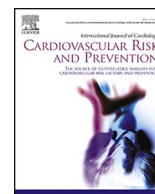




Contents lists available at [ScienceDirect](https://www.sciencedirect.com)
**International Journal of Cardiology
 Cardiovascular Risk and Prevention**

journal homepage: www.journals.elsevier.com/international-journal-of-cardiology-cardiovascular-risk-and-prevention



Heterogeneity in the prevalence of premature hypertension among Asian American populations compared with white individuals: A National Health Interview Survey study

Sina Kianoush^a, Mahmoud Al Rifai^a, Anwar T. Merchant^b, Xiaoming Jia^a, Zainab Samad^c, Aneil Bhalla^d, Ayesha Khan^c, Dongshan Zhu^e, Salim Virani^{a,f,g,h,*}

^a Section of Cardiology, Department of Medicine, Baylor College of Medicine, Houston, TX, USA

^b Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, USA

^c Department of Medicine, Aga Khan University, Karachi, Pakistan Aga Khan University, Karachi, Pakistan

^d Section of Cardiovascular Medicine, Department of Internal Medicine, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA

^e Department of Epidemiology, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China

^f Section of Cardiovascular Research, Department of Medicine, Baylor College of Medicine, Houston, TX, USA

^g Health Policy, Quality & Informatics Program, Michael E. DeBakey VA Medical Center Health Services Research & Development Center for Innovations in Quality, Effectiveness, and Safety, Houston, TX, USA

^h DeBakey Heart and Vascular Institute, Houston Methodist, Houston, TX, USA

ARTICLE INFO

Keywords:

Hypertension
 Racial disparity
 Asians

ABSTRACT

Background: Differences in prevalence of risk factors such as hypertension may explain heterogeneity in cardiovascular risk across Asian American populations.

Methods: We used National Health Interview Survey (NHIS) data from 2006 to 2018 among White, Chinese, Asian Indian, Filipino, and 'other Asians' (Japanese, Korean, and Vietnamese). Unadjusted and adjusted odds ratios (aOR) with 95% confidence intervals were reported using logistic regression models for the association between race and self-reported premature hypertension (age <50 years old). Models were adjusted for sex, education, body mass index, smoking status, diabetes, and coronary heart disease.

Results: We studied 99,864 participants with history of hypertension (mean age, 59.3 ± 0.1; 50% women, 90% US born). Asian Indians had higher prevalence of premature hypertension (37%) compared with Filipinos (27%), 'other Asians' (26%), Whites (25%), and Chinese (21%). Compared with Whites, Chinese individuals had lower odds of premature hypertension (aOR = 0.79, 0.63–0.98), but Asian Indians had higher odds (aOR = 1.85, 1.48–2.31). Compared with Chinese, odds of premature hypertension was higher for Asian Indians (aOR = 2.39, 1.74–3.27), Filipinos (aOR = 1.53, 1.16–2.04), and 'other Asians' (OR = 1.32, 1.03–1.70; aOR = 1.59, 1.20–2.10). Overall prevalence of hypertension was lower among Asian Indians (aOR = 0.52, 0.46–0.58) and 'other Asians' (aOR = 0.74, 0.68–0.79) compared with Whites.

Conclusions: There is heterogeneity in the risk of hypertension across Asian Americans by age. Asian Indians and 'other Asians' had higher prevalence of premature hypertension and lower prevalence of overall hypertension, which may call for earlier screening for risk factors among these populations.

1. Introduction

Asian Americans are amongst the fastest growing racial/ethnic populations in the US [1]. Prior studies have shown that cardiovascular

disease (CVD) risk factors are common and heterogenous among various Asian American subgroups [1–3]. High prevalence of premature CVD in high-risk Asians, particularly among South Asians and Filipinos, is a rising public health concern as demonstrated in prior epidemiologic

Abbreviations: Atherosclerotic cardiovascular disease, ASCVD; Behavioral Risk Factor Surveillance System, BRFSS; Body mass index, BMI; Cardiovascular disease, CVD; Centers for Disease Control and Prevention, CDC; Coronary heart disease, (CHD); National Health and Nutrition Examination Survey, NHANES; National Health Interview Survey, NHIS.

* Corresponding author. Baylor College of Medicine 2002 Holcombe Blvd., Houston, TX, 77030, USA.

