Decreases in Diabetes-Free Life Expectancy in the U.S. and the Role of Obesity

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OBJECTIVE—With increasing life expectancy in the U.S., it is important to know whether a longer life expectancy means a longer healthy life span or a prolonged period of later-life morbidity. This study examines changes in lifetime without diabetes, a leading cause of morbidity in later life.

RESEARCH DESIGN AND METHODS—Using demographic methods and nationally representative data, we estimated changes in diabetes-free life expectancy between 1980–1989 and 2000–2004 for adult men and women in the U.S., estimated the contribution of changes in age-specific diabetes rates, and examined the changing effects of weight status on diabetes risks.

RESULTS—While life expectancy at age 18 for men and women increased between the 1980s and the 2000s, diabetes-free life expectancy at age 18 decreased by 1.7 years for men and 1.5 years for women. The proportion of 18-year-olds who would develop diabetes in their lifetimes increased by almost 50% among women and almost doubled among men. Obese individuals experienced the greatest losses in diabetes-free life expectancy during this period, estimated at 5.6 years for men and 2.5 years for women.

CONCLUSIONS—Diabetes-free life expectancy decreased for both men and women between 1980–1989 and 2000–2004, and these decreases are almost entirely attributable to large increases in diabetes incidence among obese individuals.

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Life expectancy at birth in the U.S. has increased in past decades, reaching a record high of 77.7 years in 2006 (1). An important consideration is whether a longer life means a longer healthy life span or a prolonged period of later-life morbidity. A leading cause of morbidity in later life is diabetes, a disease with high health and financial burdens (2,3). The prevalence of diabetes in the U.S. increased nearly threefold since the 1980s (4), and the lifetime risk of diabetes was estimated at 33% for men and 39% for women in 2000 (5). However, it is unclear whether the proportion of life without diabetes has changed with improvements in life expectancy over the past decades. In addition, obesity, an established risk factor for diabetes (6), affects 32% of adults and 17% of children and adolescents in the U.S. (7). People who are obese spend, on average, more of their lives suffering from diabetes than those who are not obese (8); however, it is not known how the lifetime risk of diabetes has changed as more Americans have become obese.

This study examined changes in diabetes-free life expectancy, indicating the average number of years lived before being diagnosed with diabetes or dying, between 1980–1989 and 2000–2004 for adult men and women in the U.S. Using nationally representative data, we estimated changes in diabetes-free life expectancy and identified the contributions of changes in mortality rates, diabetes incidence, and population aging. We compared the proportions of the population expected to develop diabetes in the two time periods to determine how lifetime risks of diabetes have been changing. Finally, we examined changes in diabetes by BMI group to understand the role of increasing obesity in the population.

RESEARCH DESIGN AND METHODS

—The three data components of the analysis are age- and sex-specific mortality rates, age- and sex-specific population estimates by weight status, and age- and sex-specific diabetes incidence rates. Mortality rates were calculated based on number of deaths by sex and age from the National Vital Statistics System (9). Population estimates, including information on age, sex, height, weight, and diabetes, were drawn from the National Health Interview Survey (NHIS), an ongoing nationally representative cross-sectional survey of the civilian noninstitutionalized population. The NHIS uses multistage probability sampling to select respondents and collects self-reported health information, with marginal response rates of ∼70% for the adult sample interviews (10). Population estimates and number of diabetes cases were classified by age (10-year intervals), sex, and BMI levels (normal/underweight, <25 kg/m^2; overweight, 25 to <30 kg/m^2; and obese, ≥30 kg/m^2). Incident cases of diabetes were identified based on reported age at diagnosis of diabetes—that is, being told by a doctor or health care professional that they had diabetes—and age at time of interview. Diabetes incidence rates were derived by dividing the estimated number of people in a given age-sex group reporting that they were diagnosed during the year before the survey by the total population in each age-sex group. This method has been described

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elsewhere (11). Individuals diagnosed with diabetes >1 year before were no longer at risk for developing diabetes and so were not included in the numerator or denominator for rates. Analyses included 143,765 adults in 1980–1989 and 150,718 adults in 2000–2004, of whom 507 and 1,366, respectively, reported being diagnosed in the previous year.

