BRIEF ARTICLE

Prevalence of normoglycemic, prediabetic and diabetic A1c levels

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Abstract

AIM: To investigate normoglycemic, prediabetic and diabetic A1c levels in those with prediabetes; and prediabetic and diabetic A1c levels in those with non-prediabetes.

METHODS: The National Health and Nutritional Examination Survey (NHANES) 2007-2008 and NHANES 2009-2010 were utilized to examine and compare trends and differences among five different ethnic groups (Mexican Americans, Other Hispanics, Non-Hispanic Whites, Non-Hispanic Blacks, Other/Multiracials) with normoglycemic, prediabetic and diabetic A1c levels with self-reported prediabetes and prediabetic and diabetic A1c levels in those with self-reported non-prediabetes. Sample participants of the five ethnic groups were limited to those 20 years of age and older, who had completed the diabetes questionnaire and had A1c measured. Descriptive statistics were computed for all variables. χ^2 were performed on all five ethnic groups to examine significant differences of normoglycemic, prediabetic and diabetic A1c levels in those with self-reported prediabetes, and prediabetic and diabetic A1c levels in those with self-reported non-prediabetes.

RESULTS: This study demonstrates that of the five different ethnic groups from NHANES 2007-2008 to NHANES 2009-2010, Non-Hispanic Whites (6.5% increase) and Non-Hispanic Blacks (0.2% increase) were the only two groups with an increase in the number of self-reported prediabetes. Although the overall percentage of Mexican Americans who self-reported prediabetes had remained the same (5%) from NHANES 2007-2008 to NHANES 2009-2010, χ^2 analysis showed significant differences when examining the different ranges of A1c levels (normoglycemic, prediabetic and diabetic). Among Mexican Americans who self-reported prediabetes, normoglycemic ($P = 0.0001$) and diabetic ($P = 0.0001$) A1c levels from NHANES 2007-2008 to NHANES 2009-2010. For Non-Hispanic Whites who self-reported prediabetes, prediabetic ($P = 0.0222$); and diabetic ($P \leqslant 0.0001$) A1c levels from NHANES 2007-2008 to NHANES 2009-2010. For Non-Hispanic Blacks who self-reported prediabetes, there were significant differences ($P = 0.0001$) for all A1c levels (normoglycemic, prediabetic and diabetic A1c levels). For Other/Multi-racials with self-reported prediabetes there was significant differences in those with normoglycemic ($P = 0.0104$) and diabetic ($P = 0.0067$) A1c levels from NHANES 2007-2008 to NHANES 2009-2010. For all combined ethnic groups who self-reported not having prediabetes (non-prediabetes), 19.9% of those in NHANES 2007-2008 and 22.4% in the NHANES 2009-2010 showed to have prediabetic A1c levels. When separately examining each of the five ethnic groups who self-reported not having prediabetes, all showed an increase in those with prediabetic A1c levels from NHANES 2007-2008 to NHANES 2009-2010. Through χ^2 analysis, all five ethnic groups who self-reported not having prediabetes showed significant differences ($P < 0.0001$) in all A1c levels (normoglycemic, prediabetic and diabetic) from NHANES 2007-2008 to NHANES 2009-2010.

CONCLUSION: The findings highlight the need of prediabetes awareness and of education in the community

as ways to reduce the number of people with prediabetes.

Core tip: The National Health and Nutritional Examination Survey (NHANES) 2007-2008 and NHANES 2009-2010 data sets were used. In these data sets, trends and differences in normoglycemic, prediabetic and diabetic A1c levels among five different ethnic groups are explained in detail. Significance of these findings, limitations of these data sets, and community-based initiatives are discussed.

INTRODUCTION

Prediabetes affects an estimated 79 million adults in the United States[1]. It is projected that by 2020, 52% of United States adults will have either prediabetes or diabetes[2]. Prediabetes is usually asymptomatic and is defined as "blood glucose levels higher than normal but not high enough for diabetes"[3]. A report from the Centers for Disease Control and Prevention (CDC)[4] indicated that only 11% of those with prediabetes are aware of having it. According to the American Diabetes Association[5], 65% of those with diabetes were aware of having it.