E-mail address: virani@bcm.edu (S. Virani).

<https://doi.org/10.1016/j.ijcrp.2022.200147>

Received 10 May 2022; Received in revised form 14 July 2022; Accepted 18 July 2022

Available online 18 August 2022

2772-4875/Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

studies [1,4–8]. Differences in the prevalence and trends of early onset CVD risk factors, such as hypertension, could help understand the heterogeneity in CVD across Asian racial/ethnic populations and implement preventive strategies for high risk groups [1].

Hypertension is one of the most common CVD risk factors in the United States. Few studies investigated sociodemographic factors associated with premature hypertension among disaggregated Asian American subpopulations. One study using self-reported hypertension data from New York City Community Health Survey from 2009 to 2013 including Chinese, South Asian, and non-Hispanic White populations demonstrated that, among adults with hypertension, South Asian individuals were younger than non-Hispanic White individuals and had poorer diet quality [9]. A previous National Health Interview Survey (NHIS) demonstrated that Asian Indian and ‘other Asian’ individuals (a group consisting of Japanese, Vietnamese, and Korean) have higher likelihood of premature CHD [10]. However, studies on the likelihood of premature CVD risk factors among Asian Americans are limited. More studies on other higher risk Asian subgroups are needed to find racial/ethnic groups with earlier onset CVD risk factors, such as premature hypertension, that may benefit from earlier preventive interventions. In addition, presence of premature CVD risk factors may explain early onset CVD among racial/ethnic minorities [11]. Disparities in risk factor awareness call for identifying and controlling CVD risk factors at an earlier age among higher risk racial/ethnic groups, such as Asian Indians and Filipinos, who have worse CVD outcomes [7,11–13].

Asian American populations are understudied with respect to CVD risk factors and outcomes. Considering the heterogeneity in CVD risk factors and outcomes across Asian populations, more studies are needed to characterize populations with higher rates of hypertension. In addition, identifying sociodemographic characteristics associated with premature hypertension would be helpful in understanding premature risk factor development in higher risk Asian American groups. To inform future research and help with implementing possible interventions to curb CVD risk, we conducted this study using NHIS to identify racial/ethnic populations with higher prevalence of premature hypertension.

2. Materials and methods

We conducted a cross-sectional analysis using publicly available data from the NHIS, which is a nationally representative health survey that has been serially performed by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC) [14]. Since 1957, NHIS has collected data from US civilian, noninstitutionalized populations on a broad range of health topics through personal household interviews with the aim of providing data to track health status and progress towards reaching national health objectives [14]. Detailed information on the survey design and methods can be found elsewhere (<http://www.cdc.gov/nchs/nhis.htm>). Compared with Behavioral Risk Factor Surveillance System (BRFSS), a national telephone-administered survey, NHIS is a household-administered survey and has the advantage of collecting more detailed information on a wider range of topics with a higher response rate [15]. In addition, disaggregated data for various Asian subgroups are publicly available in NHIS, but not in BRFSS. In this study, we included 99,864 participants with history of hypertension and available self-reported race/ethnicity data from NHIS 2006–2018.

All data in NHIS is self-reported as previously described. Participants who self-identified their race/ethnicity as White, Chinese, Asian Indian, Filipino, or ‘other Asian’ were included. ‘Other Asian’ groups included Japanese, Vietnamese, and Korean adults. Disaggregated data for the ‘other Asian’ group is not available to public due to NHIS’s confidentiality regulations for populations with small sample size. Other demographic characteristics included age, sex, US birth, number of years lived in the US, level of education (less than high school graduate, high school graduate, some college, and college graduate or above), and annual income (less than \$25K, \$25–45K, \$45–75K, and \$75K or higher). Body mass index (BMI) was calculated based on self-reported

height and weight. We defined obesity as $BMI \geq 30 \text{ kg/m}^2$. Smoking status was categorized as current, former, or never. History of diabetes mellitus was defined as present if participants responded yes to the question “Have you ever been told by a doctor or other health professional that you had diabetes?”. History of coronary heart disease (CHD) was present if participants answered yes to any of the following questions: “Ever been told you had coronary heart disease?”, “Ever been told you had angina pectoris?”, or “Ever been told you had a heart attack?”. History of stroke was present if participants answered yes to the question “Ever diagnosed with a stroke?”. We defined history of atherosclerotic CVD (ASCVD) if participants were reported having a history of either CHD or stroke. Hypertension history was defined as present if participants answered 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?”. We defined premature hypertension if participants’ age were younger than 50 years old regardless of sex.

We included strata and weights in our analyses to produce nationally representative estimates using the Stata ‘svy’ command. NHIS weights included design, ratio, non-response and post-stratification adjustments. We reported demographic, social, and co-morbid characteristics of participants by race and ethnicity and overall study population. We used mean \pm standard deviation and numbers (weighted percentages) for continuous and categorical variables, respectively. We calculated and showed annual prevalence of hypertension for individuals younger than 50 years by race/ethnicity from 2006 to 2018.

We performed logistic regression analyses using premature hypertension (participants’ age younger than 50 years old) as the independent variable. We performed two sets of logistic regression models for 1) White race as the reference compared with all Asian subgroups 2) Chinese race as the reference in models excluding Whites, to compare only Asian populations to each other. Multivariable logistic regression models were used to adjust for sex, education, BMI, smoking status, and history of diabetes, and CHD. Odds ratios (ORs) with 95% confidence intervals were reported for the likelihood of premature hypertension across racial/ethnic groups. In addition, we reported ORs with 95% confidence intervals for demographic characteristics associated with premature hypertension across racial/ethnic groups.

We also performed secondary analyses by restricting the population to individuals with history hypertension and age younger than 40 years old. In addition, we did sensitivity analyses by running two sets of prediction models for all cases of hypertension regardless of age. All analyses were performed using Stata version 16.1 (StataCorp, College Station, Texas). A $P < 0.05$ was considered statistically significant.

3. Results

Out of 317,637 participants with available race/ethnicity data, 99,864 participants (31.4%) with history of hypertension were included in this study (mean age, 59.3 ± 0.1 ; 50% women, 90% US born) (Table 1). Prevalence of total hypertension among White and Asian American individuals were 29.4% and 22.4%, respectively. Among White and Asian American individuals with history of hypertension, 25.4% and 27.1% were younger than 50 years old, respectively. Of the total participants with hypertension, 94,487 (95%) of participants were White individuals, 2035 were other Asians (2.0%), 1729 were Filipinos (1.7%), 935 were Chinese (0.9%), and 678 were Asian Indian (0.7%) individuals. Mean age was lower among Asian Indian participants with hypertension (55.0 ± 0.6) compared with Chinese (61.0 ± 0.9).

Among patients with hypertension, prevalence of hypertension among those younger than 50 years old (mean age, 38.6 ± 0.1 ; 43.3% women, 85.6% US born) was significantly higher for Asian Indians (37%) as compared with Chinese (21%) ($P < 0.001$). Among patients with hypertension, prevalence of reported hypertension among those younger than 40 years old (mean age, 31.1 ± 0.1 ; 43.2% women, 87.2% US born) was also significantly higher for Asian Indians (20%) and ‘other Asians’ (18%) compared with Chinese (7%), Whites (12%), and

Table 1

Characteristic of the study population among National Health Interview Survey (NHIS) participants with history of hypertension.

	Total (N = 99,864)*	White (N = 94,487)	Chinese (N = 935)	Asian Indian (N = 678)	Filipino (N = 1729)	Other Asians (N = 2035)	P
Current age, years	59.3 ± 0.1	59.3 ± 0.1	61.0 ± 0.9	55.0 ± 0.6	57.9 ± 0.4	59.4 ± 0.5	<0.001
Women (%)	53,597 (49.6)	50,752 (49.5)	485 (50.3)	264 (41.6)	975 (53.9)	1121 (51.8)	<0.001
U.S. Born (%)	79,302 (86.8)	77,899 (90.0)	209 (20.8)	23 (0.03)	502 (28.2)	669 (28.4)	<0.001
Lived in U.S. > 10 years (%)	12,603 (89.8)	9434 (90.7)	598 (89.3)	469 (83.5)	987 (87.3)	1115 (88.7)	<0.001
Education less than college (%)	48,558 (49.5)	45,550 (49.2)	520 (57.4)	439 (61.1)	1063 (62.2)	986 (49.0)	<0.001
Income < \$25K (%)	25,202 (65.8)	23,795 (61.9)	219 (62.4)	223 (65.7)	507 (63.3)	458 (59.4)	0.58
Obesity (BMI ≥ 30), (%)	42,061 (43.3)	40,991 (44.5)	136 (14.5)	133 (19.8)	448 (26.9)	353 (17.6)	<0.001
Current cigarette smoking (%)	15,937 (16.2)	15,448 (16.6)	48 (4.9)	50 (6.2)	176 (10.5)	215 (11.1)	<0.001
Diabetes mellitus (%)	15,830 (20.9)	14,867 (20.8)	130 (15.2)	136 (27.3)	319 (22.7)	378 (25.3)	<0.001
CHD (%)	16,773 (15.9)	16,134 (16.2)	99 (9.1)	88 (10.5)	230 (12.0)	222 (9.6)	<0.001
Stroke	7035 (6.5)	6736 (6.6)	49 (4.5)	26 (3.8)	89 (5.4)	135 (6.8)	0.01
ASCVD	21,017 (71.9)	20,195 (72)	129 (71.8)	103 (69.9)	276 (74.8)	314 (66.3)	<0.001
HTN < 50 years old	78,078 (25.5)	20,457 (25.4)	184 (21.0)	253 (36.5)	438 (26.6)	454 (26.0)	<0.001
HTN < 40 years old	10,202 (11.8)	9610 (11.8)	84 (9.1)	126 (14.9)	169 (10.1)	213 (12.5)	0.02

Abbreviations: ASCVD, Atherosclerotic cardiovascular disease; BMI, body mass index; CHD, coronary heart disease; HTN, hypertension.

Filipinos (13%). (P = 0.02) (Fig. 1).

In univariate and multivariable analyses (adjusted for sex, education, body mass index, smoking status, diabetes, and CHD) using White individuals as the referent category (Table 2), Chinese individuals younger than 50 years old had lower likelihood of history of hypertension, compared with Whites as the reference in both unadjusted (OR = 0.78, 0.64–0.96) and multi-variable adjusted models (aOR = 0.79, 0.63–0.98). Asian Indians had higher likelihood of history of hypertension among those less than 50 years of age in unadjusted (OR = 1.69, 1.38–2.08), and adjusted models (aOR = 1.85, 1.48–2.31) compared with White individuals. Filipino (aOR = 1.18, 0.99–1.40) and ‘other Asian’ (aOR = 1.14, 0.98–1.34) adults had higher nominal odds of prevalent hypertension less than 40 years old. Unadjusted and multivariable adjusted logistic regression models demonstrated significantly higher likelihood of history of hypertension among participants younger than 50 years old for Asian Indian, Filipino and ‘other Asian’ populations, compared with Chinese (Table 3). There was significant interaction between age and race/ethnicity and their association with premature hypertension with all models with White or Chinese individuals as the reference.

Among Asian American populations, women (aOR = 0.68, 0.55–0.83) and individuals with a history of diabetes (aOR = 0.35, 0.26–0.46) and coronary heart disease (aOR = 0.30, 0.20–0.47) had a lower likelihood of diagnosis of hypertension younger than 50 years of age. Education level higher than college (aOR = 1.96, 1.61–2.38) and current smoking (aOR = 1.60, 1.16–2.20) were associated with higher likelihood of diagnosis of hypertension younger than 50 years of age.

From 2006 to 2018, there was an increase in the prevalence of total hypertension from 29% to 36%. However, prevalence of hypertension among individuals younger than 50 years old decreased from 27% to 19% (Supplementary Figure 1-A). Results by race/ethnicity showed similar pattern for hypertension among White adults. (P for trend <0.001) (Supplementary Figure 1-B). On the other hand, Asian Indians had consistently higher prevalence of hypertension among individuals younger than 50 years old than all other participants (Supplementary Figure 1-D). Among ‘other Asian’ population, there was an increase in total hypertension although hypertension prevalence among individuals younger than 50 years old remained relatively unchanged. (Supplementary Figure 1-F)