We estimated the number of years an individual can expect to live without diabetes given their age, sex, and BMI status while also accounting for mortality risks using multiple-decrement life table techniques (12,13). Diabetes-free life expectancy must be lower than total life expectancy, as an individual faces the competing risk of diabetes and death, both of which end diabetes-free life. To determine the contribution of each age and BMI group to changes in total diabetes-free life expectancy between 1980–1989 and 2000–2004, we used a discrete-time decomposition method by Arriaga (14). The method calculates the total effect of a change in life expectancy above age x between two points in time as the sum of the direct effect of a change in rates above age x and the sum of the change in life expectancies contributed by the additional person-years lived above age x as a result of the improvements in rates between the two periods. An extension of the method allows us to decompose changes in life expectancy by type of decrement, with the decrements in this analysis being diabetes incidence and death. The contribution of each of these two types of decrements to the total decrement at each age is calculated from the proportion of the differences in total decrements it represents between two points in time. Thus, the difference in diabetes-free life expectancy at a given age between two periods is the result of differences in diabetes incidence and mortality rates above that age (14,15).

In addition to examining the competing risks of diabetes and all-cause mortality in the entire population, we also performed these calculations for each BMI group separately. This allowed for a better understanding of the effects of secular changes in weight on diabetes incidence overall and among people of different weights, showing the number of years that a person in each BMI category can expect to live without diabetes. Using similar life table techniques (12,13), we also estimated the proportion of the population that will eventually be diagnosed with diabetes given their weight status and the current diabetes and mortality rates in the U.S.

Because data on age at diagnosis were not available for people younger than age 18 and older than age 79 in some NHIS waves, analyses were restricted to ages 18 to 79 years. This approach implies that incidence rates at younger ages are negligible or that the calculations are conditional on not having been diagnosed before age 18. It also assumes that diabetes incidence at ages older than 80 years is negligible. The results are robust to changes in these assumptions.

The calculations assume that mortality rates do not differ by weight or diabetes status. We tested this assumption by reallocating in our estimates observed mortality according to risk ratios by BMI group reported in the literature (16,17,18). We also allowed the risk ratios of nondiabetes mortality to vary. We tested the possibility that changes in diagnosis detection rather than incidence are driving the results. The results are robust to each of these sensitivity tests (Supplementary Table 1). The BMI-specific calculations do not model the transition of individuals between BMI categories. To relax this assumption, we estimated diabetes-free life expectancy for each BMI group at ages 18, 40, and 60 years, which shows how the changing weight composition of the population at each age may affect diabetes-free life expectancy in BMI groups.

RESULTS

Diabetes-free life expectancy

On the basis of NHIS data and vital statistics, we calculated that life expectancy at birth in the U.S. in 1980–1989 was 70.6 years for men and 77.4 years for women, and it had increased to 74.3 years for men and 79.0 years for women by 2000–2004. Remaining life expectancy at age 18 also increased by 3.1 years for men and 1.1 years for women (Supplementary Table 1). In contrast, diabetes-free life expectancy at age 18 decreased by 1.4 years among men (from 50.2 to 48.8 years) and 1.7 years among women (from 54.2 to 52.5 years) (Table 1 and Supplementary Fig. 1). These reductions in diabetes-free life expectancy in the context of otherwise increasing life expectancy in the U.S. indicate declines in the proportion of the lifetime spent without diabetes. The proportion of the lifetime spent without diabetes fell from 0.93 to 0.85 for men and from 0.90 to 0.85 for

Table 1—*Years of diabetes-free life expectancy by age and BMI levels, 1980–1989 vs. 2000–2004, U.S.*

	1980–1989		2000–2004		Interperiod change	
Age	Men	Women	Men	Women	Men	Women
18						
All BMI	50.2	54.2	48.8	52.5	−1.4	−1.7
Normal/underweight	51.6	57.3	53.5	59.0	1.9	1.7
Overweight	50.4	52.2	51.4	54.9	1.0	2.7
Obese	45.4	42.4	39.8	39.9	−5.6	−2.5
Years difference between normal/ underweight and obese	6.2	14.9	13.7	19.1	7.5	4.2
40						
All BMI	30.7	35.1	30.0	33.3	−0.7	−1.7
Normal/underweight	32.0	37.3	33.8	38.2	1.8	0.9
Overweight	30.9	33.7	31.8	34.7	0.9	1.0
Obese	26.6	29.3	23.8	25.3	−2.7	−4.0
Years difference between normal/ underweight and obese	5.4	8.0	10.0	12.9	4.6	4.9
60						
All BMI	16.5	19.7	17.2	19.5	0.7	−0.2
Normal/underweight	16.9	20.7	18.8	21.4	1.9	0.7
Overweight	16.5	19.0	17.6	19.7	1.1	0.7
Obese	15.6	17.7	14.6	16.3	−1.0	−1.4
Years difference between normal/ underweight and obese	1.3	3.0	4.3	5.1	2.9	2.1

Data are from National Vital Statistics System of the National Center for Health Statistics, Centers for Disease Control and Prevention, and single-year data are from the NHIS.

women between 1980–1989 and 2000–2004.

