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ORIGINAL ARTICLE

Awareness of having hypertension, diabetes and dyslipidaemia among US adults: The 2011–2018 NHANES data

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Abstract

Aim: This study aimed to investigate awareness of having hypertension, diabetes and dyslipidaemia and their associated factors among US adults. *Methods:* Data from the National Health and Nutrition Examination Survey, including 21,399 adults aged ⩾20 years (pregnant women excluded) collected between 2011 and 2018, were used. Blood pressure was measured using a Baumanometer calibrated mercury true gravity wall model sphygmomanometer. Serum total cholesterol levels were measured using enzymatic assays. The percentage of haemoglobin A1C (HbA1c), which reflects long-term blood glucose levels, was measured and used to identify diabetes. Participants self-reported whether they were told by a doctor that they have hypertension, dyslipidaemia and diabetes. Awareness was defined as alignment between objective and self-reported measures for having the conditions. Sampling weights and the Taylor series linearisation variance estimation method were used in the analyses. *Results:* The findings showed that 64.06% of people with hypertension, 54.71% of those with dyslipidaemia and 78.40% of those with diabetes were aware of having the respective condition. Age, sex and health insurance were associated with awareness of having all three conditions, but marital status was not associated with any outcome. Weight status was associated with awareness of having hypertension and dyslipidaemia, whereas ethnicity was associated with awareness of having hypertension and diabetes. Relative family income was only associated with awareness of having hypertension. ***Conclusions:*** **Large proportions of US adults with hypertension, dyslipidaemia and diabetes are not aware of having the conditions. Interventions targeting groups at higher risk of being unaware of these conditions are needed.**

Keywords: *Hyperlipidaemia, blood pressure, cholesterol, prevalence, metabolic conditions, insulin resistance*

Introduction

Hypertension, diabetes and dyslipidaemia globally ranked among the top 10 leading risk factors of deaths in 2017 [1]. In 2015–2018, about 122 million US adults aged 20 years and older had hypertension (systolic blood pressure (SBP) ⩾130 mmHg or diastolic blood pressure (DBP) ⩾80 mmHg), 94 million had total cholesterol levels ⩾200 mg/dL and about 28 million had diabetes [2].

Given the effect of these conditions on health, early detection can improve treatment and minimise complications. However, these conditions often show no symptoms, and regular check-ups are needed to detect them. It is recommended that healthy adults participate in screening for hypertension and diabetes every three years [3,4] and for dyslipidaemia every four to six years [5]. The screening frequency should be higher for those with increased risks (e.g. family history) [5].

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Studies have indicated that many adults are unaware of having these conditions. Globally, it was estimated by Saeedi et al. that about 50% of 463 million adults with diabetes [6] and by the World Health Organisation that 46% with hypertension [7] are unaware of their conditions. Separate surveys have also shown the percentages of people aged 40–79 years with undiagnosed dyslipidaemia were about 78% in Thailand; between 40% and 60% in Germany, England, Jordan, Canada and Scotland; and less than 25% in Japan and Mexico [8,9].

In the USA, several studies examining awareness of having hypertension, diabetes and dyslipidaemia were conducted using National Health and Nutrition Examination Survey (NHANES) data. One study using NHANES data for 1999–2004 found that 75.9% people aged 65 years and older were aware of having hypertension, 65.7% were aware of having dyslipidaemia and 71.4% were aware of having diabetes [10]. Another study using NHANES data for 2011–2014 found that the prevalence of awareness among people aged 18–39 years was 62.7% for hypertension, 56.9% for dyslipidaemia and 70.0% for diabetes [11]. NHANES data for 2005–2016 showed that among adults aged 18–44 years, awareness was between 68.7% and 77.7% for hypertension, 46.8% and 54.1% for dyslipidaemia and 61.1% and 74.1% for diabetes [12]. These studies focused on younger ($<$45 years of age) or older adults ($\geqslant$65 years of age). To our knowledge, there have been two NHANES studies that included adults aged 20 years and older, but they only examined hypertension [13,14]. As these conditions often develop during middle age, early awareness may motivate early lifestyle changes and other interventions necessary to prevent severe complications.

