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Research Article

Prevalence of Metabolic Conditions Differentiated by BMI in U.S. Adults

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ABSTRACT

Introduction: To investigate the prevalence of metabolic conditions by body mass index (BMI) in U.S. adults, with metabolic conditions including type 2 diabetes (T2D), hypertension and dyslipidemia for overall and undiagnosed conditions.

Methods: Adult participants were from the U.S. CDC 2013-2014 National Health and Nutrition Examination Survey. BMI categories were: under/normal weight (BMI < 25kg/m^2), overweight (25≤ BMI<30 kg/m^2) and obese (BMI ≥30 kg/m^2). The weighted prevalence and its 95% confidence interval by BMI were calculated. The proportional test identified if a significant difference in the prevalence of metabolic conditions existed using under/normal as the reference.

Results: The overall weighted prevalence of diabetes, hypertension, high cholesterol and overall abnormal cardiometabolic conditions were 16.1%, 60.3%, 57.5% and 76.3%, respectively, and 8.8%, 11.3%, 16.8% and 30.2%, respectively for the undiagnosed conditions. The prevalence of each metabolic condition increased with increasing BMI. However, among black participants, individuals with under/normal weight had a significant higher prevalence of undiagnosed T2D compared to their obese peers (12.1% vs. 7.5%).

Discussion: This study showed a notable fraction of U.S adults were suffering undiagnosed metabolic conditions, BMI remains a useful tool for identifying those at high risk for cardiometabolic conditions, however, racial differences in diseases by BMI existed.

Introduction

Cumulative evidence show that early detection and treatment could prevent or delay adverse outcomes [1-3]. However, a significant proportion of U.S adults with poor cardiometabolic health remain undiagnosed. Efficient monitoring of the undiagnosed population can be accomplished by distinguishing them by their body mass index (BMI) to identify clustering of vulnerable groups. It is well-established in epidemiological studies that cardiometabolic abnormalities including hypertension, high cholesterol and type 2 diabetes (T2D), and subsequent adverse events such as cardiovascular disease and chronic kidney disease can be attributed to a high BMI [4-11]. However, although the strong links between obesity and cardiovascular disease and related disease outcomes are well-established, cardiometabolic abnormalities may also cluster in normal weight individuals. For instance, in a cross-sectional study of two large community based cohorts from five racial/ethnic groups in the U.S, nearly one-third of all normal weight participants had at least two metabolic abnormalities, with the highest prevalence of 44% observed in South Asians [12]. Similar findings have also been noted by other studies suggesting that established BMI cut-off points may not correlate with cardiometabolic health in racial/ethnic minorities [13, 14]. These findings motivate our examination of cardiometabolic abnormalities in the undiagnosed U.S. population and our expanded focus beyond BMI categories of overweight and obese.

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Hence, this research study complements the existing literature by quantifying the prevalence of hypertension, dyslipidemia, T2D and abnormal cardiometabolic conditions by BMI categories and other sociodemographic factors in U.S adults with a focus on undiagnosed participants. In addition, our study updates previous findings on the prevalence of hypertension by defining this disease as a blood pressure reading of 130/80 mm Hg rather than 140/90 mm Hg based on new guidelines released by the American College of Cardiology and the American Heart Association in 2017 [15].

Methods

Multiple datasets were extracted from the 2013-2014 NHANES. Through multistage probability sampling, the NHANES obtains a representative sample of all civilian non-institutionalized people in the U.S. Oversampling was applied to different sub-populations to improve estimation accuracy. The current study included participants aged ≥ 20 years old who had completed examination for blood pressure, BMI, and laboratory tests for diabetes, and cholesterol and interviews for demographics and other related health issues. The Ethnics Review Board in the U.S. National Center of Health Statistics approved the study NCH IRB/ERB protocol #2011-2017 for 2013-2014 cycles.

I Body Mass Index (BMI)

BMI is a surrogate measure of body fat based on body height and weight, where BMI is defined as weight in kilograms (kg) divided by the square of height in meters (m^2). Three categories were used in this study: BMI<25kg/m^2 (under/normal weight), 25 ≤ BMI <30 kg/m^2 (overweight) and BMI ≥30 kg/m^2 (obese).

