Diabetes Trends in the U.S.: 1990–1998

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OBJECTIVE — To examine trends in diabetes prevalence in the U.S.

RESEARCH DESIGN AND METHODS — This study was conducted via telephone surveys in states that participated in the Behavioral Risk Factor Surveillance System between 1990 and 1998. The participants consisted of noninstitutionalized adults aged 18 years or older. The main outcome measure was self-reported diabetes.

RESULTS — The prevalence of diabetes rose from 4.9% in 1990 to 6.5% in 1998—an increase of 33%. Increases were observed in both sexes, all ages, all ethnic groups, all education levels, and nearly all states. Changes in prevalence varied by state. The prevalence of diabetes was highly correlated with the prevalence of obesity ($r = 0.64$, $P < 0.001$).

CONCLUSIONS — The prevalence of diabetes continues to increase rapidly in the U.S. Because the prevalence of obesity is also rising, diabetes will become even more common. Major efforts are needed to alter these trends.

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D iabetes is a major cause of morbidity and mortality in the U.S. (1). The health care costs associated with diabetes in 1997 were an estimated $98 billion (2). Recent studies have reported an increase of diabetes incidence and prevalence in the U.S. (3–6). But the most recent published data on national trends of diabetes prevalence are from the Third National Health and Nutrition Examination Survey (NHANES III) from 1988 to 1994 (5). To evaluate trends to 1998, including changes by state and sociodemographic characteristics, we examined data from a large population-based survey.

RESEARCH DESIGN AND METHODS — The Behavioral Risk Factor Surveillance System (BRFSS) is a standardized telephone survey operated by state health agencies in collaboration with the Centers for Disease Control and Prevention (CDC). The primary purpose of BRFSS is to provide state-specific estimates of behaviors that relate to the leading causes of death in the U.S. In each participating state, an independent probability sample of adult residents aged 18 years or older with telephones is selected (7). Data from all states are pooled to produce national estimates (8). All states use an identical core questionnaire, which was administered over the telephone by trained interviewers. A detailed description of the survey methods is available elsewhere (7,9).

Diabetes status was assessed by asking respondents, "Have you been told by a doctor that you have diabetes?" The answers were coded "yes" or "no" in 1990, 1991, and 1992. In 1993, the interviewers were asked to code gestational diabetes as "no." Starting in 1994, gestational diabetes was coded separately as "yes," "gestational," or "no." For our trend analyses, from 1990 to 1998, we coded gestational diabetes as "yes" between 1994 and 1998 to match the questions in the early years of BRFSS.

We calculated BMI as weight (kilograms) divided by height (meters squared), based on self-reported weight and height. Participants were classified as obese if their BMI was ≥ 30 (10). We used SAS and SUDAAN in all analyses to account for the complex sampling design (11,12).

We excluded the following 8 states from our trend analyses because they did not collect information on diabetes prevalence between 1990 and 1998: Alaska (1990), Arkansas (1990 and 1992), the District of Columbia (1995), Kansas (1990 and 1991), Nevada (1990 and 1991), New Jersey (1990), Rhode Island (1994), and Wyoming (1990, 1991, 1992, and 1993). However, we included the data for all available years for these and all other states in our maps. In 1998, all 50 states and the District of Columbia participated in the BRFSS survey, and a total of 149,806 individuals completed the BRFSS interview.

RESULTS — Compared with 1990, BRFSS participants in 1998 were older, better educated, and more likely to be obese (Table 1). The percentage of Caucasian participants decreased, and the percentages of African-Americans, Hispanics, and other ethnicities increased.

The prevalence of diabetes increased from 4.9% in 1990 to 6.5% in 1998, which, in the latter year, equaled 12 million people in the 43 participating states and 13 million people in all 50 states and the District of Columbia (Table 2). In 1998, the prevalence of diabetes was 5.5% for men and 7.4% for women. However, after we adjusted for age and race, the percentages were higher: 7.8% for men and 9.0% for women. The sex-age-race standardized prevalence of diabetes increased from 4.9% in 1990 to 5.9% in 1998—a 20% increase. Weight also increased in both men and women during this period.

