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Secular Changes in Prediabetes Indicators Among Older-Adult Americans, 1999–2010

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Abstract

Background—Sex-specific prediabetes estimates are not available for older-adult Americans.

Purpose—To estimate prediabetes prevalence, using nationally representative data, in civilian, non-institutionalized, older U.S. adults.

Methods—Data from 7,995 participants aged ≥50 years from the 1999–2010 National Health and Nutrition Examination Surveys were analyzed in 2013. Prediabetes was defined as hemoglobin A1c=5.7%–6.4% (39–47 mmol/mol [HbA1c5.7]), fasting plasma glucose of 100–125 mg/dL (impaired fasting glucose [IFG]), or both. Crude and age-adjusted prevalences for prediabetes, HbA1c5.7, and IFG by sex and three age groups were calculated, with additional adjustment for sex, age, race/ethnicity, poverty status, education, living alone, and BMI.

Results—From 1999 to 2005 and 2006 to 2010, prediabetes increased for adults aged 50–64 years (38.5% [95% CI=35.3, 41.8] to 45.9% [42.3, 49.5], p=0.003) and 65–74 years (41.3% [37.2, 45.5] to 47.9% [44.5, 51.3]; p=0.016), but not significantly for adults aged ≥75 years (45.1% [95% CI=41.1, 49.1] to 48.9% [95% CI=45.2, 52.6]; p>0.05). Prediabetes increased significantly for women in the two youngest age groups, and HbA1c5.7 for both sexes (except men aged ≥75 years), but IFG remained stable for both sexes. Men had higher prevalences than women for prediabetes and IFG among adults aged 50–64 years, and for IFG among adults aged ≥75 years. Across demographic subgroups, adjusted prevalence gains for both sexes were similar and most pronounced for HbA1c5.7, virtually absent for IFG, but greater for women than men for prediabetes.

Conclusions—Given the large, growing prediabetes prevalence and its anticipated burden, older adults, especially women, are likely intervention targets.

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Introduction

Prediabetes coexists with syndromes involving functional limitations,[1] may lead to stroke,[2] and increases the odds of developing type 2 diabetes, which has many associated complications.[3,4] Diabetes alone is highly prevalent worldwide and is projected to grow by 55%, from 381.8 million in 2013 to 591.9 million in 2035.[5] Older adults aged ≥60 years contribute about 52% to diabetes-attributable mortality worldwide, approaching 63% in North America and the Caribbean.[5] In the U.S. alone, older adults aged ≥60 years accounted for 86% of all annual diabetes deaths in 2007.[6] Diabetes complications afflict older-adult Americans and include diabetic retinopathy[8] and hospitalizations for conditions like nontraumatic lower-extremity amputation,[9] end-stage renal disease,[10] and diabetic ketoacidosis.[11] Diabetes complications often increase with age. For example, in 2010, for diabetic patients aged 64–74 years and ≥75 years, respectively, the numbers (and percentages) of all hospital discharges for diseases of the circulatory system as first-listed diagnoses were 322,000 (25.8%) and 463,000 (30.3%).[12,13] Similar increases exist for hospitalizations for lower-extremity conditions[4] and self-reported mobility limitation.[15] The associated costs of medical care for older adults with diabetes are immense. In 2012 in the U.S., $104 billion, or roughly 59%, of the $176 billion spent on total direct healthcare costs was among diabetic adults aged ≥65 years.[16] Importantly, 57%, or ≥$59 billion, went to institutional care-primarily nursing homes, where women account for 66% of all costs, and also hospice care.[16]

For these reasons, knowing the prevalence of prediabetes is important. In 2012, an estimated 86 million Americans were at high risk for diabetes assessed by fasting plasma glucose (FPG) or hemoglobin A1c (HbA1c) tests.[17] Bullard and colleagues[18] recently estimated that, during 2007–2010, about 48% of U.S. adults aged ≥65 years had prediabetes. These authors did not offer estimates by sex, greater age disaggregation, or demographic characteristics, which frequently are included for diabetes-related indicators in national surveillance systems.[7] Having refined prediabetes estimates should assist programs, such as the U.S. National Diabetes Prevention Program, which will likely target this rapidly growing age group.[19] Offering prediabetes estimates according to socioeconomic and social circumstances may potentiate a more effective physician—patient encounter.[20,21] Partitioning prediabetes data by age and sex may help illuminate the noted growth in prediabetes among those with normal BMI.[18] As such, prediabetes data were analyzed using the National Health and Nutrition Examination Survey (NHANES) for older adults aged 50–64 years, 65–74 years, and ≥75 years, with the first group serving to anticipate the growth of the older-adult population as they reach age 65 years.

Methods

Data Source and Population

Methods were previously explained in detail for a similar analysis of prediabetes using the 1999–2010 NHANES for participants aged ≥12 years.[18] The NHANES are repeated, cross-sectional surveys representative of the civilian, noninstitutionalized U.S. population, conducted by the National Center for Health Statistics (NCHS),[22–24] which uses a stratified, multistage design and independent, 2-year survey cycles. Response rates were similar across six cycles from 1999 through 2010, ranging from 75% to 80%.[22] The NCHS IRB approved the survey protocol.

