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Diabetes and Prediabetes Among Adults in Los Angeles County and the United States, 1999–2006 and 2007–2014

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Abstract

Objective—This report presents the prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, and prediabetes among adults aged 20 and over in Los Angeles County and the United States in 1999–2006 and 2007–2014. The prevalence of diagnosed diabetes, total diabetes, and prediabetes in 2007–2014 are presented by age, sex, and race and Hispanic origin.

Methods—Data are from in-home interviews and laboratory testing conducted as part of the National Health and Nutrition Examination Survey (NHANES). Los Angeles County has been selected with certainty in every NHANES cycle since 1999. Sample persons in Los Angeles County were selected and sample weights constructed so that estimates represent the county. Prevalence and 95% confidence intervals for diagnosed, undiagnosed, total diabetes, and prediabetes were estimated using self-reported diagnosis of diabetes, plasma fasting glucose, and hemoglobin A1c. Differences in prevalence were tested between Los Angeles County and the United States, between 1999–2006 and 2007–2014, and among demographic subgroups.

Results—The age-adjusted prevalence of total diabetes among adults in Los Angeles County increased from 10.5% in 1999–2006 to 14.4% in 2007–2014. In 2007–2014, 40.2% of adults in Los Angeles County had prediabetes. There were no significant differences in the overall prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, or prediabetes between Los Angeles County and the United States in 1999–2006 or 2007–2014. The prevalence of diagnosed diabetes, total diabetes, and prediabetes increased with age in both Los Angeles County and the United States. The prevalence of total diabetes was higher in non-Hispanic black adults, Hispanic adults, and Mexican-American adults than in non-Hispanic white adults in both Los Angeles County and the United States.

Conclusion—Monitoring trends in diagnosed diabetes, undiagnosed diabetes, total diabetes, and prediabetes among adults in Los Angeles County and the United States may inform the development and implementation of targeted prevention and control efforts.

Keywords: National Health and Nutrition Examination Survey (NHANES) • plasma fasting glucose • hemoglobin A1c

Introduction

Diabetes is a major cause of morbidity and mortality in the United States (1–3). Data from the California Health Interview Survey shows that 55% of the adult population in California, or 15.5 million people, were estimated to have prediabetes or diabetes in 2013–2014 (4). Los Angeles County has the largest population of any county in the United States, and has been included in the National Health and Nutrition Examination Survey (NHANES) since 1999. NHANES data from Los Angeles County for the most recent 8-year period, 2007–2014, have been used to estimate the prevalence of hypertension (5) and several infectious diseases (6), and to compare with prevalence estimates for the United States. This report presents estimates of the prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, and prediabetes for adults aged 20 and over in Los Angeles County for 1999–2006 and 2007–2014, and provides prevalence estimates by age, sex, and race and Hispanic origin for 2007–2014 for Los Angeles County and the U.S. adult population.



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Methods

Data source

NHANES is a cross-sectional survey designed to monitor the health and nutritional status of the civilian noninstitutionalized U.S. population. NHANES is conducted by the National Center for Health Statistics (NCHS) and consists of interviews conducted in the participant's home, a standardized physical examination in a mobile examination center, and laboratory tests on blood and other specimens.

The NHANES sample is based on a complex, multistage probability design that includes oversampling of particular population subgroups to obtain reliable estimates of health and nutritional measures for these groups. In 1999–2006, Mexican-American persons, and in 2007–2014 all Hispanic persons, were among the subgroups oversampled. Race and Hispanic origin-specific estimates reflect persons reporting only one race; those reporting more than one race are included in the total, but are not reported separately.

The NHANES sampling plan consists of four stages: selection of primary sampling units (PSUs), counties, or groups of contiguous counties; selection of segments within PSUs; selection of dwelling units within segments; and selection of sample persons within dwelling units (7). Because of the size and population density of Los Angeles County and the large Mexican-American and Hispanic population, a primary sampling unit in Los Angeles County was chosen with certainty in each 2-year NHANES cycle (8,9). Data were aggregated over 1999–2006 and 2007–2014 in order to increase the sample size and improve the reliability of estimates for Los Angeles County. Sample weights were calculated for Los Angeles County and U.S. survey participants for the two, 8-year periods 1999–2006 and 2007–2014; sample weighting methods are described elsewhere (9).

