Projection of Diabetes Burden Through 2050

Impact of changing demography and disease prevalence in the U.S.

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OBJECTIVE — To project the number of people with diagnosed diabetes in the U.S. through 2050, accounting for changing demography and diabetes prevalence rates.

RESEARCH DESIGN AND METHODS — We combined age-, sex-, and race-specific diagnosed diabetes prevalence rates—predicted from 1980–1998 trends in prevalence data from the National Health Interview Survey—with Bureau of Census population demographic projections. Sensitivity analyses were performed by varying both prevalence rate and population projections.

RESULTS — The number of Americans with diagnosed diabetes is projected to increase 165%, from 11 million in 2000 (prevalence of 4.0%) to 29 million in 2050 (prevalence of 7.2%). The largest percent increase in diagnosed diabetes will be among those aged ≥75 years (+271% in women and +437% in men). The fastest growing ethnic group with diagnosed diabetes is expected to be black males (+363% from 2000–2050), with black females (+217%), white males (+148%), and white females (+107%) following. Of the projected 18 million increase in the number of cases of diabetes in 2050, 37% are due to changes in demographic composition, 27% are due to population growth, and 36% are due to increasing prevalence rates.

CONCLUSIONS — If recent trends in diabetes prevalence rates continue linearly over the next 50 years, future changes in the size and demographic characteristics of the U.S. population will lead to dramatic increases in the number of Americans with diagnosed diabetes.

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In 1998, the number of people in the Unites States with diagnosed diabetes was estimated to be 10.4 million—representing an increase of 2.9 million diagnosed cases since 1980 (1). About half of this increase was attributed to the aging of the population (1). The other demographic factors to consider are changes in sex and race composition, because these differentially affect diabetes prevalence. Another factor to take into account is the recently observed increase in diabetes prevalence (1–3), probably reflecting changes in obesity and lifestyle factors (4–6).

Previous studies have projected the number of people with diabetes (7–9). One study used constant age-specific prevalence rates of diagnosed diabetes and projected a 46% increase in the number with diabetes in the U.S. through 2050 (7). These projections indicate a rise from 7.5 million individuals with diabetes in 1987 to >11 million in 2025, and to almost 12 million by 2050. Although this study took into account changes in the size and age composition of the population, it did not consider future changes in race or sex composition or diabetes prevalences. Another study developed worldwide projections of the number of individuals with diagnosed and undiagnosed diabetes for 1995, 2000, and 2025 (8). Age- and sex-specific prevalence rates for both diagnosed and undiagnosed diabetes in the U.S. were applied to population projections from the United Nations to project the number of people aged >19 years with diabetes. Projections for the U.S. suggested that the number of individuals aged ≥20 years with either diagnosed or undiagnosed diabetes will rise from 13.9 million in 1995 to almost 22 million in 2025. Although these projections reflect the anticipated total number of people with diabetes (diagnosed and undiagnosed), they do not consider changes in race composition or prevalences.

The race composition of the U.S. is likely to change over the next 50 years, with an increasing proportion of minority groups (10). Population projections from the U.S. Census Bureau indicate that blacks will represent ~14.7% of the total population by 2050, up from 12.8% in 2000. Other races will increase from 5.0% in 2000 to 10.4% in 2050, whereas whites will decrease from 82.2% in 2000 to 74.9% in 2050. Furthermore, recent trends indicate that diabetes prevalence in the U.S. is increasing. A 16% increase in diabetes prevalence was noted between 1980 and 1994 (1), and in the 8-year period from 1990 to 1998, there was a 33% increase (3).

Any projection of the number of people in the U.S. with diabetes is likely to be an underestimate if it does not consider both changes in the demographic characteristics of the population (including race composition) and increasing trends in age-, sex-, and race-specific prevalence rates of diabetes, reflecting secular changes in the prevalence of obesity and lifestyle factors. We have therefore devel-

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Abbreviations: NHIS, National Health Interview Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Prevalence of U.S. diagnosed diabetes per 1,000 whites, by age-group and sex, 1980–1998

