Trends in Diabetes and Diabetic Complications, 1980–1987

SCOTT F. WETTERHALL, MD, MPH
DAVID R. OLSON, PHD
FRANK DESTEFANO, MD, MPH
JOHN M. STEVENSON, MS
EARL S. FORD, MD, MPH
ROBERT R. GERMAN, MPH
JULIE C. WILL, PHD
JEFFREY M. NEWMAN, MD, MPH
STEPHEN J. SEPE, MPH
FRANK VINICOR, MD

OBJECTIVE — Although diabetes is a major source of morbidity and mortality in the United States, only recently has a unified national surveillance system begun to monitor trends in diabetes and diabetic complications.

RESEARCH DESIGN AND METHODS — We established a diabetes surveillance system using data for 1980–1987 from vital records, the National Health Interview Survey, the National Hospital Discharge Survey, and the Health Care Financing Administration's records to examine trends in the prevalence and incidence of diabetes, diabetes mortality, hospitalizations, and diabetic complications.

RESULTS — From 1980 through 1987, the number of individuals known to have diabetes increased by 1 million—to 6.82 million. Age-standardized prevalence for diabetes increased 9% during this period, from 25.4 to 27.6/1000 U.S. residents ($P = 0.03$). The incidence of diabetes increased among women ($P = 0.003$), particularly among those >65 yr old ($P = 0.02$). Age-standardized mortality rates (for diabetes as either an underlying or contributing cause) per 100,000 individuals with diabetes declined 12%, from 2350 to 2066. Annual mortality rates from stroke (as an underlying cause and diabetes as a contributing cause) and diabetic ketoacidosis declined 29% ($P = 0.003$) and 22% ($P < 0.001$), respectively. During these 8 yr, hospitalization rates for major CVD and stroke (as the primary diagnoses and diabetes as a secondary diagnosis) increased 34% ($P = 0.006$) and 38% ($P = 0.01$), respectively. Also during this period, hospitalization rates increased 21% for diabetic ketoacidosis ($P = 0.01$) and 29% for lower-extremity amputations ($P = 0.06$). From 1982 through 1986, treatment for end-stage renal disease related to diabetes increased >10% each year ($P < 0.001$). The prevalence of diagnosed diabetes was nearly twice as high in blacks as in whites ($P = 0.04$). Blacks also had increased rates of lower-extremity amputation ($P = 0.02$), diabetic ketoacidosis ($P < 0.001$), and end-stage renal disease ($P = 0.01$).

CONCLUSIONS — Diabetes surveillance data will be useful in planning, targeting, and evaluating public health efforts designed to prevent and control diabetes and its complications.

FROM THE DIVISION OF DIABETES TRANSLATION, CENTERS FOR DISEASE CONTROL, ATLANTA, GEORGIA.

ADDRESS CORRESPONDENCE AND REPRINT REQUESTS TO SCOTT F. WETTERHALL, MD, MPH, DIVISION OF DIABETES TRANSLATION, CENTERS FOR DISEASE CONTROL, MAILSTOP K-10, 1600 CLIFTON ROAD, ATLANTA, GA 30333.

RECEIVED FOR PUBLICATION 10 JANUARY 1991 AND ACCEPTED IN REVISED FORM 18 DECEMBER 1991.

CVD, CARDIOVASCULAR DISEASE; ESRD, END-STAGE RENAL DISEASE; CDC, CENTERS FOR DISEASE CONTROL; NHIS, NATIONAL HEALTH INTERVIEW SURVEY; NHDS, NATIONAL HOSPITAL DISCHARGE SURVEY; NCHS, NATIONAL CENTER FOR HEALTH STATISTICS; BDMS, BUREAU OF DATA MANAGEMENT AND STRATEGY; HCFA, HEALTH CARE FINANCING ADMINISTRATION; ICD9, INTERNATIONAL CLASSIFICATION OF DISEASE, NINTH REVISION; DKA, DIABETIC KETOACIDOSIS; IHD, ISCHEMIC HEART DISEASE; NHANES II, NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY II.

Diabetes has been diagnosed for ~6.8 million people in the United States, and a similar number may have the disease unknowingly (1). Each year, >700,000 new cases of diabetes are identified (1). In terms of human suffering, individuals with diabetes face not only a shortened life span but also an increased probability of incurring acute and chronic complications (2). In 1987, patients with diabetes spent ~27 million days in the hospital. The total cost (direct costs and lost productivity) of diabetes has been estimated at $20.4 billion for 1987 (3).

Current public health programs at the local, state, and federal levels are directed toward reducing morbidity, disability, cost, and mortality from diabetes. Health officials need to be able to measure accurately the magnitude of the diabetic disease burden in order to establish priorities, develop policy, target high-risk groups, plan programs, and evaluate the impact of programs. Public health surveillance—the ongoing and systematic collection, analysis, and dissemination of health data—can provide these measurements.