Measurement of diabetes and prediabetes

Participants were randomly assigned to a morning or an afternoon or evening examination session. Those assigned to the morning session were asked to fast for at least 8 hours but fewer than 24 hours prior to examination, and the estimates of diabetes prevalence presented in this report are based on adults aged 20 and over examined in the morning who fasted for at least 8 hours but fewer than 24 hours prior to examination. Pregnant women were excluded. Forward calibration equations were used to account for changes in plasma glucose laboratory procedures over time (10,11). Participants were classified as having diagnosed diabetes if they answered “yes” to the question, “Other than during pregnancy, have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?”

Current American Diabetes Association definitions were used to classify diabetes and prediabetes (12). Adults were classified as having undiagnosed diabetes if they did not have diagnosed diabetes and had a plasma fasting glucose equal to or greater than 126 mg/mL or a hemoglobin A1c equal to or greater than 6.5%. Total diabetes was defined as having either diagnosed or undiagnosed diabetes. Participants were classified as having prediabetes if they did not have diabetes (diagnosed or undiagnosed), and their plasma fasting glucose was between 100 mg/dL and 125 mg/dL or their hemoglobin A1c was between 5.7% and 6.4%.

Statistical analyses

Estimates of the prevalence of diabetes (diagnosed, undiagnosed, and total diabetes) and prediabetes in 2007–2014 are presented by age group (20–39, 40–59, and 60 and over), sex, and race and Hispanic origin (non-Hispanic white, non-Hispanic black, Hispanic, and Mexican American); the Hispanic category includes Mexican Americans. Estimates for all adults, and estimates by sex and race and Hispanic origin are age adjusted by the direct method to the projected 2000

U.S. Census population using the age groups 20–39, 40–59, and 60 and over (13). Reported prevalence estimates are age adjusted unless otherwise indicated. Differences in prevalence for all adults in 1999–2006 compared with 2007–2014, and differences in prevalence by sex and race and Hispanic origin in 2007–2014 were tested using a univariate 2-sided *t*-statistic, and linear trends across age categories were tested using logistic regression. Differences in overall prevalence estimates between the United States and Los Angeles County were tested with a univariate 2-sided *t*-statistic using the combined standard error accounting for the correlation between Los Angeles County and the United States (14). All reported differences are statistically significant ($p < 0.05$). No adjustments were made for multiple comparisons. Confidence intervals were constructed using the method of Korn and Graubard (15) and reliability of estimates was assessed using the NCHS data presentation standards for proportions, and include an evaluation of the effective sample size, degrees of freedom, confidence interval width, and relative confidence interval width (i.e., the confidence interval width divided by the estimate) (16).

Despite the aggregation of 8 years of data, statistical analyses using the Los Angeles County sample may still lack adequate power to detect differences among subgroups at a magnitude that may be meaningful for public health. Statistical power was further decreased because only one-half of the adult NHANES sample was selected for the fasting subsample (for testing plasma fasting glucose). Reduced power limited the ability to calculate reliable estimates for health conditions with a low prevalence, especially among subgroups. Consequently, reliable estimates for the prevalence of undiagnosed diabetes in Los Angeles County were calculated for the overall population, but could not be calculated for sex, age group, or race and Hispanic-origin groups.

Los Angeles County has a large proportion of Mexican-American and other Hispanic persons, and these groups were also oversampled in NHANES, resulting in a relatively large proportion of Mexican American persons in the Los

Angeles County sample. As a result, estimates for non-Hispanic white and non-Hispanic black persons may not be reliable and may have wide 95% confidence intervals when calculated using a subset of the sample (9), such as the fasting subsample. Statistical power to detect differences among race and Hispanic-origin groups in Los Angeles County was reduced substantially. Because of the issue with low statistical power in subgroups, differences between Los Angeles County and the United States for age, sex, and race and Hispanic origin were not tested statistically.

All estimates in this report were calculated using the fasting sample and are weighted to represent the civilian noninstitutionalized population of Los Angeles County and the United States. Fasting sample weights account for unequal selection probabilities, probability of selection into the morning fasting sample, noncoverage, and nonresponse. Standard errors were estimated by Taylor Series linearization, which accounts for stratification and clustering in addition to weighting. Statistical analyses were performed using R version 3.5.1 (R Foundation for Statistical Computing) (17), the SAS System for Windows, version 9.3 (SAS Institute, Inc., Cary, N.C.) and SUDAAN version 11.0 (RTI International, Research Triangle Park, N.C.).

Results

Prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, and prediabetes among adults aged 20 and over in Los Angeles County and in the United States from 1999–2006 to 2007–2014

- In Los Angeles County, the age-adjusted prevalence of diagnosed diabetes was 7.5% in 1999–2006 and 10.2% in 2007–2014, and in the United States, the age-adjusted prevalence of diagnosed diabetes increased from 7.2% in 1999–2006 to 8.6% in 2007–2014 (Table 1).

The pattern of diagnosed diabetes prevalence in Los Angeles County from 1999–2006 to 2007–2014 was similar to that of the United States, but no statistically significant difference in prevalence was detected for Los Angeles County.

- No significant difference in the age-adjusted prevalence of undiagnosed diabetes in Los Angeles County was detected between 1999–2006 (3.0%) and 2007–2014 (4.3%). In the United States, the age-adjusted prevalence of undiagnosed diabetes was similar in 1999–2006 (3.5%) and 2007–2014 (3.8%).
- Among adults with diabetes in Los Angeles County in 2007–2014, 29.9% had undiagnosed diabetes and among U.S. adults with diabetes, 30.6% had undiagnosed diabetes (data not shown).
- In Los Angeles County, the age-adjusted prevalence of total diabetes increased from 10.5% in 1999–2006 to 14.4% in 2007–2014. In the United States, the age-adjusted prevalence of total diabetes increased from 10.7% in 1999–2006 to 12.4% in 2007–2014.
- In Los Angeles County, the age-adjusted prevalence of prediabetes was 37.3% in 1999–2006 and 40.2% in 2007–2014, and in the United States the age-adjusted prevalence of prediabetes increased from 37.2% in 1999–2006 to 42.4% in 2007–2014. No statistically significant difference in prevalence between 1999–2006 and 2007–2014 was detected for Los Angeles County.
- No statistically significant differences in the prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, or prediabetes were detected between Los Angeles County and the United States in 1999–2006 or 2007–2014.
- In 2007–2014 in Los Angeles County, the crude prevalence of diagnosed diabetes (9.9%), undiagnosed diabetes (4.1%), total diabetes (14.0%), and prediabetes (39.7%) was similar to age-adjusted estimates. The pattern of crude prevalence in Los Angeles County

and the United States in 1999–2006 and 2007–2014 was similar to that of the age-adjusted prevalence.

Prevalence of diagnosed diabetes among adults in Los Angeles County and the United States by age, sex, and race and Hispanic origin, 2007–2014

- In Los Angeles County, the prevalence of diagnosed diabetes increased with age from 0.3% among adults aged 20–39 to 14.9% among those aged 40–59 and 19.4% among adults aged 60 and over (Table 2). In the United States, the prevalence of diagnosed diabetes increased with age, from 1.5% in adults aged 20–39 to 9.4% in adults aged 40–59 and 19.3% in adults aged 60 and over.
- A higher prevalence of diagnosed diabetes was observed among men compared with women in Los Angeles County (13.1% compared with 7.5%), although a statistically significant difference was not detected. In the United States, the prevalence of diagnosed diabetes among men and women was similar (9.1% compared with 8.1%).
- In Los Angeles County, the prevalence of diagnosed diabetes was 5.5% among non-Hispanic white adults, 7.7% among non-Hispanic black adults, and 10.3% among Hispanic adults; however, significant differences among these estimates were not detected. In the United States, the prevalence of diagnosed diabetes was higher among non-Hispanic black adults (13.3%) and Hispanic adults (12.4%) compared with non-Hispanic white adults (7.1%). Prevalence was also higher among Mexican-American adults (13.4%) compared with non-Hispanic white adults in the United States.

Prevalence of total diabetes among adults in Los Angeles County and the United States by age, sex, and race and Hispanic origin, 2007–2014

- In Los Angeles County, the prevalence of total diabetes increased with age from 1.1% among adults aged 20–39 to 19.8% among adults aged 40–59, and 28.6% among adults aged 60 and over. In the United States, the prevalence of total diabetes increased with age, from 3.1% among adults aged 20–39 to 13.5% among adults aged 40–59, and 26.6% among adults aged 60 and over (Table 2).
- Men had a higher prevalence of total diabetes than women in Los Angeles County (19.0% compared with 10.4%) and in the United States (14.0% compared with 11.0%).
- In Los Angeles County, the prevalence of total diabetes was higher among non-Hispanic black adults (17.9%) and Hispanic adults (14.9%) than among non-Hispanic white adults (6.4%). In the United States, the prevalence of total diabetes was also higher among non-Hispanic black adults (18.7%) and Hispanic adults (18.2%) compared with non-Hispanic white adults (10.3%). Prevalence was also higher among Mexican-American adults compared with non-Hispanic white adults in Los Angeles County (16.5% compared with 6.4%) and the United States (19.7% compared with 10.3%).

Prevalence of prediabetes among adults in Los Angeles County and the United States by age, sex, and race and Hispanic origin, 2007–2014

- In Los Angeles County, the prevalence of prediabetes increased with age from 23.5% among adults aged 20–39 to 46.7% among adults aged 40–59, and 58.5% among adults aged 60 and over. In the United States, the prevalence of prediabetes increased with age, from 33.2% among adults aged 20–39

to 46.5% among adults 40–59, and 51.7% among adults aged 60 and over (Table 2).

- In Los Angeles County, a higher prevalence of prediabetes was observed among men (42.0%) compared with women (38.0%), although no statistically significant difference was detected. In the United States, the prevalence of prediabetes was higher among men (48.2%) than women (36.5%).
- In Los Angeles County, the prevalence of prediabetes was 33.3% among non-Hispanic white adults, 40.6% among non-Hispanic black adults, and 41.2% among Hispanic adults; however, these observed differences were not statistically significant. In the United States, there were no statistically significant differences in prediabetes prevalence among non-Hispanic black adults (43.3%), non-Hispanic white adults, and Hispanic adults. Prevalence was higher among Mexican-American adults (45.0%) compared with non-Hispanic white adults in the United States.

Discussion

The prevalence of total diabetes among adults in Los Angeles County increased from 10.5% in 1999–2006 to 14.4% in 2007–2014. A similar increase in total diabetes prevalence occurred among adults in the United States. Among adults with diabetes in Los Angeles County in 2007–2014, 29.9% had undiagnosed diabetes and among U.S. adults with diabetes, 30.6% had undiagnosed diabetes. In 2007–2014, the prevalence of prediabetes was 40.2% in Los Angeles County and 42.2% in the United States. No significant differences in the overall prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes, or prediabetes were detected between Los Angeles County and the United States in 1999–2006 or 2007–2014.

The prevalence of diagnosed diabetes, total diabetes, and prediabetes increased with age in both Los Angeles County and the United States.

The prevalence of total diabetes was higher among non-Hispanic black adults,

Hispanic adults, and Mexican-American adults than among non-Hispanic white adults in both Los Angeles County and the United States in 2007–2014.

Non-Hispanic black and Mexican-American adults had a pattern of higher prevalence of diagnosed diabetes and prediabetes compared with non-Hispanic white adults in both Los Angeles County and the United States.