There are three methods [*i.e.*, fasting plasma glucose (FPG), glycosylated hemoglobin (A1c) and 2-h oral glucose tolerance test] used to measure prediabetes and diabetic ranges, but the most common clinical tool used to measure and test blood glucose levels for diagnosing diabetes (*i.e.*, A1c $\geq$ 6.5%) in non-pregnant adults is (A1c)[6]. According to the National Institute of Diabetes and Digestive and Kidney Diseases[7], A1c is "a blood test that provides information about a person's average levels of blood glucose over the past 3 mo." Prediabetes is also known as impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT), which are the leading risk factors for diabetes[8]. Of those with prediabetes, 15%-30% will progress and develop diabetes within 5 years[9]. But, if a person with prediabetes makes lifestyle changes (*i.e.*, lose weight and increase physical activity), blood glucose levels could potentially return to normal. For example, the Diabetes Prevention Program (DPP) showed that people with prediabetes can often prevent or delay diabetes if a person loses a modest amount of weight (*i.e.*, 5%-7% of body weight) and increases physical activity, allowing blood glucose levels to return to normal[10]. The DPP study and other studies have shown that with lifestyle changes, prediabetes could be reversed and diabetes avoided. Hence, early diagnosis, treatment and management of prediabetes could avoid, reduce or delay its progression to diabetes and diabetes-related complications (*e.g.*, heart disease and stroke).

The number of people with diabetes in the United States is rapidly growing, the ethnic diversity is changing, and there is a disproportionate prevalence of diabetes in some ethnic groups. It is important to know if this is the same for prediabetes. Data on prediabetes is scarce, which makes knowing the prevalence of those with prediabetes necessary, including those with reversed prediabetes, and undiagnosed diabetes, including differences among ethnic/racial groups. Another important trend to examine are those with undiagnosed prediabetes. Table 1 has the definitions of diagnosed, undiagnosed and reversed prediabetes, and undiagnosed diabetes.

As prediabetes is detectable, treatable and reversible, it is especially important that its trends be monitored in diverse populations. Also, given that prediabetes is a risk factor for diabetes, it is vital to examine trends of those with undiagnosed diabetes among different ethnic/racial groups. Therefore, descriptive data on United States Non-Hispanic Whites, Non-Hispanic Blacks, Mexican Americans, Other Hispanics, and Other/Multi-racial groups with prediabetes presents vital information regarding trends and differences in the prevalence of reversed, diagnosed and undiagnosed prediabetes, and undiagnosed diabetes, including the distribution by ethnicity among these groups.

Literature review

Three different PUBMED searches were conducted of articles published from January 2003 to June 2013. One search used the key words prediabetes, which identified 2094 studies. Another used the keywords prediabetes and ethnic groups, which identified 73 articles. Of those 73 results, 59 were studies conducted in the United States, and 14 were conducted outside the United States. Of the 59 United States studies, 28 included more than one ethnic group, and of the 14 non-United States studies, 8 included more than one ethnic group. The keywords prediabetes and ethnic groups and race identified 45 studies, and the keywords prediabetes and ethnic groups and race and undiagnosed identified 4 studies, all of which were part of the 73 identified from the previous keyword search. Hence, these 4 studies were the final articles considered for this review.

One study using NHANES data reported findings of metabolic syndrome on four ethnic groups (*i.e.*, Non-Hispanic White, Non-Hispanic Black, Hispanics and Others)[11]. A second study using NHANES reported prediabetes trends from 1988-2008 among different ethnic groups (*i.e.*, Non-Hispanic Black, Non-Hispanic White, and Mexican American/Other Hispanic)[12]. The study reported that Non-Hispanic Blacks had a significantly higher prediabetes rate than Non-Hispanic

Table 1 Definitions of current study variables within different groups

Different groups	Responses and A1c levels
Prediabetes group	
Self-reported Prediabetes	"Yes" response to "ever told you have prediabetes," and a "no" response to "doctor told you have diabetes."
Reversed prediabetes	Self-reported "yes" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have normoglycemic A1c levels (< 5.7%).
Diagnosed prediabetes	Self-reported "yes" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have prediabetic A1c levels (5.7%-6.4%).
Undiagnosed diabetes	Self-reported "yes" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have diabetic A1c levels ($\geqslant$ 6.5%).
Non-Prediabetes group	
Self-reported non-prediabetes	"No" response to "ever told you have prediabetes," and a "no" response to "doctor told you have diabetes."
Not having prediabetes	Self-reported "no" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have normoglycemic A1c levels (< 5.7%).
Undiagnosed prediabetes	Self-reported "no" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have prediabetic A1c levels (5.7%-6.4%).
Undiagnosed diabetes	Self-reported "no" response to "ever told you have prediabetes," "no" response to "doctor told you have diabetes" and have diabetic A1c levels ($\geqslant$ 6.5%).