This study used the most recent NHANES data (2011–2018) to examine awareness of having hypertension, dyslipidaemia and diabetes and their associated factors among US adults with the conditions. The findings of this study offer insights that could guide intervention strategies, potentially improving awareness and thus facilitating early detection of these chronic conditions in the community.

Methods

Data source

NHANES is a continuous survey conducted by the National Center for Health Statistics (NCHS) to assess the health and nutrition status of the US non-institutionalised population [15]. It uses a complex four-stage probability sampling method to select 5000 participants per year in 15 counties across the USA. This study only used adult data (i.e. participants $\geqslant$20 years of age) collected between 2011 and 2018. The reason for this timeframe is due to changes over time in methodology for some laboratory measures and sample design. Approval for the NHANES was obtained from the NCHS Research Ethics Review Board (protocol #2011-2017). Informed consent was obtained from all participants.

Of the 37,017 screened adults, 21,646 (58.5%) were interviewed and examined. The examination response rates were 64.5% in 2011–2012, 63.7% in 2013–2014, 58.1% in 2015–2016 and 49.8% in 2017–2018 [16]. Pregnant women (n=247) were excluded from the analysis.

Measures

All variables primarily measured with details on how they were measured, including laboratory procedures, can be found elsewhere [15]. A summary of this information is provided below.

Demographic characteristics

Age, sex, marital status, ethnicity, education level, family income and health insurance status were self-reported. A ratio of family income to the poverty guidelines specific to the survey year, family size and geographic location was calculated, and if $<$1, family income was classed as being below the poverty line. This poverty/income ratio was categorised with cut-off points of 0–1.3 for 'low,' $>$1.3–3.5 for 'middle' and $>$3.5–5 for 'high' relative family income [17]. Participants were considered to have health insurance if they were covered by any plan obtained through employment or government programmes.

Participants' height and weight were measured in the mobile examination centre by trained staff. Body mass index (BMI) was calculated by dividing the weight in kilograms by the height in metres squared. Those with a BMI $<$25 kg/m^2 was classified as healthy/underweight, and those with a BMI $\geqslant$25 kg/m^2 were classified as overweight/obese.

Awareness

During the visit to the mobile examination centre, certified examiners measured participants' blood pressure using a Baumanometer calibrated mercury true gravity wall model sphygmomanometer. Participants were seated at rest for at least five minutes. An appropriate cuff size was selected. Three SBP and DBP measurements were taken 30 seconds apart. A fourth measure was obtained if the previous measurement was interrupted. Participants were

excluded if both arms had rashes, open sores, wounds or other conditions, or if the cuff didn't fit properly. Blood pressure readings were averaged (for those with only one reading, that reading was used) and used to identify hypertension [18]. Participants with a SBP of ⩾130 mmHg or a DBP of ⩾80 mmHg or those on antihypertensive medication were considered to have hypertension [19]. Awareness of having hypertension was defined as those with hypertension and self-reporting 'yes' to the question 'Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?'

Serum total cholesterol levels were measured using enzymatic assays. A total cholesterol level of <200 mg/dL was considered healthy for adults [2]. Therefore, those with a total cholesterol level of ⩾200 mg/dL or those on anti-dyslipidaemia medication and answering affirmatively to the question 'Have you ever been told by a doctor or other health professional that your blood cholesterol level was high?' were classified as being aware of having dyslipidaemia.

The percentage of haemoglobin A1C (HbA1c), which reflects long-term blood glucose levels, was measured and used to identify diabetes. Participants with a HbA1c ⩾6.5% [4], taking insulin or diabetic pills and answering affirmatively to the question 'Other than during pregnancy, have you been told by a doctor or health professional that you have diabetes or sugar diabetes?' were considered as being aware of having diabetes.

Data analysis

SAS v9.4 (SAS Institute, Cary, NC) was used for analyses. Following the guideline, eight-year examination sampling weights were recalculated by dividing the two-year weights by four. Missing values were 9.9% (n=2120) for poverty/income ratio, 2.8% (n=588) for awareness of having hypertension, 4.8% (n=1033) for awareness of having dyslipidaemia, 4.1% (n=884) for awareness of having diabetes, 1.4% (n=306) for BMI and <0.2% for other demographic variables. Missing data were excluded in the analyses. Survey procedures in SAS were used to account for the complex survey design. The Taylor series linearisation variance estimation method was used for all analyses.