Diabetes prevalence increased from 1990 to 1998 in men and women, across all sociodemographic groups and in nearly all states (Table 3 and Figs. 1–4). Individuals aged 30–39 years and those with higher

Table 1—*Characteristics of participants in the BRFSS: 1990 and 1998*

	1990	1998
Sex		
Male	48.0 (0.28)	48.0 (0.22)
Female	52.0 (0.28)	52.0 (0.22)
Age-groups (years)		
18–29	25.9 (0.27)	22.0 (0.20)
30–39	23.1 (0.24)	21.1 (0.18)
40–49	16.9 (0.21)	19.7 (0.17)
50–59	12.1 (0.19)	14.2 (0.15)
60–69	11.8 (0.19)	11.2 (0.14)
≥70	10.2 (0.16)	11.9 (0.13)
Race		
Caucasian	80.2 (0.29)	75.5 (0.21)
African-American	9.6 (0.19)	9.9 (0.14)
Hispanic	7.6 (0.21)	10.5 (0.17)
Other	2.6 (0.10)	4.1 (0.11)
Education		
Less than high school	18.3 (0.24)	13.7 (0.16)
High school	36.3 (0.28)	32.7 (0.21)
Some college	21.9 (0.24)	27.2 (0.20)
College graduate or more	23.5 (0.25)	26.4 (0.19)
Smoking		
Never	51.3 (0.29)	52.8 (0.22)
Ex-smoker	24.6 (0.25)	24.2 (0.19)
Current	24.1 (0.25)	23.0 (0.19)
Weight category		
Underweight	3.2 (0.10)	2.4 (0.07)
Normal	53.2 (0.29)	43.7 (0.23)
Overweight	32.5 (0.27)	35.9 (0.22)
Obese	11.1 (0.18)	18.0 (0.17)

Data are % (SEM).

education levels had the largest increase. There was a large variation by state in diabetes prevalence and in percentage increase. In 1998, Oklahoma had the highest rate (9.1%), and Arizona had the lowest rate (2.9%). Minnesota and Illinois had the highest percentage increases from 1990 to 1998 (94 and 87%, respectively). In 4 states, the prevalence was lower in 1998 than in 1990, and, in another 4 states, there was no change. In 1998, the rank correlation between the prevalence of diabetes and obesity among the participating states was 0.64 ($P < 0.001$).

To account for the effects of adding gestational diabetes to our trend analyses, we computed the crude diabetes prevalence for both sexes, excluding gestational diabetes, for 1994–1998. The prevalence of nongestational diabetes was 4.4, 4.7, 4.9, 5.3, and 5.7% for these years—an ~26% increase in 4 years compared with ~23% for the same period in our trend analyses.

CONCLUSIONS — From 1990 to 1998, the prevalence of diabetes increased by about one-third in the 43 participating states. This increase was observed across all age-groups, races, educational levels, levels of smoking status, weight levels, and nearly all states. We observed increases of 76% in individuals aged 30–39, increases of 64% in those with "some college," increases of 52% in ex-smokers, and increases of 47% in individuals who had at least a college

Table 2—*Diabetes prevalence and mean weight by year (BRFSS, 1990–1998)*

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Diabetes (%)									
Total	4.9 (0.12)	5.0 (0.12)	5.4 (0.11)	4.7 (0.10)	5.3 (0.11)	5.5 (0.13)	5.4 (0.10)	6.1 (0.11)	6.5 (0.11)
Men	4.1 (0.16)	4.4 (0.17)	4.5 (0.15)	4.5 (0.15)	4.4 (0.16)	4.4 (0.16)	4.6 (0.15)	5.0 (0.15)	5.5 (0.15)
Women	5.6 (0.17)	5.6 (0.16)	6.2 (0.16)	5.0 (0.14)	6.2 (0.15)	6.6 (0.21)	6.2 (0.14)	7.1 (0.15)	7.4 (0.16)
Weight (kg)									
Total	72.6 (0.09)	73.1 (0.09)	73.7 (0.08)	74.1 (0.08)	74.6 (0.09)	75.0 (0.11)	75.3 (0.08)	75.5 (0.08)	76.2 (0.08)
Men	81.0 (0.12)	81.5 (0.12)	82.0 (0.11)	82.4 (0.11)	83.1 (0.12)	83.5 (0.16)	83.5 (0.11)	83.8 (0.11)	84.3 (0.11)
Women	64.6 (0.10)	65.2 (0.10)	65.7 (0.09)	66.1 (0.10)	66.4 (0.10)	66.9 (0.10)	67.4 (0.09)	67.6 (0.09)	68.5 (0.10)
Diabetes (%)									
Total*	4.9 (0.12)	4.9 (0.11)	5.3 (0.11)	4.6 (0.10)	5.3 (0.11)	5.3 (0.12)	5.1 (0.10)	5.6 (0.10)	5.9 (0.10)
Men†	4.1 (0.16)	4.3 (0.16)	4.5 (0.15)	4.4 (0.14)	4.3 (0.15)	4.2 (0.15)	4.3 (0.14)	4.5 (0.13)	5.0 (0.13)
Women†	5.6 (0.17)	5.6 (0.16)	6.1 (0.16)	4.9 (0.13)	6.2 (0.15)	6.4 (0.19)	5.9 (0.13)	6.7 (0.14)	6.9 (0.14)
Weight (kg)									
Total*	72.6 (0.09)	73.1 (0.07)	73.6 (0.07)	74.0 (0.07)	74.5 (0.08)	75.0 (0.09)	75.1 (0.07)	75.4 (0.07)	76.1 (0.0)
Men†	81.0 (0.12)	81.6 (0.11)	82.1 (0.11)	82.5 (0.11)	83.1 (0.12)	83.7 (0.15)	83.6 (0.11)	84.0 (0.11)	84.5 (0.11)
Women†	64.6 (0.10)	65.2 (0.10)	65.8 (0.09)	66.2 (0.09)	66.5 (0.09)	66.9 (0.10)	67.3 (0.09)	67.5 (0.09)	68.3 (0.09)