After completing a household interview, NHANES participants undertook a physical examination and other interviews at a mobile examination center. The final analytic sample included 7,995 participants (3,951 men and 4,044 nonpregnant women) from the morning mobile examination center session who had fasted 8–23.9 hours, had complete data for HbA1c and FPG, and offered self-report of diagnosed diabetes.

Measures

HbA1c assays were completed with high-performance liquid chromatography using certified instruments[22] and incorporating the reference method used for the Diabetes Control and Complications Trial. During 1999–2010, three modifications influenced NHANES HbA1c measurement methods: two instrument changes, a laboratory site change, and a high-performance liquid chromatography method change described elsewhere.[18] NCHS recommended no corrections for HbA1c data.[26]

A hexokinase enzymatic method[27,28] was used for FPG measurements having two instrument changes. To ensure comparability to earlier years, NCHS recommended using Deming regression equations[27,28] as follows: 1999–2004 (FPG × 0.9835) and 2005–2010 (0.9835 × FPG − 1.139).

Data were aggregated to produce reliable estimates for two 6-year periods (1999–2004 and 2005–2010). Prediabetes was defined as havingHbA1c=5.7%–6.4% (39–47.9 mmol/mol [HbA1c5.7]), FPG of 100.0–125.9 mg/dL (impaired fasting glucose [IFG]), or both. Participants with values of HbA1c or FPG beyond these respective upper limits, or those with self-reported diagnosed diabetes, were classified as having diabetes (*n*=3,197; 2,764 diagnosed, 433 undiagnosed). Standardized weight and height measurements yielded three BMI (weight [kg]/height [m]^2) categories of normal (and under-) weight (<25.0), overweight (25.0–29.9), and obese (≥30). Standard data for age (years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other race/ethnicity), poverty-to-income ratio (PIR; <1.0, 1–2.9, ≥3.0), education (less than high school, high school graduate, some college or higher), and living alone (no/yes) were used. All variables were used previously,[18] except living alone, which may increase the risk of diabetes.[29]

Statistical Analysis

All analyses were conducted in 2013. As previously done,[18] missing data for PIR (*n*=755), BMI (*n*=254), and education (*n*=20) were imputed using the PROC MI procedure in SAS, version 9.2. All dependent, independent, and design variables were included in each imputation model.

Participants with diabetes were included in the denominator to estimate prevalences of prediabetes, HbA1c5.7, and IFG for 1999–2004 and 2005–2010.

For comparison to prior work,[18] computed age-adjusted estimates using the direct method were standardized to the 2000 U.S. Census population based on three age groups: 50–64 years, 65–74 years, and ≥75 years. Age-adjusted prevalences for the two periods were compared with a *t*-test. Multivariable logistic regression was used to calculate and evaluate adjusted prevalences (predictive margins), independent of major risk factors for prediabetes, by controlling for age, sex, race/ethnicity, PIR, education, living alone, BMI, and survey period for the U.S. population aged ≥50 years, those aged ≥65 years, and for selected subgroups.

First-order interactions of survey period with each sociodemographic variable and BMI were tested using Satterthwaite-adjusted *F* statistics.[30] A dichotomous variable represented each period (eg., 1=1999–2004, 2=2005–2010). Appropriate sampling weights were used by ensuring that their summation was equivalent to the total U.S. popuation,[31] to account for the NHANES complex sampling design and nonresponse Multiple comparisons were not accounted for owing to the descriptive nature of the study.[32] Values of $p < 0.05$ were considered statistically significant; however, given the large number of comparisons and the descriptive nature of the study, the significance should be interpreted together with the magnitude of the difference.

All analyses were performed using SAS-callable SUDAAN, version 10.0.1.

Results

For both men and women aged ≥50 years, there were no significant changes in the distributions of age, racial/ethnic, and income groups (Table 1). The proportion of men living alone, however, increased significantly by 4.3 percentage points (ppts; p<0.01). Among women, the BMI distribution changed significantly (p<0.05); however, only the proportion classified as being obese increased significantly by 5.0 ppts (p=0.012).

During the 12-year span, the proportions of older adults with normal glycemic status decreased significantly for those aged 50–64 years, 65–74 years, and ≥75 years, respectively by: −8.4 ppts (from 45.7% [95% CI=42.1, 49.4] to 37.3% [95% CI=34.5, 40.3]), −8.5 ppts (from 32.6% [95% CI=28.7, 36.9] to 24.1% [95% CI=20.8, 27.8]), and −8.8 ppts (from 33.6% [95% CI=29.6, 37.8] to 24.8% [95% CI=21.8, 28.2]) (p< 0.001 for each comparison, data not shown). Focusing only on 2005–2010 proportions, normoglycemia decreased significantly as age increased from 50–64 years to 65–74 years (13.2 ppts; p< 0.001) and to age ≥75 years (12.5 ppts; p< 0.001). However, there was no significant change in normoglycemia between those aged 65–74 years and ≥75 years (p>0.05).

Table 2 provides prevalences for diagnosed and undiagnosed diabetes and prediabetes, which, when totaled, reflect all dysglycemia. By 2005–2010, dysglycemia prevalence ranged from 55.6% for women aged 50–64 years to 78.1% for men aged ≥75 years. Notably, there was a sex disparity in dysglycemia that decreased with age from 14.9 ppts for ages 50–64 years (70.4% vs 55.6% for men and women, respectively) to roughly 5 ppts for ages 65–74 years (77.9% vs 74.2%), and ≥75 years (78.1% vs 73.2%).