Weighted percentages and standard errors were reported for demographic characteristics, hypertension, diabetes and dyslipidaemia in the general population. Additionally, weighted percentages and standard errors of awareness of having each condition among those with the condition were presented by demographic groups. PROC SURVEYLOGISTIC was used to identify associations between demographic characteristics and the outcomes (i.e. awareness of having the condition). Model 1, including one of the demographic characteristics adjusting for survey cycles, was run for each outcome. As health insurance and relative family income were highly correlated, two multivariable models which included survey cycle, age group, sex, marital status, ethnicity, education level, weight status and either health insurance (model 2) or relative family income (model 3) were separately conducted for each outcome. Scheffe's method was used to adjust for multiple comparisons for variables with more than two categories. Additionally, as the definition of hypertension was inconsistent over time, a sensitivity analysis was conducted for hypertension using the definition of SBP ⩾140 mmHg or DBP ⩾90 mmHg. Odds ratios were reported with 95% confidence intervals. p-Values were two-sided and were considered significant if <0.05.

Results

Table I shows weighted percentages for socio-demographic characteristics, hypertension, diabetes and dyslipidaemia, as well as awareness of having these conditions in the general population. About one third self-reported as having hypertension (33.94%) and dyslipidaemia (34.68%), and more than one tenth self-reported as having diabetes (10.94%). At the examination, about half (including those on medication) were identified as having hypertension (49.46%) and dyslipidaemia (53.04%), and about one tenth were identified as having diabetes (12.47%).

Among adults with hypertension, about 64% (n=7506) were aware of having the condition (Table II), while 36% (n=3786) were unaware. The weighted percentages were about 54% and 78% for awareness of having dyslipidaemia and diabetes, respectively. Across the demographic characteristics, the percentages ranged between 41.28% and 76.32% for awareness of having hypertension, 24.71% and 69.70% for awareness of having dyslipidaemia, and 62.17% and 82.96% for awareness of having diabetes.

Table III shows the associations between awareness among people with the conditions and demographic characteristics. Across the models, people aged 60 years and older were more likely to be aware of having hypertension, dyslipidaemia and diabetes compared to those aged between 20 and 40 years (p<0.001). The odds of awareness among those aged 40–60 years were about twice (hypertension), three times (dyslipidaemia) and 1.6 times (diabetes) higher than among those aged 20–40 years. People with

Table I. Weighted proportions for socio-demographic characteristics and metabolic conditions in the general population.