Whites, but Mexican Americans and Other Hispanic rates were not significantly higher than Non-Hispanic Whites. Unlike the study by Sentell *et al*[12] the current study includes the most recent NHANES data currently available, examining NHANES 2007-2008 and NHANES 2009-2010 data of those with prediabetes, undiagnosed prediabetes and undiagnosed diabetes among five specific ethnic/racial groups (Non-Hispanic Whites, Non-Hispanic Blacks, Mexican Americans, Other Hispanics, and Other/Multiracial).

Purpose

The purpose of this article is twofold: (1) to investigate A1c levels for normoglycemia, prediabetes and diabetes prevalence in those with self-reported prediabetes; and (2) to investigate A1c levels for prediabetes and diabetes in those with self-reported non-prediabetes (*i.e.*, self-report indicates has not ever had prediabetes).

This study will begin to address a research gap by reporting on the results of a secondary analysis of A1c levels among five ethnic groups (Non-Hispanic Whites, Non-Hispanic Blacks, Mexican Americans, Other Hispanics and Other/Multiracials) who self-reported prediabetes and who self-reported non-prediabetes, in order to discuss methods of enhancing community outreach in this population. While further research on prediabetes is essential, the findings in this article also discusses community initiatives that health care providers can implement to integrate prediabetes awareness, care and management goals into practice for their patients with prediabetes.

Research hypotheses

This study's hypotheses were as follows: (1) There are significant differences between normoglycemic, prediabetic and diabetic A1c levels among five different ethnic groups (Non-Hispanic Whites, Non-Hispanic Blacks, Mexican Americans, Other Hispanics and Other/Multiraical) with self-reported prediabetes; and (2) There are significant differences between prediabetic and diabetic

A1c levels among the five different ethnic groups (Non-Hispanic Whites, Non-Hispanic Blacks, Mexican Americans, Other Hispanics and Other/Multiraical) with self-reported non-prediabetes.

MATERIALS AND METHODS

The National Center for Health Statistics (NCHS), which is part of the CDC, designs, develops and maintains health-related systems and surveys; and collects United States demographic and health and nutritional data[13]. Among its surveys are NHANES 2007-2008 and NHANES 2009-2010. As part of each survey design, NCHS provides weights for researchers to use for data analysis; the method of usage for NHANES 2007-2008 is in the Analytic and Reporting Guidelines. NHANES design, survey methods, examination and laboratory techniques, and sample selection have been reported previously in detail[14].

Sample

For NHANES 2007-2008 and NHANES 2009-2010, data were collected on a probability sample of the entire civilian, non-institutionalized United States population categorized by ethnic group: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black and Other/Multiracial.

Both NHANES surveys contained questionnaire and laboratory data. Secondary analysis of the raw data utilized the sample weight representing the sample population provided by NHANES 2007-2008 and NHANES 2009-2010 surveys. Details on the NHANES sample procedures are outlined in Aponte[14].

Sample selection procedures

For the current study, participants were limited to members of each of the five ethnic groups, 20 years of age and older, who had completed the diabetes questionnaire and had A1c measured. The demographic variables of age and gender were also included in this study but not

identified as risk factors. The current study utilized a number of different self-reported data. Table 1 provides the definitions of variables for two groups: those with self-reported prediabetes and non-prediabetes. Both questions were in the diabetes questionnaires of the NHANES surveys. The prediabetes question "ever told you have prediabetes" included the terms IFG, IGT or borderline diabetes in the question and these terms were explained as "blood sugar (glucose) level that are higher than normal but not high enough to be diabetes". In addition, the prediabetes question is not specific to the current prediabetes status. In order to ensure that these participants had not converted to having diabetes, a diabetes question (*i.e.*, "doctor told you have diabetes") was included in the data analysis. Only those who responded "no" to this diabetes question were included in all of the analysis of this current study.