The role of diabetes incidence in these reductions in diabetes-free life expectancy can be better appreciated by standardizing mortality levels: if mortality rates had remained the same between 1980–1989 and 2000–2004 instead of improving by 2.4 years for men and 0.8 years for women, diabetes-free life expectancy would have fallen even more—by 3.8 years for men and 2.5 years for women (not shown). In fact, mortality rates decreased, so reductions in diabetes-free life expectancy result solely from increases in diabetes incidence or diagnoses rather than from increases in mortality.

While overall diabetes-free life expectancy decreased between the 1980s and the 2000s, there are substantial differences between BMI groups. Diabetes-free life expectancy at age 18 among normal/underweight individuals increased from 51.6 to 53.5 for men and from 57.3 to 59.0 for women, as shown in Table 1. The diabetes-free life expectancy of overweight individuals was slightly lower than those of normal/underweight individuals at both time periods. However, the diabetes-free life expectancy of overweight individuals also increased, from 50.4 to 51.4 for men and from 52.2 to 54.9 for women. Obese individuals had by far the lowest expected diabetes-free lifetimes in both time periods. Furthermore, this was the only group to experience decreases in diabetes-free life expectancy between the 1980s and the 2000s, and these decreases were large: 5.6 years for men and 2.5 years for women. Thus, all of the observed reductions in diabetes-free life expectancy at the population level were actually due to increases in diabetes only among obese individuals, a situation that also holds for diabetes-free life expectancy at ages 40 and 60. In fact, when we decomposed the contributions of each BMI group to changes in the U.S. population overall, we found that improvements in the other weight groups countered these reductions in diabetes-free life expectancy without completely offsetting them.

Obese individuals experienced relative as well as absolute increase in diabetes risks. In 2000–2004, obese 18-year-old men and women could expect to live 13.7 and 19.1 fewer years without diabetes than normal and underweight 18-year-old men and women, respectively. These numbers represent increases in the difference in diabetes-free life expectancy between obese and normal/underweight individuals of 7.5 years for men and 4.2 years for women compared with the 1980s.

Our decomposition of the contribution of each age group to changes in diabetes-free life expectancy shows that losses in years of life without diabetes occurred generally at younger ages for men than for women (Fig. 1). Normal and underweight women saw improvements at all ages, with the greatest improvements at ages 18 to 39; overweight women also experienced improvements at most ages. On the other hand, obese women saw reductions in diabetes-free life expectancy at all ages >30. For men, the gains in diabetes-free life expectancy among normal/underweight and overweight men were less even, with some losses in the 3rd decade of life. Obese men in all age groups experienced decreases in diabetes-free life expectancy, with the greatest losses among men younger than age 50.

Lifetime risk of diabetes

The proportion of 18-year-olds who would develop diabetes increased greatly between 1980–1989 and 2000–2004 (Fig. 2). In the 1980s, 23.3% of 18-year-old women and