For adults aged ≥50 years, the age-adjusted prevalence of prediabetes increased significantly over time by 6.4 ppts from 40.6% (95% CI=37.8, 42.9; crude: 40.3% [95% CI=37.8, 42.9]) to 47.0% (95% CI=45.0, 49.1; crude: 46.9% [95% CI=44.7, 49.1] (p< 0.001). By sex, the age-adjusted prevalences of prediabetes for men did not change significantly from 46.5% (95% CI= 43.1, 50.0; crude: 46.3% [95% CI=42.7, 50.0]) to 50.1% (95% CI=46.9, 53.2; crude: 50.5% [95% CI=46.9, 53.4]). However, for women, the age-adjusted prevalence increased significantly by 8.7 ppts from 35.6% (95% CI=32.8, 38.5; crude: 35.3% [95% CI=32.5, 38.2]) to 44.3% (95% CI=41.6, 47.0; crude: 44.1% [95% CI=41.4, 46.9]) (p<0.001).

Age-specific prevalences of prediabetes for men and women combined increased significantly as follows for adults aged: 50–64 years, by 7.4 ppts (from 38.5% [95% CI=35.3, 41.8] to 45.9% [95% CI=42.3, 49.5]; p=0.003); 65–74 years, by 6.6 ppts (from 41.3% [95% CI=37.2, 45.5] to 47.9% [95% CI=44.5, 51.3]; p=0.016); but not for ≥75 years (from 45.1% [95% CI=41.1,49.1] to 48.9% [95% CI=45.2, 52.6]; p>0.05).

Table 3 presents sex-specific changes in multivariate-adjusted prevalences of prediabetes status. For adults aged 65–74 years and ≥75 years, there were no significant changes in prevalence for prediabetes or for IFG, except for women aged 65–74 years, among whom prediabetes increased 9.5 ppts, from 38.5% to 48% (p=0.014). The absence of significant increases for prediabetes occurred despite significant increases in HbA1c5.7. Specifically, HbA1c5.7 increased significantly (p<0.05) for all sex–age groups, except men aged ≥75 years, and were large (e.g., roughly 10–15 ppts) in magnitude.

For the five other characteristics in Table 3, prediabetes prevalence among men remained stable over time. However, women manifested significant increases for non-Hispanic white (p=0.004); the middle PIR group (p=0.044); less than high school education (p< 0.001) and some college or higher (p<0.05); living alone (p=0.009); and those having normal weight (p=0.005). Conversely, for IFG, non-Hispanic black women showed decreased prevalence (p=0.03), with no other significant changes for women or men across all other characteristics. Men showed significant increases in HbA1c5.7 for non-Hispanic white (p=0.012); the highest PIR group (p< 0.001); those with some college education or higher (p=0.04); both living-alone categories (p=0.03 for each); and those who were overweight (p=0.04). Women manifested increases for the same characteristics as men, but additionally for the lowest PIR group (p=0.003); the middle PIR group (p=0.002); those with less than high school education (p=0.03); and those of normal weight (p< 0.001).

Among adults aged 50–64 years, prediabetes prevalence was significantly greater among men than women by 15.3 ppts (46.6% vs 31.3%; p=0.04) in the first time period and 10.2 ppts (p=0.003) in the second time period (Table 2). A similar pattern was found for IFG for adults aged 50–64 years (p<0.001 for each), ≥75 years (p=0.028 for 1999–2004, and p=0.003 for 2005–2010). Table 3 provides the multivariate-adjusted prevalence of IFG in the first time period, which was higher for men than for women: at age ≥75 years (p=0.041); among non-Hispanic whites (6.8 ppts, p=0.04); the highest PIR group (p=0.02); in those with less than high school education (9.8 ppts, p=0.048); and in those with normal weight (p=0.01). Except for those with less than high school education, these significant sex differences persisted into the second time period and also included the middle PIR group (p=0.03) and overweight group (p=0.02).

Sex differences in crude prevalence were not found for HbA1c5.7 (Table 2). After multivariate adjustment (Table 3), for only the second time period, women had a significantly higher prevalence of HbA1c5.7 than men among those aged ≥75 years (6.6 ppts; p=0.03); the lowest- (20.7 ppts; p<0.001) and middle PIR groups (8.8 ppts, p<0.05); those with some college or higher education (12.8 ppts, p<0.001); those not living alone (8.2 ppts, p=0.012); and those who were overweight (10.7 ppts, p=0.04).

IFG yielded significantly higher multivariable-adjusted prevalence among non-Hispanic whites than non-Hispanic blacks of either sex (Table 3). In both time periods, estimates for non-Hispanic white men were significantly higher than for non-Hispanic black men, 16.4 ppts (p<0.003) and 18.2 ppts (p<0.001), respectively. Comparable racial/ethnic differences for women were 10.2 ppts (p=0.02) and 18.3 ppts (p<0.001), respectively. The differences between non-Hispanic whites and Mexican-Americans were only significant among men in the first time period (9 ppts, p=0.04). HbA1c5.7 prevalence was significantly higher among non-Hispanic black men than non-Hispanic white men in the first time period (9.7 ppts, p=0.04), with no other racial/ethnic differences. In light of these changes, prediabetes prevalence was significantly higher in the second time period among non-Hispanic white than non-Hispanic black adults (for men, 15.8 ppts, p=0.002; for women, 11.8 ppts, p=0.02) or Mexican American women (11.8 ppts, p=0.02).