Additional self-reported data were: age, ethnicity, pregnancy status from questionnaires, as well as A1c levels collected from laboratory findings. According to the ADA[6], an A1c of less than 5.7% means normoglycemic levels (*i.e.*, no prediabetes or diabetes); 5.7% to 6.4% is prediabetes, and 6.5% and greater means diabetes. Normoglycemic, prediabetic and diabetic A1c levels were examined in both the self-reported prediabetes and non-prediabetes groups.

A1c is used to diagnose prediabetes and diabetes in non-pregnant adults. To ensure the sample were not pregnant, a reproductive question regarding pregnancy status was included in data analysis. In both the NHANES 2007-2008 and NHANES 2009-2010 surveys, the reproductive question (*i.e.*, "are you pregnant now?") was only asked of women 20 to 59 years of age. This reproductive question was not asked of women 60 years and older or of men, and for this reason the question was only included in the data analysis for women 20-59 years of age. To ensure all participants in the current study were non-pregnant adults, each of the following ways to stratify were used in the analysis for both groups (prediabetes and non-prediabetes): (1) self-reported prediabetes or self-reported non-prediabetes, and women 20 to 59 years of age who responded "no" to the reproductive health question; (2) self-reported prediabetes or self-reported non-prediabetes and all adult men; or (3) self-reported prediabetes or self-reported non-prediabetes in women 60 years of age and older. This created a total of three groups in those who self-reported prediabetes and three groups in those who self-reported non-prediabetes. The three groups in each category (self-reported prediabetes and non-prediabetes) were combined for the analysis of this current study.

Secondary analysis of NHANES 2007-2008 and NHANES 2009-2010 raw data was approved with exempt status by the Hunter College Human Research Protection Program Office, Institutional Review Board of Hunter College, City University of New York.

Data collection
Original collection measures: Data collection for NHANES 2007-2008 and NHANES 2009-2010 occurred through personal interviews (initial questionnaire component);

and health examinations (supplemental questionnaires, physical examination and laboratory component).

The NHANES 2007 to 2008 and NHANES 2009 to 2010 phase 1 consisted of two questionnaires: (1) sample questionnaire, which included questions on individual health status, including self-report of prediabetes and diabetes diagnosis; and (2) family questionnaire, which included self-reported questions on family members.

The health examinations were conducted in a mobile examination center, where each participant was physically examined. A laboratory component included blood tests of A1c levels for diabetes risk and status. Other questionnaires included information on physical activity, tobacco use, prostate conditions for men, reproductive history for women, sexual activity, alcohol consumption, and drug use.

The method used to administer the questions in phase 2 was the same as the method used to collect NHANES 2007 to 2010 data, as previously described by Aponte[14]. The NHANES 2007 to 2008 and NHANES 2009 to 2010 data are stored by NCHS and can be downloaded for review and analysis.

Current study collection measures: For the current study, raw data from the NHANES 2007 to 2008 and NHANES 2009 to 2010 data sets were used to examine ethnicity (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other/Multi racial) and A1c levels.

For descriptive analysis, A1c levels were examined in two groups independently, those who: (1) self-reported prediabetes; and (2) non-prediabetes. To facilitate analysis, numerical values differentiating normoglycemic (< 5.7%) from prediabetic (5.7%-6.4%) or diabetic levels ($\geq$ 6.5%) were created.

Statistical analysis
All data analysis was conducted by utilizing NCHS's recommended weights, available in the NHANES 2007-2008 and NHANES 2009-2010[15] data sets. The NHANES 2007-2008 and NHANES 2009-2010 data on diabetes, reproductive interview and laboratory data were reported as overall raw data without statistical analysis. Descriptive statistics were computed for all variables to examine the prevalence of normoglycemic, prediabetic and diabetic ($\geq$ 6.5%) A1c levels among five ethnic groups with self-reported prediabetes, and prediabetic and diabetic A1c levels in those with self-reported non-diabetes. χ^2 of independence were used to compute significance differences among all five ethnic groups. The significance level used in this current study was $P < 0.05$. Findings reported are those that were or were not significant. In this secondary analysis, the raw data were analyzed by using the statistical software product SAS version 9.3© (SAS Institute Inc, Cary, NC).