The NHANES sample design and physical exam and laboratory components allowed estimation of health measures, such as the prevalence of diagnosed and undiagnosed diabetes and prediabetes, for the Los Angeles County population. The smaller sample size for Los Angeles County was further reduced because only the fasting half-sample had plasma fasting glucose levels available for analysis. Although 8 years of data were combined in order to increase sample sizes, statistical power was still reduced for detecting small but potentially meaningful differences in prevalence among subgroups. For example, the prevalence of total diabetes and diagnosed diabetes, but not undiagnosed diabetes, increased significantly in the United States from 1999–2006 to 2007–2014; there was a similar pattern in Los Angeles County, but a significant difference in prevalence was detected for total diabetes only. Statistical testing of differences in prevalence between Los Angeles County and the United States for subgroups was not presented, but prevalence estimates for the United States were presented for reference.

Community-based lifestyle change programs (18,19), diabetes self-management education (20,21), and team-based medication therapy management (22) are some approaches to the prevention of diabetes and its related complications. Monitoring trends in diagnosed diabetes, undiagnosed diabetes, total diabetes, and prediabetes among adults in Los Angeles County and the United States may inform the development and implementation of targeted prevention and control efforts at the national and local levels.

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Table 1. Age-adjusted and crude prevalence of diagnosed, undiagnosed, and total diabetes, and prediabetes among adults aged 20 and over: Los Angeles County and the United States, 1999–2006 and 2007–2014

Characteristic	Los Angeles County		United States	
	1999–2006	2007–2014	1999–2006	2007–2014
Sample size	342	456	7,554	9,596
Age-adjusted prevalence	Percent (95% confidence interval)			
Total diabetes	10.5 (7.5, 14.2)	¹ 14.4 (11.3, 18.1)	10.7 (9.7, 11.7)	¹ 12.4 (11.4, 13.5)
Diagnosed diabetes	7.5 (4.9, 10.8)	10.2 (6.7, 14.6)	7.2 (6.4, 8.0)	¹ 8.6 (7.7, 9.5)
Undiagnosed diabetes	² 3.0 (1.1, 6.4)	4.3 (2.5, 6.8)	3.5 (3.0, 4.1)	3.8 (3.4, 4.3)
Prediabetes	37.3 (30.9, 44.1)	40.2 (35.1, 45.6)	37.2 (35.2, 39.3)	¹ 42.4 (40.9, 44.0)
Crude prevalence				
Total diabetes	9.5 (6.6, 13.0)	14.0 (10.4, 18.3)	10.6 (9.7, 11.6)	¹ 13.1 (12.1, 14.1)
Diagnosed diabetes	6.8 (4.5, 9.9)	9.9 (6.3, 14.6)	7.1 (6.4, 7.9)	¹ 9.1 (8.2, 10.0)
Undiagnosed diabetes	2.6 (1.1, 5.2)	4.1 (2.4, 6.5)	3.5 (3.0, 4.0)	4.0 (3.6, 4.5)
Prediabetes	36.1 (29.8, 42.7)	39.7 (33.5, 46.1)	37.2 (35.0, 39.4)	¹ 43.0 (41.4, 44.7)

¹Significantly different from 1999–2006.²Estimate does not meet NCHS standards of reliability.

NOTES: CI is confidence interval. Prevalence estimates were age adjusted by the direct method to the projected 2000 U.S. census population using the age groups 20–39, 40–59, and 60 and over.

SOURCE: NCHS, National Health and Nutrition Examination Survey, 1999–2014.