Discussion

Older adults in the U.S. contribute significantly to the growing diabetes burden. Normal glycemia was found to decrease over time, whereas dysglycemia (e.g., all diabetes and prediabetes) afflicted almost three in four older adults aged ≥65 years by 2005–2010. Almost 50% of men and 40% of women aged 50–64 years (i.e., most baby boomers) were identified as having prediabetes (Appendix Figure 1, available online), and by 2030 they will all be aged ≥65 years. For this increasingly large segment of the U.S. population,[33] complications may result from prediabetes itself or its progression to diabetes, resulting in reduced function and well-being. These outcomes are particularly important to women in the context of institutional care. For example, despite nearly equal numbers of diabetic men and women in the U.S.,[16] among nursing home residents with diabetes in 2004, women outnumbered men by almost 2.9-fold (60,200 vs 20,800, respectively).[34]

Fortunately, a major U.S. clinical trial revealed the potential to prevent or delay the progression to diabetes among high-risk adults.[35] In that trial, adults aged ≥60 years experienced a 71% reduction in risk of developing diabetes via intensive lifestyle intervention, but no reduction with metformin. Over a 10-year follow-up, older adults maintained a high percentage of initial weight loss (e.g., 6.6% or 4 kg).[36] As such, lifestyle intervention may be the only way to prevent or delay diabetes in this age group, among whom efficacy was apparently higher than their younger counterparts.[35,36] Cost effectiveness analyses have even suggested that lowering the Medicare eligibility age from 65 to 60 years could produce considerable economic benefit.[37] Providing prediabetes estimates by sociodemographic characteristics should help to tailor effective interventions to the specific needs of older adults, including those with physical function limitations and comorbid conditions[1] as was examined among those with diabetes.[38]

There was a marked discordance between prediabetes estimates based on FPG or HbA1c alone, or as compared to prediabetes overall. This discordance also existed between the sexes, which is consistent with reports from populations of the U.S.,[3,39] Sub-Saharan Africa,[40] and Korea.[41] The plausible biological mechanism for this sex difference seems to be less related to anthropometric differences, and more related to differences in insulin sensitivity and beta cell function.[42] Given the current and projected preponderance of older women in the U.S., the common use of FPG may likely undercount the numbers of older women at high risk of prediabetes and its complications.

When using 6-year time periods, it was found that the previously noted increasing prediabetes prevalence of 8.8% among Americans aged ≥12 years with normal BMI[18] was manifested only among women aged ≥50 years for prediabetes (10.2 ppts), and especially for HbA1c5.7 (13.8 ppts) (Appendix Table 1, available online). Women had even greater increases when partitioned into age ≥65 years, reaching 12 ppts for prediabetes, and almost 17 ppts for HbA1c5.7. Bullard et al.[18] did not identify reasons for this increase in the general U.S. population. For older adults, it may be that sarcopenia plays a role. For example, using 1988–1994 NHANES III data, Srikanthan and colleagues[43] found that adult men and women aged ≥60 years with sarcopenia but no obesity, compared to their peers having neither condition, had significantly higher odds of having insulin resistance or prediabetes (IFG or HbA1c=6.0%–6.4%) by 34% and 50%, respectively. Sarcopenia without obesity was not associated with HbA1c alone, perhaps due to more restrictive HbA1c cutoff points.[43] Although not pertaining exclusively to normal-weight women, this provides a limited explanation for the association found for the overall prediabetes estimate. Future research efforts might seek to better explain the large increase in prediabetes prevalence among the oldest women in the U.S. population.

A major strength of the study was the use of nationally representative samples of the U.S. noninstitutionalized population. Standardized protocols enhanced comparability across NHANES survey cycles and consistent prediabetes criteria were used, despite changing definitions for prediabetes since 2003.[44,45] There were, however, some limitations. First, using single laboratory measurements of HbA1c and FPG may have misclassified prediabetes owing to intra-individual variability. Second, NHANES sampling changes from 2003 to 2010 could have induced nonrandom error, thereby potentially affecting HbA1c or FPG values, and prediabetes prevalence patterns. Third, changes in measurement methods of HbA1c and FPG because the 2003–2004 NHANES cycle[26–28] might have influenced data quality, although NCHS deemed these measures suitable for analysis.[26] Aggregating 6 years of data and using HbA1c and FPG measures to assess prediabetes not only stabilized estimates but also attenuated the effect of these potential limitations. Finally, using cross-sectional surveys eliminated the ability to fully assess transitions between different glycemic states. Future prospective cohort studies will better characterize glycemic transitions.

Ideally, population-level interventions to prevent or reduce the rightward shift in the distribution of glucose across the life stages, notably in young adulthood and mid-life, should be the goal, given the profound implications for a subsequent late-life societal burden in lost productivity and institutional care. However, the very large and growing prevalence of prediabetes in older-adult Americans, among whom associated burdens are more likely to be imminent and most profound, especially for women, makes them a target group that could be of paramount importance for interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Appendix: Supplementary Data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2014.10.004.