RESULTS
Self-reported prediabetes
Descriptive analysis: The total weighted sample of NH-

Table 2 United States Population 20 years and older with self-reported prediabetes *n* (%)

Glycated hemoglobin (A1c)	Self-report of: "Yes" ever being told they have prediabetes; and "No" being told they had diabetes	
	NHANES 2007-2008 Weighted	NHANES 2009-2010 Weighted
Normoglycemic levels (< 5.7%) reversed prediabetes	3565229/6566166 (54.3)	3281804/7569333 (43.4)
Prediabetic levels (5.7%-6.4%) prediabetes	2435163/6566166 (37.1)	3071030/7569333 (40.6)
Diabetic levels (> 6.5%) undiagnosed/unaware diabetes	564774/6566166 (8.6)	1216499/7569333 (16.0)
Total	*n* = 6566166	*n* = 7569333

Table 3 Percentage of different ethnic groups 20 years and older with self-reported prediabetes *n* (%)

	NHANES 2007-2008			NHANES 2009-2010		
Ethnicity	Weighted	SD		Weighted	SD	*P*
Mexican American	325142/6566166 (5.0)			379370/7569333 (5.0)		
Normoglycemic A1c (< 5.7%)	102664/325142 (31.6)	0.33		154730/379370 (40.8)	0.43	< 0.0001
Prediabetic A1c (5.7%-6.4%)	140099/325142 (43.1)	0.46		161539/379370 (42.6)	0.43	< 0.0001
Diabetic A1c (≥ 6.5%)	82379/325142 (25.3)	0.44		63101/379370 (16.6)	0.22	0.8521
Other Hispanic	172116/6566166 (2.6)			175097/7569333 (2.3)		
Normoglycemic A1c (< 5.7%)	94137/172116 (54.7)	0.16		104638/175097 (59.8)	0.43	0.3841
Prediabetic A1c (5.7%-6.4%)	73430/172116 (42.7)	0.43		56802/175097 (32.4)	0.42	0.3472
Diabetic A1c (≥ 6.5%)	4549/172116 (2.6)	0.36		13657/175097 (7.8)	0.12	0.9457
Non-Hispanic White	4757294/6566166 (72.5)			5976593/7569333 (79.0)		
Normoglycemic A1c (< 5.7%)	2571794/4757294 (54)	0.46		2696814/5976593 (45.1)	0.4	0.7869
Prediabetic A1c (5.7%-6.4%)	1872875/4757294 (39.4)	0.43		2311252/5976593 (38.7)	0.4	0.0222
Diabetic A1c (≥ 6.5%)	312625/4757294 (6.6)	0.23		968527/5976593 (16.2)	0.09	0.0024
Non-Hispanic Black	645476/6566166 (9.8)			757648/7569333 (10)		
Normoglycemic A1c (< 5.7%)	269742/645476 (41.8%)	0.46		212317/757648 (28%)	0.44	< 0.0001
Prediabetic A1c (5.7%-6.4%)	210513/645476 (32.6%)	0.42		483049/757648 (63.8%)	0.44	< 0.0001
Diabetic A1c (≥ 6.5%)	165221/645476 (25.6%)	0.43		62282/757648 (8.2%)	0.16	< 0.0001
Other/Multi-Racial	666138/6566166 (10.1%)			280625/7569333 (3.7%)		
Normoglycemic A1c (< 5.7%)	527892/666138 (79.2%)	0.27		113305/280625 (40.3%)	0.41	0.0104
Prediabetic A1c (5.7%-6.4%)	138246/666138 (20.8%)	0.27		58388/280625 (20.8%)	0.41	0.7737
Diabetic A1c (≥ 6.5%)	0/666138 (0.0%)	0.00		108932/280625 (38.8%)	0.13	0.0067
Total	*n* = 6566166			*n* = 7569333		

SD: Shine-dalgarnosequence.

ANES 2007-2008 (*n* = 6566166) and NHANES 2009-2010 (*n* = 7569333) comprised all participants aged 20 years and older with self-reported prediabetes (Table 2). For those with self-reported prediabetes, normoglycemic (< 5.7%), prediabetic (5.7%-6.4%) and diabetic (≥ 6.5%) A1c levels were examined. Of the total weighted sample in NHANES 2007-2008 and NHANES 2009-2010, there was a rise in the percentage of those participants with prediabetes (37.1% and 40.6%, respectively) and diabetic (8.6% and 16%, respectively) A1c levels, and a decrease in those with normoglycemic A1c levels (54.3% and 43.4%, respectively) (Table 2). When examining ethnic groups in NHANES 2007-2008 and NHANES 2009-2010, Non-Hispanic Whites (72.5% and 79%, respectively) had the largest growing percentage of self-reported prediabetes, followed by Non-Hispanic Blacks (9.8% and 10%, respectively). Other/Multi-racials (19.1% and 3.7%, respectively) and Other Hispanics (2.6% and 2.3%, respectively) were two ethnic groups who had a reduction in the number of people with self-reported prediabetes from NHANES 2007-2008 to NHANES 2009-2010. Mexican Americans were the only ethnic

group in which the combined percentage of normoglycemic, prediabetic and diabetic A1c levels, remained at 5% in both NHANES 2007-2008 and NHANES 2009-2010 surveys (Table 3).