Table 2. Age-adjusted prevalence of diagnosed diabetes, total diabetes, and prediabetes among adults aged 20 years and older by age, sex, and race and Hispanic origin: Los Angeles County and United States, 2007–2014

Characteristic	Los Angeles County		United States	
	Sample size	Prevalence percentage (95% confidence interval)	Sample size	Prevalence percentage (95% confidence interval)
Diagnosed diabetes				
Age:				
20–39	146	¹ 0.3 (0.0, 1.8)	3,094	¹ 1.5 (1.1, 2.1)
40–59	166	14.9 (8.4, 23.9)	3,296	9.4 (8.1, 10.8)
60 and over	144	19.4 (11.4, 29.9)	3,206	19.3 (17.2, 21.5)
Sex:				
Men	216	13.1 (7.9, 20.2)	4,654	9.1 (8.1, 10.3)
Women	240	7.5 (4.1, 12.3)	4,942	8.1 (7.1, 9.2)
Race and Hispanic origin:				
Non-Hispanic white	68	^{2,3} 5.5 (1.3, 14.5)	4,302	7.1 (6.1, 8.3)
Non-Hispanic black	43	^{2,3,7} 7.7 (0.5, 29.6)	1,834	⁴ 13.3 (11.8, 15.0)
Hispanic	261	10.3 (6.8, 14.7)	2,494	⁴ 12.4 (11.1, 13.7)
Mexican American ⁵	190	11.6 (7.2, 17.2)	1,468	⁴ 13.4 (11.7, 15.2)
Total diabetes				
Age:				
20–39	146	¹ 1.1 (0.2, 3.6)	3,094	¹ 3.1 (2.4, 3.9)
40–59	166	19.8 (12.5, 29.0)	3,296	13.5 (11.8, 15.3)
60 and over	144	28.6 (20.2, 38.3)	3,206	26.6 (24.6, 28.8)
Sex:				
Men	216	19.0 (13.4, 25.6)	4,654	14.0 (12.6, 15.4)
Women	240	⁶ 10.4 (6.5, 15.6)	4,942	⁶ 11.0 (9.9, 12.1)
Race and Hispanic origin:				
Non-Hispanic white	68	^{2,3} 6.4 (1.9, 15.2)	4,302	10.3 (9.1, 11.6)
Non-Hispanic black	43	^{2,3,4} 17.9 (4.1, 43.2)	1,834	⁴ 18.7 (16.7, 20.7)
Hispanic	261	⁴ 14.9 (10.3, 20.7)	2,494	⁴ 18.2 (16.3, 20.3)
Mexican American ⁵	190	⁴ 16.5 (10.3, 24.3)	1,468	⁴ 19.7 (17.2, 22.3)
Prediabetes				
Age:				
20–39	146	¹ 23.5 (16.4, 31.9)	3,094	¹ 33.2 (30.8, 35.7)
40–59	166	46.7 (35.7, 57.9)	3,296	46.5 (44.2, 48.9)
60 and over	144	58.5 (47.0, 69.3)	3,206	51.7 (48.9, 54.4)
Sex:				
Men	216	42.0 (35.3, 48.9)	4,654	48.2 (45.8, 50.7)
Women	240	38.0 (29.7, 47.0)	4,942	⁶ 36.5 (34.8, 38.2)
Race and Hispanic origin:				
Non-Hispanic white	68	^{2,3} 33.3 (15.2, 56.1)	4,302	41.7 (39.6, 43.9)
Non-Hispanic black	43	^{2,3,4} 40.6 (14.6, 71.3)	1,834	43.3 (40.7, 45.9)
Hispanic	261	41.2 (35.1, 47.5)	2,494	43.9 (41.8, 46.2)
Mexican American ⁵	190	42.7 (34.1, 51.7)	1,468	⁴ 45.0 (42.3, 47.8)

¹Significantly increasing trend across age categories.²Estimate does not meet NCHS standards of reliability.³Standard error based on less than 8 degrees of freedom.⁴Significantly different from non-Hispanic white adults.⁵Hispanic includes Mexican American.⁶Significantly different from men.

NOTES: CI is confidence interval. Prevalence estimates were age adjusted by the direct method to the projected 2000 U.S. census population using the age groups 20–39, 40–59, and 60 and over.

SOURCE: NCHS, National Health and Nutrition Examination Survey, 1999–2014.

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