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Table 1

Characteristics of U.S. Adults Aged ≥50 Years, by Sex and Survey Period, NHANES 1999–2010

	Men		**Women**	
	Prevalence (95% CI) by survey periods		**Prevalence (95% CI) by survey periods**	
Characteristic	**1999–2004**	**2005–2010**	**1999–2004**	**2005–2010**
n	1,806	2,145	1,873	2,171
Population size (millions)	35.7	41.2	42.8	48.3
Age group (years), %				
50–64	60.3 (57.0, 63.5)	60.7 (58.0, 63.3)	56.8 (54.3, 59.4)	56.3 (52.9, 59.7)
65–74	24.3 (22.1, 26.8)	23.3 (20.9, 25.9)	22.8 (20.1, 25.7)	23.6 (21.1, 26.2)
≥75	15.3 (13.6, 17.2)	16.0 (14.5, 17.6)	20.4 (18.2, 22.7)	20.1 (17.5, 23.0)
Race/ethnicity, %[a]				
Non-Hispanic white	81.2 (76.6, 85.1)	78.1 (74.1, 81.6)	79.4 (75.1, 83.1)	77.6 (73.6, 81.2)
Non-Hispanic black	7.6 (6.0, 9.4)	9.5 (7.6, 11.8)	9.0 (6.9, 11.8)	10.0 (7.9, 12.6)
Mexican American	3.8 (2.6, 5.4)	4.7 (3.3, 6.8)	3.5 (2.2, 5.5)	4.6 (3.3, 6.5)
Other	7.4 (4.9, 11.1)	7.7 (5.9, 10.2)	8.1 (5.5, 11.7)	7.7 (6.0, 10.0)
PIR group, %				
<1.0	8.0 (6.4, 10.0)	7.9 (6.6, 9.5)	11.6 (9.4, 14.3)	10.1 (8.6, 11.8)
1–2.9	33.6 (30.0, 37.4)	34.7 (31.5, 38.1)	41.0 (37.8, 44.4)	40.1 (36.8, 43.5)
≥3.0	58.4 (54.6, 62.2)	57.3 (53.6, 61.0)	47.3 (43.8, 50.9)	49.9 (46.0, 53.7)
Education, %				
<High school	23.8 (21.3, 26.6)	20.4 (17.8, 23.2)	25.4 (22.6, 28.3)	20.2 (17.8, 22.9)
High school graduate	22.4 (19.5, 25.7)	23.1 (20.1, 26.6)	27.8 (25.3, 30.5)	28.9 (26.3, 31.6)
Some college or higher	53.8 (49.2, 58.2)	56.5 (51.8, 61.1)	46.8 (43.5, 50.1)	50.9 (47.6, 54.3)
Living alone, %[b]				
No	**88.0** (85.9, 89.8)*	**83.7** (81.9, 85.5)*	74.4 (71.7, 77.0)	75.8 (73.1, 78.2)
Yes	**12.0** (10.2, 14.1)*	**16.3** (14.5, 18.1)*	25.6 (23.0, 28.3)	24.2 (21.8, 26.9)
BMI group (kg/m^2), %				
Normal (<25.0)	25.9 (23.6, 28.4)	24.0 (21.5, 26.6)	**33.9** (30.4, 37.6)**	**30.5** (27.8, 33.3)**
Overweight (25.0–29.9)	42.5 (39.0, 46.0)	39.4 (37.0, 41.8)	**32.1** (29.0, 35.4)**	**30.5** (27.9, 33.3)**
Obese (≥30.0)	31.6 (29.0, 34.3)	36.7 (33.4, 40.0)	**34.0** (31.0, 37.1)**	**39.0** (36.6, 41.4)**

Note: Data presented are weighted percentages unless otherwise noted. Boldface indicates statistical significance (*p=0.003; **p=0.044).

[a]Individuals for other racial/ethnic groups are included in the denominator but their separate estimates are not presented.

[b]p-values for equal proportions were calculated from an F-test.

NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio.

Table 2

Crude Prevalence of Glycemic Status for Older-adult Americans, by Age and Survey Period, 1999–2010