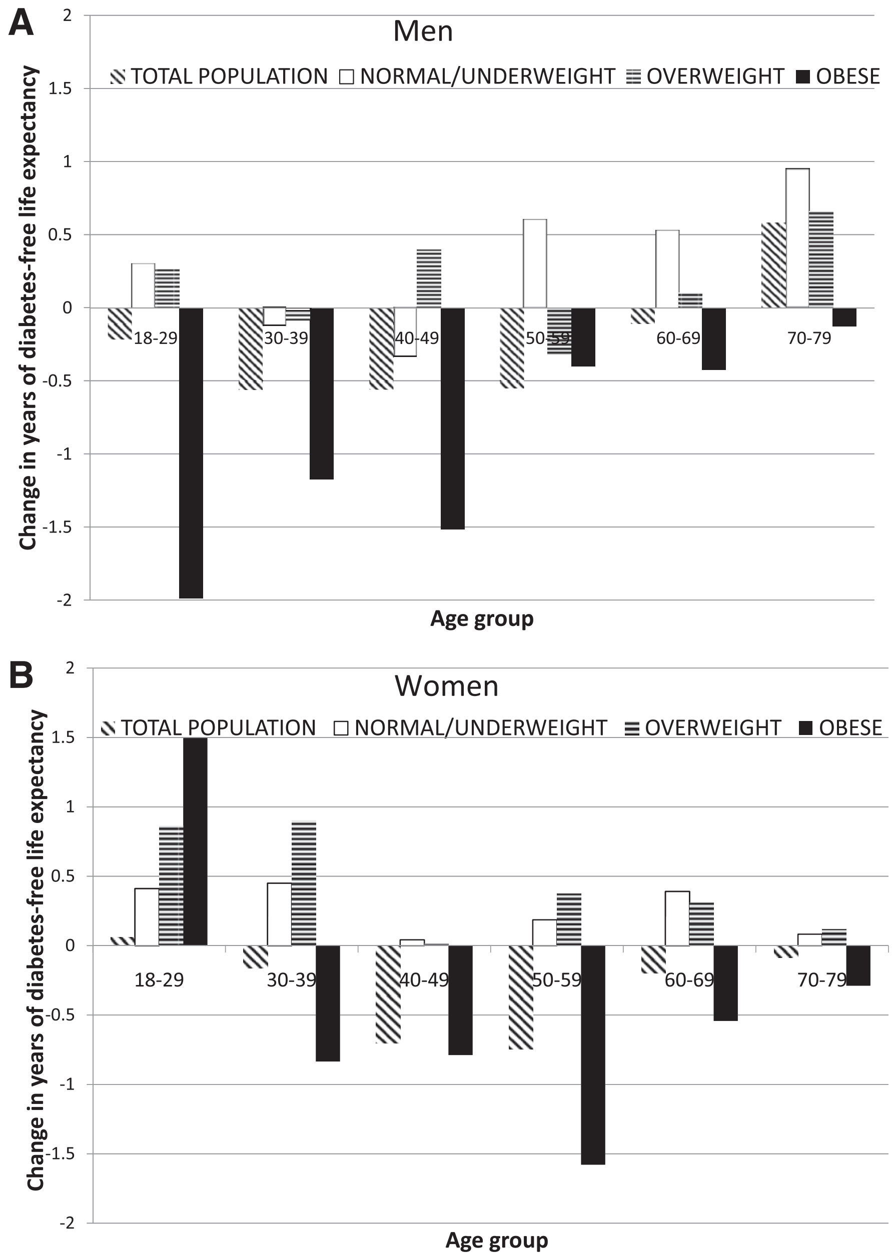

Figure 1—*Contribution of age groups to changes in diabetes-free life expectancy between 1980–1989 and 2000–2004 in the U.S.*

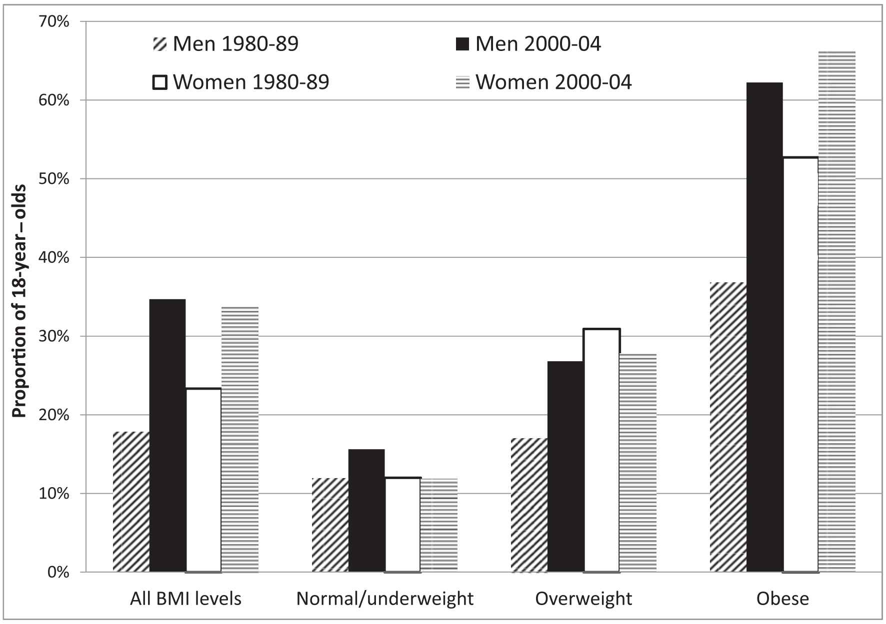

Figure 2—*Proportion of 18-year-olds in the U.S. who will develop diabetes, by sex, BMI, and period.*