Data are means for weight, % for diabetes, and (SEM). *Direct standardization to sex, age, and race distribution in 1990; †direct standardization to age and race distribution in 1990.

education. Of the 43 states in our comparison, 35 showed an increase.

While interpreting our findings, the likelihood that the rates are substantial underestimations must be appreciated. First, people without telephones are not included in the BRFSS, and such individuals are likely to be of low socioeconomic status—a factor associated with both obesity (13,14) and diabetes (15). In fact, in the NHANES III, individuals without a telephone were more likely to be obese and diabetic (16). Second, undiagnosed diabetes was not counted. In fact, in surveys in which diabetes was assessed directly by laboratory testing, the prevalence of diagnosed diabetes in 1988–1994 was estimated to be 5.1% for U.S. adults aged 20 years or older, the prevalence of undiagnosed diabetes was 2.7%, and the prevalence of impaired fasting glucose was 6.9% (5).

Both BMI and weight gain are major risk factors for diabetes (15,17). Indeed, BMI is one of the strongest predictors of diabetes, and previous studies have shown that changes in BMI foreshadow changes in diabetes (18–22). At the population level, for every kilogram of increase in measured weight, the risk of diabetes increased by 4.5% in a national sample of adults (22). In our study, for every kilogram increase in self-reported weight, diabetes increased by ~9%. This large difference in added risk imparted by an increase in weight of 1 kg may be explained by the rapid increase in obesity prevalence in the U.S. (23). In brief, the association between the increase in obesity and diabetes prevalence may not be linear.

We should point out that the recent increases in the public's awareness of diabetes might explain some of the increased prevalence we found. The percentage of undiagnosed diabetes was ~50% of total diabetes in the NHANES II (1976–1980) (24) but only 44% in the NHANES III (1988–1994) (5). However, whether the awareness of diabetes has continued to increase during the period covered by our study, especially after 1994, is unknown. Advancements in medical care from 1990 to 1998 may also have affected prevalence, but probably to a lesser extent because other studies have suggested an increase in the incidence of diabetes (3,4,6). The change in the demographics of the U.S. population from 1990 to 1998 was not responsible for the increase in diabetes, because the prevalence of diabetes in 1998 was 5.9% using the sex, age, and race distribution of 1990.

Table 3—*Changes in diabetes prevalence from 1990 to 1998 by selected characteristics and state*

	1990	1998	Difference	% Difference
Sex				
Male	4.1 (0.16)	5.5 (0.15)	1.4	34.2
Female	5.6 (0.17)	7.4 (0.16)	1.8	32.1
Age-groups (years)				
18–29	1.5 (0.15)	1.6 (0.12)	0.1	9.1
30–39	2.1 (0.16)	3.7 (0.18)	1.6	69.9
40–49	3.6 (0.26)	5.1 (0.22)	1.5	39.8
50–59	7.5 (0.44)	9.8 (0.38)	2.3	30.9
60–69	10.9 (0.50)	12.8 (0.45)	1.9	17.1
≥70	11.6 (0.50)	12.7 (0.39)	1.1	10.1
Race				
Caucasian	4.6 (0.12)	5.9 (0.11)	1.3	29.3
African-American	7.0 (0.43)	8.9 (0.39)	1.9	26.1
Hispanic	5.6 (0.58)	7.7 (0.48)	2.1	37.7
Other	3.5 (0.53)	6.6 (0.73)	3.1	87.6
Education levels				
Less than high school	8.8 (0.35)	11.6 (0.41)	2.8	31.5
High school	4.8 (0.19)	6.4 (0.19)	1.6	32.7
Some college	3.6 (0.23)	5.9 (0.20)	2.3	63.2
College graduate or more	3.0 (0.19)	4.4 (0.17)	1.4	47.3
Weight categories				
Underweight	2.5 (0.41)	3.5 (0.63)	1.0	39.7
Normal	3.0 (0.12)	3.5 (0.12)	0.5	16.9
Overweight	5.5 (0.23)	6.6 (0.19)	1.1	19.6
Obese	11.8 (0.53)	13.5 (0.38)	1.7	14.0
Smoking status				
Never	4.8 (0.16)	5.8 (0.14)	1.0	21.8
Ex-smoker	6.1 (0.27)	9.3 (0.27)	3.2	51.9
Current	3.8 (0.20)	5.0 (0.20)	1.2	30.7
State				
Alabama	5.6 (0.54)	7.6 (0.59)	2.0	34.0
Arizona	3.9 (0.57)	2.9 (0.59)	−1.0	−26.2
California	4.1 (0.44)	6.9 (0.47)	2.8	67.4
Colorado	3.1 (0.43)	5.1 (0.54)	2.0	64.6
Connecticut	5.3 (0.61)	5.3 (0.50)	—	—
Delaware	5.9 (0.63)	4.7 (0.46)	−1.2	−19.3
Florida	5.7 (0.54)	7.1 (0.41)	1.4	24.1
Georgia	4.9 (0.54)	6.7 (0.58)	1.8	36.7
Hawaii	5.2 (0.61)	6.4 (0.74)	1.2	23.6
Idaho	3.2 (0.43)	5.0 (0.37)	1.8	56.1
Illinois	4.0 (0.45)	7.5 (0.55)	3.5	87.7
Indiana	5.7 (0.50)	6.5 (0.57)	0.8	14.2
Iowa	4.7 (0.57)	6.1 (0.47)	1.4	28.0
Kentucky	5.7 (0.57)	6.0 (0.41)	0.3	5.8
Louisiana	5.3 (0.92)	7.2 (0.69)	1.9	35.1
Maine	4.7 (0.68)	4.1 (0.49)	−0.6	−12.7
Maryland	4.3 (0.53)	5.8 (0.55)	1.5	35.6
Massachusetts	3.8 (0.62)	4.6 (0.37)	0.8	19.5
Michigan	4.9 (0.48)	8.1 (0.61)	3.2	64.7
Minnesota	3.2 (0.31)	6.2 (0.40)	3.0	96.1
Mississippi	6.9 (0.76)	8.1 (0.66)	1.2	17.2
Missouri	6.4 (0.67)	6.6 (0.51)	0.2	2.9
Montana	2.8 (0.43)	4.1 (0.47)	1.3	48.7
Nebraska	4.6 (0.55)	5.5 (0.45)	0.9	21.3
New Hampshire	4.5 (0.56)	4.5 (0.61)	—	—
New Mexico	5.2 (0.71)	5.8 (0.43)	0.6	11.5
New York	5.2 (0.61)	6.6 (0.59)	1.4	28.1

Table 3—*Continued*

	1990	1998	Difference	% Difference
North Carolina	6.0 (0.58)	7.0 (0.58)	1.0	18.0
North Dakota	3.5 (0.46)	4.7 (0.56)	1.2	34.5
Ohio	4.7 (0.61)	6.7 (0.62)	2.0	42.6
Oklahoma	5.2 (0.65)	9.1 (0.62)	3.9	75.5
Oregon	3.7 (0.35)	5.9 (0.63)	2.2	57.6
Pennsylvania	5.9 (0.53)	6.2 (0.45)	0.3	3.6
South Carolina	6.3 (0.57)	6.2 (0.48)	−0.1	−0.5
South Dakota	3.8 (0.45)	3.8 (0.42)	—	—
Tennessee	5.8 (0.55)	6.6 (0.56)	0.8	13.3
Texas	4.8 (0.61)	6.6 (0.39)	1.8	36.7
Utah	3.7 (0.50)	5.2 (0.53)	1.5	37.7
Vermont	3.4 (0.60)	5.1 (0.42)	1.7	50.6
Virginia	4.3 (0.51)	5.3 (0.55)	1.0	24.9
Washington	4.4 (0.47)	5.6 (0.46)	1.2	28.0
West Virginia	7.5 (0.58)	6.5 (0.55)	−1.0	−13.0
Wisconsin	4.1 (0.63)	4.8 (0.52)	0.7	16.0

Data are % (SEM).

Figure 1—*Prevalence of diabetes among U.S. adults in the BRFSS, 1990.*

Figure 2—*Prevalence of diabetes among U.S. adults in the BRFSS, 1991–1992.*

When an increase of 33% in diabetes in just 8 years is considered with the disturbing reality that the effects of the obesity epidemic have not fully unfolded, an alarming scenario indeed unfolds. Regardless of whether this increase relates partly to an increased awareness of diabetes, it is clear that the need for diabetes care will rise dramatically in the future. By focusing on the challenge that diabetes presents and by increasing awareness of its great potential to result in profoundly detrimental physical conditions, we intend to encourage physicians and health care professionals to become more involved in dealing with this increasing threat to the nation's overall health and well-being.

As we confront the challenge of diabetes, we should consider that since 1990, the prevalence of obesity has also increased
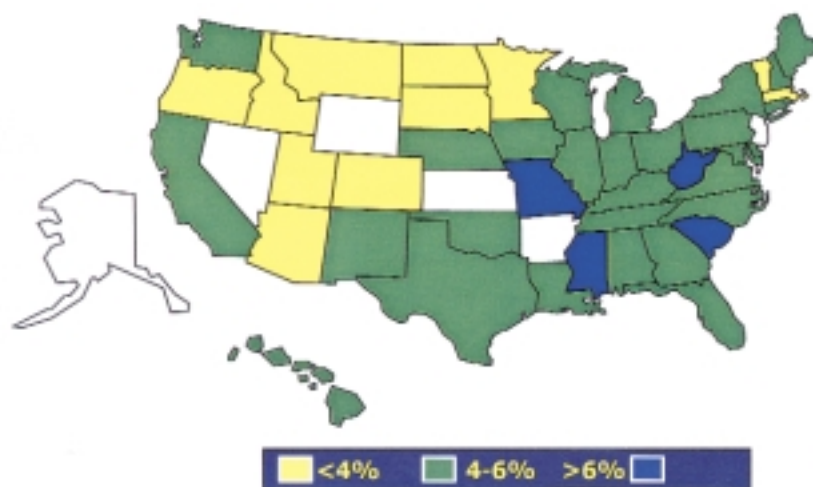
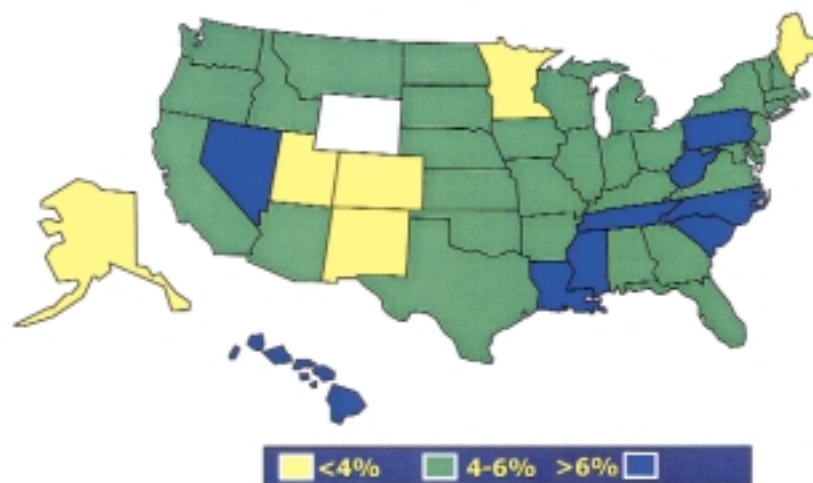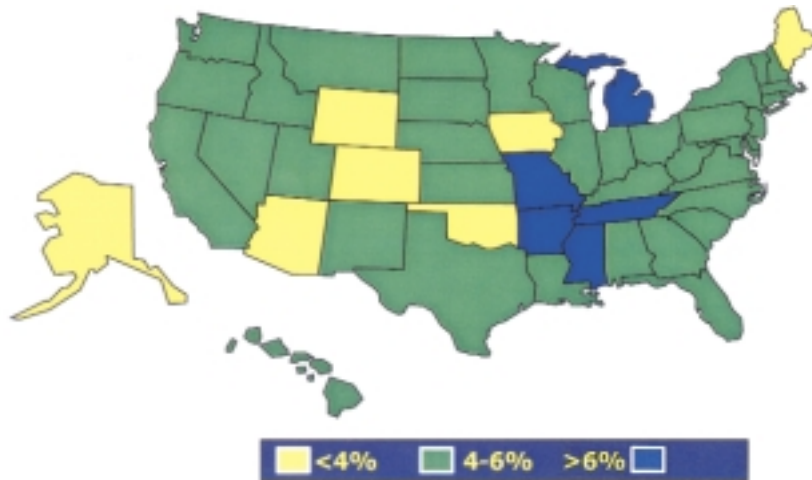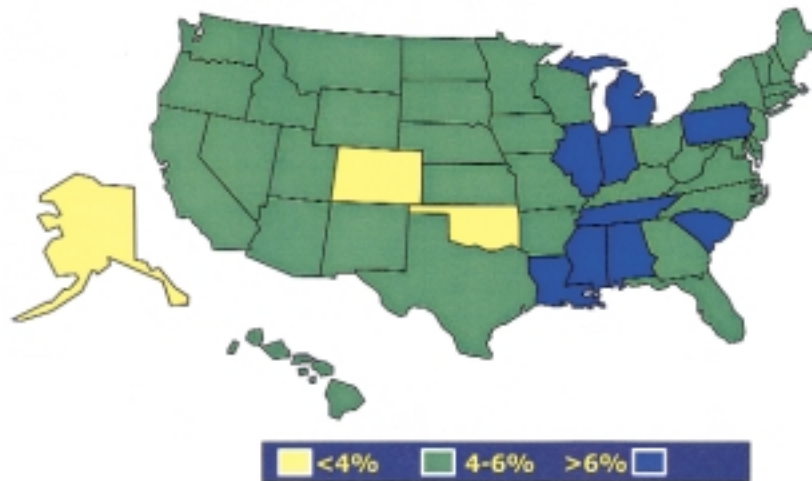**Figure 3**—*Prevalence of diabetes among U.S. adults in the BRFSS, 1993–1994.*

Figure 4—*Prevalence of diabetes among U.S. adults in the BRFSS, 1995–1996.*
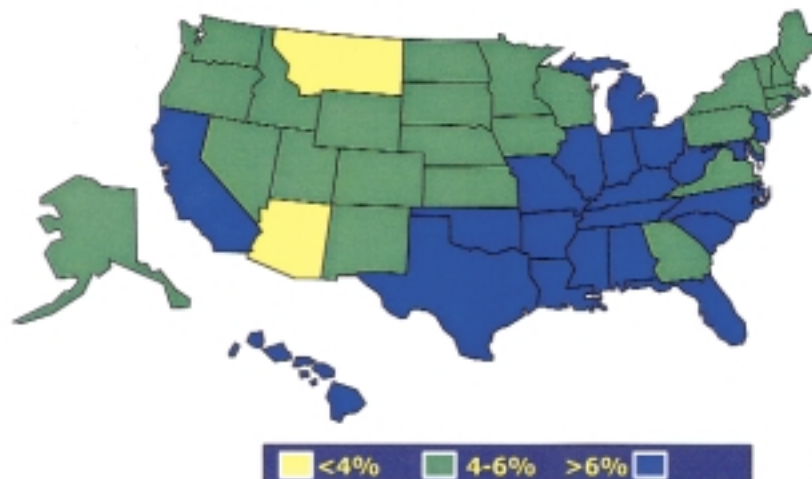

Figure 5—*Prevalence of diabetes among U.S. adults in the BRFSS, 1997–1998.*

rapidly in the U.S. (23). This increase will have a major impact on diabetes and other chronic diseases. For diabetes specifically, much of the impact of the upsurge in obesity may be felt some years from now, because there is a substantial delay between the onset of obesity and the subsequent development of diabetes. Thus, we can expect the prevalence of diabetes to increase in the future. Public health strategies to limit this increase and address its potential impact on health resources are urgently needed.

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