	2011–2012		2013–2014		2015–2016		2017–2018		Total	
	n	% (SE)	*n*	% (SE)	*n*	% (SE)	*n*	% (SE)	*n*	% (SE)
Age										
20–<40 years	1824	35.57 (2.44)	1818	35.49 (1.06)	1798	35.47 (1.33)	1538	35.55 (1.28)	6978	35.52 (0.80)
40–<60 years	1751	38.31 (1.37)	1920	37.36 (0.91)	1797	36.23 (1.19)	1654	34.97 (1.35)	7122	36.69 (0.62)
⩾60 years	1687	26.12 (1.29)	1785	27.16 (0.96)	1809	28.30 (1.51)	2018	29.47 (1.58)	7299	27.79 (0.68)
Sex										
Male	2620	48.50 (0.85)	2669	48.64 (0.67)	2624	48.67 (0.62)	2541	48.66 (0.86)	10454	48.62 (0.38)
Female	2642	51.50 (0.85)	2854	51.36 (0.67)	2780	51.33 (0.62)	2669	51.34 (0.86)	10945	51.38 (0.38)
Marital status										
Not in a relationship	2308	38.83 (2.02)	2273	37.87 (1.28)	2143	36.17 (1.57)	2158	37.91 (1.25)	8882	37.68 (0.78)
In a relationship	2950	61.17 (2.02)	3247	62.13 (1.28)	3259	63.83 (1.57)	3047	62.09 (1.25)	12503	62.32 (0.78)
Ethnicity										
Non-Hispanic white	1931	66.54 (3.87)	2374	65.98 (3.25)	1774	64.04 (3.85)	1793	62.36 (2.55)	7872	64.69 (1.72)
Non-Hispanic black/others	1536	14.00 (2.25)	1289	13.95 (1.66)	1339	15.00 (2.17)	1490	16.09 (1.69)	5654	14.78 (0.98)
Non-Hispanic Asian	745	5.21 (0.91)	630	5.34 (0.63)	640	5.79 (1.26)	748	5.86 (1.00)	2763	5.56 (0.49)
Mexican American/other	1050	14.25 (2.49)	1230	14.73 (2.36)	1651	15.17 (2.62)	1179	15.69 (1.94)	5110	14.97 (1.18)
Hispanic										
Education										
High school or below	2361	37.11 (2.58)	2434	37.11 (2.09)	2456	35.28 (2.34)	2280	38.42 (2.02)	9531	36.99 (1.14)
Above high school	2897	62.89 (2.58)	3084	62.89 (2.09)	2945	64.72 (2.34)	2918	61.58 (2.02)	11844	63.01 (1.14)
Relative family income										
Low (0–1.3)	1762	25.40 (1.85)	1753	24.65 (2.34)	1573	21.06 (1.76)	1286	20.09 (0.72)	6374	22.79 (0.88)
Middle (>1.3–3.5)	1608	33.80 (2.09)	1769	34.80 (1.08)	1921	36.67 (1.48)	1871	35.99 (1.81)	7169	35.32 (0.82)
High (>3.5–5.0)	1444	40.80 (3.08)	1576	40.55 (2.68)	1351	42.27 (2.82)	1365	43.92 (2.00)	5736	41.89 (1.33)
Health insurance										
Yes	4004	79.94 (1.38)	4351	81.89 (1.14)	4461	86.58 (1.34)	4414	86.2 (1.90)	17230	83.72 (0.73)
No	1256	20.06 (1.38)	1170	18.11 (1.14)	939	13.42 (1.34)	791	13.8 (1.90)	4156	16.28 (0.73)
Weight status										
Healthy/underweight	1662	31.02 (1.64)	1645	29.35 (0.80)	1466	28.40 (1.54)	1328	26.35 (1.34)	6101	28.74 (0.68)
Overweight/obese	3519	68.98 (1.64)	3810	70.65 (0.80)	3871	71.60 (1.54)	3792	73.65 (1.34)	14992	71.26 (0.68)
Hypertension (self-report)										
Yes	1891	32.99 (1.38)	2079	35.81 (1.26)	1977	33.13 (1.24)	2002	33.81 (1.60)	7949	33.94 (0.69)
No	3192	67.01 (1.38)	3329	64.19 (1.26)	3310	66.87 (1.24)	3031	66.19 (1.6)	12862	66.06 (0.69)
Hypertension (examination or on medication)										
Yes	2681	48.99 (1.65)	2755	47.35 (1.11)	2868	49.48 (1.04)	2988	51.92 (1.33)	11292	49.46 (0.65)
No	2402	51.01 (1.65)	2653	52.65 (1.11)	2419	50.52 (1.04)	2045	48.08 (1.33)	9519	50.54 (0.65)
Dyslipidaemia (self-report)										
Yes	1701	34.31 (1.41)	1924	36.05 (0.79)	1823	34.43 (1.27)	1803	33.92 (1.47)	7251	34.68 (0.63)
No	3245	65.69 (1.41)	3396	63.95 (0.79)	3324	65.57 (1.27)	3150	66.08 (1.47)	13115	65.32 (0.63)
Dyslipidaemia (lab test or on medication)										
Yes	2736	56.12 (1.15)	2772	51.84 (1.74)	2725	53.40 (1.10)	2607	50.96 (1.87)	10840	53.04 (0.77)
No	2210	43.88 (1.15)	2548	48.16 (1.74)	2422	46.6 (1.1)	2346	49.04 (1.87)	9526	46.96 (0.77)
Diabetes (self-report)										
Yes	669	9.64 (0.60)	702	10.39 (0.52)	802	11.57 (0.80)	833	12.05 (0.53)	3006	10.94 (0.31)
No	4331	90.36 (0.6)	4652	89.61 (0.52)	4359	88.43 (0.8)	4167	87.95 (0.53)	17509	89.06 (0.31)
Diabetes (lab test or on medication)										
Yes	803	11.26 (0.74)	802	11.62 (0.41)	897	13.04 (0.95)	991	13.88 (0.48)	3493	12.47 (0.34)
No	4197	88.74 (0.74)	4552	88.38 (0.41)	4264	86.96 (0.95)	4009	86.12 (0.48)	17022	87.53 (0.34)

health insurance were also more likely to be aware of having the conditions ($p<0.001$). Although sex was a significant factor associated with awareness of having these conditions, the direction of association was inconsistent across the conditions. Men were less likely to be aware of having hypertension ($p<0.001$) but more likely to be aware of having dyslipidaemia ($p<0.001$) and diabetes ($p<0.05$) than women were. Marital status was not associated with awareness of having any condition. While overweight/obese adults were more likely to be aware of having hypertension and dyslipidaemia ($p<0.001$), the association was not significant regarding awareness of having diabetes. Relative family income was not associated with awareness of having dyslipidaemia and diabetes. However, adults with a high relative family income were less likely to be aware of having hypertension than those with a low income. While Hispanic adults were less likely to be aware of having hypertension, Asians were less likely to be aware of having diabetes than non-Hispanic white participants. The sensitivity analysis for hypertension with the cut-off of 140/90

Table II. Weighted percentages for awareness of having hypertension, dyslipidaemia and diabetes by socio-demographic characteristics among those with the conditions.

All adults	Hypertension		Dyslipidaemia		Diabetes	
	n	% (SE)	*n*	% (SE)	*n*	% (SE)
	7506	64.06 (0.82)	6046	54.71 (0.77)	2713	78.40 (0.97)
Age						
20–<40 years	665	41.28 (1.54)	448	24.71 (1.20)	130	62.17 (3.80)
40–<60 years	2396	60.18 (1.31)	2084	53.58 (1.13)	831	75.33 (1.94)
⩾60 years	4445	76.32 (0.96)	3514	69.70 (1.03)	1752	82.96 (1.28)
Sex						
Male	3593	59.66 (1.08)	2954	56.16 (1.02)	1447	80.56 (1.51)
Female	3913	68.72 (1.03)	3092	53.38 (1.07)	1266	76.04 (1.40)
Marital status						
Not in a relationship	3277	65.13 (1.17)	2340	53.40 (1.26)	1115	79.59 (1.32)
In a relationship	4223	63.39 (1.06)	3698	55.37 (0.94)	1596	77.76 (1.31)
Ethnicity						
Non-Hispanic white	2871	65.29 (1.08)	2504	56.72 (0.98)	850	81.33 (1.52)
Non-Hispanic black/others	2468	67.98 (1.07)	1455	54.08 (1.56)	832	76.24 (1.63)
Non-Hispanic Asian	662	54.43 (1.90)	695	49.05 (1.76)	305	70.63 (2.36)
Mexican American/other Hispanic	1505	55.46 (1.63)	1392	46.84 (1.13)	726	73.57 (1.63)
Education						
High school or below	3722	65.9 (0.99)	2751	54.35 (1.09)	1459	78.17 (1.20)
Above high school	3771	62.8 (1.06)	3288	54.92 (0.93)	1248	78.60 (1.39)
Relative family income						
Low (0–1.3)	2285	66.14 (1.26)	1597	50.55 (1.53)	882	76.73 (1.57)
Middle (>1.3–3.5)	2594	66.16 (1.07)	2057	54.60 (1.07)	970	79.13 (1.45)
High (>3.5–5.0)	1838	60.90 (1.24)	1815	56.99 (1.37)	557	77.65 (2.36)
Health insurance						
Yes	6634	66.02 (0.92)	5466	58.04 (0.84)	2407	80.17 (1.02)
No	867	50.36 (1.73)	577	32.00 (1.64)	305	64.00 (2.79)
Weight status						
Healthy/underweight	1306	52.08 (1.81)	1203	45.74 (1.55)	353	81.41 (3.02)
Overweight/obese	6038	66.56 (0.71)	4755	57.29 (0.92)	2290	77.90 (1.09)

mmHg shows similar results for all three models (Supplemental Table SI).

Discussion

Our findings showed that about one third of people with hypertension, half of those with dyslipidaemia and a quarter of those with diabetes were unaware of having the condition. While awareness of having hypertension in this study was less than that globally (36% vs. 46%), it was comparable to those in other high-income countries (33%) [20]. However, unawareness of having diabetes among US adults with the condition (about 23%) was lower compared to a global estimate of 50% and those in Europe (40.7%), North America and the Caribbean (37.8%) [6]. Although a global estimate of unawareness for dyslipidaemia was not found, studies found that the percentage of unawareness of dyslipidaemia was higher in Canada (57%) [9] and Italy (56%) [21] than in this study (45%). However, it is worth noting that comparisons on awareness of having hypertension, dyslipidaemia and diabetes across studies are relative, as criteria used in defining the conditions (e.g. HbA1C was used in identifying diabetes rather than other glucose tests) and sample characteristics were often different.

Across the three conditions, younger adults were less likely to be aware of having the conditions. This finding is consistent with studies in Canada showing that awareness of having dyslipidaemia [9] and in Malaysia showing that awareness of having hypertension, dyslipidaemia and diabetes increased with age [22]. An explanation may be that young adults were less likely to visit general practitioners and were therefore less likely to be examined for hypertension [23]. Given the low prevalence of these conditions in young adults, cost-effective methods need to be developed to identify at-risk people early so that lifestyle modification programmes and treatment can be implemented in a timely manner to minimise risks of developing cardiovascular diseases later in life.

Previous studies have found that men in Sweden [24], Sardinia (Italy) [25] and Mayotte (France) [26] were less aware of hypertension than women. However, no sex difference in awareness of dyslipidaemia and diabetes was found in the Sardinian study [25] and in Canadian adults [9]. Although our

Table III. Associations between awareness among people with the conditions and demographic characteristics (odds ratios and 95% confidence intervals).

	Awareness of hypertension			Awareness of dyslipidaemia			Awareness of diabetes		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age									
40–<60 years vs. 20–<40 years	2.14*** (1.76, 2.59)	2.05*** (1.67, 2.51)	2.17*** (1.75, 2.70)	3.54*** (2.92, 4.29)	3.46*** (2.84, 4.23)	3.48*** (2.83, 4.27)	1.86** (1.13, 3.05)	1.61 (0.98, 2.66)	1.79* (1.09, 2.94)
⩾60 years vs. 20–<40 years	4.56*** (3.75, 5.55)	4.29*** (3.47, 5.31)	4.78*** (3.88, 5.89)	7.05*** (5.72, 8.69)	6.67*** (5.36, 8.30)	7.36*** (5.95, 9.11)	2.96*** (1.86, 4.70)	2.30*** (1.39, 3.82)	2.71*** (1.59, 4.60)
Sex									
Male vs. female	0.67*** (0.60, 0.76)	0.78*** (0.68, 0.89)	0.78*** (0.68, 0.89)	1.12* (1.00, 1.25)	1.33*** (1.16, 1.53)	1.31*** (1.13, 1.51)	1.31* (1.01, 1.69)	1.31* (1.01, 1.71)	1.28 (0.97, 1.70)
Marital status									
Not in a relationship vs. in a relationship	1.08 (0.95, 1.22)	1.05 (0.91, 1.21)	0.96 (0.83, 1.11)	0.92 (0.82, 1.04)	1.04 (0.91, 1.19)	1.02 (0.87, 1.20)	1.12 (0.90, 1.39)	1.15 (0.94, 1.42)	1.18 (0.94, 1.47)
Ethnicity									
Hispanic vs. non-Hispanic white	0.66*** (0.53, 0.83)	0.76* (0.60, 0.97)	0.67*** (0.51, 0.87)	0.67*** (0.56, 0.81)	1.03 (0.85, 1.25)	0.93 (0.77, 1.13)	0.64* (0.44, 0.93)	0.78 (0.51, 1.19)	0.74 (0.49, 1.13)
Non-Hispanic Asian vs. non-Hispanic white	0.64*** (0.51, 0.81)	0.83 (0.65, 1.07)	0.80 (0.61, 1.05)	0.73*** (0.59, 0.91)	1.05 (0.83, 1.33)	1.01 (0.78, 1.30)	0.55** (0.35, 0.86)	0.57* (0.35, 0.94)	0.57* (0.35, 0.92)
Non-Hispanic black/ others vs. non-Hispanic white	1.13 (0.96, 1.34)	1.33*** (1.10, 1.60)	1.21 (0.99, 1.48)	0.90 (0.75, 1.08)	1.08 (0.87, 1.33)	1.04 (0.84, 1.30)	0.74 (0.51, 1.07)	0.81 (0.55, 1.21)	0.75 (0.50, 1.14)
Education									
High school or below vs. above high school	1.14* (1.03, 1.28)	1.18* (1.04, 1.34)	1.04 (0.90, 1.20)	0.98 (0.88, 1.08)	0.98 (0.87, 1.11)	0.96 (0.85, 1.08)	0.98 (0.80, 1.20)	1.07 (0.85, 1.35)	1.05 (0.82, 1.35)
Relative family income									
Middle (>1.3–3.5) vs. low (0–1.3)	1.00 (0.85, 1.18)	n/a	0.89 (0.74, 1.07)	1.17 (0.98, 1.41)	n/a	0.99 (0.82, 1.19)	1.15 (0.84, 1.56)	n/a	1.08 (0.79, 1.46)
High (>3.5–5.0) vs. low (0–1.3)	0.80** (0.69, 0.94)	n/a	0.70*** (0.58, 0.85)	1.29** (1.06, 1.58)	n/a	1.10 (0.88, 1.38)	1.05 (0.70, 1.59)	n/a	0.97 (0.64, 1.46)
Health insurance									
Yes vs. no	1.94*** (1.65, 2.29)	1.38*** (1.14, 1.67)	n/a	2.95*** (2.50, 3.48)	2.17*** (1.78, 2.64)	n/a	2.27*** (1.74, 2.95)	1.74*** (1.29, 2.33)	n/a
Weight status									
Overweight/obese vs. healthy/underweight	1.84*** (1.62, 2.09)	2.12*** (1.84, 2.44)	2.23*** (1.91, 2.60)	1.58*** (1.37, 1.83)	1.65*** (1.41, 1.93)	1.67*** (1.40, 1.99)	0.80 (0.52, 1.22)	0.76 (0.49, 1.19)	0.81 (0.50, 1.31)

*$p<0.05$; **$p<0.01$; ***$p<0.001$.

finding showed that men were less aware of hypertension, they were more aware of dyslipidaemia and diabetes than women were. One explanation may be due to differences in the screening recommendations in the USA for hypertension and dyslipidaemia. While the recommendation at the time for screening hypertension was the same for men and women (⩾18 years old), screening for lipid disorders was recommended for younger men (i.e. ⩾35 years old) compared to 45 years and older for women, and therefore men with the condition may be diagnosed earlier. However, the sex differences in percentages of awareness of having dyslipidaemia and diabetes were small (<5%).

Although weight status was associated with hypertension and dyslipidaemia, this was not the case for diabetes. This finding is consistent with the findings from a Swedish study that overweight/obese people were more aware of hypertension [24], whereas no association between weight status and awareness of hypertension was found in the Mayotte study [26]. Studies in Malaysia [22] and Singapore [27] also found that obese people were more likely to be aware of hypertension and dyslipidaemia. While our finding that weight status was not associated with diabetes is consistent with that from the Malaysian study [22], a Singaporean study found a reverse association that obesity was associated with greater unawareness [27]. This is interesting because it would be expected that overweight/obese people would be more likely to be screened for these conditions. As there was a lack of studies examining these associations, including those in high-income countries, it is difficult to reach a firm conclusion.