17.8% of 18-year-old men would eventually have diabetes given the current mortality and diabetes incidence rates. In the 2000s, this proportion had increased to just over one-third of the population, specifically 33.8% of women and 34.7% of men, suggesting closing gender gaps in diabetes incidence.

Normal/underweight, overweight, and obese individuals experienced different changes in lifetime risk of diabetes. For women, in the 1980s, 12, 31, and 53% of normal/underweight, overweight, and obese 18-year-olds, respectively, could expect to be diagnosed with diabetes. By 2000–2004, these risks did not change for normal/underweight and overweight women but did increase for obese women to 66%. During the 1980s, normal/underweight men had similar risks of developing diabetes in their lifetimes to those faced by women (12%). However, heavier men were at considerably lower risk than women: 17% for overweight and 37% for obese. By the 2000s, the proportion of men who would develop diabetes in their lifetime increased for all weight groups to 16, 27, and 63% for normal/underweight, overweight, and obese men, respectively. These represent increases in lifetime risk of diabetes of 60–80%.

Sensitivity analyses

The calculations above assume that there were no differences in mortality by diabetes or weight status. In robustness check, we incorporated risk ratios from the literature into our estimates. Allowing for differential mortality between BMI groups and by diabetes status does not change the finding that diabetes-free life expectancy decreased and that this decrease resulted from increasing diabetes incidence among obese individuals (Supplementary Table 1 and Supplementary Fig. 1).

It could be that fewer obese individuals with diabetes were undiagnosed in the 2000s than in the 1980s, meaning that diabetes incidence would appear to be higher even if there were no change in incidence. Previous research has shown that the proportion of diagnosed cases has increased significantly only for those with BMIs >35 (19). We reestimated our calculations, inflating diabetes incidence to include possibly undiagnosed cases. The resulting diabetes-free life expectancy at age 18 is 3 years lower than implied by diagnosed incidence rates, falling in the 2000s to 46.0 years for men and 49.4 years for women. Accounting for changes in undiagnosed diabetes does not fully explain the decreases in incidence among normal/underweight and overweight men and women (with the possible exception of overweight men), nor does it explain the increases in diabetes incidence among the obese population. Thus, even if diabetes detection has improved disproportionately in obese patients, obese individuals still bear the burden of decreases in diabetes-free life expectancy that occurred during the past 20 years.

CONCLUSIONS—In this study, we used demographic techniques and large national datasets to examine changes in diabetes-free life expectancy between 1980–1989 and 2000–2004 for adult men and women in the U.S. and to examine the changing role of body mass for diabetes risks. These methods offer the advantage of allowing us to examine the changing incidence of diabetes while holding the improvements in mortality during the period constant. They also allow us to estimate the contributions of changing diabetes incidence rates for different levels of body weight to overall diabetes-free life expectancy, which makes it possible to better understand the observed changes in overall diabetes risks and the differing risks in the population.

We found that the proportion of 18-year-olds who would develop diabetes in their lifetimes increased by almost 50% among women and almost doubled among men between the 1980s and the 2000s. While life expectancy for men and women in the U.S. increased, diabetes-free life expectancy at age 18 decreased by 1.7 years for women and 1.4 years for men, indicating declines in the proportion of the lifetime spent without diabetes. This pattern points to the emergence of a prolonged period of morbidity rather than longer healthy life spans, but only among obese individuals. Obese individuals experienced the greatest losses in diabetes-free life expectancy. In 2000–2004, obese 18-year-old men and women could expect to live 13.7 and 19.1 fewer years without diabetes, respectively, compared with normal/underweight 18-year-old men and women. Increases in diabetes incidence among obese people led to reductions in diabetes-free life expectancy so large that the overall diabetes-free life expectancy of the adult U.S. population decreased in spite of improvements in diabetes-free life expectancy among nonobese individuals, who represent the majority of the population.