	Men			Women		
	Prevalence (95% CI) by survey period			Prevalence (95% CI) by survey period		
Glycemic or prediabetes status by age group	**1999–2004**	**2005–2010**	**Absolute prevalence change**	**1999–2004**	**2005–2010**	**Absolute prevalence change**
Glycemic status (50–64 years)						
Normal	35.8 (31.6, 40.2)	29.6 (25.3, 34.3)	−6.2	54.5 (50.1, 58.9)	44.5 (40.8, 48.3)	**−10.0*** **
Diagnosed diabetes	11.9 (10.4, 13.6)	12.8 (11.0, 14.8)	0.9	10.2 (8.6, 12.0)	12.1 (9.8, 14.8)	1.9
Undiagnosed diabetes	5.7 (3.9, 8.3)	6.4 (4.5, 9.0)	0.7	4.0 (2.6, 6.0)	2.5 (1.5, 4.1)	−1.5
Prediabetes[a]	46.6 (41.8, 51.4)	51.2 (46.3, 56.1)	4.6	31.3 (27.9, 35.1)	41.0 (36.5, 45.6)	**9.7** **
Total	100.0	100.0		100.0	100.0	
Glycemic status (65–74 years)						
Normal	26.4 (21.9, 31.3)	22.1 (18.0, 26.8)	−4.3	38.2 (31.7, 45.2)	25.8 (20.7, 31.7)	**−12.4** **
Diagnosed diabetes	19.6 (16.8, 22.7)	20.9 (17.5, 24.8)	1.3	17.2 (14.4, 20.5)	19.3 (16.2, 22.8)	2.1
Undiagnosed diabetes	10.1 (7.6, 13.4)	9.7 (6.4, 14.4)	−0.4	5.6 (3.3, 9.3)	6.5 (3.9, 10.6)	0.9
Prediabetes	43.9 (38.1, 49.8)	47.3 (42.2, 52.4)	3.4	38.9 (33.7, 44.4)	48.4 (42.8, 54.0)	**9.5** **
Total	100.0	100.0		100.0	100.0	
Glycemic status (≥75 years)						
Normal	29.2 (24.3, 34.6)	21.9 (17.4, 27.1)	**−7.3** *	36.4 (30.6, 42.7)	26.8 (22.9, 31.2)	**−9.6** *
Diagnosed diabetes	13.9 (11.4, 16.8)	17.5 (13.9, 21.7)	3.6	16.8 (13.5, 20.7)	17.5 (15.3, 20.0)	0.7
Undiagnosed diabetes	7.8 (5.2, 11.4)	10.4 (7.7, 13.9)	2.6	4.3 (2.8, 6.5)	7.6 (5.4, 10.6)	3.3
Prediabetes	49.2 (43.5, 55.0)	50.2 (45.2, 55.2)	1.0	42.5 (36.8, 48.3)	48.0 (43.5, 52.5)	5.5
Total	100.0	100.0		100.0	100.0	
HbA1c5.7 by age						
50–64 years	14.5 (11.6, 17.9)	25.0 (21.2, 29.2)	**10.5*** **	16.5 (13.9, 19.3)	27.1 (23.7, 30.9)	**10.6*** **
65–74 years	17.4 (13.3, 22.5)	27.4 (21.9, 33.8)	**10.0** *	23.2 (19.1, 27.8)	33.4 (26.8, 40.7)	**10.2** *
≥75 years	24.1 (20.2, 28.5)	29.2 (24.4, 34.4)	5.1	21.3 (16.7, 26.6)	35.7 (31.5, 40.1)	**14.4*** **
IFG by age						
50–64 years	40.9 (36.4, 45.5)	43.4 (39.2, 47.8)	2.5	25.8 (22.0, 30.0)	28.8 (24.6, 33.5)	3.0

Glycemic or prediabetes status by age group	Men: Prevalence (95% CI) by survey period 1999–2004	Men: Prevalence (95% CI) by survey period 2005–2010	Men: Absolute prevalence change	Women: Prevalence (95% CI) by survey period 1999–2004	Women: Prevalence (95% CI) by survey period 2005–2010	Women: Absolute prevalence change
65–74 years	37.5 (32.1, 43.2)	38.2 (33.3, 43.4)	0.7	31.6 (26.5, 37.2)	31.0 (26.0, 36.5)	−0.6
≥75 years	45.2 (38.9, 51.7)	42.9 (38.0, 48.0)	−2.3	35.8 (30.5, 41.4)	31.8 (26.6, 37.4)	−4.0

Note: *p*-values were calculated from a *t*-test. Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$).

[a]Prediabetes is defined by HbA1c5.7 and/or IFG.

HbA1c5.7, hemoglobin A1c=5.7%–6.4% (39–47 mmol/mol); IFG, impaired fasting glucose (fasting plasma glucose=100–125 mg/dL).

Table 3

Multivariate-adjusted[a] Prediabetes Prevalence for U.S. Adults Aged ≥65 Years by Sociodemographic Characteristics, NHANES, 1999–2010