Until now, there was no unified national surveillance system for monitoring trends in diabetes and complications due to diabetes. In 1989, the Division of Diabetes Translation at the Centers for Disease Control (CDC) began to establish an ongoing surveillance system that would systematically compile national data on diabetes and its complications. In April 1990, the Division published its first surveillance report, which includes data from 1980 through 1987 (4). The report provides information on the prevalence and incidence of diabetes, hospitalizations and deaths due to diabetes, and several diabetic complications, including CVD, lower-extremity amputations, ketoacidosis, and ESRD. In this study, we describe the components of this surveillance system and summarize the temporal trends in diabetes and diabetic complications in the U.S. from 1980 through 1987.

RESEARCH DESIGN AND METHODS — Data related to diabetes morbidity and mortality are collected in several national data sources and surveys. We attempted to identify sources that provide annual representative data of the disease burden of diabetes at the national level. Data sources meeting these criteria were the National Health Interview Survey (NHIS), vital statistics, and the National Hospital Discharge Survey (NHDS) from the National Center for Health Statistics (NCHS); data on treatment for ESRD came from the Health Care Financing Administrations (HCFA), Bureau of Data Management and Strategy. We generated the data in this report by primary data analysis of public-use computer data tapes available from the CDC's NCHS. For primary analysis of data on ESRD, we made special arrangements to obtain necessary data tapes from the HCFA.

Incidence and prevalence of self-reported diabetes was determined from the NHIS. This survey, which has been conducted continuously since 1957, collects information on members of 36,000–46,000 households each year, yielding annual probability samples that range from 92,000 to 135,000 individuals. Responsible adult household members may provide information on other household members, although attempts are made to interview all adult household members in person. Methods used in conducting these surveys have been described elsewhere (5). Each year, a subsample ranging from one-sixth to one-third of survey participants, are asked the following questions: *1*) During the past 12 months, did anyone in the family have diabetes? *2*) Who was this? *3*) During the past 12 months, did anyone else have diabetes? If a person in the household has diabetes, it is ascertained when the diabetes was first noticed.

Diabetes prevalence is calculated by determining the proportion of individuals with diabetes, regardless of when it began. Annual diabetes incidence (the number of new or incident cases of diabetes developing within the survey group during a 1-yr period) is calculated by counting only those individuals who report having first noticed that they have diabetes during the 12 mo before the survey interview.

To enumerate deaths from diabetes, we used mortality data tapes available from the CDC's NCHS. Methods used in collecting and compiling state vital record data at the national level have been described previously (6). Vital statistics data were available for 1980 through 1986. For each record on mortality tapes, a single underlying cause and a maximum of 19 contributory causes of death can be coded. We identified deaths attributable to diabetes (as either the underlying or a contributory cause) with code 250 of the ninth revision of the International Classification of Disease (ICD9) (7).

We used data from the NHDS to estimate the number of diabetes-related hospitalizations in U.S. noninstitutional, nonfederal hospitals. The NHDS is a continuous voluntary survey conducted since 1965. Methods used in conducting this survey have been described previously (8). Briefly, a sample of inpatient medical records are obtained from a national sample of short-stay general and specialty hospitals. In 1987, for example, about 181,000 medical records from 400 hospitals were included in the survey. Data from hospital records are manually abstracted onto medical abstract forms or (beginning in 1987) are obtained from an automated system of computer tapes purchased from commercial abstracting services. A maximum seven diagnoses and four procedures may be coded for each medical record in the sample.

For analysis, we selected all discharges for which any of the discharge diagnoses listed were coded to ICD9 code 250. Diabetes-related lower-extremity amputations were identified with ICD9 procedure code 84.1 (amputation of lower limb) and ICD9 disease code 250 in the same hospitalization. Traumatic amputations of the toe, foot, and leg (ICD9 disease codes 895–897) were excluded from analysis. For DKA, ICD9 code 250.1 (diabetes with ketoacidosis) was used to identify hospital discharges in which DKA was listed as either a primary or secondary diagnosis. Code 250.1 was also used to identify deaths in which DKA was listed on vital statistics data tapes as either an underlying or a contributory cause.

NHDS data also were used to determine the number of hospital discharges for CVD among persons with diabetes. We enumerated hospital discharges for which major CVD (ICD9 390–448), IHD (ICD9 410–414), or stroke (ICD9 430–434, 436–438) was listed as the primary diagnosis and diabetes (ICD9 250) was listed as a secondary diagnosis. We also enumerated deaths for which major CVD, IHD, or stroke was listed as an underlying cause of death and diabetes was listed as a contributory cause.

We also used data available for 1980–1986 from the ESRD program management and medical information system of the HCFA (9). We identified cases of ESRD for which diabetes was listed by treatment providers as the primary diagnosis on the Chronic Renal Disease Medical Evidence Report.

We used two different denominators when calculating rates. For prevalence and incidence of diabetes, we used the resident population of the U.S. as the denominator. We used 1980 census estimates for 1980 and intercensal estimates for subsequent years (10). To develop precise estimates of annual incidence, we pooled 3 yr of data and used 3-yr moving averages because of the small sample sizes.

To analyze diabetes-related deaths, hospitalizations, and ESRD, we calculated rates using (as the denominator) an estimate of the number of individuals in the U.S. known to have diabetes. We estimated that number using data from the annual NHIS. These rates indicate the rate for various complications among individuals with diabetes.

The rates are not dependent on disease prevalence but are dependent on disease severity and health-care utilization among individuals with diabetes.