In the main models, we standardized mortality across BMI groups to isolate the effect of changes in diabetes incidence. The approach allowed us to determine that changes in diabetes incidence rather than mortality were responsible for the decrease in diabetes-free life expectancy. It also allowed us to identify the ages at which the greatest changes in diabetes incidence occurred. Sensitivity analyses show that our results are robust to adjusting mortality rates by diabetes and weight status to the rate ratios reported in the literature.

Since our estimates did not directly model transitions between BMI groups, we have not shown the effect of gaining or losing weight on the expected life span without diabetes, as was also the case for previous studies (20). The measures yield cumulative estimates of diabetes-free life expectancy for people starting at a given BMI level at age 18. Because the BMI composition of cohorts tends to change over time, with people gaining weight as they age, we also relaxed this assumption to account for weight increases by estimating diabetes-free life expectancy for each BMI group at age 40 and 60. Shifts in the BMI composition of the population likely have reinforced changes in diabetes risks within BMI categories; that is, as the proportion of the population who is obese has increased, higher incidence rates of diabetes seen among heavier individuals affect a larger proportion of the population, leading to increases in diabetes cases.

There are several possible explanations for our finding that the decreases in diabetes-free life expectancy have been borne almost exclusively by the obese population. One explanation is that rates of diabetes detection have changed, specifically among obese individuals. Robustness checks indicate that changes in undiagnosed diabetes in obese patients relative to others explain part but not all of the reductions in diabetes-free life experienced by this group. Another reason may be changes in weight distributions within BMI groups, because our analyses indicate that weight increases were greatest among obese men and women: the average obese American was >3.4% heavier in the 2000s than in the 1980s. Since diabetes risk increases with BMI (2,3), that the average obese person was heavier in the 2000s explains some of the increases in diabetes risk. Another consideration could be changes in the racial composition within each BMI category, since previous studies showed that the prevalence of diabetes has increased more among non-Hispanic blacks and Hispanics relative to non-Hispanic whites in the normal and overweight categories but less in the obese category (21). NHIS data show that the change in racial composition of BMI groups was lowest among obese individuals, leading to a relatively higher proportion of whites in the obese category. Thus, the racial distribution in the BMI categories is not likely to explain the observed trends. Another possible explanation is that diabetes risks are higher with younger age of obesity onset; indeed, the prevalence of obesity has tripled among children since the 1970s (22). Our estimates are not conditional on BMI level before the age to which they pertain, so earlier onset of obesity could explain some of the increases in diabetes risk for obese individuals.

A limitation of this study is our reliance on self-reported data on diabetes diagnosis, weight, and height, which have been shown to be biased (23) and may be systematically different by sex, ethnicity, and age (24). Our sensitivity analyses accounted in part for misreporting of diabetes status. In addition, NHIS data are collected via rigorous in-person interviews, and the differences in reported and measured BMI are not large and do not affect health risk estimates, including those associated with diabetes (24). Furthermore, in spite of this limitation, the NHIS is the only dataset with sufficient sample size to conduct this analysis.

Since 34% of the U.S. adult population is obese (25), these findings entail that more than one-third of Americans can expect to develop diabetes, even if they reached adulthood without diabetes; this proportion stands at approximately two-thirds of obese men and women. These estimates suggest a large future increase in the prevalence of diabetes and its complications, especially among obese individuals. Our results suggest that in the face of budgetary or logistic constraints, new efforts to prevent diabetes can have the greatest impact among obese individuals, because those who are not obese generally have experienced decreases in risks during the past 2 decades with current prevention efforts.

This study highlights the growing prevalence of diabetes, implying greater future health care demand at younger ages and for longer life spans. This will necessitate medical and public health professionals with training in diabetes management and facilities well equipped for the management of diabetes and treatment of comorbidities among obese individuals. The many dimensions of changing population and individual health must be well understood and tracked with methods such as those demonstrated in this study to improve health care planning and health.

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S.A.C. developed research, analyzed data, and wrote the manuscript. F.R. analyzed data and wrote the manuscript. J.W. researched and prepared data, contributed to discussion, and edited the manuscript. J.P.B. and D.B.R. contributed to discussion and reviewed the manuscript. L.S.G. contributed to discussion and reviewed and edited the manuscript.

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