χ^2: When analyzing each A1c level separately, there were differences in normoglycemic (< 5.7%), prediabetic (5.7%-6.4%) and diabetic (≥ 6.5%) A1c levels among the five ethnic groups with self-reported prediabetes in NHANES 2007-2008 and NHANES 2009-2010. There was a significant increase in the proportion of those Mexican Americans with self-reported prediabetes and a normoglycemic (< 5.7%) A1c level (31.6% and 40.8%, respectively, $P \leq 0.0001$); and a significant decrease for those with prediabetic (5.7%-6.4%) A1c levels (43.1% and 42.6%, respectively, $P \leq 0.0001$) from the NHANES 2007-2008 to NHANES 2009-2010 surveys. Although not significant, there was a slight increase in the proportion of those Other Hispanics with self-reported prediabetes who had a normoglycemic (< 5.7%) (54.7% and 59.8%, respectively, $P = 0.3841$) and diabetic (≥ 6.5%) (2.6% and 7.8%, respectively, $P = 0.9457$) A1c levels. For

Table 4 United States population 20 years and older with self-reported non-prediabetes _n_ (%)

Glycated hemoglobin (A1c)	Self-report of: "No" ever being told they have prediabetes; and "No" being told they had diabetes	
	2007-2008 weighted	2009-2010 weighted
Normoglycemic levels (< 5.7%) no prediabetes or diabetes	128918166/164914962 (78.2)	122536437/161120813 (76.0)
Prediabetic levels (5.7%-6.4%) undiagnosed/unaware prediabetes	32926568/164914962 (19.9)	36065705/161120813 (22.4)
Diabetic levels (≥ 6.5%) undiagnosed/unaware diabetes	3070228/164914962 (1.9)	2518671/161120813 (1.6)
Total	_n_ = 164914962	_n_ = 161120813

Table 5 Different ethnic groups 20 years and older with self-reported non-prediabetes _n_ (%)

NHANES 2007-2008		NHANES 2009-2010	
Ethnicity	Weighted	Weighted	_P_
Mexican American	15104701/164914962 (9.2)	15411565/161120804 (9.6)	
Normal (A1c ≤ 5.7%)	12524514/15104701 (82.9)	11245974/15411161 (73)	< 0.0001
Prediabetes (A1c= 5.7%-6.4%)	2248885/15104701 (14.9)	3608202/15411161 (23.4)	< 0.0001
Diabetes (A1c ≥ 6.5%)	331302/15104701 (2.2)	557389/15411161 (3.6)	< 0.0001
Other Hispanic	8878061/164914962 (5.4)	8645012/161120804 (5.4)	
Normal (A1c ≤ 5.7%)	7011142/8878061 (78.9)	6519914/8645012 (75.4)	< 0.0001
Prediabetes (A1c= 5.7%-6.4%)	1655906/8878061 (18.7)	1950442/8645012 (22.6)	< 0.0001
Diabetes (A1c ≥ 6.5%)	211013/8878061 (2.4)	174656/8645012 (2)	< 0.0001
Non-Hispanic White	113923737/164914962 (69.1)	109714993/161120804 (68.1)	
Normal (A1c ≤ 5.7%)	90029378/113923737 (79)	85687554/109714993 (78.1)	< 0.0001
Prediabetes (A1c = 5.7%-6.4%)	22273553/113923737 (19.6)	22770821/109714993 (20.8)	< 0.0001
Diabetes (A1c ≥ 6.5%)	1620806/113923737 (1.4)	1256618/109714993 (1.1)	< 0.0001
Non-Hispanic Black	17698774/164914962 (10.7)	17766570/161120804 (11)	
Normal (A1c ≤ 5.7%)	12238510/17698774 (69.1)	11922107/17766570 (67.1)	< 0.0001
Prediabetes (A1c = 5.7%-6.4%)	4864294/17698774 (27.5)	5436479/17766570 (30.6)	< 0.0001
Diabetes (A1c ≥ 6.5%)	595970/17698774 (3.4)	407984/17766570 (2.3)	< 0.0001
Other/Multi-Racial	9309689/164914962 (5.6)	9582664/161120804 (5.9)	
Normal (A1c ≤ 5.7%)	7114622/9309689 (76.4)	7160888/9582664 (74.7)	< 0.0001
Prediabetes (A1c = 5.7%-6.4%)	1883930/9309689 (20.2)	2299761/9582664 (24)	< 0.0001
Diabetes (A1c ≥ 6.5%)	311137/9309689 (3.4)	112015/9582664 (1.2)	< 0.0001
Total	_n_ = 164914962	_n_ = 161120804	

Non-Hispanic Whites with prediabetes, there was a significant decrease in those with a prediabetic (5.7%-6.4%) (39.4% and 38.7%, respectively, _P_ = 0.0222) A1c levels and a significant decrease in those with diabetic (≥ 6.5%) (6.6% and 16.2%, respectively, _P_ = 0.0024) A1c levels. There was a significant increase in prediabetic (5.7%-6.4%) (32.6% and 63.8%, respectively, _P_ ≤ 0.0001) A1c levels for Non-Hispanic Blacks with self-reported prediabetes, and significant decreases in those with normoglycemic (< 5.7%) (41.8% and 28%, respectively, _P_ ≤ 0.0001) and diabetic (≥ 6.5%) (25.6% and 8.2%, respectively, _P_ ≤ 0.0001) A1c levels. For Other/Multi-racials with self-reported prediabetes, there was a significant reduction of those with a normoglycemic (<5.7%) A1c levels (79.2% and 40.3%, respectively, _P_ = 0.0104) and a significant increase in those with diabetic (≥ 6.5%) (0% and 38.8%, respectively, _P_ = 0.0067) A1c levels (Table 4).

Self-reported: Non-prediabetes
Descriptive analysis: The total weighted sample of NHANES 2007-2008 (_n_ = 164914962) and NHANES 2009-2010 (_n_ = 161120813) comprised all participants aged 20 years and older with non-prediabetes based on self-report. For this group, over 19% of the participants in the NHANES 2007-2008 and NHANES 2009-2010 surveys had prediabetes based on A1c levels (Table 4). For all five ethnic groups, based on A1c levels, there was an increase in those with prediabetes (5.7%-6.4%) and a reduction in diabetes (≥ 6.5%), except for Mexican Americans (Table 5).

χ^2: There was significant differences for all ethnic groups in all A1c levels in participants of the NHANES 2007-2008 and NHANES 2009-2010 surveys (Table 5).

Overall, for those in both categories – self-reported prediabetes and self-reported non-prediabetes – there was a combined total of 2.1% (3635002) in NHANES 2007-2008 and 2.3% (3735170) in NHNAES 2009-2010 with undiagnosed diabetes.

DISCUSSION
Self-reported prediabetes
The current study demonstrates a shift in those with self-reported prediabetes in NHANES 2007-2008 (6566166) and NHANES 2009-2010 (7569333). In this sample finding, there was a 10.9% decrease in normoglycemic A1c levels (reversed prediabetes), a 3.5% increase in

prediabetic and a 7.4% increase in diabetic A1c levels from NHANES 2007-2008 to NHANES 2009-2010. This shows an inverse change, indicating that the two NHANES surveys are 2-year apart, potentially those who once had reversed prediabetes in NHANES 2007-2008 developed either prediabetes or diabetes in NHANES 2009-2010. Studies have shown that most with prediabetes will develop diabetes within 10 years unless they make lifestyle changes (losing 5%-7% of their body weight and increase physical activity)[10].

When examining different ethnic groups, the current study demonstrates that the number of Mexican Americans, Other Hispanics and Non-Hispanic Whites with self-reported prediabetes and a prediabetic A1c level either decreased or remained the same, but Non-Hispanic Blacks nearly doubled (32.6% and 63.8%, respectively). There is no published data on the number of Non-Hispanic Blacks with prediabetes, but it is known that Non-Hispanic Black adults are twice as likely than Non-Hispanic Whites to have diagnosed diabetes[16]. The findings of this study indicate that it is the same for Non-Hispanic Blacks with prediabetes.

Given the paucity of prediabetes data on different ethnic groups, this current study showed a shift from prediabetic and diabetic A1c levels from NHANES 2007-2008 and NHANES 2009-2010. First, there was a reduction of prediabetic A1c levels (10.3%) in Other Hispanics, but an increase with diabetic (5.2%) A1c levels. There was a reduction in normoglycemic (8.9%) and prediabetic (0.7%) A1c levels in Non-Hispanic Whites, but an increase in diabetic (9.6%) A1c levels. Finally, there was a reduction in normoglycemic (38.9%) A1c levels, which was directly reflected in an increase in diabetic (38.9%) A1c levels in Other/Multi-racials. These findings show that, among these three ethnic groups with self-reported prediabetes who had either normoglycemic or prediabetic A1c levels, more than half of them actually had diabetic A1c levels, showing they were undiagnosed and unaware of having diabetes. These findings support the CDC study, which reports that 90%-95% of all cases of diabetes are of people who once had prediabetes[4], and who are at high risk of developing diabetes complications, resulting from a lack of treatment and management of the disease.

Non-prediabetes

The current study demonstrates that of the total weighted sample in NHANES 2007-2008 (164914962) and NHANES 2009-2010 (161120813), there was a rise in the percentage of those participants within those time-frames with undiagnosed prediabetic (19.9% and 22.4%, respectively) A1c levels, but a slight reduction of those with undiagnosed diabetic (1.9% and 1.6%, respectively) A1c levels. More than 20% of these participants either had undiagnosed prediabetes or diabetes (Table 4). For ethnic groups with non-prediabetes, there was a rise in the combined percentages of both undiagnosed prediabetes and diabetes in those from NHANES 2007-2008

to NHANES 2009-2010. The largest increase was among Mexican Americans: in NHANES 2007-2008, there was a combined 17.1% of Mexican Americans with undiagnosed prediabetes and diabetes. In NHANES 2009-2010, it had increased to 27% (Table 5). But when combining undiagnosed prediabetes and undiagnosed diabetes among both groups (self-reported prediabetes and self-reported non-prediabetes), the percentage of those with undiagnosed prediabetes and diabetes is 22.9%. These findings show that these groups who are undiagnosed are also unaware of their condition and risks, making early identification and improved awareness of prediabetes and diabetes critical first steps to motivate and encourage them to make healthy lifestyle changes.

Overall, from 2007-2009, the number of people who self-report their prediabetes has grown. There have also been a growing number of people with undiagnosed diabetes who are unaware of their condition. Those with undiagnosed diabetes had A1c levels indicating they had the disease, yet self-reported not having prediabetes or diabetes. Given that diabetes is a growing epidemic, it is essential and vital that awareness on the importance of those with risk for developing diabetes occurs early. It also is important for healthcare providers to actively screen those at risk for diabetes. These growing numbers of people with undiagnosed prediabetes and diabetes is a grave concern, given the lack of preventative care, treatment (e.g., medications) and of overall healthcare services (i.e., receiving a glucometer) they are not receiving and initiating. Hence, it is especially important that prediabetes trends and differences in the prevalence of reversed, diagnosed and undiagnosed prediabetes, and undiagnosed diabetes, including the prevalence of ethnicity among these groups be monitored.

Implications for Practice

There are evidenced-based recommendations, which were developed by the American College of Endocrinology (ACE) and the American Association of Clinical Endocrinologists (AACE)[17]. In addition, the AACE has an algorithm specific for prediabetes management[18]. These recommendations and algorithm were developed for all healthcare providers, and can be used in any healthcare setting, with the goal of maintaining normal blood pressure, lipid and glucose control. The recommendations emphasize that people with prediabetes should follow the same management goals as those with diabetes. They provide treatment modalities for people with prediabetes which can be provided in any setting. For example, in an outpatient setting, the healthcare provider, during assessment, has the opportunity to gather the patient's prediabetes health history (diabetes family history, overweight or obese status or sedentary lifestyle); develop with the patient an individualized, patient-centered prediabetes plan of care; teach patients that prediabetes is a risk factor for diabetes; teach normal A1c, blood pressure and lipid levels; and evaluate the patient's adherence to the treatment plan. Also, the provider would include in the teach-

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