	Men			Women		
	Prevalence (95% CI) by survey period			Prevalence (95% CI) by survey period		
Prediabetes status/characteristic	1999–2004	2005–2010	Absolute prevalence change	1999–2004	2005–2010	Absolute prevalence change
Prediabetes[b]						
Older adults aged						
≥65 years	46.0 (41.9, 50.1)	48.4 (44.6, 52.2)	2.4	40.5 (36.7, 44.3)	48.3 (45.0, 51.7)	**7.8****
Age group (years)						
65–74	44.0 (38.2, 49.8)	47.2 (41.9, 52.5)	3.2	38.5 (33.3, 43.7)	48.0 (42.5, 53.5)	**9.5***
≥75	49.1 (43.3, 54.9)	50.4 (45.4, 55.4)	1.3	42.8 (36.9, 48.7)	48.5 (44.0, 53.0)	5.7
Race/ethnicity						
Non-Hispanic white	46.8 (42.3, 51.3)	49.2 (44.7, 53.7)	2.4	40.7 (36.3, 45.1)	49.4 (45.4, 53.4)	**8.7****
Non-Hispanic black	35.7 (25.4, 46.0)	33.4 (24.7, 42.1)	−2.3	38.6 (31.1, 46.1)	37.6 (28.4, 46.8)	−1.0
Mexican American	41.4 (33.0, 49.8)	45.3 (32.6, 58.0)	3.9	37.6 (29.0, 46.2)	37.6 (28.5, 46.7)	0.0
Other	49.4 (30.6, 68.2)	56.7 (44.5, 68.9)	7.3	42.1 (29.5, 54.7)	53.6 (41.4, 65.8)	11.5
PIR group						
<1.0	41.0 (31.7, 50.3)	47.3 (38.0, 56.6)	6.3	43.4 (32.0, 54.8)	52.8 (42.7, 62.9)	9.4
1–2.9	47.5 (41.4, 53.6)	46.7 (41.8, 51.6)	−0.8	42.3 (38.2, 46.4)	48.7 (44.0, 53.4)	**6.4****
≥3.0	45.5 (39.3, 51.7)	50.2 (43.9, 56.5)	4.7	36.4 (28.4, 44.4)	45.9 (40.1, 51.7)	9.5
Education						
<High school	43.5 (36.3, 50.7)	44.3 (36.1, 52.5)	0.8	34.2 (27.3, 41.1)	48.0 (43.1, 52.9)	**13.8****
High school graduate	48.6 (40.4, 56.8)	48.1 (40.0, 56.2)	−0.5	43.2 (34.9, 51.5)	44.7 (38.5, 50.9)	1.5
Some college or higher	46.1 (39.9, 52.3)	50.9 (46.4, 55.4)	4.8	43.2 (37.5, 48.9)	51.4 (45.9, 56.9)	**8.2***
Living alone						
No	46.5 (42.1, 50.9)	48.0 (43.7, 52.3)	1.5	41.7 (36.6, 46.8)	50.3 (46.3, 54.3)	**8.6***
Yes	43.1 (35.0, 51.2)	50.5 (42.5, 58.5)	7.4	38.4 (32.9, 43.9)	44.7 (38.5, 50.9)	6.3
BMI group (kg/m^2)						
Normal (<25)	44.9 (37.3, 52.5)	46.0 (39.9, 52.1)	1.1	33.7 (28.3, 39.1)	45.7 (39.3, 52.1)	**12.0****

Prediabetes status/characteristic	Men: Prevalence (95% CI) by survey period 1999–2004	Men: Prevalence (95% CI) by survey period 2005–2010	Men: Absolute prevalence change	Women: Prevalence (95% CI) by survey period 1999–2004	Women: Prevalence (95% CI) by survey period 2005–2010	Women: Absolute prevalence change
Overweight (25–29.9)	48.6 (43.5, 53.7)	53.3 (47.2, 59.4)	4.7	46.9 (39.9, 53.9)	54.3 (49.1, 59.5)	7.4
Obese (≥30)	43.7 (34.7, 52.7)	44.4 (38.0, 50.8)	0.7	41.0 (34.3, 47.7)	44.8 (38.5, 51.1)	3.8
HbA1c5.7						
Older adults aged						
≥65 years	20.3 (17.3, 23.3)	27.8 (23.3, 32.3)	**7.5****	22.3 (19.0, 25.7)	34.5 (30.4, 38.6)	**12.2*****
Age group (years)						
65–74	17.2 (12.7, 21.7)	26.8 (20.8, 32.8)	**9.6***	23.0 (18.6, 27.4)	33.1 (26.2, 40.0)	**10.1***
≥75	25.1 (20.9, 29.3)	29.5 (24.7, 34.3)	4.4	21.4 (16.3, 26.5)	36.1 (32.1, 40.1)	**14.7*****
Race/ethnicity						
Non-Hispanic white	18.8 (15.3, 22.3)	27.1 (21.6, 32.6)	**8.3***	21.1 (17.3, 24.9)	34.8 (29.8, 39.8)	**13.7*****
Non-Hispanic black	28.5 (19.9, 37.1)	24.6 (16.6, 32.6)	−3.9	28.0 (19.3, 36.7)	33.0 (23.6, 42.4)	5.0
Mexican American	24.5 (16.4, 32.6)	31.7 (19.1, 44.3)	7.2	23.8 (16.7, 30.9)	26.9 (18.4, 35.4)	3.1
Other	27.6 (13.7, 41.5)	39.3 (24.2, 54.4)	11.7	29.5 (18.9, 40.1)	36.3 (24.1, 48.5)	6.8
PIR group						
<1.0	18.7 (11.3, 26.1)	19.4 (11.9, 26.9)	0.7	21.1 (13.7, 28.5)	40.1 (29.9, 50.3)	**19.0****
1.0–2.9	22.8 (17.2, 28.4)	25.8 (20.2, 31.4)	3.0	24.0 (19.3, 28.7)	34.6 (29.7, 39.5)	**10.6****
≥3.0	18.0 (12.8, 23.2)	31.5 (25.6, 37.4)	**13.5****	20.0 (14.2, 25.8)	32.4 (25.1, 39.7)	**12.4****
Education						
<High school	18.9 (12.7, 25.1)	27.3 (18.3, 36.3)	8.4	20.7 (14.3, 27.1)	30.7 (24.1, 37.3)	**10.0***
High school graduate	25.0 (17.6, 32.4)	30.4 (22.3, 38.5)	5.4	23.0 (16.5, 29.5)	31.5 (23.9, 39.1)	8.5
Some college or higher	18.8 (13.9, 23.7)	27.0 (21.1, 32.9)	**8.2***	22.6 (16.3, 28.9)	39.8 (35.4, 44.2)	**17.2*****
Living alone						
No	19.9 (16.6, 23.2)	26.7 (21.7, 31.7)	**6.8***	23.3 (18.7, 27.9)	34.9 (30.1, 39.7)	**11.6****
Yes	22.2 (16.3, 28.1)	33.6 (25.5, 41.7)	**11.4***	20.5 (16.2, 24.8)	33.9 (27.0, 40.8)	**13.4*****
BMI group (kg/m^2)						
Normal (<25)	17.5 (11.8, 23.2)	23.6 (16.6, 30.6)	6.1	16.8 (11.9, 21.7)	33.4 (26.4, 40.4)	**16.6*****
Overweight (25–29.9)	20.7 (16.0, 25.4)	29.4 (22.6, 36.2)	**8.7***	25.4 (18.6, 32.2)	40.1 (32.7, 47.5)	**14.7****