	Age-group (years)							
	0–44		45–64		65–74		75 and older	
Year	Male	Female	Male	Female	Male	Female	Male	Female
1980	5.1	6.8	51.2	48.1	92.8	84.9	73.7	92.5
1981	5.3	6.9	51.3	48.1	84.3	88.5	78.8	83.8
1982	5.7	6.5	51.4	49.9	73.3	82.5	84.0	78.3
1983	5.6	6.5	47.8	50.7	73.9	88.8	91.0	76.0
1984	5.6	6.6	46.0	49.6	85.1	91.6	93.4	82.5
1985	5.0	7.5	51.5	49.5	93.8	92.3	98.1	91.3
1986	6.0	7.8	55.6	48.1	97.4	88.8	104.0	86.3
1987	6.4	7.1	56.3	48.0	89.8	85.5	104.3	80.5
1988	6.9	6.8	53.0	47.2	84.0	89.1	89.1	76.9
1989	6.1	6.7	48.6	47.2	85.3	90.9	78.9	75.4
1990	6.5	8.2	50.2	50.2	88.8	90.9	77.2	81.9
1991	6.6	8.3	50.3	50.7	100.1	95.0	89.6	86.7
1992	7.5	8.6	56.1	52.5	95.9	98.2	100.3	95.1
1993	7.3	8.0	56.9	51.9	100.1	98.6	104.8	92.7
1994	6.9	8.3	57.5	52.9	106.5	102.1	107.1	99.1
1995	6.2	8.6	51.6	51.1	114.6	91.6	107.0	90.1
1996	5.6	9.1	49.7	50.8	121.1	90.3	108.2	93.8
1997	8.1	9.6	67.1	76.6	115.4	155.4	126.7	107.2
1998	8.5	9.2	71.8	76.1	130.8	138.6	108.4	125.8

*From reference 1.

oped total and age-, sex-, and race-specific projections by extrapolating nationally representative data on age-, sex-, and race-specific prevalence rates of diabetes and applying these rates to the most recent Bureau of Census population projections. We also include sensitivity analyses in which we conservatively hold age-, sex-, and race-specific prevalence rates constant over the projection horizon.

RESEARCH DESIGN AND METHODS

Projection model

The model is similar to those used in other studies (7–9) and involves combining prevalence data with population projections. Specifically, to project the number of people with diagnosed diabetes (henceforth, diabetes) from 2000 to 2050, we multiplied the U.S. Census Bureau's age-, sex-, and race-specific population projections by predicted diabetes prevalence rates for each age, sex, and race subgroup.

Data

Data on the age-, sex-, and race-specific prevalence of diabetes from the U.S. representative National Health Interview Survey (NHIS) were used. The NHIS is an annual survey that asks a subsample of respondents in each year whether any household member has diabetes. Diabetes prevalence data based on the NHIS are available by race (whites, including whites of Hispanic origin; blacks, including black Hispanic; and other, comprised of Asians, Pacific Islanders, and Native Americans) for the years 1980–1998, and these data are reported for male and female respondents and the following four age-groups: 0–44, 45–64, 65–74, and ≥75 years (1). These prevalence rates for whites and blacks are listed in Tables 1 and 2. Predicted prevalence rates were determined by regressing the 19 years (1980–1998) of age-, sex-, and race-specific prevalence rates of diabetes against time. In all cases, the coefficient on time was positive and significant, indicating that prevalence rates increased during the 1980–1998 period for all subgroups, consistent with previous reports (2,3).

The U.S. Census Bureau has developed, as the most likely scenario, a middle series of population projections through 2050 on an intermediate set of assumptions regarding fertility rates, life expectancies, and net immigration (10). For each year from 2000 to 2050, population projections are available by age, sex, and race/ethnicity. We aggregated these population projections to get the projected population for each age, sex, and race subgroup for which diabetes prevalence

Table 2—*Prevalence of U.S. diagnosed diabetes per 1,000 blacks, by age-group and sex, 1980–1998