II Type 2 Diabetes (T2D)

Type 1 and type 2 diabetes were not distinguished in NHANES. However, this study excluded those with a high probability of type 1 diabetes by eliminating participants who were diagnosed with diabetes at age 25 years old or less or were being treated with insulin from the dataset [15, 16]. Three laboratory measures of diabetes, including glycated hemoglobin A_{1c} in blood, fasting plasma glucose (FPG) and a 2-hour plasma glucose (PG), were collected. Participants categorized as having T2D if they were diagnosed with diabetes by a doctor or other health professional or exhibited any of the following three conditions: (1) hemoglobin A_{1c} ≥ 6.5%, (2) FPG ≥126 mg/dL, (3) PG ≥200 mg/dL.

III Hypertension

Certified blood pressure examiners, who completed a training program from Shared Care Research and Education Consulting, measured participants' blood pressure using mercury sphygmomanometer and appropriate-size arm cuffs. Three consecutive systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings were recorded after resting for 5 minutes quietly in a sitting position. A fourth reading was made if there was an interruption. The calculation of the average SBP and DBP was based on individual readings according to the NHANES specifications. Hypertension was present if the participant was diagnosed by a health professional or exhibited at least one of two conditions (1) average SBP was ≥130 mm Hg or (2) average DBP was ≥ 80 mm Hg.

IV Dyslipidemia

Dyslipidemia was defined using the criteria set by the National Cholesterol Education Expert Panel [16]. Participants were categorized as having a form of dyslipidemia if they were diagnosed by a health professional or if the following conditions were present in lipd profile measures: (1) total cholesterol ≥ 240mg/dL or (2) low density lipoprotein (LDL) cholesterol ≥ 160mg/dL (high LDL-C) or (3) high density lipoprotein (HDL) cholesterol ≤ 40mg/dL (low LDL-C) or (4) triglycerides ≥ 200mg/dL.

V Abnormal Cardiometabolic Conditions

T2D, hypertension and dyslipidemia were considered in this study. Individuals were categorized as having an abnormal cardiometabolic condition if they had at least one of these three conditions.

VI Diagnosis Status

An individual was referred to as undiagnosed if their chronic condition – hypertension, dyslipidemia and diabetes – were first identified during the testing procedures for the NHANES survey. Diagnosed participants were those who received a formal diagnosis for hypertension, high cholesterol and diabetes from a doctor or another health professional.

VII Demographics and Socioeconomic Status (SES)

Demographic variables included three self-reported variables: age (years), gender (male, female) and race/ethnicity (Hispanic, White, Black and other races). Age was stratified as 20-39 years, 40-59 years and ≥60 years. SES included family poverty and education levels. According to federal poverty level (FPL) guidelines, poverty level (PL) was categorized into three groups: PL<100% FPL, 100%FPL ≤ PL<300%FPL and PL≥300%FPL. Education had three categories: <12 years, 12 years (equivalent to high school diploma), and >12 years of education.

VIII Statistical Analysis

In this study, the weighted prevalence of four outcomes (T2D, hypertension, dyslipidemia and abnormal metabolic conditions) by BMI categories and within each subgroup were calculated for U.S adults and by diagnosis status. The corresponding weighted 95% confidence interval (CI) were also calculated. By treating under/normal weight as the reference, the proportional test was used to identify if significant prevalence existed in two comparisons of each of these scenarios: overweight vs. under/normal weight and obese vs. under/normal weight. A p-value of less than 0.05 was considered statistically significant. All data management and data analyses were performed using the Statistical Analysis System (SAS, version 9.4, Cary NC).

Results

The current study included 3,731 adults aged 20 years old or over, representing 15, 6673,899 U.S. adults, who had completed household interviews, physical examinations and related laboratory test for T2D, hypertension and dyslipidemia measures in 2013-2014. Participants had a weighted mean age (SE) of 37.6 (0.28) years old. A total of 1,135 participants were undiagnosed for at least one cardiometabolic

abnormality. The overall weighted prevalence of T2D, hypertension, dyslipidemia and comorbid conditions in the study population was 16.1%, 42.0%, 57.5% and 77.0%, respectively. The prevalence of undiagnosed diabetes, hypertension, dyslipdemia and abnormal cardiometabolic conditions are 8.8%, 12.5%, 16.8% and 30.8%, respectively. Overall, the prevalence of the examined disease conditions increased with increasing BMI in both the general population and by diagnosis status. Obese participants had the highest prevalence of T2D, hypertension, dyslipidemia and overall abnormal cardiometabolic conditions.

I Type 2 Diabetes

Table 1 showed that the prevalence of undiagnosed T2D was highest in obese individuals for variables in the following categories: 40 -59 years (13.6%), female (10.7%), and < 12 years of education (10.3%). Notably, a significantly greater prevalence of undiagnosed T2D existed among black participants in the under/normal weight category compared to those in the obese category (12.1% vs. 7.5%). In the general population, we observed a similar prevalence pattern for T2D among black adults although this was not statistically significant.

Table 1: The prevalence of total diabetes and undiagnosed diabetes by BMI among U.S. adults.

	Total T2D	Total T2D	Total T2D	undiagnosed T2D	undiagnosed T2D	undiagnosed T2D
(n)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)
Overall (3731)	14.94(12.81-17.06)	16.62(13.78-19.47)	17.24(14.47-20.01)	7.49(5.99-8.99)	9.04(6.82-11.27)	10.53(8.23-12.83) *
Age group (yrs)						
20-39 (1225)	14.35(10.80-17.90)	17.67(12.84-22.50)	15.86(11.68-20.04)	7.06(4.49-9.64)	9.22(5.52-12.92)	7.53(4.54-10.53)
40-59(1313)	15.23(11.60-18.85)	14.26(9.51-19.01)	19.95(14.56-23.35)	7.64(5.17-10.12)	8.37(4.54-12.20)	13.56(8.82-18.29) *
>=60(1193)	15.24(11.39-19.09)	18.63(13.38-23.90)	15.51(11.02-19.99)	7.80(5.03-10.57)	9.77(5.74-13.80)	10.53(6.66-14.40)
Sex						
Male (1768)	12.32(9.48-15.16)	15.23(11.15-19.32)	17.99(13.77-22.22) *	6.16(4.19-8.14)	7.51(4.42-10.61)	10.36(6.88-13.83) *
Female (1963)	17.30(14.19-20.40)	17.89(13.91-21.86)	16.54(12.92-20.17)	8.69(6.47-10.91)	10.43(7.25-13.62)	10.70(7.64-13.75)
Race/ethnicity						
White (1677)	15.44(12.51-18.36)	16.48(12.65-20.31)	16.36(12.63-20.08)	6.97(4.95-9.00)	8.57(5.60-11.55)	10.72(7.58-13.86) *
Black (746)	18.43(14.01-22.84)	13.05(8.17-17.93) *	16.22(10.87-21.57)	12.07(8.36-15.78)	9.68(5.28-14.07)	7.49(3.60-11.38) *
Hispanic (780)	10.71(7.12-14.29)	18.46(12.63-24.29)*	19.73(14.03-25.43) *	6.84(3.95-9.73)	11.14(6.40-15.89)	11.75(7.12-16.39) *
Other (528)	12.66(7.73-17.59)	20.48(12.82-28.13)*	21.21(13.43-28.98) *	6.21(2.97-9.45)	8.70(3.49-13.91)	10.48(4.64-16.32)
Poverty level						
<100% FPL (818)	15.40(11.32-19.48)	15.43(10.34-20.52)	16.69(11.20-22.18)	8.38(5.24-11.51)	8.65(4.81-12.50)	9.84(5.06-14.61)
100%FPL≤PL≤300% FPL (1486)	14.48(11.19-17.71)	14.45(10.35-18.56)	16.15(12.17-20.13)	8.10(5.64-10.56)	5.95(3.53-8.37)	10.12(6.84-13.39)
>300%FPL (1427)	15.15(11.75-18.55)	18.63(13.90-23.37)	18.19(13.67-22.72)	6.77(4.48-9.05)	11.51(7.50-15.53)*	11.05(7.29-14.81) *
Education						
<12 (1604)	12.22(7.98-16.46)	13.82(8.75-18.89)	19.62(13.68-25.56)*	6.98(3.94-10.01)	6.77(3.46-10.07)	10.33(5.83-14.83)
12(993)	16.65(11.92-21.38)	16.11(9.97-22.25)	16.43(10.78-22.09)	8.36(4.99-11.73)	8.26(3.76-12.77)	7.54(3.58-11.50)
>12(1134)	14.91(12.18-17.65)	17.46(13.67-21.25)	16.98(13.32-20.63)	7.30(5.38-9.22)	9.85(6.79-12.91)	11.58(8.41-14.75)*

*p<0.05with one tail proportion test (BMI<25 as a reference)

Table 2: Prevalence of hypertension by BMI among U.S. adults.

