CHAPTER 34

DIABETES AND DISABILITY

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SUMMARY

This chapter reviews findings from national studies of prevention of and trends in diabetes-related disability, summarizes the modifiable risk factors and mechanisms for the excess disability prevalence associated with diabetes, and reviews evidence that physical disability can be prevented or modified.

Cross-sectional and prospective studies have consistently found persons with diabetes to have 50%–90% increased risk of several domains of disability, including mobility loss, reduced instrumental activities of daily living (IADL) or basic activities of daily living (ADL), and work disability. The association of diabetes with increased disability risk is likely multifactorial, with obesity, coronary heart disease, lower extremity diseases, depression, and stroke among the most consistently observed factors explaining the difference in disability risk between people with and without diabetes. Additionally, several studies have suggested that specific physiological factors, including inflammation, insulin resistance, hyperglycemia, and sarcopenia, may also mediate the higher diabetes-related disability risk.

In nationally representative analyses conducted for *Diabetes in America, 3rd edition*, 40% of diabetic women and 25% of diabetic men reported major mobility disability, about one-fourth of diabetic adults reported work disability, and one-tenth reported IADL disability. When disability prevalence was expressed as either disability or impairments, more than one-third of men were impacted in work (36%) and mobility (44%), almost one-fourth (23%) were impacted in IADL, and 14% were impacted in ADL. Among older adults (ages 65–74 and ≥75 years), prevalences of mobility disability, IADL, and work disability were generally similar among those with normal glucose, prediabetes, and undiagnosed diabetes but were appreciably higher among those with diagnosed diabetes. Among middle-aged adults (age 45–64 years), the association between glucose classification and disability risk was more continuous, with successively higher disability prevalences across those with normal glucose, prediabetes, undiagnosed diabetes, diabetes duration <15 years, and duration ≥15 years. The percentage of adults with diagnosed diabetes reporting limitations in mobility, IADL, and ADL tended to decline between 1997 and 2000 but remained largely unchanged between 2000 and 2011 for all age strata. The percentage of diabetic adults reporting work disability declined from 23.8% in 1997 to a low of 17.9% in 2006, increasing to 19.7% in 2011.

Lifestyle interventions, including weight loss with physical activity, have emerged as particularly promising approaches to reduce diabetes-related disability. However, further research is needed to determine the impact of other preventive care and diabetes management practices on disability risk, and continued surveillance is needed to determine the impact of primary and secondary prevention approaches on disability risk in the coming decades.

BACKGROUND AND PREMISE

Diabetes is considered a serious threat to the health of the American public due to its growing prevalence, the diverse microvascular, neuropathic, and macrovascular complications that result, and the direct impact diabetes can have on quality of life (1,2,3,4). For middle-aged and older adults in particular, diabetes and its complications frequently lead to various functional impairments and disabilities (5,6,7,8,9,10), with physical disability in particular being observed as one of the most consistent sequelae of diabetes. The impact of diabetes on disability appears to be mediated through several classic diabetes complications and is partly due to hyperglycemia itself, making disability a valuable index of the collective impact of diabetes on health status for both the individual and the population (7,9,11,12,13,14).

The importance of physical disability is heightened by several trends in the diabetes epidemic. Absolute rates of mortality have declined, and absolute rates of diabetes prevalence have increased, particularly among older adults (5,6). These factors have led to especially large increases in prevalence of diabetes in older adults. These increases in prevalence, combined with movement of the "baby boom" birth strata (born between 1945 and 1960) into the age range (50–65 years) corresponding to particularly high incidence of diabetes and complications, could increase the absolute numbers of persons with diabetes-related disability (7). This combination of factors will likely lead to an increased burden of disability and other aging-related conditions on clinical and public health systems (8).

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Understanding the relationship between diabetes and disability is important from several distinct perspectives. For individuals with diabetes, loss of physical functioning may be more concerning and of greater damage to quality of life than the diagnosis of traditional clinical complications, such as retinopathy and neuropathy (9,10). For both individuals with diabetes and clinicians who care for them, prevention of disability could be a goal of preventive care. Furthermore, the presence of disabilities may affect the targets and goals of diabetes treatment for two reasons. First, disability alters the life expectancy and, therefore, the likelihood of benefit from long-term treatments (11). Second, the presence of disability makes diabetes self-management more difficult because of the physical and cognitive requirements of tasks such as physical activity, food preparation, taking medications, and monitoring blood sugar. Disability can also take a profound emotional, physical, and economic toll on family and caregivers. For employers, disability affects work productivity and health insurance costs. Finally, at the population level, rates and trends in disability are important global indicators of the progress of public health programs toward the goal of increasing the number of healthy years of life and reducing the average number of years of morbidity in the population (12,13,14).

The objectives of this chapter are to: (1) summarize the association of diabetes with physical disability; (2) identify the key modifiable and nonmodifiable determinants of disability among the diabetic population, along with the key factors explaining the excess disability prevalence among older adults; (3) describe trends in diabetes-related disability in the United States; and (4) review evidence that physical disability can be prevented or modified. Because of limitations in the specificity of national surveys, estimates in this chapter generally refer to the combination of persons with type 1 and type 2 diabetes, with the vast majority of cases being type 2 diabetes.

DEFINITION AND MEASUREMENT OF DISABILITY

Several conceptual frameworks have evolved to define and measure disability in ways that are useful to diverse stakeholders, including the patient, family, clinical system, employer, clinical researcher, population health, and economic assessment (15,16,17). These frameworks, which have several aspects in common, have been incorporated into the model described by the International Classification of Functioning, Disability and Health, developed by the World Health Organization (18). In this model, disability is an umbrella term encompassing impairments, activity limitations, and restrictions in participation. Disability may be a consequence of impairments that may be physical, cognitive, mental, or developmental. *Contextual factors*, such as the social, economic, and physical environment, interact with *health conditions*, such as diseases, disorders, and injuries, to lead to *body impairments*. Impairments affect *activities* and *participation* and, in turn, disability. The key measurement indices of functioning and disability are divided into the assessment of *capacity*, which is a person's intrinsic ability to carry out tasks independent of the environment, and *performance*, which measures how well these are carried out in the environment. The capacity and performance of activities has been assessed across numerous domains ranging from communication and social relationships to daily domestic activities and physical mobility. Other conceptual frameworks have divided the domains of functioning into physical, psychological, social, and role functioning.

Both objective and subjective tools and scales to measure capacity for and performance of functioning have been developed for clinical and epidemiologic settings, with multi-item questionnaires and simple physical tests used most often to assess the impact of chronic diseases on disability. The most commonly used questionnaire-based tools ask about the respondent's ability to carry out specific activities (15). In addition, objective physical tests have been developed to assess the ability to carry out tasks of mobility or daily functioning (13,19).

This chapter focuses on physical disability, including disabilities related to mobility and activities of daily living (ADL), such as bathing, eating, and dressing, because of the evidence for its strong association with diabetes through several mechanisms, the potential for modification of risk, and because physical disability is highly predictive of subsequent decline and morbidity. Disability related to instrumental activities of daily living (IADL) and work/occupation are also discussed because of their impact on quality of life and for their effects on families, caregivers, and employers. IADLs refer to activities that are not necessary for fundamental functioning but are necessary for living independently, such as doing housework, preparing meals, and managing money. For additional discussion of the association of diabetes with other domains of function and disability, the reader is referred to Chapters 16 *Diabetes in Older Adults*, 24 *Diabetes and Cognitive Impairment*, and 33 *Psychiatric and Psychosocial Issues Among Individuals Living With Diabetes*.

ASSOCIATION OF DIABETES WITH LIMITATIONS AND DISABILITIES IN PHYSICAL FUNCTIONING: CROSS-SECTIONAL STUDIES

Perhaps the earliest population-based estimates of the association of diabetes with disability were published in 1960, when the National Center for Health Statistics reported prevalences of diagnosed diabetes and disability due to diabetes based on data from the National Health Interview Surveys (NHIS) 1957–1959 (20). Prevalence of diagnosed diabetes among the overall population was only 0.9% at the time (vs. 9% in 2010), and even among the peak age group of 65–74 years, prevalence was 3% in men and 5% in women (in contrast, more than 27% of adults age >65 years had diabetes in 2010). Among those with diabetes, fewer than 10% of women and 7% of men reported any limitation in mobility; even among those age >65 years, prevalence of any mobility limitation was 18%. About 20% reported at least one day of restricted activity due to diabetes in the previous year, and 9% reported more than one day in bed in the previous year due to diabetes-associated disability.

National studies since that early report have described stronger magnitudes of associations of diabetes with disabilities, including associations with a broad spectrum of specific domains and perspectives of disability, including mobility and IADL. Although the diagnostic criteria for diabetes had not yet been standardized in 1960, the large difference in prevalence, combined with the fact that mobility limitations were assessed using similar methods, underscores the large increases that have occurred in prevalence of both diabetes and mobility limitations. In *Diabetes in America*, *2nd edition*, Songer reported that in 1989 the prevalence of any activity limitations was about three times as high among people with diagnosed diabetes (56% of persons with non-insulin-dependent diabetes [NIDDM]; 43% of persons with insulin-dependent diabetes [IDDM]) as among those without diabetes (16%) (21). Twenty-one percent of those with NIDDM and 14% of those with IDDM reported an inability to carry out their major activity, defined as the ability to work in a job or business for those age <70 years and difficulty with IADL for those age ≥70 years. These prevalence estimates were three to five times those for people without diabetes (4%). These findings were supported by several other contemporaneous studies from the 1990s, wherein diabetes was a consistent and strong correlate of functional limitations, physical disability, and indicators of unhealthy aging (22,23,24,25,26).

In a more comprehensive, nationally representative analysis of the association of diabetes and physical disability in 1988–1994, among women and men age >60 years, 25% of women with diabetes were unable to walk a quarter mile compared to 12% of nondiabetic women (27). Similarly, women with diabetes were much more likely to be unable to climb steps (19%) and do housework (14%) than women without diabetes (9% for climbing steps and 6% for doing housework). Although the absolute prevalence levels of disability were lower for all indicators among men compared to women, the magnitude of association of diabetes with disability was similar for men and women. Among both men and women, these associations of diabetes with self-reported disability were also present for objective physical performance tests. Diabetic men were twice as likely as men without diabetes to perform poorly on tests of walking speed, 89% more likely to perform poorly on balance tests, and 36% more likely to perform poorly on chair stands, a test of lower extremity function. These findings from the National Health and Nutrition Examination Surveys (NHANES) 1988–1994 were largely replicated in analyses of the subsequent NHIS 1997–1999, wherein adjusting for age, sex, and race/ethnicity showed that diabetes was associated with three times the odds of physical limitations across a diverse spectrum of physical tasks (28).

In a subsequent, similar analysis using NHANES 1999–2006 data, Kalyani *et al.* (29) examined the association of diabetes in U.S. adults age >60 years across six domains. Seventy-four percent of participants with diabetes reported difficulty in tasks of general physical mobility (e.g., stooping, crouching, standing up), and 52% reported difficulty in lower extremity mobility (walking a quarter mile, climbing stairs). In addition, 44% of participants reported difficulty in IADL (e.g., cooking, cleaning), 37% in ADL (e.g., eating, dressing), and 34% in leisure and social activities (e.g., going out to movies and shopping; leisure activities at home). The odds ratios of disability associated with diabetes ranged from 1.97 for general mobility to 2.53 for ADL. Also of note, when disability was defined according to more severe thresholds—an inability (as opposed to "difficulty") to carry out tasks—the odds ratios of disability associated with diabetes were higher, ranging from 2.64 for general mobility to 3.93 for ADL. An analysis of cross-sectional data from the Health, Aging, and Body Composition (Health ABC) Study showed that diabetes was associated with a 40% higher odds of functional decline when defined by objective, subclinical measures, including chair stands, standing balance, and gait speed, in analyses adjusting for age, sex, body mass index (BMI, kg/m^2), and comorbid conditions (30).

A systematic review quantified the impact of cross-sectional studies conducted between 1996 and 2010, including the U.S. studies described above (27,29,31). Ten studies were conducted in North America, five in Asia, nine in Europe, and one in Australia (31). For the association of diabetes with mobility disability, odds ratios ranged from 1.10 to 2.20, and the pooled odds ratio was 1.68 (95% confidence interval [CI] 1.50–1.86). For IADL, odds ratios ranged from 1.20 to 3.30, and the pooled odds ratio was 1.67 (95% CI 1.57–1.77). There was somewhat more heterogeneity for the association of diabetes with ADL disability, as odds ratios ranged from 1.51 to 4.61, and the pooled odds ratio was 1.87 (95% CI 1.66–2.10). The authors reported that there were inadequate data to estimate heterogeneity in associations according to diabetes duration.

Studies of the impact of diabetes on work productivity, absenteeism, and early retirement have found significant differences between adults with and without diabetes (32,33,34,35,36,37,38). Persons with diabetes had about twice the absenteeism rate (5–18 days per year across studies) than those without diabetes (3–9 days per year) (32). In the most extensive study of work productivity, defined as time lost from work or impaired at work due to illness, U.S. adults with diabetes without neuropathy lost an average of 12 days per year, while diabetic adults with neuropathy lost an average of 26 days per year (38).

NATIONAL ESTIMATES OF PREVALENCE: 2005–2010

In new analyses conducted for *Diabetes in America, 3rd edition*, Tables 34.1 and 34.2 and related Figures 34.1 and 34.2 describe national estimates of impairment and disability based on NHANES 2005–2010 data across four domains: mobility, IADL, ADL, and work.

PREVALENCE BY DEMOGRAPHIC FACTORS

About 40% of diabetic women and 25% of diabetic men reported mobility disability, and 20%–30% of diabetic men and women reported work disability (Tables 34.1 and 34.2). Ten to thirteen percent of diabetic men and women reported IADL disability, and 1%–2% reported ADL disability.

When expanding the outcome to include impairment, more than half of diabetic women had either disability or impairment in mobility (58%), including 43% who had work disability or impairment, 37% with IADL disability or impairment, and 18% with ADL disability or impairment (Table 34.1). A substantial burden of disability was observed even among relatively young women; 24% of women age 20–44 years had mobility disability and 30% had work disability; these prevalence estimates were five to six times those of their same-aged, nondiabetic counterparts. In age-standardized analyses, prevalences of disability related to mobility, IADL, ADL, and work were 2.5–4 times as high for diabetic women as nondiabetic women (Figure 34.1).

Among men as well, the age-standardized prevalences of disability in mobility, IADL, ADL, and work were about twice as high for persons with diabetes as those without diabetes (Figure 34.2, Table 34.2). In unadjusted analyses, over one-third of men with diabetes had disability or impairment in work (36%) and mobility (44%), almost

TABLE 34.1. Prevalence of Disability Among Adult Women Age ≥20 Years, by Diabetes Status and Age, U.S., 2005–2010

	PERCENT (STANDARD ERROR)											
	Diabetes						No Diabetes					
			Age (Years)						Age (Years)			
	Unadjusted	Age-standardized*	20–44	45–64	65–74	≥75	Unadjusted	Age-standardized*	20–44	45–64	65–74	≥75
Mobility disability†	41.3 (2.00)	32.0 (2.70)	23.9 (4.77)	29.7 (2.46)	51.7 (3.60)	66.1 (3.84)	12.4 (0.64)	13.0 (0.63)	4.4 (0.53)	13.6 (1.52)	25.8 (3.07)	45.3 (3.96)
Mobility impairment‡	16.2 (1.32)	13.1 (1.34)	9.0 (2.25)	15.2 (1.94)	23.4 (3.64)	14.7 (2.30)	9.7 (0.63)	10.2 (0.58)	4.3 (0.55)	9.8 (1.19)	29.5 (3.07)	23.6 (2.92)
IADL disability§	12.6 (1.22)	8.0 (1.14)	3.9 (1.58)[2]	7.1 (1.76)	12.6 (2.29)	30.4 (3.38)	1.7 (0.32)	1.8 (0.31)	0.7 (0.35)[2]	[3]	3.7 (1.20)[1]	11.5 (2.72)
IADL impairment‖	24.1 (1.38)	20.4 (2.05)	17.4 (3.95)	19.1 (2.08)	35.0 (3.00)	26.4 (2.77)	9.2 (0.48)	9.6 (0.49)	3.5 (0.47)	11.2 (1.13)	20.3 (2.20)	24.9 (2.08)
ADL disability¶	1.6 (0.44)	0.8 (0.23)	[3]	1.1 (0.46)[2]	[3]	4.3 (1.78)[2]	0.1 (0.04)	0.2 (0.05)[1]	[3]	[3]	[3]	1.1 (0.55)[2]
ADL impairment#	16.5 (1.45)	14.3 (1.72)	12.5 (2.95)	13.8 (1.96)	16.5 (3.15)	25.0 (3.13)	4.3 (0.32)	4.5 (0.36)	1.3 (0.22)	5.0 (0.69)	10.1 (1.93)	14.2 (2.17)
Work disability**	29.4 (1.99)	29.4 (2.83)	29.7 (5.29)	28.7 (2.45)	30.9 (4.56)	28.6 (3.89)	9.2 (0.58)	9.4 (0.58)	6.0 (0.78)	10.9 (0.97)	13.1 (2.36)	17.5 (2.72)
Work impairment††	13.2 (0.97)	9.3 (1.01)	5.6 (1.88)[1]	8.8 (1.61)	16.9 (2.63)	23.8 (2.60)	7.9 (0.49)	8.2 (0.49)	4.4 (0.56)	7.8 (1.03)	15.2 (2.51)	24.2 (3.26)

Diabetes is based on self-reported diabetes diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; ADL, activities of daily living; IADL, instrumental activities of daily living.

* Standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years.

† Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed.

‡ Mobility impairment is defined as self-reporting some difficulty with: (1) stoop/crouch/kneel, (2) walk between rooms, (3) stand up from armless chair, or (4) get in/out of bed.

§ IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals.

‖ IADL impairment is defined as self-reporting some/much difficulty with: (1) household chores or (2) prepare meals.

¶ ADL disability is defined as self-reporting unable/do not: (1) use fork/knife/drink or (2) dress oneself.

ADL impairment is defined as self-reporting some/much difficulty with: (1) use fork/knife/drink or (2) dress oneself.

** Work disability is defined as self-reporting limitations keeping you from working.

†† Work impairment is defined as self-reporting limitations in the amount of work you can do.

[1] Relative standard error >30%–40%

[2] Relative standard error >40%–50%

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

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

TABLE 34.2. Prevalence of Disability Among Adult Men Age ≥20 Years, by Diabetes Status and Age, U.S., 2005–2010

	PERCENT (STANDARD ERROR)											
	Diabetes						No Diabetes					
			Age (Years)						Age (Years)			
	Unadjusted	Age-standardized*	20–44	45–64	65–74	≥75	Unadjusted	Age-standardized*	20–44	45–64	65–74	≥75
Mobility disability†	25.2 (1.87)	17.7 (1.42)	5.2 (2.09)[2]	25.4 (2.31)	26.5 (3.06)	44.2 (4.12)	7.1 (0.67)	8.5 (0.68)	2.1 (0.52)	8.4 (1.17)	15.7 (2.68)	37.2 (3.88)
Mobility impairment‡	18.5 (1.33)	13.7 (1.28)	7.5 (2.29)[1]	14.6 (1.48)	28.6 (3.48)	27.6 (3.19)	9.1 (0.82)	10.4 (0.81)	3.9 (0.67)	9.5 (1.24)	31.3 (2.84)	27.9 (2.93)
IADL disability§	10.0 (1.30)	6.8 (0.95)	[3]	7.3 (1.20)	11.8 (2.00)	25.7 (3.81)	3.0 (0.24)	3.8 (0.31)	0.5 (0.21)[2]	2.6 (0.45)	12.0 (2.05)	18.5 (2.79)
IADL impairment‖	12.7 (0.95)	9.8 (1.29)	5.3 (2.60)[2]	12.2 (1.45)	15.6 (2.85)	18.3 (2.15)	4.1 (0.49)	4.4 (0.50)	1.7 (0.34)	6.3 (0.97)	8.0 (2.09)	7.5 (1.61)
ADL disability¶	1.2 (0.37)	0.9 (0.29)[1]	[3]	1.3 (0.58)[2]	[3]	1.3 (0.56)[2]	[3]	[3]	[3]	[3]	[3]	[3]
ADL impairment#	12.7 (1.27)	8.6 (0.86)	[3]	14.5 (1.61)	11.8 (2.09)	20.4 (3.75)	4.0 (0.42)	4.5 (0.46)	1.3 (0.26)	5.4 (0.97)	9.2 (2.08)	13.6 (2.36)
Work disability**	23.7 (1.17)	19.3 (1.42)	11.7 (2.82)	26.8 (1.98)	25.9 (3.05)	21.8 (3.46)	7.9 (0.81)	8.6 (0.80)	4.5 (0.61)	10.5 (1.72)	14.6 (1.80)	15.7 (2.30)
Work impairment††	12.3 (1.20)	11.1 (1.54)	9.9 (3.04)[1]	9.3 (1.67)	13.6 (2.23)	23.4 (3.49)	6.4 (0.55)	7.2 (0.55)	3.8 (0.57)	6.4 (1.24)	13.9 (2.53)	22.2 (2.89)

Diabetes is based on self-reported diabetes diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; ADL, activities of daily living; IADL, instrumental activities of daily living.

* Standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years.

† Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed.

‡ Mobility impairment is defined as self-reporting some difficulty with: (1) stoop/crouch/kneel, (2) walk between rooms, (3) stand up from armless chair, or (4) get in/out of bed.

§ IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals.

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** Work disability is defined as self-reporting limitations keeping you from working.

†† Work impairment is defined as self-reporting limitations in the amount of work you can do.

[1] Relative standard error >30%–40%

[2] Relative standard error >40%–50%

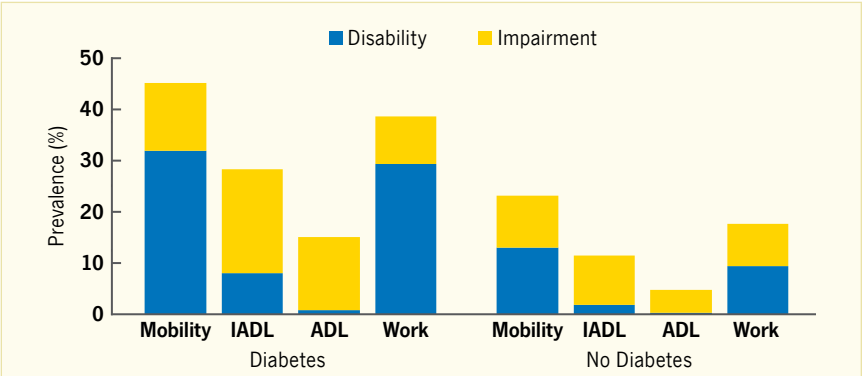
[3] Estimate is too unreliable to present; ≤1 case or relative standard error >50%.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

one-fourth (23%) IADL disability or impairment, and 14% had ADL disability or impairment. The excess disability risk (i.e., compared to their same-aged, nondiabetic peers) was also notably higher among persons of younger age compared to those of older age. The most notable differences between men with and without diabetes were apparent among those age 45–64 years, wherein prevalence of disability among diabetic men was about three times that of their nondiabetic counterparts (Table 34.2).

Prevalence of mobility disability among 20–44-year-olds was about five times that of same-aged persons without diabetes for women and about 2.5 times as high for men. Women tended to have higher age-standardized prevalence of disability than men, and the diabetes-related differences in disability were more pronounced among women than men (Figures 34.1 and 34.2).

FIGURE 34.1. Age-Standardized Prevalence of Impairment and Disability Among Adult Women Age ≥20 Years, by Diabetes Status, U.S., 2005–2010

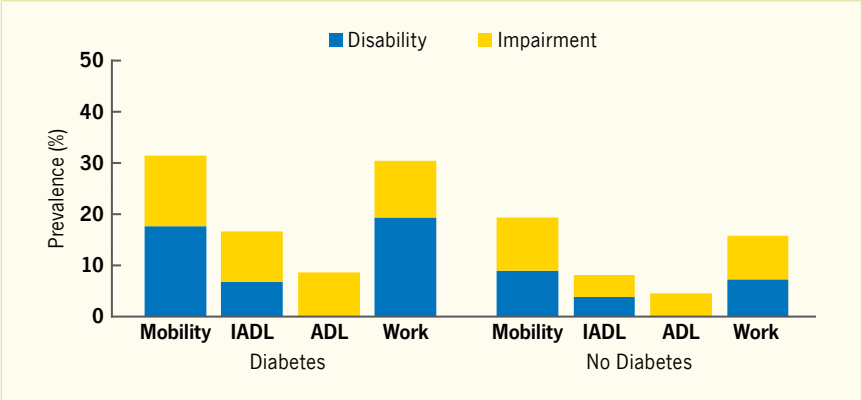


Diabetes is defined as self-reported diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed. Mobility impairment is defined as self-reporting some difficulty with: (1) stoop/crouch/kneel, (2) walk between rooms, (3) stand up from armless chair, or (4) get in/out of bed. IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals. IADL impairment is defined as self-reporting some/much difficulty with: (1) household chores or (2) prepare meals. ADL disability is defined as self-reporting unable/do not: (1) use fork/knife/drink or (2) dress oneself. ADL impairment is defined as self-reporting some/much difficulty with: (1) use fork/knife/drink or (2) dress oneself. Work disability is defined as self-reporting limitations keeping you from working. Work impairment is defined as self-reporting limitations in the amount of work you can do. Data are standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; ADL, activities of daily living; IADL, instrumental activities of daily living.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

In addition to the consistent association of greater age and female sex with higher prevalence of mobility disability, disability rates among those with diabetes were strongly associated with education level for mobility, IADL, and work disability (Table 34.3). College graduates had notably lower prevalence of age-standardized mobility disability (16%) than those with some college (29%) or those with no college (38%–42%). This association was also found for work disability, as 15% of college graduates and 22% of those with some college education were disabled compared to about one-third (30%–37%) of those with less than a college education. This latter finding may also be confounded by persons of lower education having occupations that either demand more physical labor or are more likely to lead to work-related disability. BMI had a steep association with age-standardized disability, as 42% persons with BMI >35 kg/m² had mobility disability compared to 25%–29% of those with lower BMI levels.

FIGURE 34.2. Age-Standardized Prevalence of Impairment and Disability Among Adult Men Age ≥20 Years, by Diabetes Status, U.S., 2005–2010



Diabetes is defined as self-reported diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed. Mobility impairment is defined as self-reporting some difficulty with: (1) stoop/crouch/kneel, (2) walk between rooms, (3) stand up from armless chair, or (4) get in/out of bed. IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals. IADL impairment is defined as self-reporting some/much difficulty with: (1) household chores or (2) prepare meals. ADL disability is defined as self-reporting unable/do not: (1) use fork/knife/drink or (2) dress oneself; not reported because estimate of nondiabetic population too unreliable; ≤1 case or relative standard error >50%. ADL impairment is defined as self-reporting some/much difficulty with: (1) use fork/knife/drink or (2) dress oneself. Work disability is defined as self-reporting limitations keeping you from working. Work impairment is defined as self-reporting limitations in the amount of work you can do. Data are standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; ADL, activities of daily living; IADL, instrumental activities of daily living.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

TABLE 34.3. Prevalence of Disability Among Adults Age ≥20 Years With Diabetes, by Demographic and Health Status Factors, U.S., 2005–2010

	PERCENT (STANDARD ERROR)							
	Mobility Disability*		IADL Disability†		ADL Disability‡		Work Disability§	
CHARACTERISTICS	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖
Age (years)								
20–44	13.9 (2.71)	-	2.9 (1.00)[1]	-	[3]	-	20.0 (2.82)	-
45–64	27.3 (1.91)	-	7.2 (1.03)	-	1.2 (0.36)	-	27.7 (1.67)	-
65–74	38.9 (2.48)	-	12.2 (1.45)	-	1.3 (0.22)	-	28.3 (2.69)	-
≥75	56.8 (2.33)	-	28.4 (2.70)	-	3.0 (1.05)[1]	-	25.7 (2.54)	-
Sex								
Men	25.2 (1.87)	26.1 (1.80)	10.0 (1.30)	10.8 (1.29)	1.2 (0.37)[1]	1.2 (0.36)	23.7 (1.17)	23.6 (1.21)
Women	41.3 (2.00)	40.1 (1.99)	12.6 (1.22)	12.0 (1.20)	1.6 (0.44)	1.5 (0.41)	29.4 (1.99)	29.3 (1.99)
Education								
<9th grade	46.4 (2.61)	41.6 (2.26)	21.8 (2.69)	19.7 (2.71)	2.9 (0.98)[1]	2.6 (0.81)[1]	37.9 (3.11)	36.5 (2.95)
9th–11th grade	42.5 (2.66)	41.8 (2.75)	13.4 (1.57)	12.9 (1.53)	0.8 (0.32)[1]	0.9 (0.34)[1]	31.4 (2.45)	31.7 (2.43)
High school graduate	38.3 (2.56)	37.6 (2.59)	10.9 (1.80)	10.6 (1.76)	1.6 (0.60)[1]	1.6 (0.56)[1]	30.1 (1.71)	30.0 (1.67)
Some college	26.7 (2.53)	29.3 (2.52)	8.9 (1.45)	10.6 (1.57)	1.4 (0.63)[2]	1.6 (0.64)[1]	21.6 (2.28)	21.6 (2.36)
College graduate	14.6 (2.15)	16.0 (2.20)	5.1 (1.27)	6.1 (1.49)	[3]	[3]	14.5 (1.99)	14.6 (2.03)
Race/ethnicity								
Non-Hispanic white	34.0 (1.84)	33.7 (1.97)	11.2 (1.26)	13.6 (1.65)	1.4 (0.29)	1.9 (0.39)	25.5 (1.80)	25.3 (1.86)
Non-Hispanic black	36.6 (2.12)	32.7 (1.86)	11.8 (1.37)	10.4 (1.23)	1.3 (0.48)[1]	1.4 (0.30)	33.3 (2.04)	25.4 (1.84)
All Hispanic	27.6 (2.24)	39.2 (1.96)	10.2 (1.56)	13.5 (1.48)	1.6 (0.38)	1.7 (0.64)[1]	23.4 (1.87)	32.8 (2.03)
Mexican American	27.4 (2.96)	33.8 (2.10)	10.7 (1.87)	14.4 (1.88)	1.7 (0.38)	2.2 (0.50)	23.8 (2.71)	25.2 (2.63)
Duration of diabetes¶#								
Undiagnosed	24.6 (3.54)	31.7 (4.06)	10.1 (2.55)	12.0 (1.86)	[3]	[3]	26.1 (2.91)	23.5 (3.27)
<2 years	29.3 (3.67)	36.3 (1.92)	9.0 (1.51)	10.8 (1.49)	[3]	1.6 (0.60)[1]	25.6 (3.59)	25.8 (2.01)
2–<5 years	36.1 (1.84)	31.0 (3.77)	10.3 (1.38)	12.2 (2.65)	1.6 (0.63)[1]	[3]	25.8 (2.05)	29.1 (3.15)
5–<15 years	44.9 (2.44)	41.3 (2.48)	17.3 (1.22)	15.5 (1.24)	2.3 (0.45)	2.1 (0.46)	33.1 (2.68)	32.1 (2.67)
≥15 years	25.6 (2.26)	25.4 (2.32)	8.8 (1.59)	8.7 (1.55)	[3]	[3]	22.1 (2.32)	22.1 (2.31)
Body mass index**								
<25 kg/m²	32.2 (3.63)	29.1 (3.29)	12.0 (2.57)	9.2 (1.95)	[3]	[3]	30.1 (3.26)	30.3 (3.31)
25–29 kg/m²	26.2 (2.13)	24.5 (2.13)	10.7 (1.48)	9.5 (1.27)	[3]	[3]	21.6 (1.89)	21.6 (2.10)
30–34 kg/m²	28.0 (2.04)	28.4 (1.94)	7.5 (1.42)	7.7 (1.43)	[3]	[3]	22.1 (1.95)	21.7 (1.75)
≥35 kg/m²	36.8 (2.45)	42.2 (2.41)	9.9 (1.54)	12.6 (1.71)	0.9 (0.30)[1]	1.1 (0.41)[1]	28.1 (2.22)	28.1 (2.34)

Table 34.3 continues on the next page.

TABLE 34.3. (continued)

CHARACTERISTICS	PERCENT (STANDARD ERROR)							
	Mobility Disability*		IADL Disability†		ADL Disability‡		Work Disability§	
	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖	Unadjusted	Age-standardized‖
Current smoker#								
Yes	36.7 (3.33)	43.2 (3.19)	9.9 (1.90)	12.7 (2.50)	1.1 (0.45)[2]	0.9 (0.34)[1]	35.5 (2.87)	36.1 (2.83)
No	35.4 (2.12)	32.4 (2.09)	14.0 (1.66)	12.0 (1.47)	2.0 (0.56)	1.7 (0.57)[1]	29.1 (2.29)	28.1 (2.42)
Coronary heart disease#								
Yes	48.8 (3.79)	47.2 (4.97)	18.0 (2.95)	14.5 (2.54)	3.1 (0.79)	2.4 (0.95)[1]	37.8 (3.52)	41.3 (4.39)
No	30.8 (1.50)	31.9 (1.45)	10.3 (0.97)	11.0 (0.99)	1.2 (0.22)	1.2 (0.24)	24.8 (1.25)	24.8 (1.25)
Cancer#								
Yes	45.0 (3.24)	41.4 (4.23)	16.7 (2.54)	12.7 (2.38)	2.7 (0.57)	1.8 (0.37)	33.3 (3.10)	37.4 (3.84)
No	30.7 (1.39)	32.3 (1.34)	10.2 (0.87)	11.2 (0.89)	1.2 (0.25)	1.3 (0.29)	25.1 (1.34)	25.4 (1.36)
Arthritis#								
Yes	48.8 (1.82)	48.0 (1.98)	15.2 (1.32)	14.1 (1.30)	1.9 (0.27)	1.8 (0.27)	35.9 (2.10)	37.2 (2.15)
No	19.6 (1.67)	21.9 (1.68)	8.0 (1.13)	9.3 (1.22)	1.0 (0.33)[1]	1.2 (0.39)[1]	18.4 (1.24)	19.0 (1.20)
Stroke#								
Yes	68.3 (2.82)	69.2 (3.36)	24.7 (2.67)	24.4 (4.99)	7.8 (1.83)	6.6 (2.16)[1]	54.1 (3.38)	61.0 (3.48)
No	29.5 (1.32)	30.4 (1.30)	9.8 (0.97)	10.4 (0.99)	0.8 (0.18)	0.8 (0.19)	23.6 (1.30)	23.6 (1.30)

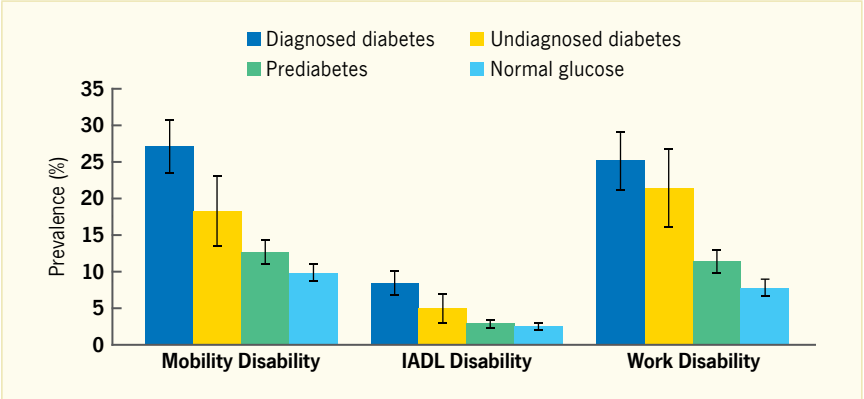
A1c, glycosylated hemoglobin; ADL, activities of daily living; IADL, instrumental activities of daily living.
* Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, 4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed.
† IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals.
‡ ADL disability is defined as self-reporting unable/do not: (1) use fork/knife/drink or (2) dress oneself.
§ Work disability is defined as self-reporting limitations keeping you from working.
‖ Standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years.
¶ Self-reported diabetes diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Conversions for glucose and A1c values are provided in *Diabetes in America Appendix 1 Conversions*.
# Self-reported data.
** Body mass index based on measured height and weight.
[1] Relative standard error >30%–40%
[2] Relative standard error >40%–50%
[3] Estimate is too unreliable to present; ≤1 case or relative standard error >50%.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

PREVALENCE BY PREDIABETES, DIABETES, AND MORBIDITY STATUS

Figure 34.3 describes disability prevalence according to diabetes and prediabetes diagnostic classification status. The association between glucose classification and disability risk was generally continuous, with successively higher disability prevalences across those with normal glucose, prediabetes, undiagnosed diabetes, and diagnosed diabetes. The exception was young and middle-aged adults (ages 20–44 and 45–64 years), among whom those with prediabetes had prevalence rates of mobility and work disability that were approximately twice as high as among those with normal glucose, but only about one-third as high as persons with undiagnosed and diagnosed diabetes (Table 34.4). Among middle-aged adults (age 45–64 years), the association between glucose classification and disability risk was more continuous, with successively higher disability prevalence estimates from persons with normal glucose, up through

FIGURE 34.3. Age-Standardized Prevalence of Disability Among Adults Age ≥20 Years, by Diabetes Status, U.S., 2005–2010



Diabetes is based on self-reported diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Prediabetes is defined as A1c 5.7%–6.4% or fasting plasma glucose 100–125 mg/dL. Normal glucose is defined as A1c <5.7% and fasting plasma glucose <100 mg/dL. Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed. IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals. Work disability is defined as self-reporting limitations keeping you from working. Data are standardized to the National Health Interview Survey 2010 overall population using age categories 20–44, 45–64, 65–74, and ≥75 years. Error bars represent 95% confidence intervals. Conversions for A1c and glucose values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; IADL, instrumental activities of daily living.

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

those with prediabetes, undiagnosed diabetes, diabetes duration <15 years, and diabetes duration of ≥15 years. This trend contrasted with findings in older adults, among whom associations of diabetes with disability status were weaker due to the impact of advancing age on overall disability. Among adults age ≥65 years, prediabetes was not significantly associated with a higher prevalence of functional limitations compared with normal glucose. Among the oldest men (age ≥75 years), differences in disability across diabetes duration were less pronounced than among younger men, but among the oldest women, those with undiagnosed and diagnosed diabetes had appreciably higher disability prevalence than those with prediabetes and normal glucose, with more than two-thirds of those with diagnosed diabetes having mobility disability and more than one-third having IADL disability. Self-reported history of stroke had a particularly profound association with all domains of disability, as 69% of diabetic adults with stroke had mobility disability (vs. 30% of diabetic adults without stroke), 24% had IADL disability (vs. 10%), 7% had ADL disability (vs. 1%), and 61% had work disability (vs. 24%) (Table 34.3). Associations with disability were also quite strong for coronary heart disease (CHD) and arthritis and, to only a slightly lesser extent, smoking and history of cancer.

Observations from the NHANES 2005–2010 described above are also consistent with those from the 2006 wave of the Health and Retirement Study, a nationally representative cohort study of adults age >53 years (39). In that study, prediabetes was associated with 18%–31% higher odds of mobility, ADL, IADL, and lower extremity limitations than normal glucose levels, after controlling for age and sex. The authors point out that in addition to the implications of prediabetes as a risk factor for disability, the relatively high prevalence of functional limitations (32% with mobility and 56% with lower extremity limitations) could potentially affect the ability of older adults to participate in prevention programs.

TABLE 34.4. Prevalence of Disability Among Adults, by Diabetes Status, Age, and Sex, U.S., 2005–2010

SEX, AGE, DIABETES STATUS	PERCENT (STANDARD ERROR)		
	Mobility Disability*	IADL Disability†	Work Disability‡
Men, age 20–44 years			
Diagnosed diabetes ≥15 years	13.8 (6.82)[2]	[3]	[3]
Diagnosed diabetes <15 years	4.8 (1.97)[2]	[3]	10.9 (3.38)[1]
Undiagnosed diabetes	[3]	[3]	14.1 (5.85)[2]
Prediabetes	3.5 (0.97)	[3]	6.7 (1.16)
Normal glucose	1.4 (0.53)[1]	0.4 (0.17)[2]	3.5 (0.73)
Women, age 20–44 years			
Diagnosed diabetes ≥15 years	[3]	[3]	25.6 (11.27)[2]
Diagnosed diabetes <15 years	24.2 (5.50)	[3]	28.7 (6.15)
Undiagnosed diabetes	24.8 (10.31)[2]	[3]	34.5 (11.62)[1]
Prediabetes	8.2 (1.73)	[3]	12.3 (2.57)
Normal glucose	3.5 (0.56)	0.8 (0.38)[2]	4.6 (0.88)
Men, age 45–64 years			
Diagnosed diabetes ≥15 years	38.3 (6.19)	15.1 (3.35)	32.9 (5.01)
Diagnosed diabetes <15 years	25.4 (2.25)	6.9 (1.54)	28.6 (3.64)
Undiagnosed diabetes	19.5 (4.62)	[3]	20.8 (4.02)
Prediabetes	11.1 (1.63)	3.5 (0.79)	12.6 (2.07)
Normal glucose	4.3 (1.45)[1]	[3]	7.3 (1.75)
Women, age 45–64 years			
Diagnosed diabetes ≥15 years	34.9 (5.91)	10.2 (4.09)[2]	38.6 (7.08)
Diagnosed diabetes <15 years	32.7 (3.96)	7.2 (2.14)	27.6 (3.70)
Undiagnosed diabetes	15.3 (3.69)	3.8 (1.72)[2]	20.4 (5.24)
Prediabetes	17.1 (2.50)	[3]	13.3 (1.44)
Normal glucose	10.8 (1.48)	[3]	9.2 (1.42)
Men, age 65–74 years			
Diagnosed diabetes ≥15 years	40.2 (6.47)	13.0 (3.87)	35.8 (8.25)
Diagnosed diabetes <15 years	23.0 (3.57)	9.9 (1.97)	24.7 (4.93)
Undiagnosed diabetes	22.8 (5.87)	13.9 (3.98)	21.3 (6.39)
Prediabetes	15.6 (3.23)	11.1 (2.54)	13.2 (2.21)
Normal glucose	15.9 (4.16)	14.0 (3.28)	17.8 (4.31)
Women, age 65–74 years			
Diagnosed diabetes ≥15 years	59.5 (8.21)	20.2 (6.00)	35.0 (6.06)
Diagnosed diabetes <15 years	52.7 (4.90)	7.2 (1.79)	25.7 (4.11)
Undiagnosed diabetes	38.0 (8.75)	[3]	36.6 (13.54)[1]
Prediabetes	23.8 (3.54)	3.8 (1.60)[2]	14.2 (3.04)
Normal glucose	29.6 (4.89)	[3]	11.2 (3.62)[1]
Men, age ≥75 years			
Diagnosed diabetes ≥15 years	46.4 (6.83)	30.2 (6.89)	28.3 (7.91)
Diagnosed diabetes <15 years	41.2 (4.73)	28.6 (4.84)	21.9 (4.18)
Undiagnosed diabetes	45.6 (8.50)	18.6 (6.49)[1]	17.2 (5.09)
Prediabetes	38.2 (4.84)	18.1 (3.42)	15.4 (3.04)
Normal glucose	34.9 (6.70)	19.5 (5.35)	16.4 (3.58)
Women, age ≥75 years			
Diagnosed diabetes ≥15 years	74.1 (4.34)	31.0 (4.96)	34.0 (6.22)
Diagnosed diabetes <15 years	65.5 (5.21)	34.6 (5.10)	27.4 (4.54)
Undiagnosed diabetes	58.2 (7.30)	23.9 (7.01)	23.3 (6.75)
Prediabetes	44.5 (4.55)	11.6 (3.44)	15.9 (3.77)
Normal glucose	46.8 (5.21)	11.5 (3.93)[1]	20.4 (3.39)

Diabetes is based on self-reported diagnosis or A1c ≥6.5% or fasting plasma glucose ≥126 mg/dL. Prediabetes is defined as A1c 5.7%–6.4% or fasting glucose 100–125 mg/dL. Normal glucose is defined as A1c <5.7% and fasting glucose <100 mg/dL. Conversions for glucose and A1c values are provided in *Diabetes in America Appendix 1 Conversions*. A1c, glycosylated hemoglobin; IADL, instrumental activities of daily living.

* Mobility disability is defined as self-reporting needing special equipment to walk or have much difficulty/unable/do not: (1) walk a quarter mile, (2) walk up 10 steps, (3) stoop/crouch/kneel, (4) walk between rooms, (5) stand up from armless chair, or (6) get in/out of bed.

† IADL disability is defined as self-reporting unable/do not do: (1) household chores or (2) prepare meals.

‡ Work disability is defined as self-reporting limitations keeping you from working.

[1] Relative standard error >30%–40%

[2] Relative standard error >40%–50%

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

SOURCE: National Health and Nutrition Examination Surveys 2005–2010

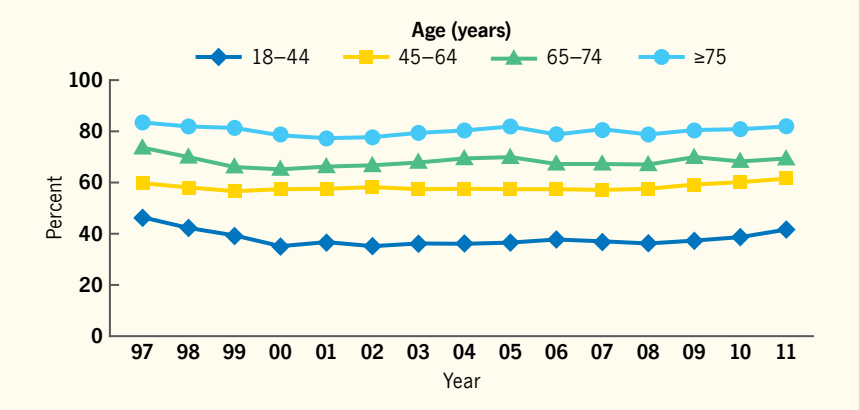
TRENDS IN NATIONAL ESTIMATES

From 1997 to 2011, the National Diabetes Surveillance System reported yearly estimates of the percentage of adults with and without diabetes reporting any limitations in mobility, IADL, and ADL disability (Figures 34.4–34.6) (1,40). The percentage of adults with diagnosed diabetes reporting these limitations tended to decline between 1997 and 2000 but remained largely unchanged between 2000 and 2011 for all age strata. In new analyses conducted for *Diabetes in America, 3rd edition*, the age-standardized percentage of diabetic adults reporting work disability declined from 23.8% in 1997 to a low of 17.9% in 2006, increasing to 19.7% in 2011 (Table 34.5). This reduction paralleled similar reductions in rates of disability among the nondiabetic population that were similar in relative terms but smaller in absolute terms (from 9.8% in 1997 to a low of 5.8% in 2010).

Arthritis was the most commonly reported cause of disability among the diabetic population, ranging from 35% to 44% of the diabetic population over the period 1997–2011 (Table 34.5). Diabetes itself, back/neck problems, heart problems, and musculoskeletal/connective tissue problems were the next most common; however, the proportion reporting diabetes or heart problems as the primary causes of their disability declined substantially between 1997 and 2011, while the proportion reporting back/neck problems and musculoskeletal/connective tissue problems tended to increase.

At least seven studies have examined the longitudinal association of diabetes with disability risk (Table 34.6) (31,41,42,43, 44,45,46,47,48,49,50,51). Longitudinal studies provide advantages over cross-sectional studies, including the ability to estimate incidence of disability, to separate disability as an effect rather than a cause, and to examine factors that may explain the association of diabetes with disability. All seven studies examined samples of men or women age ≥65 years for follow-up periods ranging from 18 months to 9 years, from three separate locations (United States, United Kingdom,

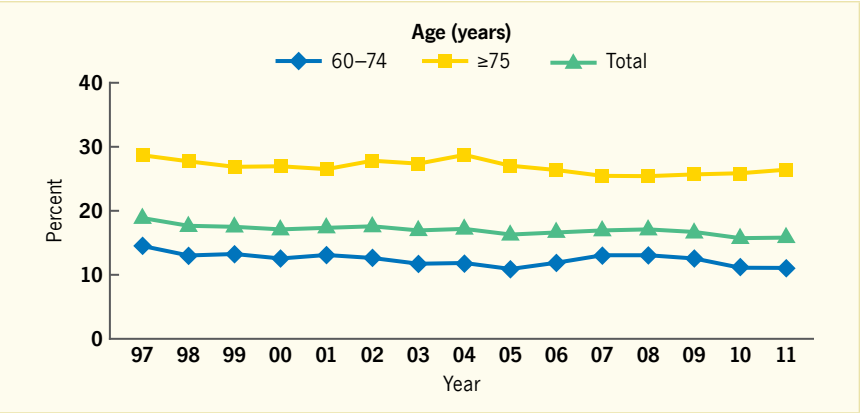
FIGURE 34.4. Percent of Adults Age ≥18 Years With Diagnosed Diabetes Reporting Any Mobility Limitation, by Age, U.S., 1997–2011



Diagnosed diabetes is based on self-report. Mobility limitations are based on walking a quarter mile, walking up 10 steps, standing for 2 hours, and stoop, bend, or kneel.

SOURCE: Reference 1

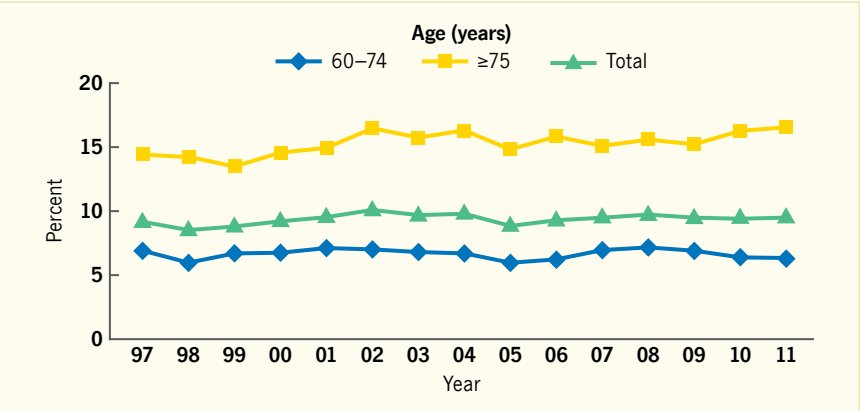
FIGURE 34.5. Percent of Adults Age ≥60 Years With Diagnosed Diabetes Who Needed Assistance With Instrumental Activities of Daily Living, by Age, U.S., 1997–2011



Diagnosed diabetes is based on self-report. Instrumental activities of daily living refers to routine needs, such as everyday household chores, doing necessary business, shopping, and getting around for other purposes.

SOURCE: Reference 1

FIGURE 34.6. Percent of Adults Age ≥60 Years With Diagnosed Diabetes Who Needed Assistance With Activities of Daily Living, by Age, U.S., 1997–2011



Diagnosed diabetes is based on self-report. Activities of daily living refer to personal care needs, such as eating, bathing, dressing, or getting around inside the home.

SOURCE: Reference 1

TABLE 34.5. Age-Standardized Trends in Disability Status Among Adults Age ≥20 Years, by Diabetes Status, U.S., 1997–2011

	PERCENT (STANDARD ERROR)														
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Work disability*															
Diabetes†	23.8 (1.17)	22.7 (1.15)	21.4 (1.14)	21.0 (0.97)	20.1 (1.01)	19.3 (0.91)	20.5 (0.99)	18.3 (0.91)	19.3 (0.84)	17.9 (1.06)	18.5 (1.10)	18.2 (1.05)	18.2 (0.95)	18.8 (0.92)	19.7 (0.82)
No diabetes	9.8 (0.26)	9.2 (0.26)	6.9 (0.22)	7.0 (0.23)	6.4 (0.20)	6.9 (0.25)	6.7 (0.24)	6.2 (0.22)	6.4 (0.23)	6.4 (0.25)	7.1 (0.28)	6.8 (0.28)	6.4 (0.26)	5.8 (0.20)	7.1 (0.24)
Diabetes as a cause of disability‡	2.3 (0.15)	2.1 (0.13)	1.8 (0.12)	2.1 (0.12)	2.5 (0.14)	2.1 (0.13)	2.4 (0.14)	2.5 (0.14)	2.2 (0.12)	2.6 (0.17)	2.3 (0.14)	2.0 (0.15)	2.2 (0.16)	1.6 (0.09)	2.5 (0.13)
Top five causes of disability among people with diabetes§															
1. Arthritis/rheumatism	37.9 (1.54)	34.7 (1.68)	37.1 (1.65)	38.7 (1.49)	39.1 (1.69)	41.5 (1.55)	44.3 (1.53)	43.0 (1.48)	42.8 (1.49)	43.7 (1.76)	40.2 (1.83)	43.6 (1.76)	42.4 (1.93)	41.3 (1.37)	39.9 (1.17)
2. Diabetes	33.9 (1.48)	29.5 (1.54)	30.1 (1.57)	33.0 (1.57)	32.6 (1.59)	28.9 (1.53)	32.4 (1.57)	30.9 (1.49)	27.8 (1.41)	28.0 (1.65)	26.3 (1.34)	22.0 (1.58)	22.6 (1.46)	24.5 (1.21)	24.4 (1.14)
3. Back/neck problem	20.2 (1.14)	21.1 (1.33)	17.2 (1.30)	20.3 (1.30)	20.9 (1.26)	23.2 (1.47)	23.3 (1.29)	22.2 (1.31)	26.4 (1.39)	23.4 (1.53)	22.6 (1.57)	25.3 (1.55)	23.9 (1.47)	24.7 (1.26)	25.4 (1.05)
4. Heart problem	17.8 (1.23)	15.9 (1.13)	16.1 (1.30)	16.4 (1.37)	16.0 (1.21)	15.6 (1.02)	17.2 (1.16)	15.7 (1.06)	13.0 (0.95)	12.9 (1.16)	13.0 (1.34)	11.2 (1.02)	10.6 (1.10)	11.1 (0.87)	11.2 (0.80)
5. Musculoskeletal/ connective tissue problem	7.0 (0.83)	7.6 (0.97)	5.9 (0.81)	5.5 (0.68)	9.6 (1.04)	9.1 (0.94)	8.9 (0.92)	12.8 (1.06)	12.7 (0.98)	12.0 (0.99)	15.1 (1.34)	16.0 (1.33)	15.1 (1.23)	17.1 (1.07)	19.5 (1.06)

Data are standardized to the National Health Interview Survey 2010 diabetes population using age categories 20–44, 45–64, and ≥65 years.
* Self-reported unable to work due to a disability or health reason
† Self-reported diabetes status
‡ Self-reported functional limitation(s) due to diabetes
§ Self-reported top five causes of functional limitation in 1997–2011 combined
All relative standard errors ≤30%

SOURCE: National Health Interview Surveys 1997–2011

TABLE 34.6. Prospective Studies of Disability Incidence

STUDY, YEARS (REF.)	POPULATION	FOLLOW-UP (YEARS)	OUTCOME DEFINITION	OUTCOME: RELATIVE RISK (95% CI)	OUTCOME: ABSOLUTE RISK
(46)	1,334 Hong Kong adults age ≥70 years	1.5	ADL	1.60 (0.70–2.34)	NR
Study of Osteoporotic Fractures, 1986–1998 (42)	6,971 U.S. community-dwelling women age ≥65 years	9	Mobility inability	1.80 (1.47–2.20)	Mobility Diabetes: 4.3% per year No diabetes: 1.9% per year
			IADL	1.58 (1.36–1.84)	IADL Diabetes: 9.8% per year No diabetes: 4.7% per year
Asset and Health Dynamics Among the Oldest Old (43)	4,228 U.S. adults age ≥70 years	5	ADL	1.44 (1.05–1.97)	NR
			IADL	1.35 (1.08–1.70)	NR
Women's Health and Aging Study, 1992–1998 (44)	729 U.S. women age ≥65 years	3	ADL	1.57 (1.15–2.14)	ADL Diabetes: 68% over 3 years No diabetes: 55% over 3 years
			Mobility	1.78 (1.25–2.53)	Mobility Diabetes: 79.6% over 3 years No diabetes: 70.9% over 3 years
			Objective function	NR	Objective function Diabetes: 0.96 decline per year No diabetes: 0.66 decline per year
Medical Research Council Cognitive Function and Ageing Study, 1991–1996 (48)	10,582 U.K. men and women age ≥65 years	2	IADL	1.70 (1.20–2.41)	NR
Hispanic Established Populations for Epidemiologic Studies of the Elderly, 1993–2001 (50)	1,835 Mexican American adults age ≥65 years	7	ADL	2.05 (1.58–2.65)	NR
			Objective mobility	1.46 (1.15–1.85)	Mobility Diabetes: 39.8% over 7 years No diabetes: 48.7% over 7 years
Health, Aging, and Body Composition Study, 1997–2002 (47)	2,920 U.S. adults age 70–79 years	5	Mobility	1.44 (1.27–1.63)	Mobility Diabetes: 18.1 per year No diabetes: 11.2 per year

ADL, activities of daily living; CI, confidence interval; IADL, instrumental activities of daily living; NR, not reported.

SOURCE: References are listed within the table.

Hong Kong). A quantitative meta-analysis of these studies found pooled relative risks of disability due to diabetes of 1.51 for mobility loss, 1.45 for IADL disability, and 1.82 for ADL disability (31).

These risk ratios translated to substantial differences in absolute incidence rates in women. In the Study of Osteoporotic Fractures, incidence of mobility loss, defined as inability to walk a quarter mile, was 4.3% per year for diabetic individuals compared to 1.9% per year for nondiabetic individuals, a difference of 2.4 cases per 100 per year. Incidence of any physical disability, defined as inability of walking, doing housework, or climbing stairs, was 9.8% for diabetic women compared to 4.7% for nondiabetic women, a difference of 5.1 cases per 100 per year (42). In the Women's Health and Aging Study (WHAS), diabetes was associated with two to three times the incidence of frailty and difficulty walking (51). Similar to findings from the Study of Osteoporotic Fractures (42), this translated to an approximate difference of two cases per 100 per year of walking impairment. The WHAS reported considerably higher differences in incidence (17.6% vs. 11.4% per year) but used a more inclusive outcome definition—incidence of any mobility limitation over two consecutive visits. These longitudinal studies describe a consistent picture across diverse domains of disability.

FACTORS EXPLAINING THE ASSOCIATION OF DIABETES WITH DISABILITY

Several studies have attempted to determine the factors and mechanisms whereby diabetes is associated with increased disability risk. This research has been conducted in three ways: first, by examining the impact of removing selected covariates from multivariate models of diabetes and disability risk; second, by comparing the strength of the diabetes-disability association between participants in different strata; and third, by examining the predictors of disability within samples of people with diabetes. Cross-sectional data from the NHANES III (1988–1994) found CHD and obesity together explained over half of the excess disability risk associated with diabetes among women, whereas among men, CHD and stroke were the two most dominant factors (27). Several other factors, including stroke, visual impairment, and arthritis, played significant roles in both men and women having disabilities. Subsequent analyses from the WHAS found peripheral arterial disease and peripheral nerve dysfunction to be prominent factors in disability (44). Other studies have found depression to be a major factor as well (22).

The degree to which hyperglycemia itself explains the association of diabetes and disability remains unclear (51). The WHAS found that compared to women with glycosylated hemoglobin (A1c) levels <5.5% (<37 mmol/mol), those with A1c levels of ≥8.0% (≥64 mmol/mol) had about three times the incidence of frailty, difficulty walking, low walking speed, and low physical performance, adjusted for BMI and comorbidities. However, women with A1c levels in the 6.0%–7.9% (42–63 mmol/mol) range had only modest, nonsignificant differences in disability incidence compared to those with lower A1c levels. Frequent hypoglycemia, or other factors related to overtreatment, could also theoretically affect disability risk, but the authors are not aware of studies that have examined such an association.

Sarcopenia, or the natural loss of muscle mass that occurs with aging, may be a central mechanism underlying the association of diabetes and disability. Hyperinsulinemia, insulin resistance, hyperglycemia, diabetes status, and longer duration of diabetes have each been associated with sarcopenia (52,53). The association of diabetes with sarcopenia may be multifactorial, as factors in underlying behavior (physical inactivity and reduced energy expenditure), central adiposity and resulting inflammatory factors, concurrent hormonal changes (e.g., hypogonadism, vitamin D deficiency), or concurrent comorbid conditions (e.g., kidney disease, peripheral artery disease) could connect diabetes to sarcopenia (53). The impact of exercise and dietary interventions on muscle mass may be a promising avenue to reduce disability risk (54).

In summary, these studies found the relationship between diabetes and disability to be multifactorial and to vary between men and women and according to the definition of disability. Obesity, CHD, lower extremity diseases, stroke, and depression appeared to be the most prominent factors explaining the difference in disability risk between people with and without diabetes. Other studies suggested that factors earlier in the pathogenesis of diabetes, including inflammation, insulin resistance, and sarcopenia, may also mediate the higher disability risk in people with diabetes. Volpato and Maraldi organized explanatory factors into a conceptual model wherein diabetes interacts in a bidirectional manner with obesity, CHD, hypertension, stroke, and depression to influence several primary impairments, including visual acuity, peripheral neuropathy, cognitive function, and strength, which combined with underlying comorbidities, lead to functional limitations and disabilities (41).

DISABILITY AND DIABETES RISK

Epidemiologic studies of diabetes and disability have primarily been conducted to examine the potential for diabetes to cause disability. However, the association could conceivably act in the reverse direction, with disability increasing the risk of diabetes, particularly among high-risk adults. In a longitudinal analysis of data from 22,878 middle-aged and older adults, prevalent mild disability was associated with a 28% increased risk of diabetes incidence, while incident mild disability was associated with a 40% increased diabetes risk (55). More severe disability was associated with an even higher magnitude of diabetes risk (63% for prevalent disability and 81% for incident disability). The authors speculated that disability could contribute to diabetes risk through increases in sedentary behavior, muscle disuse, and change in the ratio of lean to fat mass affecting insulin sensitivity in vulnerable adults.

EFFECTIVENESS OF INTERVENTIONS TO REDUCE DISABILITY RISK

Only a few controlled intervention trials have examined the effectiveness of approaches to reduce disability among adults with diabetes or at risk for diabetes. Studies conducted among adults (with and without diabetes) with arthritis-mediated functional impairment found that lifestyle-based weight loss of 5%–6% over 18 months resulted in significant improvements in functional status (56,57). Similar effects have been reported in adults with CHD and preexisting functional limitations (58,59). In the largest intervention study to date to examine disability incidence, and the first large study among adults with diabetes, the Look AHEAD (Action for Health in Diabetes) study found that over 4 years, overweight diabetic adults assigned to an intensive lifestyle intervention achieved a sevenfold greater weight loss and 48% reduced incidence of mobility loss than persons receiving a limited diabetes education (60). The findings were strongest for severe disability; prevalence of severe mobility disability increased only 7.3 percentage points among the intensive lifestyle intervention group compared to an increase of 11.0 percentage points in the diabetes support and education group.

In addition to lifestyle interventions, the observational studies of disability incidence point to several other potential ways to reduce disability risk. For example, the associations of depression, CHD, lower extremity arterial disease, and glycemic control suggest that achieving recommended screening and management of risk factors in primary care could also affect disability risk.

CONCLUSIONS

This review of the relationship of diabetes and disability yielded several conclusions and key points. Diabetes is associated with a twofold to threefold increased risk of functional disability, including disability related to mobility, IADL, ADL, and work; longitudinal studies indicate that diabetes precedes the onset of disability in many cases, but that the diabetes and disability association is also bidirectional. Diabetes-related disability is most common among women and persons of lower education and increases rapidly with age; however, the relative associations of diabetes with disability are highest among middle-aged adults. The majority of diabetes-related disability occurs after the diagnosis of diabetes; however, prediabetes is associated with an increased disability risk in young and middle-aged adults. Prevalence of work disability among the diabetes population has gradually declined between 1997 and 2011, but prevalences of mobility and IADL disability have remained unchanged.

The association of diabetes with disability is explained by multiple factors, including some that precede diabetes diagnosis as part of the pathogenesis of diabetes (e.g., obesity, insulin resistance, elevated inflammatory markers), hyperglycemia itself, diabetes-related complications (e.g., CHD, lower extremity arterial disease, stroke, visual impairment), and other comorbidities that may or may not be caused by diabetes (notably, depression and arthritis). Interventions that involve regular physical activity and weight loss appear to be effective in reducing risk for disability among overweight adults with diabetes; lifestyle interventions to prevent diabetes and primary care-based management of depression and cardiovascular disease risk management could also plausibly affect disability risk, but this hypothesis has not been examined in randomized controlled outcome trials.

Continued surveillance of disability levels is important to determine whether clinical and public health approaches are reducing the collective impact of diabetes on morbidity. Inclusion of older adults and mobility and disability outcomes in future clinical trials will be important to improve the evidence base about which interventions reduce disability.

LIST OF ABBREVIATIONS

A1c. . . . . .glycosylated hemoglobin
ADL . . . . . .activities of daily living
BMI . . . . . .body mass index
CHD. . . . . .coronary heart disease
CI. . . . . .confidence interval
IADL. . . . . .instrumental activities of daily living
IDDM . . . . . .insulin-dependent diabetes
Look AHEAD . .Action for Health in Diabetes
NHANES . . . . .National Health and Nutrition Examination Survey
NHIS . . . . . .National Health Interview Survey
NIDDM. . . . . .non-insulin-dependent diabetes
WHAS . . . . . .Women's Health and Aging Study

CONVERSIONS

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

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DUALITY OF INTEREST

Drs. Gregg and Menke reported no conflicts of interest.

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