	Age-group (years)							
	0–44		45–64		65–74		75 and older	
Year	Male	Female	Male	Female	Male	Female	Male	Female
1980	7.4	10.6	98.7	108.2	108.1	132.5	103.6	151.2
1981	6.4	9.0	97.2	120.8	116.8	172.3	79.3	144.9
1982	6.0	7.9	93.2	135.6	120.1	197.9	83.7	134.1
1983	3.5	10.5	104.2	124.9	142.7	243.6	79.8	160.1
1984	5.2	9.7	108.3	115.4	145.0	224.0	111.6	170.6
1985	5.9	8.1	110.1	104.8	159.2	216.6	107.3	211.6
1986	7.6	7.6	99.8	112.0	143.3	167.8	119.5	219.7
1987	8.2	9.4	100.9	110.2	160.5	163.5	104.4	247.1
1988	7.2	11.4	116.8	94.2	128.6	174.6	150.9	230.1
1989	6.7	11.2	117.3	89.8	116.7	199.4	159.4	190.6
1990	5.0	11.8	115.1	84.1	109.4	226.1	172.9	140.7
1991	5.2	12.1	80.5	100.9	173.1	222.2	127.6	148.1
1992	7.5	12.4	89.5	104.0	211.6	201.0	83.0	167.5
1993	8.5	12.6	95.6	127.3	190.5	181.2	109.3	181.8
1994	10.5	10.6	113.8	135.5	176.0	199.1	117.0	193.9
1995	8.5	9.9	128.0	146.5	176.3	205.0	188.8	199.1
1996	8.4	8.9	131.3	138.8	220.7	207.6	179.3	229.0
1997	13.2	14.9	142.5	154.7	217.0	257.0	209.9	230.1
1998	13.4	12.1	148.5	133.4	191.5	299.1	150.2	180.1

*From reference 1.

Table 3—*Projections (in thousands) of the number of males and females with diagnosed diabetes by age-group for selected years, using increasing predicted prevalence rates combined with the middle Bureau of Census U.S. population projections (most likely scenario)

	Age-group (years)									
	0–44		45–64		65–74		75 and older			%
Year	Male	Female	Male	Female	Male	Female	Male	Female	Total	2000
2000	839 (0.93)	898 (1.01)	2,303 (7.77)	2,362 (7.49)	1,115 (13.58)	1,463 (14.66)	790 (12.61)	1,212 (11.67)	10,982 (3.99)	100
2005	891 (0.98)	965 (1.08)	2,769 (7.97)	2,826 (7.67)	1,242 (14.76)	1,519 (15.13)	929 (13.46)	1,335 (12.12)	12,476 (4.34)	114
2010	946 (1.04)	1,034 (1.16)	3,165 (8.18)	3,213 (7.85)	1,543 (15.90)	1,777 (15.52)	1,041 (14.34)	1,425 (12.61)	14,144 (4.72)	129
2025	1,196 (1.21)	1,335 (1.37)	3,371 (8.86)	3,402 (8.43)	3,251 (19.63)	3,228 (16.95)	1,886 (16.98)	2,244 (14.09)	19,913 (5.89)	181
2050	1,734 (1.48)	1,990 (1.73)	4,293 (9.88)	4,226 (9.26)	4,446 (26.22)	3,692 (19.37)	4,243 (21.95)	4,491 (16.85)	29,115 (7.21)	265
%2000†	207	222	186	179	399	252	537	371		

*Numbers in parentheses are the number of people with diagnosed diabetes in the cell expressed as a percentage of the projected population in the cell, i.e., prevalence of diagnosed diabetes in the cell. †The last row is the 2050 projected numbers as a percentage of the 2000 projected numbers.

rate data were available. Population projections based on the middle series suggest that the U.S. population is likely to grow from ~275 million people in 2000 to almost 404 million in 2050 (+47%). The Census Bureau has also created a lowest and a highest series by varying assumptions regarding fertility rates, life expectancies, and net immigration (10).

Sensitivity analyses

We conducted sensitivity analyses by varying the following two inputs: the population projections and the projected prevalence rates of diabetes. The Census Bureau's three population projection scenarios (low, middle, and high) were combined with two scenarios for projected prevalence rates (constant 1998 prevalence rates over the entire period of 2000–2050 and the set of predicted increasing prevalence rates) to yield six scenarios for the future burden of diabetes.

RESULTS

Projections

Projections of the number of people with diabetes based on the most likely scenario are shown in Table 3. The total number of people with diabetes will rise from ~11 million in 2000 to almost 20 million in 2025. By 2050, this is projected at >29 million people—a 165% increase over the 2000 level. Note that these projections imply a steady increase in the overall prevalence of diabetes, from 3.99% in 2000 to 7.21% in 2050. The largest increases in the number of people with diabetes are likely to occur in the oldest age category. The number of women ≥75 years of age with diabetes will rise from ~1.2 million in 2000 to >4.4 million in 2050 (+271%). The number of men with diabetes in this same age-group will rise from ~0.8 million in 2000 to >4.2 million in 2050 (+437%).