(n)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)
(n)	total	total	total	undiagnosed	undiagnosed	undiagnosed
Overall (3731)	32.7(29.78-35.59)	44.98(41.08-48.88)*	52.30(48.68-55.92)*	7.71(5.96-9.46)	14.08(11.31-16.85)*	17.82(15.07-20.57)*
Age group (yrs)						
20-39 (1225)	33.36(28.55-38.16)	46.89(40.51-53.28)*	52.25(46.46-58.05)*	6.92(4.11-9.73)	18.55(13.50-23.60)*	18.87(14.31-23.43)*
40-59(1313)	34.57(29.58-39.57)	42.95(36.19-49.72)*	50.08(43.68-56.49)*	8.17(5.17-11.17)	13.90(9.06-18.73)*	15.93(11.36-20.51)*
>=60(1193)	29.30(24.04-34.56)	45.37(38.30-52.44)*	55.25(48.58-61.92)*	8.04(4.75-11.33)	8.49(4.627-12.35)	18.91(13.66-24.16)*
Sex						
Male (1768)	31.15(26.86-35.44)	47.80(41.99-53.62)*	52.47(47.11-57.82)*	8.27(5.48-11.07)	16.55(12.22-20.88)*	18.71(14.61-22.82)*
Female (1963)	34.07(30.12-38.01)	42.41(37.17-45.66)*	52.14(47.21-57.07)*	7.20(5.04-9.36)	11.84(8.30-15.37)*	17.00(13.31-20.68)*
Race/ethnicity						
White (1677)	33.85(29.85-37.85)	47.12(41.88-52.37)*	52.73(47.80-57.67)*	8.80(6.36-11.26)	14.99(11.20-18.77)*	17.93(14.21-21.64)*
Black (746)	29.25(24.04-34.46)	40.62(33.52-47.73)*	48.91(41.63-56.20)*	3.60(1.62-5.59)	11.56 (7.00 – 16.13)*	13.07(8.31-17.84)*
Hispanic (780)	28.47(23.04-33.91)	40.00(32.47-47.54)*	50.91(43.91-57.91)*	5.28(2.56-7.99)	11.69(6.81 - 16.57)*	15.00(10.08-19.91)*
Other (528)	35.07(27.60-42.55)	39.85(29.74-49.97)	55.06(45.94- 64.18)*	8.63(3.46-13.80)	13.64(6.99- 20.30)	27.21(18.57-35.84)*
Poverty level						
<100% FPL (818)	33.76(28.04-39.48)	45.37(36.88-53.86)*	49.10(41.54-56.66)*	5.70(2.53-8.87)	16.90(10.24-23.55)*	18.75(12.61-24.88)*
100%FPL≤PL≤300%FPL (1486)	31.91(27.29-36.53)	41.43(35.50-47.35)*	54.61(48.99-60.23)*	8.34(5.48-11.19)	14.11(9.66-18.56)*	21.97(17.21-26.73)*
>300%FPL (1427)	32.92(28.36-37.47)	47.55(41.41-53.70)*	51.63(45.94-57.32)*	7.87(5.14-10.60)	13.20(9.05-17.36)*	14.56(10.62-18.49)*
Education						
<12 (1604)	27.45(21.50-33.41)	46.34(37.63-55.05)*	53.01(45.30-60.72)*	7.72(3.54-11.90)	16.34(9.51-23.18)*	20.01(13.90-26.12)*
12(993)	33.33(27.01-39.67)	46.33(37.86-54.80)*	58.62(51.01-66.24)*	9.08(5.02-13.13)	16.42(9.96-22.88)	19.65(13.28-26.02)*
>12(1134)	33.57(29.82-37.33)	44.19(39.15-49.23)*	50.02(45.30-54.75)*	7.23(5.07-9.39)	12.73(9.32-16.15)*	16.71(13.263-20.179)*

*p<0.05 with one tail proportion test (BMI<25 as a reference)

II Hypertension

Table 2 showed that the overall prevalence of undiagnosed hypertension was highest among obese participants in the other racial category (27.2 %), 100% FPL – 300% FPL (22%) and < 12 years of education (20%). These prevalence levels were significantly from prevalence levels in the under/normal weight category. Additionally, a significantly higher prevalence of undiagnosed hypertension existed in the overweight category compared to the under/normal weight category.

III Dyslipidemia

Altogether, significant differences in the prevalence of dyslipidemia were not preponderant among different BMI groups in the majority of the subgroups. It was observed, as seen in (Table 3), that obese individuals aged 40 - 59 years old had the highest prevalence of undiagnosed dyslipidemia (18.9%) It was interesting that obese Hispanic and other races had significantly smaller prevalence of dyslipidemia compared to their peers in the under/normal weight category.

IV Abnormal Cardiometabolic Conditions

In the final analysis with results in (Table 4), the highest prevalence of abnormal cardiometabolic conditions among undiagnosed participants was observed among those in the other racial category (41.5%) significant higher prevalence of abnormal cardiometabolic conditions for undiagnosed obese participants were observed among all age categories, males, Hispanics, other races and in the <100% FPL and >300% FPL.

Table 3: Prevalence of dyslipidemia by BMI among U.S. adults.

(n)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)
(n)	total	total	total	undiagnosed	undiagnosed	undiagnosed
Overall (3731)	58.28(55.26-61.30)	57.80(53.95-61.66)	56.01(52.42-59.60)	17.33(14.97-19.70)	15.68(12.80-18.56)	17.00(14.21-19.78)
Age group (yrs)						
20-39 (1225)	55.12(50.08-60.16)	55.79(49.44-62.14)	53.20(47.42-58.98)	14.23(10.69-17.78)	16.29(11.59-20.99)	15.95(11.54-20.35)
40-59(1313)	61.00(55.95-66.04)	61.41(54.84-67.99)	56.49(50.17-62.80)	20.32(16.08-24.57)	17.73(12.37-23.10)	18.94(13.82-24.06)
>=60(1193)	58.38(52.74-64.03)	55.29(48.22-62.36)	59.09(52.49-65.69)	16.99(12.61-21.37)	11.94(7.57-16.31)*	15.84(10.96-20.71)
Sex						
Male (1768)	56.54(51.99-61.09)	59.53(53.82-65.24)	58.68(53.42-63.94)	14.81(11.47-18.15)	15.10(10.87-19.33)	17.77(13.54-22.01)
Female (1963)	59.85(55.84-63.86)	56.23(51.00-61.47)	53.54(48.64-58.45)	19.61(16.28-22.94)	16.20(12.27-20.14)	16.28(12.62-19.95)
Race/ethnicity						
White (1677)	56.91(52.76-61.07)	58.23(53.06-63.41)	56.58(51.70-61.46)	18.44(15.14-21.73)	16.62(12.74-20.51)	17.43(13.63-21.22)
Black (746)	57.93(52.29-63.58)	56.51(49.38-63.65)	60.15(52.97-67.33)	16.86(12.53-21.20)	13.90(8.94-18.87)	15.96(10.68-21.24)
Hispanic (780)	61.93(56.07-67.80)	58.44(50.79-66.08)	52.72(45.74-59.70)*	15.50(11.24-19.77)	12.46(7.57-17.35)	17.68(12.43-22.94)
Other (528)	64.29(57.23-71.34)	54.21(43.32-65.11)	52.29(43.10-61.48)*	11.68(7.53-15.82)	15.25(5.70-24.79)	13.60(6.19-21.01)
Poverty level						
<100% FPL (818)	57.55(51.72-63.38)	59.62(51.41-67.83)	55.58(48.09-63.06)	16.39(12.25-20.54)	15.22(9.88-20.56)	18.27(11.96-24.58)
100%FPL≤PL≤300%FPL(1486)	58.13(53.31-62.96)	57.42(51.44-63.40)	54.12(48.50-59.74)	15.05(11.65-18.45)	16.12(11.57-20.66)	18.13(13.66-22.61)
>300%FPL (1427)	58.61(53.88-63.34)	57.54(51.47-63.61)	57.50(51.89-63.11)	19.31(15.38-23.23)	15.49(10.91-20.07)	15.79(11.56-20.01)
Education						
<12 (1604)	57.20(50.40-64.00)	63.26(54.90-71.62)	57.48(49.89-65.08)	16.37(11.65-21.09)	13.55(8.07-19.03)	16.10(10.77-21.42)
12(993)	63.35(57.23-69.47)	58.06(49.73-66.39)	57.59(49.98-65.21)	23.02(17.22-28.82)	20.59(13.55-27.63)	17.84(11.36-24.31)
>12(1134)	56.73(52.80-60.67)	56.43(51.42-61.44)	55.15(50.46-59.84)	15.54(12.65-18.44)	14.46(10.85-18.08)	16.92(13.34-20.49)

*p<0.05 with one tail proportion test (BMI<25 as a reference).

Table 4: Prevalence of chronic conditions by BMI among U.S. adults.

	total[a]	total	total	undiagnosed[b]	undiagnosed	undiagnosed
(n)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)	BMI<25 (1604) (ref.)	25≤BMI<30 (993)	BMI≥30(1134)
Overall (3731)	73.92(1.24-76.60)	77.65(74.42-80.88)*	80.82(77.97-83.66)*	26.57(23.85-29.29)	30.99(27.36-34.63)*	36.45(32.95-39.96)*
Age group (yrs)						
20-39 (1225)	70.15(65.44-74.85)	76.11(70.62-81.60)*	78.46(73.54-83.37)*	22.68(18.41-26.95)	34.04(27.98-40.09)*	33.78(28.24-39.33)*
40-59(1313)	77.34(73.08-81.60)	78.47(73.02-83.92)	82.96(78.43-87.50)*	30.17(25.40-34.95)	31.73(25.26-38.19)	39.93(33.60-46.25 bb)*
>=60(1193)	73.80(68.80-78.80)	78.51(72.67-84.34)	81.12(75.71-86.53)*	26.35(21.31-31.38)	25.95(19.89-31.13)	35.43(29.13-41.72)*
Sex						
Male (1768)	72.60(68.52-76.68)	79.07(74.42-83.72)*	82.39(78.26-86.52)*	24.55(20.54-28.57)	31.72(26.25-37.21)*	37.54(32.33-42.76)*
Female (1963)	75.10(71.57-78.63)	76.36(71.87-80.86)	79.36(75.42-83.30)*	28.38(24.68-32.09)	30.33(25.48-35.18)	35.45(30.72-40.17)
Race/ethnicity						
White(1677)	73.39(69.6977.09)	78.27(73.98-82.55)*	80.29(76.404.18)*	27.75(23.98-31.51)	31.33(26.4436.22)	37.17(32.39-41.94)*
Black(746)	73.44(68.39-78.49)	75.30(69.13-81.46)	81.34(75.50-87.17)*	26.15(21.12-31.18)	28.19(21.67-34.713)	30.04(23.42-36.64)
Hispanic(780)	74.19(68.91-79.48)	77.83(71.28-84.378)	81.25(75.89-86.60)*	23.33(18.32-28.35)	29.801(22.82-36.77)	34.49(27.85-41.12)*
Other(528)	78.71(73.25 – 84.174)	74.80(64.35-85.24)	83.680(76.64-92.72)	22.61(6.28-28.95)	34.59(23.97-45.21)*	41.47(32.21-50.73)*
Poverty level						
<100% FPL (818)	75.55(70.61-80.48)	79.83(73.67-85.99)	83.68(78.62-88.74)*	25.49(20.43-30.55)	33.62(25.82-41.43)*	40.60(32.94-48.25)*
100%FPL≤PL≤300% FPL (1486)	72.36(69.05-77.67)	73.55(68.11-78.99)	81.43(77.02-85.84)*	25.53(21.33-29.74)	29.29(23.73-34.84)	39.13(33.59-44.66)
>300%FPL(1427)	73.82(69.61-78.03)	80.10(75.23-84.96)	79.49(74.92-84.07)*	27.67(23.31-32.03)*	31.48(25.72-37.25)	33.25 (27.87-38.635)*
Education						
<12 (1604)	75.51(69.73-81.29)	79.76(72.80-86.72)	81.73(75.52-87.93)*	26.42(20.46-32.38)	30.07(22.10-38.05)	39.45(32.00-46.90)
12(993)	75.64(70.31-80.98)	79.54(72.85-86.24)	83.84(78.39-89.30)*	31.16(24.98-37.34)	38.58(30.25-46.92)	36.06(28.42-43.71)
>12(1134)	72.97(69.43-76.51)	76.50(72.24-80.75)	79.60(75.80-83.40)*	24.99(21.56-28.42)	28.56(23.97-33.15)	35.91(31.37 - 40.45)*

*p<0.05 with one tail proportion test (BMI<25 as a reference)

A) an individual has at least one condition of diabetes, hypertension or high cholesterol.

b) an individual does not know he/she has at least one of undiagnosed diabetes, hypertension or high cholestero