We standardized rates according to the direct method (11) and used the 1980 U.S. resident population to standardize incidence and prevalence. We used the 1980 U.S. population of individuals with diabetes (estimated from the NHIS) to standardize rates for the diabetic population. In all standardizations, the age groupings used were 0–44, 45–64, 65–74, and ≥75 yr old.

For calculation of SE, we used the SESUDAAN computer package (12), which accounts for the complex sampling designs used in conducting the NHIS and NHDS. A priori, we decided to conduct the analyses of and report upon only those subgroups for which point estimates had relative SE values of ≤30%. For statistical analysis of temporal trends, we used weighted linear regression (13), with the estimated SE of the observed rates as weights. We used standard Z tests for analyses comparing two proportions (11).

RESULTS

Prevalence and incidence

In 1987, 6.82 million people in the U.S. were known to have diabetes. From 1980 through 1987, the number of individuals with diabetes increased by >1 million. The relative increase in the number with diabetes varied by race and sex. In 1980, 2.08 million white males had diabetes. In 1987, the number had increased by 33%—to 2.76 million. This large increase was attributable in part to the near doubling in cases of diabetes (from 311,000 to 578,000) in the youngest age-group (birth to age 45 yr). In contrast, the number of white females with diagnosed diabetes was 2.75 million in 1987, nearly identical to the number (2.72 million) in 1980. The number of black males with diabetes increased by 16%—from 350,000 in 1980 to 406,000 in 1987. Among black females, the increase was from 538,000 to 669,000. The large increase among black females was largely due to a doubling in cases in the ≥75-yr-old age-group (from 71,000 in 1980 to 146,000 in 1987).

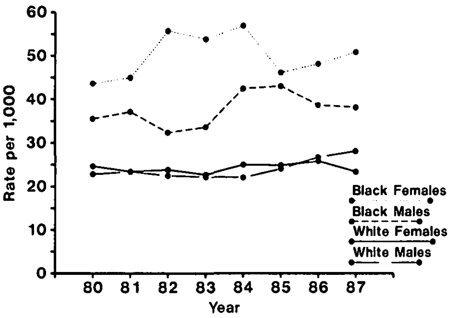

Figure 1—*Age-standardized prevalence of diabetes by race, sex, and year in the United States, 1980–1987.*

Age-standardized prevalence for diabetes increased nearly 10% during this period, from 25.4 to 27.6/1000 U.S. residents ($P = 0.03$). Each year, age-standardized prevalence was higher for blacks than for whites (Fig. 1). In 1987, the age-standardized prevalence (per 1000 residents) for black females (50.9) was more than twice that for white females (23.4) ($P < 0.001$). Age-standardized prevalence for males was ~33% higher for blacks than for whites ($P = 0.04$). Age-standardized prevalence was higher for black females than for black males ($P = 0.07$); for whites, however, the prevalence was similar between sexes.

The annual number of incident cases of diabetes increased from 541,000 in 1980 to 731,000 in 1987. The age-standardized incidence increased significantly during this period ($P = 0.02$). The age-standardized incidence per 1000 residents was 2.35 in 1980, 2.98 in 1983, and 2.89 in 1987. During this 8-yr period, incidence for males was fairly stable—at an average of 2.34/1000 residents yr. For females, however, annual incidence steadily increased from 1980 through 1987—from 2.42 to 3.42/1000 residents ($P = 0.003$). The rising incidence was most evident in women ≥65 yr old, for whom the annual incidence per 1000 residents increased from 6.33 to 10.61 ($P = 0.02$).

Mortality

Diabetes-related deaths include deaths for which diabetes was listed as either an underlying or a contributing cause on the death certificate. In each year, the number of deaths in which diabetes was listed as a cause of death was ~4 times the number in which diabetes was selected as the underlying cause of death. In 1980, the number of deaths for which diabetes was listed as a cause (underlying or contributory) was 135,931. The number of these diabetes-related deaths increased each year and reached 150,120 in 1986 (the latest year for which data were available). In that year, 37,184 deaths were from diabetes as an underlying cause.

Temporal trends in mortality rates were similar for diabetes as an underlying cause and as any listed cause of death. The age-standardized mortality rate for diabetes as any listed cause decreased from 2350/100,000 individuals with diabetes in 1980 to 2066/100,000 in 1986, a 12% decline ($P = 0.14$). However, not all age-groups showed similar temporal trends. Age-specific mortality rates declined among individuals ≥45 yr old, but these trends were not statistically significant. The largest decline was among individuals ≥75 yr old. In this age-group, the annual mortality rate for diabetes-related deaths (per 100,000 individuals with diabetes) decreased from 7299 in 1980 to 5620 in 1986, a 23% decline ($P = 0.12$). In contrast, the mortality rate for individuals <45 yr old increased significantly during this period. In 1980, the mortality rate for this age-group was 320/100,000 individuals with diabetes; by 1986, the rate had increased 20% to 384 ($P = 0.004$).