It is important to test the effects of increasing prevalence rates and projected demographic changes in the U.S. population from 2000 to 2050 on the projected numbers of people with diabetes. To do this, we compared three projection scenarios. The first projections—11.8, 13.3, and 15.9 million people with diabetes in 2010, 2025, and 2050, respectively—are based on constant prevalence rates and the middle population series adjusted to 2000 demographics, i.e., the year 2000 age, sex, and race distribution for all years from 2000 to 2050. The second—12.9, 16.1, and 22.4 million in 2010, 2025, and 2050, respectively—uses increasing prevalence rates and the middle series, again adjusted to 2000 demographics. And the third is the most likely total projection scenario in Table 3—14.1, 19.9, and 29.1 million people in 2010, 2025, and 2050, respectively. Thus, by 2010 an additional 3.1 (14.1–11) million people are projected to have diabetes, and 0.8 (11.8–11) million of this increase is attributable to population growth, 1.1 (12.9–11.8) million is due to increasing prevalence rates, and 1.2 (14.1–12.9) million is due to changing demographics. As seen in Fig. 1, it is demographic changes that account for the largest share of the increases.

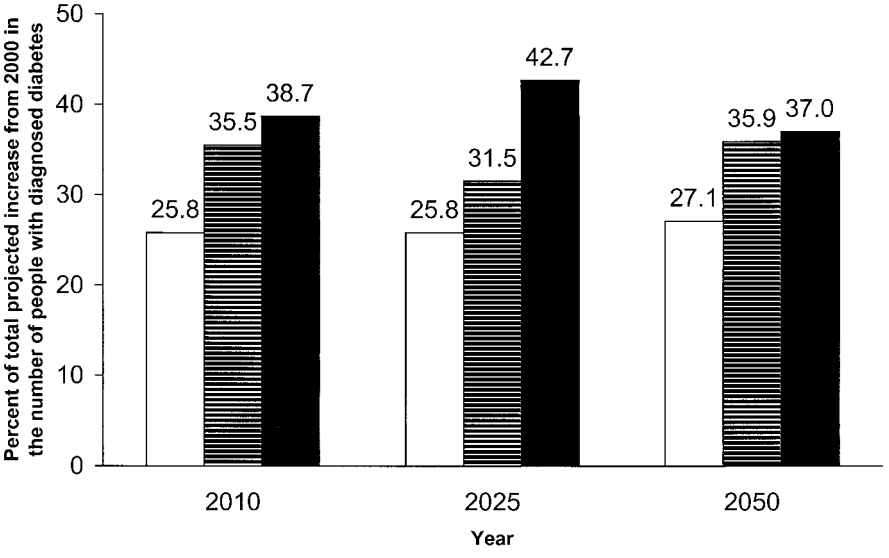

Figure 1—*Percentage breakdowns of the projected increase in the total number of people with diagnosed diabetes due to population growth, increasing prevalence rates, and demographic changes for the years 2010, 2025, and 2050 (most likely scenario). □, Population growth; ▤, increasing prevalence rates; ■ demographic changes.*

Table 4—*Sensitivity analyses: projections (in thousands) of the total number of people with diagnosed diabetes using constant or increasing prevalence rates combined with low, middle, or high Bureau of Census U.S. population projections

	Constant 1998 prevalence rates			Increasing prevalence rates		
Year	Low	Middle	High	Low	Middle	High
2000	10,864 (3.95)	10,864 (3.95)	10,864 (3.95)	10,982 (3.99)	10,982 (3.99)	10,982 (3.99)
2005	11,806 (4.16)	11,899 (4.14)	12,014 (4.11)	12,377 (4.36)	12,476 (4.34)	12,599 (4.31)
2010	12,788 (4.39)	13,014 (4.34)	13,303 (4.28)	13,894 (4.77)	14,144 (4.72)	14,464 (4.65)
2025	15,342 (4.98)	16,266 (4.82)	17,542 (4.61)	18,768 (6.09)	19,913 (5.89)	21,501 (5.65)
2050	17,048 (5.44)	20,047 (4.97)	25,017 (4.53)	24,661 (7.87)	29,115 (7.21)	36,480 (6.60)

*Numbers in parentheses are the total number of people with diagnosed diabetes expressed as a percentage of the total projected population, i.e., total population prevalence of diagnosed diabetes.

The largest increases in race-specific projections of diabetes also occur in the oldest age-groups. The number of white men ≥75 years of age with diabetes is likely to increase, from ~686,000 in 2000 to ~3.1 million in 2050 (+352%). For black men in the same age-group, a >10-fold increase in the number with diabetes (from 84,000 to 932,000) is projected between 2000 and 2050. The projected number of white women ≥75 years of age with diabetes is likely to increase by 210% between 2000 and 2050 (from 1.0 million to 3.1 million), whereas the number of black women with diabetes in this age-group will rise by 555% (from 168,000 to 1.1 million). The number of whites (males/females) with diabetes increases from 4.0/4.6 million in 2000 to 9.9/9.5 million in 2050, with the numbers projected to be equal at 7.8 million in 2030. The number of blacks (male/female) with diabetes increases from 0.8/1.2 million to 3.7/3.8 million from 2000 to 2050. Although whites account for the majority of the projected people with diabetes, the largest percentage increases occur among blacks, with ~4.6 times as many black males with diabetes in 2050 as in 2000. Black females with diabetes are the next fastest growing group, with white males and females following.

Sensitivity analyses

The results are shown in Table 4 for selected years. Assuming constant 1998 prevalence rates, projections based on the low, middle, and high population series are quite similar through 2010, differing by only ~500,000 at the extremes (12.8 million and 13.3 million). At 2025 these projections are more divergent, and by 2050 they differ by ~8 million (17.0–25.0 million). Under the assumption of increasing prevalence rates, the projected numbers are larger, and the differences in the three scenarios are more pronounced, with a spread of ~12 million by 2050 (24.7–36.5 million). Note that in all six projection scenarios, overall prevalences of diabetes increase. It is also interesting to note that with the middle population projections, if we project prevalences to increase to 2010 but remain constant thereafter, there are 22.2 million people predicted to have diabetes in 2050, still more than twice the number in 2000.

CONCLUSIONS — Based on the most likely scenario, we project that in 50 years the number of people with diagnosed diabetes in the U.S. will increase by 165%, from 11 million in 2000 to 29 million in 2050. The biggest percent increases will be among people aged ≥75 years (336%) and among blacks (275%).

The projections we report suffer from several limitations. Of concern is the omission of Hispanic-specific projections. To the extent that Hispanic prevalence rates are overtaking those of whites or blacks, our projections may understate the future burden of diabetes. Also, our projections do not assume advances in diabetes prevention or the possibility of a cure for diabetes in the next 50 years, which may reduce the numbers with diabetes. On the other hand, unforeseen increases in life expectancy or higher propensity for diabetes screening (11) may increase the numbers with diagnosed diabetes. Also, changes in diagnostic criteria (e.g., cut points) could affect prevalences, as well as increased or decreased access to medical care. There is also evidence of increasing prevalence of childhood diabetes (12), which may also increase the future number of people with diabetes. We have assumed a linear increase in diabetes prevalence. However, diabetes prevalences increased by 16% between 1980 and 1994 (1) and 33% between 1990 and 1998 (3). Should the rise in diabetes prevalence rates be nonlinear, our projections may be underestimates. Also, prevalences may rise at rate that is less than linear, and thus our projections may be overestimates. The reported projections seem reasonable if things continue as in the past, with no major changes occurring.

Limitations aside, our projections indicate that previous predictions concerning future diabetes burden in the U.S. are too low. With worldwide changes in lifestyle and demography, this situation concerning future diabetes burden is likely to be true for several countries. Therefore, the estimates of the global burden of diabetes reported by the World Health Organization (8) are likely to be underestimates if the anticipated changes in demographic composition and diabetes prevalence rates (which may capture obesity and lifestyle changes) are accounted for.

Diabetes is already recognized as a public health problem of pandemic proportions (13). Our projection of diabetes burden in the U.S. indicate that the situation may be more alarming than previously believed. Advances in primary prevention (14) may help reduce the number of people with diabetes. However, those who already have the disease deserve better translation of available treatment (15). The economic cost of diabetes is already staggering, and future increases in the number of people with the disease and future advances in technology will likely increase these costs further. Given the reality of finite resources, the optimal management of diabetes will be an increasingly tougher challenge, and something to which we need to respond.

By 2050, there will be an additional 18 million people with diagnosed diabetes in the U.S. alone, and 37% of this increase will be due to changes in the age, sex, and race composition of the population, 27% will be due to population growth, and 36% will be due to changes in prevalence rates. The elderly and minority groups in the U.S., already disproportionately affected by diabetes, will experience the most rapid growth in the number of people with diabetes. These numbers speak for the challenges ahead.

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