.00)

Data are self-reported.

SOURCE: National Health Interview Surveys 2009–2010

APPENDIX 16.8. Microvascular Complications Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010

MICROVASCULAR COMPLICATIONS	PERCENT (STANDARD ERROR)			
	Age (Years)			
	≥65	60–69	70–79	≥80
Trouble seeing*	18.5 (1.04)	16.7 (1.11)	18.8 (1.47)	21.9 (1.99)
Blindness	8.5 (1.76)	5.6 (1.66)	7.7 (2.25)	13.2 (4.38)[1]
Weak/failing kidney	9.0 (0.70)	7.4 (0.86)	9.6 (1.02)	10.7 (1.77)

Data are self-reported.
* Trouble seeing was reported by 12.3% of nondiabetic adults age ≥60 years.
1 Relative standard error >30%–40%

SOURCE: National Health Interview Surveys 2009–2010

APPENDIX 16.9. Chronic Pain Among Adults Age ≥60 Years With Diabetes, by Age, U.S., 2009–2010

SITE OF CHRONIC PAIN	PERCENT (STANDARD ERROR) Age (Years) 60–69	70–79	≥80
Joint pain, past 30 days	59.4 (1.63)	56.7 (1.88)	58.7 (2.50)
Pain in neck, past 3 months	20.9 (1.27)	18.5 (1.47)	18.4 (1.86)
Lower back pain, past 3 months	41.2 (1.50)	37.8 (1.91)	38.0 (2.31)
Facial/jaw ache, past 3 months	6.1 (0.73)	4.4 (0.73)	4.1 (0.93)
Migraine/headache, past 3 months	12.2 (0.99)	8.6 (1.03)	10.6 (1.68)

Data are self-reported.

SOURCE: National Health Interview Surveys 2009–2010