Age-standardized mortality rates for diabetes-related deaths decreased in each race-sex category (Fig. 2). From

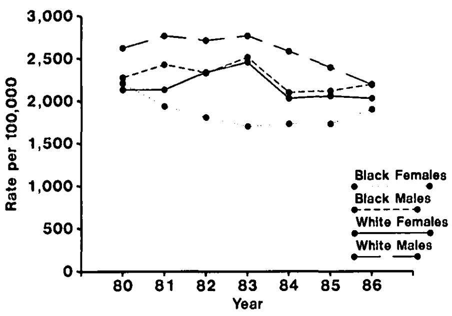

Figure 2—*Age-standardized mortality rate for diabetes as any listed cause of death per 100,000 diabetic population by race, sex, and year in the United States, 1980–1986.*

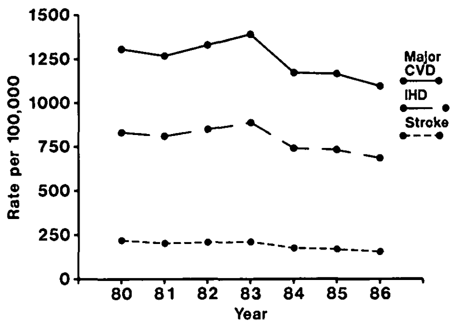

Figure 3—*Age-standardized mortality rate for major CVD, IHD, and stroke as underlying cause of death per 100,000 diabetic population by year in the United States, 1980–1986.*

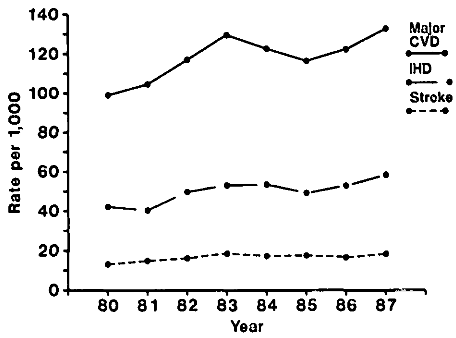

Figure 4—*Age-standardized rate of hospital discharge for major CVD, IHD, and stroke as primary diagnosis per 1000 diabetic population by year in the United States, 1980–1987.*

1980 through 1986, diabetes-related mortality rates declined 17% for white males ($P = 0.06$), 14% for black females ($P = 0.13$), 5% for white females ($P = 0.61$), and 4% for black males ($P = 0.23$).

Cardiovascular disease

The number of deaths in which major CVD was the underlying cause and diabetes was a contributing cause increased somewhat during the period—75,594 such deaths were reported for 1980 and 80,129 for 1986. For IHD, a principal subset of major CVD, the number of deaths increased from 48,169 in 1980 to 49,793 in 1986. In contrast, the number of deaths in which stroke was the underlying cause declined during these years from 12,735 to 11,705.

Although the number of deaths from major CVD and IHD increased between 1980 and 1986, the mortality rates for these conditions decreased (Fig. 3). For major CVD, the annual age-standardized mortality rate (per 100,000 individuals with diabetes) decreased from 1307 to 1097, a 16% decline ($P = 0.07$). For IHD, the corresponding rate of decline was 18% (from 833 in 1980 to 687 in 1986) ($P = 0.06$). For stroke, the age-standardized mortality rate declined 29%, from 220 to 156 ($P = 0.003$). Mortality rates for major CVD, IHD, and stroke declined in each race-sex group.

From 1980 through 1987, the number of hospitalizations for major CVD, IHD, or stroke as the primary diagnosis and diabetes as a secondary diagnosis increased. In 1980, the number of hospitalizations for major CVD was 573,000; for IHD, 245,000; and for stroke, 77,000. In 1987, the corresponding numbers were 902,000 (57% increase), 390,000 (59% increase), and 128,000 (66% increase), respectively.

Age-standardized rates of hospital discharges also increased during the period (Fig. 4). In 1987, the age-standardized hospital discharge rate (per 1000 individuals with diabetes) for major CVD (133) was 34% higher than in 1980 ($P = 0.006$). In 1987, the rate for IHD (58.4) was 38% higher than in 1980 ($P = 0.005$). For stroke, the rate increased 40% between 1980 and 1983 (to 18.8/1000 individuals with diabetes), then leveled off ($P = 0.01$).

Lower-extremity amputations

In 1980, 36,000 hospital discharges were made for nontraumatic amputation among individuals with diabetes. By 1987, the number had increased >50%—to 56,000 discharges/yr. During this period, the age-standardized rate increased from 6.3 to 8.1/1000 individuals with diabetes ($P = 0.06$). Discharge rates, on average, were ~20% higher for males than for females ($P = 0.001$). In 1987, the age-standardized rate per 1000 individuals with diabetes was 8.8 for males and 8.1 for females. Discharge rates were also higher for blacks than for whites ($P = 0.02$). In 1987, the age-standardized rate per 1000 individuals with diabetes was 9.0 for blacks and 6.3 for whites.

DKA

The number of hospital discharges made for DKA steadily increased during the period of surveillance. In 1980, 70,000 such hospital discharges were made; for 59,000 of these discharges, DKA was listed as the primary diagnosis. In 1987, 110,000 such hospital discharges were made; for 93,000 of these, DKA was the primary diagnosis.

In general, the trend in hospital discharge rates for DKA as any listed diagnosis was similar to that for DKA as the primary diagnosis. From 1980 through 1987, the age-standardized rate of hospital discharge for DKA as a primary diagnosis showed an overall increase ($P = 0.02$) (Fig. 5). The age-standardized rate (per 1000 individuals with diabetes) was 10.3 discharges in 1980; it peaked at 14.6 in 1984 and then declined slightly to 12.5 in 1987. During this period, the rate was consistently highest for black males, and, with few

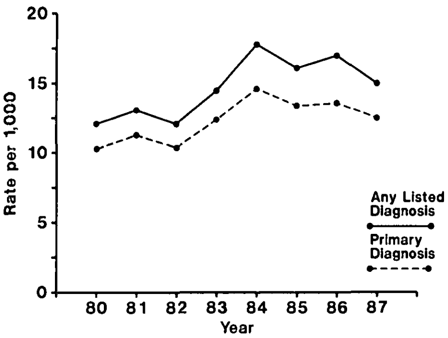

Figure 5—*Age-standardized rate of hospital discharge for DKA per 1000 diabetic population by type of diagnosis and year in the United States, 1980–1987.*

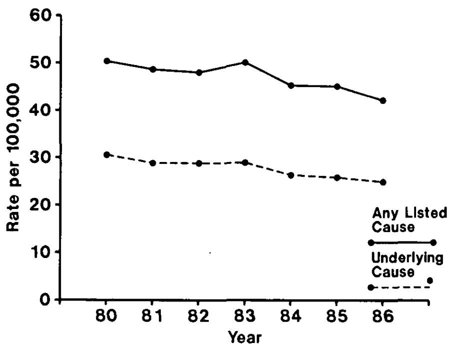

Figure 6—*Age-standardized mortality rate per 100,000 diabetic population for DKA as underlying or any listed cause of death by year in the United States, 1980–1986.*

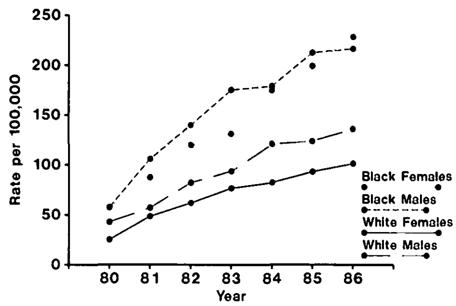

Figure 7—*Age-standardized incidence rate of ESRD caused by diabetes per 100,000 diabetic population by race, sex, and year in the United States, 1980–1986.*

exceptions, it was lowest for white males. In 1987, the age-standardized rate for black males, 24.7/1000 individuals with diabetes, was nearly threefold higher than the corresponding rate for white males (8.7) ($P < 0.001$). In contrast, the rates for black females and for white females were nearly identical, 12.4 and 12.0, respectively ($P = 0.45$).

The number of deaths for which DKA was the underlying cause declined slightly, from 1772 in 1980 to 1735 in 1986. For DKA as any listed cause, the corresponding numbers for these 2 yr were 2915 and 2969. Among persons with diabetes, the mortality rate for DKA as either an underlying or contributing cause of death declined during the 7-yr period (Fig. 6). For DKA as an underlying cause, the age-standardized mortality rate (per 100,000 individuals with diabetes) fell from 30.6 in 1980 to 25.0 in 1986—a decrease of 18% ($P < 0.001$). Mortality rates declined among all race-sex groups during this period. For black males and black females, DKA mortality rates decreased 26% ($P = 0.11$ and $P = 0.07$, respectively). The corresponding rate decreases for white males and white females were 21% ($P = 0.003$) and 10% ($P = 0.16$), respectively.

ESRD

The number of individuals being treated for ESRD attributed to diabetes increased more than fourfold—from 5955 in 1980 to 27,919 in 1986. Similarly, the number of individuals with ESRD attributed to diabetes for whom treatment was initiated (incident cases) increased from 2202 in 1980 to 8994 in 1986. The age-standardized incidence per 100,000 individuals with diabetes increased from 37.9 in 1980 to 138.0 in 1986 ($P < 0.001$). Incidence was consistently lowest for white females, but all four race-sex groups had significant rate increases ($P < 0.001$) during this 7-yr period (Fig. 7). For 1986, with white females as the reference group, the age-adjusted incidence ratios were 2.2 for black females ($P < 0.001$), 2.1 for black males ($P = 0.003$), and 1.3 for white males ($P = 0.03$).

CONCLUSIONS— Establishing a national diabetes surveillance system has enabled us to analyze available data to document the disease burden of diabetes and its complications and to identify trends and high-risk groups in the United States. From 1980 through 1987, the increase in the number of individuals known to have diabetes resulted from a rising diabetes prevalence rate and from growth in the population, particularly in older age-groups. The incidence of diabetes increased among women, particularly those >65 yr old. The prevalence rate of diabetes, which reflects both increasing incidence and declining diabetes-related mortality, may continue to rise. Moreover, if the prevalence rate of diabetes were to level off or even decline, the number of individuals with diabetes in the United States could still rise further because, with the aging of the population, the pool of individuals at increased risk for this disease will continue to expand (14).