Prediabetes status/characteristic	Men: Prevalence (95% CI) by survey period 1999–2004	Men: Prevalence (95% CI) by survey period 2005–2010	Men: Absolute prevalence change	Women: Prevalence (95% CI) by survey period 1999–2004	Women: Prevalence (95% CI) by survey period 2005–2010	Women: Absolute prevalence change
Obese (≥30)	22.5 (14.6, 30.4)	29.9 (22.6, 37.2)	7.4	24.9 (19.0, 30.8)	29.9 (22.9, 36.9)	5.0
IFG						
Older adults aged						
≥65 years	40.5 (36.0, 45.0)	40.1 (36.7, 43.5)	−0.4	33.5 (29.8, 37.2)	31.4 (27.7, 35.1)	−2.1
Age group (years)						
65–74	37.4 (31.8, 43.0)	38.1 (33.0, 43.2)	0.7	31.2 (26.2, 36.2)	30.8 (25.6, 36.0)	−0.4
≥75	45.2 (38.7, 51.7)	43.1 (38.3, 47.9)	−2.1	36.2 (30.5, 41.9)	32.1 (26.7, 37.5)	−4.1
Race/ethnicity						
Non-Hispanic white	41.6 (36.6, 46.6)	40.9 (36.7, 45.1)	−0.7	34.8 (30.6, 39.0)	33.1 (28.8, 37.4)	−1.7
Non-Hispanic black	25.2 (15.6, 34.8)	22.7 (14.0, 31.4)	−2.5	24.6 (17.2, 32.0)	14.8 (9.4, 20.2)	**−9.8***
Mexican American	32.6 (25.9, 39.3)	33.9 (20.8, 47.0)	1.3	31.0 (23.1, 38.9)	27.3 (19.5, 35.1)	−3.7
Other	46.3 (26.9, 65.7)	50.9 (38.7, 63.1)	4.6	29.9 (13.2, 46.6)	35.4 (21.7, 49.1)	5.5
PIR group						
<1.0	34.7 (23.0, 46.4)	40.7 (30.9, 50.5)	6.0	36.6 (23.8, 49.4)	33.3 (23.5, 43.1)	−3.3
1.0–2.9	41.0 (34.7, 47.3)	39.3 (35.1, 43.5)	−1.7	35.7 (31.3, 40.1)	33.1 (28.6, 37.6)	−2.6
≥3.0	41.1 (35.2, 47.0)	40.8 (35.1, 46.5)	−0.3	28.6 (20.0, 37.2)	27.8 (22.0, 33.6)	−0.8
Education						
<High school	38.6 (31.4, 45.8)	37.0 (28.6, 45.4)	−1.6	28.8 (22.3, 35.3)	32.9 (27.8, 38.0)	4.1
High school graduate	41.3 (33.4, 49.2)	36.4 (28.4, 44.4)	−4.9	34.4 (27.2, 41.6)	29.8 (24.0, 35.6)	−4.6
Some college or higher	41.2 (34.9, 47.5)	43.6 (38.9, 48.3)	2.4	36.6 (30.7, 42.5)	31.7 (25.3, 38.1)	−4.9
Living alone						
No	40.8 (36.3, 45.3)	40.3 (36.8, 43.8)	−0.5	34.5 (29.9, 39.1)	32.5 (28.3, 36.7)	−2.0
Yes	38.8 (29.6, 48.0)	39.2 (29.8, 48.6)	0.4	31.9 (26.1, 37.7)	29.5 (23.9, 35.1)	−2.4
BMI group (kg/m^2)						
Normal (<25)	38.6 (30.9, 46.3)	36.3 (30.2, 42.4)	−2.3	26.3 (21.1, 31.5)	25.1 (19.4, 30.8)	−1.2
Overweight (25–29.9)	43.3 (37.8, 48.8)	45.4 (39.5, 51.3)	2.1	40.1 (33.7, 46.5)	35.7 (29.8, 41.6)	−4.4
Obese (≥30)	38.7 (29.7, 47.7)	36.7 (30.7, 42.7)	−2.0	34.0 (27.5, 40.5)	33.5 (27.5, 39.5)	−0.5

Note: p values were calculated from a t-test. Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$).

[a]Estimated from a logistic regression model, controlling for age, sex, race/ethnicity, PIR, education, living alone, and BMI. Individuals for other racial/ethnic groups are included in the denominator but their separate estimates are not presented.

[b]Prediabetes is defined by HbA1c5.7 and/or IFG.

HbA1c5.7, hemoglobin A1c=5.7%–6.4% (39–47 mmol/mol); IFG, impaired fasting glucose (fasting plasma glucose=100–125 mg/dL); NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio.