# Diabetes in America: Epidemiology and Scope of the Problem

MAUREEN I. HARRIS, PHD, MPH

Epidemiological studies performed over the past 40 years have shown that the prevalence of diagnosed diabetes has increased dramatically in the U.S. and that a substantial proportion of the population has undiagnosed diabetes, impaired fasting glucose, and impaired glucose tolerance. Diabetes is most prevalent in minority populations, such as African-Americans, Native Americans, and Mexican Americans. Increasing prevalence of diabetes has led to increases in microvascular complications such as blindness, end-stage renal disease, and lower limb amputations. Poor glycemic control contributes to the high incidence of these complications, yet community-based studies of diabetic patients show their mean fasting plasma glucose concentration is generally >180 mg/dl compared with 100 mg/dl for nondiabetic individuals. In people with diabetes, risk factors for cardiovascular disease including elevated fasting plasma glucose, blood pressure, total cholesterol, triglycerides, and obesity partly explain the high proportion of deaths (60–70%) caused by cardiovascular disease in people with diabetes. More intensive diabetes management and improved glycemic control could minimize long-term complications of the disease and would be expected to reduce the morbidity, mortality, and costs associated with diabetes.

*Diabetes Care* 21 (Suppl. 3):C11–C14, 1998

Over the past several decades, studies on the epidemiology of diabetes have contributed to our understanding of the scope and impact of this disease. Surveys of representative U.S. population samples documented the increasing prevalence of diabetes, the existence of a large segment of the population with undiagnosed diabetes, high rates of complications, and excess mortality. These surveys and community-based epidemiological studies show that minority populations—including African-Americans, Native Americans, and Mexican Americans—are particularly at risk for diabetes and that their complications are more frequent and more severe. Epidemiology has contributed to understanding the etiology of diabetes and to defining and quantifying risk factors for the disease. Through the latter, we are now able to begin nationwide programs to intervene in these risk factors, with the aim of preventing the development of diabetes. National surveys have documented that the burden of diabetes is also economic, accounting for billions of dollars in additional health care expenditures each year in the U.S. An examination of the epidemiology of diabetes suggests that opportunities for improvement in diagnosis and management have the potential to significantly reduce diabetes-related morbidity and mortality while also reducing the costs of diabetes care.

**PREVALENCE OF DIABETES IN THE U.S.** — Several national sample surveys are performed in the U.S. each year by the National Center for Health Statistics, and the data derived from these surveys have been used by the National Institutes of Health's National Diabetes Data Group over the past 20 years to assess the prevalence of diabetes and its associated complications. Each year, the National Health Interview Survey questions ~100,000 people about a variety of health conditions, including diabetes. The respondents are asked specifically whether they have ever received a diagnosis of diabetes from a physician. When this survey was first performed in 1958, the data indicated that approximately 1.5 million Americans had been diagnosed with diabetes (1). There has been a steady increase in prevalence over the past 40 years, with the result that about 10.5 million people are estimated to have diagnosed diabetes in 1998. About 90% of these individuals have type 2 diabetes. Diagnosed diabetes is most prevalent in the middle-aged and elderly populations, affecting ~6% of people aged 45–64 years and 11% of those aged ≥65 years, but only 1.5% of those aged 18–44 years.

The prevalence of diabetes is similar for women and men. However, a striking feature of the epidemiology of type 2 diabetes in the U.S. is the variation in disease rates among racial/ethnic groups. The Third National Health and Nutrition Examination Survey (NHANES III) conducted in 1988–1994 collected data on the medical history of diabetes, measured fasting plasma glucose, and performed oral glucose tolerance tests in a sample of the U.S. population aged 40–74 years. In this survey, the prevalence of diagnosed diabetes (positive medical history) among non-Hispanic whites was 7.2%, compared with 12.5% among African-Americans and 13.7% among Mexican Americans (2). Prevalence of undiagnosed diabetes using the criterion of fasting plasma glucose ≥126 mg/dl was 4.0% among non-Hispanic whites, 5.6% among African-Americans, and 6.6% among Mexican Americans. Using the criteria of fasting plasma glucose ≥140 mg/dl or 2-h plasma glucose ≥200 mg/dl, prevalence of undiagnosed diabetes was 6.1% among non-Hispanic whites, 6.7% among African-Americans, and 9.9% among Mexican Americans. The large proportions of undiagnosed people show that the burden of diabetes in the U.S. is substantially greater than the known, diagnosed cases of the disease.

In addition to the high prevalence of diabetes, data from the NHANES III survey

From the National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, Maryland.

Address correspondence and reprint requests to Dr. Maureen I. Harris, NIDDK/NIH, Building 45, Room 5AN24, Bethesda, MD 20892. E-mail: harrism@ep.niddk.nih.gov.

Received for publication 1 October 1997 and accepted in revised form 6 February 1998.

This article is based on a presentation at a symposium sponsored by Amylin Pharmaceuticals, Inc. Its publication in a supplement to *Diabetes Care* is made possible by an educational grant from Amylin and Ortho-McNeil Pharmaceutical, Inc.

**Abbreviations:** ESRD, end-stage renal disease; NHANES III, Third National Health and Nutrition Examination Survey; WESDR, Wisconsin Epidemiologic Study of Diabetic Retinopathy.

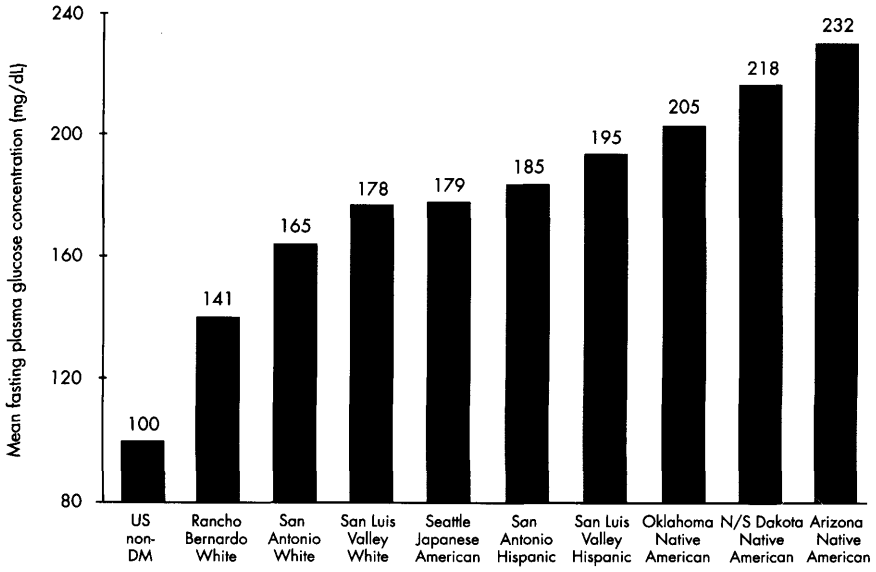


**Figure 1**—*The mean fasting plasma glucose level (milligrams per deciliter) in people without diabetes in the NHANES survey and in patients with diabetes in community-based studies. DM, diabetes mellitus.*

indicate that ~9.7% of the population aged 40–74 years has impaired fasting glucose (fasting plasma glucose 110–125 mg/dl) and 15.6% has impaired glucose tolerance (fasting plasma glucose <140 mg/dl and 2-h plasma glucose 140–199 mg/dl) (2). The prognostic significance of impaired fasting glucose is not fully defined. Impaired glucose tolerance is an important risk factor for development of type 2 diabetes and also conveys increased risk for cardiovascular disease.

## MICROVASCULAR COMPLICATIONS OF DIABETES

— There is considerable morbidity associated with diabetes, including blindness, end-stage renal disease (ESRD), and lower-extremity amputations. Retinopathy as a result of diabetes is the leading cause of blindness in the U.S. for people aged 20–74 years. On the basis of data from the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR), 80% of people with type 2 diabetes for 20 years will have at least some degree of retinopathy and 20% will have proliferative retinopathy (3). Retinopathy affects virtually all patients with type 1 diabetes, and proliferative retinopathy is found in 60% of patients by 20 years after diagnosis.

Information from the U.S. Medicare database showed that there were ~5,000 new cases of diabetic ESRD in 1982, accounting for 22% of all new ESRD patients. The incidence of diabetic ESRD has increased steadily over time, and in 1996 there were ~31,000 new cases, comprising 42% of all new cases of ESRD (4). Diabetes is the leading cause of ESRD; hypertension accounts for 26% of new cases of ESRD, glomerulonephritis for 11%, and a variety of other conditions for the remaining cases.

Diabetes is also the leading cause of nontraumatic lower-extremity amputations. Results from the U.S. National Hospital Discharge Survey showed that 51% of nontraumatic lower-limb amputations are performed in people with diabetes (5). Of these amputations, 40% were of the toes, 15% were of the foot and ankle, 25% were below the knee, and 20% were above the knee.

## GLYCEMIC CONTROL AND MORBIDITY

— Poor glycemic control is a major reason for the high incidence of microvascular complications of the eyes, kidneys, and nerves in people with diabetes. The Diabetes Control and Complications Trial clearly demonstrated the benefits of improved glycemic control in reducing both the incidence and progression of retinopathy and nephropathy in people with type 1 diabetes (6). Substantial clinical and epidemiological evidence suggests that the same principle applies to these patients. For example, the U.K. Prospective Diabetes Study clinical trial showed reductions in incidence of diabetes-related complications with intensive glycemic control in a sample of patients with type 2 diabetes (7). In WESDR, there was a strong correlation between glycosylated hemoglobin concentration at study entry and the risk of retinopathy 10 years later. In all three WESDR populations—people with type 1 diabetes, people with type 2 diabetes using insulin, and people with type 2 diabetes not using insulin—the incidence of retinopathy was similar when people with equivalent baseline glycosylated hemoglobin concentrations were compared (3). This indicates that the incidence of microvascular complications such as retinopathy is influenced most strongly by long-term glycemic control, rather than by the type of diabetes or treatment modality.

Despite strong evidence that improved control of blood glucose is associated with a reduction in the risk of microvascular complications, people with diabetes in the U.S. generally do not have glycemia levels that will lead to avoidance of diabetic complications. In community-based studies of people with diabetes, mean fasting plasma glucose was generally >180 mg/dl, compared with a mean fasting plasma glucose of ~100 mg/dl for people without diabetes (Fig. 1) (8). Hyperglycemia is most severe among Hispanics and Native Americans.

## MACROVASCULAR MORBIDITY AND MORTALITY

— People with diabetes experience high rates of macrovascular complications, including ischemic heart disease, stroke, and peripheral vascular disease. A 22-year follow-up of people who participated in the NHANES in 1971–1975 found that the age-adjusted mortality rate of any cardiovascular disease as an underlying cause of death was 12 per 1,000 person-years for nondiabetic men and 30 per 1,000 person-years in men with diabetes (9). Similarly, the age-adjusted rate of death due to ischemic heart disease was 7 per 1,000 person-years among nondiabetic men compared with 23 per 1,000 person-years among men with diabetes. Cardiovascular disease was the underlying cause in 60% of deaths in men with diabetes, and 41% of the deaths were due to ischemic heart disease. This high death rate from cardiovascular causes is partially explained by the high number and high levels of risk factors for heart disease in people with diabetes. These risk factors include elevated fasting plasma glucose, blood pressure, cholesterol, and triglycerides; the presence of obesity; and cigarette smoking (Fig. 2) (10).

Even after adjusting for these cardiovascular risk factors, however, people with diabetes have an excess risk of mortality from cardiovascular disease. For example, people with diabetes were identified in the screening

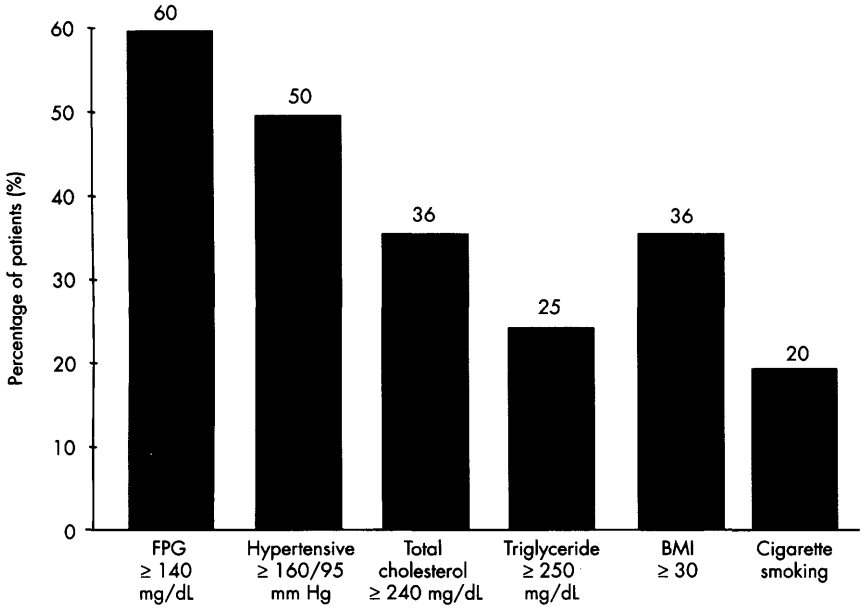


**Figure 2**—*The frequency of risk factors for cardiovascular disease among people with diabetes in the U.S. FPG, fasting plasma glucose. From Harris (10).*

stage of the Multiple Risk Factor Intervention Trial. When mortality data from this group and the group without diabetes were stratified according to the presence of three risk factors at baseline—high serum cholesterol, high systolic blood pressure, and cigarette smoking—the death rate from cardiovascular disease within each risk category was substantially higher for people with diabetes than for nondiabetic subjects (11).

It is possible that the increased incidence of macrovascular disease in diabetes is partially due to elevated blood glucose concentrations. Population studies of diabetic patients in Finland, Framingham, and the WESDR found that coronary heart disease increased with increasing levels of glycemia (12–14). Although the data on this topic are less conclusive than for diabetes-associated microvascular disease, hyperglycemia may be a more important factor in the development of coronary heart disease in diabetic patients than previously thought. In contrast, the evidence for glycemia as a risk factor for coronary heart disease in nondiabetic subjects is inconsistent. Their risk is generally confined to the upper 2nd to 5th percentile of nondiabetic glycemia and may result from these individuals developing diabetes during the study period.

## THE COST OF MEDICAL CARE FOR DIABETES

— People with diabetes incur considerable costs managing their illness. In the National Medical Expenditure Survey, the health care expenditures (excluding nursing-home care) of a national sample of families were determined for several years. The average per capita cost each year was over $11,000 for people with diabetes compared with $2,600 for people without diabetes (15). About 64% of the costs for medical care of the diabetic patients were due to inpatient hospitalization. In the U.S., ~60% of the costs of diabetes care are paid with public money through such agents as Medicare, Medicaid, and the Veterans Administration. Almost 25% of the costs of care of patients with diabetes are paid by private or employment-based health insurance, and 15% are paid directly by the patient (16).

The high cost of medical care for diabetes patients is not accounted for by care through diabetes specialists, because the majority of people with diabetes in the U.S. are not managed by these physicians. On the basis of the U.S. National Ambulatory Medical Care Survey, we estimate that of all visits made by people with diabetes to office-based physicians, only 8% are to either diabetologists or endocrinologists (8). Of the remaining visits, 37% are to internists, 20% to family practitioners, 14% to general practitioners, and 21% to a variety of other physician specialists.

## CONCLUSIONS

— Results of epidemiological surveys performed over the past 40 years show that the prevalence of diagnosed diabetes in the U.S. has increased dramatically and now affects about 10 million people. These studies of representative samples of U.S. adults also found that there are large numbers of people with undiagnosed type 2 diabetes. Minority populations—including African-Americans, Mexican Americans, and Native Americans—are most frequently and most severely affected. The increased prevalence of diabetes has been accompanied by increases in the prevalence of end-stage complications. Diabetes is the leading cause of blindness, ESRD, and lower-extremity amputations in the U.S., and a major risk factor for these conditions is poor glycemic control. Coronary heart disease is the leading cause of death in people with diabetes, and there is increasing evidence that excessive glycemic exposure can influence the incidence of cardiovascular morbidity and mortality beyond the effect of the classical cardiovascular risk factors.

Given the evidence of the relation of glycemia to microvascular and macrovascular complications, better glycemic control in patients with diabetes would be expected to reduce the human and economic burden of diabetes (17). Management of diabetes by physicians and other health care professionals who apply the principles of good glycemic control and reduction in macrovascular risk factors should minimize the long-term complications of the disease and reduce the overall health care burden. Prevention of the onset of type 2 diabetes, or delaying onset to older ages, should also become an important component of medical care for people at risk for developing diabetes.

**Acknowledgments**— This work was presented at The Worldwide Burden of Diabetes Workshop, 5–7 December 1996, Phoenix, Arizona.

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