Discussion

In our study of a representative sample of U.S adults aged 20 years and older, we found a prevalence of 16.9%, 60.3%, 57.5% and 76.3% T2D, hypertension, dyslipidemia and chronic conditions respectively in the general population. Additionally, the prevalence of undiagnosed T2D, hypertension, dyslipidemia and comorbid conditions were 8.8%, 11.3%, 16.8% and 30.2%, respectively. Geiss and his colleagues used the 2008-2012 National Health Interview Survey to estimate the prevalence of type I and II diabetes as 8.3%, which was based on self-reports of diabetes from the participants. Additionally, based on lab test diagnosis, Menke et al. estimated a 14.3% prevalence of total diabetes and 5.2% prevalence of undiagnosed diabetes from the 2011-2012 NHANES [17]. With a similar method, we used the 2013-2014 NHANES and found an increased prevalence of overall and undiagnosed T2D. Whether these variations in estimates might be indicative of declines or increases in the investigated conditions need further studies.

Unsurprisingly, our updated estimates of hypertension prevalence using the new definitions is much higher than NHANES estimates for the same

year and 2015 - 2016 among adults, 18 years and older [18]. Estimates of undiagnosed hypertension from the same NHANES survey as our study indicated a prevalence of 15.9% compared to our estimate of 11.3% [19]. Additionally, our prevalence estimates for dyslipidemia and undiagnosed dyslipidemia also differed from prevalence estimates of hypercholesterolemia and undiagnosed hypercholesterolemia of 11% and 5.8% due to differences in definition [19]. Mirroring previous research, Obese individuals have a higher burden of most of the cardiometabolic abnormalities [4, 5, 8]. Unexpectedly, prevalence of T2D in Blacks at lower BMI was higher compared to obese individuals in the undiagnosed population. Similarly, in the general population, the prevalence of T2D was also highest in the lowest BMI category among Black participants while overweight individuals had the lowest prevalence of T2D. Wildman et al. explored this phenomenon of being normal weight and having cardiometabolic abnormalities and suggests that it may be due to risk factors such as central obesity and cigarette smoking [13]. Otherwise, several reasons could underlie this confounding result. First, the presence of adult onset autoimmune diabetes, which is not associated with BMI could lead to a positive T2D test result [20]. Secondly, respondents may have experienced weight loss due to T2D, other comorbidities or lifestyle changes. Unfortunately, these speculations cannot be confirmed from the dataset due to the lack of information on these factors, hence, further studies are warranted to confirm the validity of our findings. Additionally, some of our findings that require further research include: the higher prevalence of dyslipidemia observed in some subgroups in the lowest BMI category. For instance, among women aged 60 or greater, undiagnosed respondents in the BMI <25 category surprisingly had highest prevalence of high cholesterol compared to those in the overweight category. In the general population, a higher prevalence of high cholesterol was observed in the lowest BMI category for Hispanics, other races, and in the near poor. To investigate more factors associated with cardiometabolic risk factors in individuals of normal or underweight is imperative for effective intervention planning.

The current study is strengthened by the national representativeness of NHANES that permitted the calculation of prevalence estimates for the US population. In addition, due to the availability of well-written protocols, NHANES study data are rigorously collected. However, blood pressure levels were determined at a single examination rather than multiple examinations, which could potentially impact the accuracy of the measurement. Although we tried to select only suspected T2D cases with our analytical procedures, we cannot say that this was successful as we were unable to directly distinguish individuals with Type 1 from those with Type 2 diabetes in our study. Additionally, by defining diabetes based on self-report, which was unverified, or a single measurement of glycated hemoglobin A_1c in blood, FPG and a 2-hour PG rather than two measurements for confirmation purposes we may have inadvertently misclassified diabetes exposure [21].

In conclusion, our study provides prevalence estimates for cardiometabolic abnormalities and undiagnosed cardiometabolic abnormalities in the overall U.S population and within categories of BMI. Among other interesting findings, we revealed an increasing prevalence of T2D in the general and undiagnosed population and a higher prevalence of T2D in normal weight or underweight Blacks compared obese blacks. Our findings suggest that normal weight individuals should not be ignored in screening for T2D and other cardiometabolic risk factors.

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Disclosure

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Known Facts of Obesity

I More Americans are getting fatter: obesity is very prevalent in U.S. adults.
II Obesity may contribute to heart disease and other chronic disease.

What This Study Adds

I Differentiate prevalence of metabolic conditions by BMI was presented in this study.
II This study used up-to-date NHANES data to represent all non-institutionalized adults in the US.

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