Having health insurance was associated with a higher awareness across the three conditions. This is to be expected, as health insurance was found to reduce medical costs and increase access to care and utilisation, resulting in increased rates of diagnosing and treating chronic conditions [28]. Another study in China found similar results, although the health-care system in China may be different from that in the USA [29]. Given that many Americans (11%; 29.6 million) had no health insurance in 2021 [30], attention to identify and provide treatment to the uninsured is needed to prevent higher costs imposed on the system later on due to the development of severe complications and cardiovascular diseases.

Consistent with studies in Sweden [24], France [26] and Malaysia [22], marital status was not associated with awareness of having hypertension, dyslipidaemia and diabetes in this study. While relative family income was not associated with awareness of having dyslipidaemia and diabetes, differences were found in some post-hoc comparisons for awareness of having hypertension. In particular, adults with a high relative family income were less likely to be aware of having hypertension than those with a low relative family income. While the reason is unclear, we speculate that people with a higher relative family income were likely to obtain an early diagnosis and treatment of hypertension and thus were able to control it [31]. In contrast, those with hypertension despite being wealthy may be too busy and pay insufficient attention to their blood pressure and therefore are unaware of it.

Moreover, this study found that Hispanic Americans were less likely to be aware of hypertension and non-Hispanic Asians were less likely to be aware of diabetes compared to non-Hispanic white participants. A reason for the difference between Hispanic Americans and non-Hispanic white participants may be due to the use of home devices to self-monitor blood pressure, which was lower among Hispanic Americans than non-Hispanic white participants (81.4% vs. 76.1%) [32]. For the difference between non-Hispanic Asians and non-Hispanic white participants, one explanation could be due to cultural pressure and social stigmas against Asian patients which discouraged them from disclosing their condition [33,34]. Another reason may be because Asians were likely to have worse access to care and be more hesitant to seek health care than white participants [35]. Although the associations were independent of socio-demographic factors (e.g. family relative income and education), there may be other social determinants of health which contributed to the ethnic differences. Identifying these factors may be of significant interest, as the information would help in the design of more targeted interventions to improve people's awareness.

This study used nationally representative data from one of the highest-quality surveys in the USA. The large sample from multiple survey cycles improves the precision of estimates. Diagnosis of the conditions was based on the standard clinical measurements. However, there are limitations. First, the results may not be generalisable to other populations, especially those in low- and middle-income countries and with different health-care systems. Second, self-report of having the metabolic conditions was used to define awareness and thus was subject to recall and social desirability bias (i.e. some people may be reluctant to report their condition, as they are afraid of being judged by others). Third, HbA1C was used as a single criterion for diagnosing diabetes, whereas it is more typical to use multiple tests in clinical practice. The decision to use HbA1C was because (a) plasma fasting glucose and oral glucose tolerance test were only conducted for the morning section sample (half of the full sample), (b) these tests were not

available for all survey cycles and (c) HbA1C better captures chronic hyperglycaemia which is more appropriate for studies on awareness that needs time to develop. Finally, types of diabetes were not identified, and including type 1 diabetes may overestimate awareness of diabetes. As type 1 diabetes usually occurs in young ages and requires insulin treatment, people with type 1 diabetes are likely already aware of their condition.

Conclusions

Prevalence of hypertension, dyslipidaemia and diabetes was high among US adults, with large proportions being unaware of having hypertension, dyslipidaemia and diabetes. Age, sex and health insurance were associated with all three outcomes. Weight status was associated with awareness of having hypertension and dyslipidaemia, whereas ethnicity was associated with awareness of having hypertension and diabetes. Relative family income was only associated with awareness of having hypertension.

These findings inform policymakers and revision of guidelines for screening recommendations. The information can also be used to develop interventions targeting groups at higher risk of unawareness. Policies and actions are necessary to improve health literacy among US adults. Future research examining differences in direction of associations between sex and awareness of hypertension, dyslipidaemia and diabetes as well as on associations between ethnicity, education and income are needed.

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Supplemental material

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