Several favorable trends were identified. Mortality rates for stroke and DKA decreased significantly during the observed period. Overall mortality rates showed modest declines, with a decrease that approached statistical significance for white males. However, other trends were less encouraging. Hospitalization rates for diabetic individuals increased for major CVD, IHD, stroke, and DKA. In addition, the incidence of ESRD related to diabetes increased by >10%/yr between 1982 and 1986.

Blacks are at increased risk for diabetes and its complications. The prevalence of diagnosed diabetes is nearly twice as high for blacks as for whites. The smallest relative decline in overall mortality rates was for black males. Blacks had increased rates of lower-extremity amputations, DKA, and ESRD.

Each of the data sources we used has limitations. Estimates of incidence and prevalence rely on potentially inaccurate self-reporting of disease status. However, research indicates good agreement between self-report and medical records of an individual's diabetes status (15). Thus, self-reported data adequately estimate incidence and prevalence of diagnosed diabetes.

Incomplete detection of cases of diabetes may influence estimates of prevalence and mortality. For surveillance of temporal trends, however, incomplete case detection is unlikely to be a problem when the degree of underdetection is constant over time and similar among population groups. A substantial proportion, perhaps as much as 50%, of individuals with diabetes are not diagnosed, according to data from the Second National Health and Nutrition Examination Survey (NHANES II) (16). However, the proportion of individuals with undiagnosed diabetes was similar for males and females and for blacks and whites. We do not suspect that diabetes detection changed from 1980 through 1987, but we cannot be certain until NHANES III is completed. Data from NHANES III will be useful in interpreting the increase in self-reported diabetes noted from 1980 through 1987.

Underreporting of diabetes on vital records has been noted previously. Several studies have shown that diabetes is recorded on the death certificate for only ~40% of individuals known to have diabetes (17–19). This proportion has been fairly constant from the mid-1970s to the mid-1980s (17–19). The proportion has been similar for different race and sex groups. Thus, for diabetes prevalence and mortality, the rates reported herein underestimate the actual U.S. rates. Nonetheless, the temporal trends and relative differences between race and sex groups are probably valid and not the result of differences in reporting.

Several limitations are also associated with use of NHDS data. First, the NHDS sample is for hospital discharges, not individuals. Thus, individuals who were hospitalized more than once for the same condition may have been counted more than once. This is not a serious problem for public health purposes, however, because we are primarily concerned with the impact of diabetes on overall health-care use, and multiple hospitalizations certainly are a part of such use. At the same time, the use of this information could be enhanced if data collection and reporting procedures could be modified to allow identification of risk factors for repeated hospitalization, while maintaining appropriate and necessary levels of confidentiality regarding individual patient and health-care facility identification.

Second, the NHDS is limited to the civilian population of the United States and thus probably underestimates diabetes-related hospital discharge rates. Finally, although the reliability of data from the NHDS is good (20), little is known about the accuracy with which diabetes diagnoses are recorded on hospital discharge records. Using data from the NHANES I Epidemiologic Follow-up Study, we found that 62% of hospital discharge records among individuals with self-reported diabetes at baseline who were hospitalized during the 10-yr follow-up period had an ICD9 code 250.0–250.9 listed (21). These results suggest that diabetes hospitalizations may be underestimated by ~40%. However, because sensitivity did not vary over time or by age, race, or sex, this limitation should not affect the temporal patterns nor the relative differences among population groups. Nonetheless, trends in hospitalizations for DKA, lower-extremity amputation, and CVD must be interpreted with caution because, in 1983, the HCFA instituted diagnosis-related groups, a prospective reimbursement program that may have influenced hospitalization practices (22).

Use of HCFA data for surveillance of ESRD poses several problems. Because ESRD is defined by treatment with dialysis or transplantation, individuals with advanced renal failure who do not receive therapy are not detected (23). In addition, ~7% of ESRD among individuals with diabetes is not reimbursed by the HCFA, and therefore would not appear in the data set (23). For these reasons, the rates reported herein would underestimate the true rate of ESRD among individuals with diabetes. At the same time, diabetes may be imprecisely classified as the primary cause of renal failure (24). Furthermore, we cannot distinguish increased disease incidence from increased availability and use of treatment. Nonetheless, the HCFA ESRD program provides useful indicators of the morbidity and public health burden of diabetic ESRD in the United States.

In our analysis of CVD complications, we restricted our analysis to those events for which CVD was the primary cause of death and diabetes was a contributory cause. For hospitalizations, similarly, we restricted our analysis to those discharges in which CVD was the primary diagnosis and diabetes was a secondary diagnosis. In so doing, we focused on trends in CVD complications to which diabetes contributes. Analysis of deaths in which diabetes is the underlying cause and CVD is a contributory cause addresses a different issue—the contribution of CVD to diabetes mortality. Similarly, an analysis of hospital discharges for which diabetes is the primary diagnosis and CVD a secondary diagnosis would examine the role of this complication in causing hospitalizations for diabetes.

Although national data are available for monitoring many complications of diabetes, some gaps in data occur. According to a 1978 estimate, diabetes is the leading cause of new cases of blindness among adults in the United States (25), but recent national data are not available on eye disease and blindness related to diabetes (26). Women with diabetes are at increased risk for adverse outcomes of pregnancy (27) including having children with birth defects, although national data are not available for monitoring pregnancy outcomes among women with diabetes.

Many complications of diabetes are preventable through behavioral changes and preventive health-care services. Examples include prevention of foot trauma to decrease the risk of lower-extremity amputation (28) and provision of annual eye examinations with retinal photographs to decrease the risk of diabetes-related vision loss (29). Public health interventions aimed at preventing the complications of diabetes will have to focus on these behaviors and health-care practices, even though national data are not available about trends in such behaviors and practices.

Minority groups, such as blacks, Hispanics, and Native Americans, are at increased risk for diabetes and its complications (30,31). Use of national survey data for analyzing minority health problems has been difficult in the past partly because, for all minority groups, the sample size in most national surveys is too small to provide stable estimates of rates.

Local-area estimates of diabetes and its complications, particularly at the state level, are generally not available, except for mortality rates and ESRD treatment. State-specific estimates of the disease burden from diabetes are available (32,33). Moreover, several states are developing the capacity to collect and analyze their own diabetes-related data. Such state-level data will be useful for planning, targeting, and evaluating local-level public health efforts designed to prevent and control diabetes.

Information provided by a public health surveillance system, such as the one we have established, can be used to direct research. As we have shown, analysis of surveillance data can indicate general disease trends and differences among population subgroups. Identifying differences and trends can be useful for raising questions and pointing out areas for more specific and rigorous research. A few examples of research questions identified through analysis of these surveillance data that have policy and programmatic implications are: *1)* What accounts for the increasing incidence of diabetes among women, particularly among those ≥65 yr old? *2)* How will secular trends in the prevalence of physical inactivity and obesity impact on the prevalence of diabetes? *3)* Why are mortality rates increasing among diabetic individuals who are <45 yr old but declining in older age-groups? *4)* Why are hospitalization rates for CVD among individuals with diabetes increasing at the same time mortality rates are decreasing? *5)* Does this divergence in rates merely reflect changes in hospital discharge record coding practices encouraged by adoption of a prospective payment system, or are there more fundamental changes taking place that suggest improvements in health-care access and treatment? *6)* Why are blacks at increased risk for diabetic complications, including lower-extremity amputation, DKA, and ESRD? *7)* How do these differences in race-specific risk reflect disparities in health-care access and use?

Answers to the above questions will impact policy and program development and resource allocation at the local, state, and national level. Thus, a surveillance system can play a useful role in developing public health strategies for reducing the morbidity and mortality associated with diabetes. National health objectives for the year 2000 have been formulated for diabetes and its complications (34). These objectives call for reductions in diabetes incidence and prevalence, diabetes-related deaths, and reductions in the severe complications of diabetes (ESRD, blindness, lower-extremity amputation, and—for offspring of women with diabetes—perinatal mortality, and major congenital anomalies). A major goal of this formulation is to improve access to preventive services for all U.S. residents with diabetes (34). Achievement of this goal will have impact on the disease burden that diabetes imposes on society, because many of the above diabetic complications can be prevented or ameliorated with behavioral changes by the patient or the health-care provider or both (2, 28, 29, 34).

As prevention policies are developed and programs are funded and implemented, a system for monitoring and evaluating program progress will need to be in place. Surveillance—the systematic collection, analysis, and dissemination of health data—implies an ongoing process. The Division of Diabetes Translation plans to update the information presented in this report and to explore use of additional data sources to document changes in the diabetes disease burden, including issues of disability and cost. In this fashion, the national surveillance of temporal trends in diabetes can play a role in monitoring the progress toward meeting U.S. health objectives.

Acknowledgments— We thank Barbara L. Dougherty, Annabelle H. Alter, Linda S. Geiss, Marion Meador, and Robert D. Moran for important contributions to this work.

Copies of the full report, *Diabetes Surveillance, 1980–1987*, can be obtained from the Division of Diabetes Translation, Centers for Disease Control (MS K-10), 1600 Clifton Road, Atlanta, GA 30333.

References

1. Centers for Disease Control: Prevalence and incidence of diabetes mellitus—United States, 1980–1987. *MMWR* 39: 809–12, 1990
2. Carter Center of Emory University: Closing the gap: the problem of diabetes mellitus in the United States. *Diabetes Care* 8:391–406, 1985
3. Center for Economic Studies in Medicine: *Direct and indirect costs of diabetes in the United States in 1987*. Alexandria, VA, Am. Diabetes Assoc., 1988
4. Centers for Disease Control: *Diabetes Surveillance, 1980–1987*. Atlanta, GA, U.S. Dept. of Health and Human Services, 1990 (DHHS, Public Health Service)
5. National Center for Health Statistics: Current estimates from the National Health Interview Survey, United States,

1985. *Vital and Health Statistics*. Washington, DC, U.S. Gov't Printing Office, 1986 (DHHS, publ. no. PHS 86–1588, ser. 10, no. 160)

6. National Center for Health Statistics: *Advance Report of Final Mortality Statistics, 1986*. Hyattsville, MD, U.S. Gov't Printing Office, 1988 (DHHS, Public Health Service, publ. no. PHS 88–1120)
7. National Center for Health Statistics: U.S. vital statistics: ICD-9 underlying cause-of-death lists for tabulating mortality statistics. Hyattsville, MD, U.S. Gov't Printing Office, 1979 (Dept. of Health, Education, and Welfare, Public Health Service)
8. National Center for Health Statistics, Hospital Care Statistics Branch: *1987 Summary: National Hospital Discharge Survey*. Hyattsville, MD, National Center for Health Statistics, 1988 (DHHS publ. no. PHS 88–1250)
9. U.S. Renal Data System: *USRDS 1989 Annual Data Report*. Bethesda, MD, NIH, National Institute of Diabetes and Digestive and Kidney Diseases, 1989
10. Irwin R: *Intercensal estimates of the population by age, sex, race, 1980–1988*. Alexandria, VA, Demo-Detail, 1989
11. Fleiss JL: *Statistical Methods for Rates and Proportions*. 2nd ed. New York, Wiley, 1981
12. Shah BV: SESUDAAN: Standard errors program for computing of standardized rates from sample survey data. Research Triangle Park, NC, Research Triangle Inst., 1981
13. Neter J, Wasserman W, Kutner MH: Applied linear regression models. Homewood, IL, Irwin, 1983
14. Schneider EL, Guralnik JM: The aging of America: impact on health care costs. *JAMA* 263:2335–40, 1990
15. Bush TL, Miller SR, Golden AL, Hale WE: Self-report and medical record report agreement of selected medical conditions in the elderly. *Am J Public Health* 79:1554–56, 1989
16. Harris MI, Hadden WC, Knowler WC, Bennett PH: Prevalence of diabetes and impaired glucose tolerance and plasma glucose levels in U.S. population aged 20–74 yr. *Diabetes* 36:523–34, 1987
17. Brousseau JD: Occurrence of diabetes among decedents in North Dakota. *Diabetes Care* 10:542–43, 1987
18. Ochi JW, Melton LJ, Palumbo PJ, Chu C-P: A population-based study of diabetes mortality. *Diabetes Care* 8:224–29, 1985
19. Palumbo PJ, Elveback LR, Chu C-P, Connolly DC, Kurland LT: Diabetes mellitus: incidence, prevalence, survivorship, and causes of death in Rochester, Minnesota, 1945–1970. *Diabetes* 25:566–73, 1976
20. Institute of Medicine: Report of a study: reliability of National Hospital Discharge Survey Data. Washington, DC, National Academy of Sciences, 1980
21. Ford ES, Wetterhall SF: The validity of diabetes on hospital discharge diagnoses (Abstract). *Diabetes* 40 (Suppl. 1):499A, 1991
22. Weinberger M, Ault K, Vinicor F: Prospective reimbursement and diabetes mellitus: impact upon glycemic control and utilization of health services. *Med Care* 26:77–83, 1988
23. Eggers PW, Connerton R, McMullan M: The Medicare experience with end-stage renal disease: trends in incidence, prevalence, and survival. *Health Care Financ Rev* 5:69–88, 1984
24. Kasinath BS, Mujais SK, Spargo BH, Katz AI: Nondiabetic renal disease in patients with diabetes mellitus. *Am J Med* 75: 613–17, 1983
25. National Society to Prevent Blindness: Vision problems in the United States: data analysis, definitions, data sources, detailed data tables, analysis, interpretation. New York, National Society to Prevent Blindness, 1980
26. Will JC, Geiss LS, Wetterhall SF: Diabetic retinopathy (Letter). *N Engl J Med* 323:613, 1990
27. Hare JW: Pregnancy and diabetes. In *Joslin's Diabetes Mellitus*. 12th ed. Marble A, Krall LP, Bradley RF, Christlieb AR, Soeldner JS, Eds. Philadelphia, PA, Lee & Febiger, 1985, p. 698–711
28. Pecoraro RE, Reiber GE, Burgess EM: Pathways to diabetic limb amputation: basis for prevention. *Diabetes Care* 13: 513–21, 1990
29. Dasbach EJ, Fryback DG, Newcomb PA, Klein R, Klein BEK: Cost-effectiveness of strategies for detecting diabetic retinopathy. *Med Care* 29:20–39, 1991
30. Dept. of Health and Human Services: Report of the Secretary's Task Force on Black and Minority Health. Vol 1. Washington, DC, U.S. Gov't Printing Office, 1985, p. 149–56
31. Harris MI, Hamman RF, Eds. *Diabetes in America*. NIH, Washington, DC, 1985 (DHHS publ. no. NIH 85–1468)
32. Centers for Disease Control: Diabetes Fact Sheets, 1990: state-specific estimates of diabetes disease burden. Atlanta, GA, U.S. Dept. of Health and Human Services, Public Health Service, 1990
33. Centers for Disease Control: Regional variation in diabetes mellitus prevalence—United States, 1988 and 1989. *MMWR* 39:805–809, 1990
34. U.S. Public Health Service: Healthy people 2000: national health promotion and disease prevention objectives. U.S. Gov't Printing Office, 1991, Washington, DC, p. 44–62 (DHHS, publ. no. PHS 91-50212)