Secondary analyses among participants younger than 40 years using

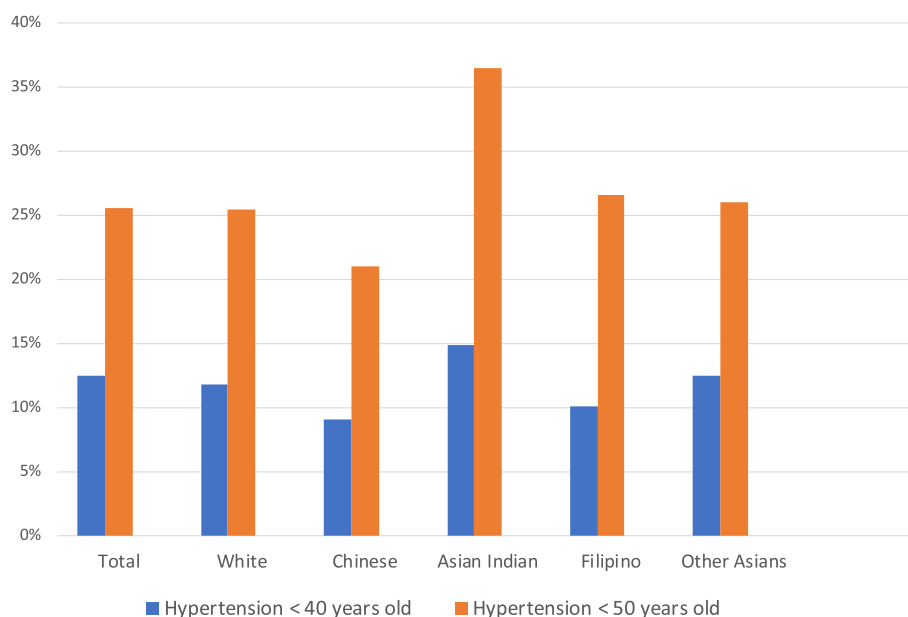


Fig. 1. Proportion of participants in National Health Interview Survey (2006–2018) with history of hypertension among those <50 and <40 years old, stratified by racial/ethnic groups.

Table 2

Regression analyses evaluating the association between various Asian groups and prevalence of hypertension at age less than 50 years old among National Health Interview Survey (NHIS) participants (White race as the referent group).

Variable	Unadjusted			Adjusted ^a		
	OR	95% CI		OR	95% CI	
White	Ref	—		Ref	—	
Chinese	0.78	0.64	– 0.96	0.79	0.63	– 0.98
Asian Indian	1.69	1.38	– 2.08	1.85	1.48	– 2.31
Filipino	1.06	0.91	– 1.24	1.18	0.99	– 1.4
Other Asian	1.03	0.89	– 1.2	1.14	0.98	– 1.34
Sex	–	–	–	.64	.62	– .67
Education higher than college	–	–	–	1.22	1.17	– 1.28
BMI	–	–	–	1.01	1.01	– 1.01
Current smoking	–	–	–	2.39	2.26	– 2.53
Diabetes	–	–	–	.44	.41	– .47
Coronary heart disease	–	–	–	.24	.22	– .27

^a Adjusted for sex, education, body mass index (BMI), smoking status, diabetes, and coronary heart disease.

Table 3

Regression analyses evaluating the association between various Asian groups and prevalence of hypertension at age less than 50 years old among National Health Interview Survey (NHIS) participants (Chinese as the referent group).

Variable	Unadjusted			Adjusted ^a		
	OR	95% CI		OR	95% CI	
Chinese	Ref	—		Ref	—	
Asian Indian	2.17	1.61	– 2.91	2.39	1.74	– 3.27
Filipino	1.36	1.05	– 1.76	1.53	1.16	– 2.04
Other Asian	1.32	1.03	– 1.70	1.59	1.20	– 2.10
Sex	–	–	–	.68	.55	– .83
Education higher than college	–	–	–	1.96	1.61	– 2.38
BMI	–	–	–	1.02	1.01	– 1.02
Current smoking	–	–	–	1.6	1.16	– 2.2
Diabetes	–	–	–	.35	.26	– .46
Coronary heart disease	–	–	–	.30	.20	– .47

^a Adjusted for sex, education, body mass index (BMI), smoking status, diabetes, and coronary heart disease.

White individuals as the referent category (Supplementary Table 1) showed higher likelihood of hypertension among Asian Indian population in unadjusted (OR = 1.31, 1.02–1.67) and multi-variable adjusted models (aOR = 1.34, 1.04–1.73) compared with Whites. Likelihood of hypertension among those less than 40 years old was non-significantly lower for Chinese (OR = 0.75, 0.56–1.01; aOR = 0.75, 0.55–1.03) and Filipinos (OR = 0.89, 0.71–1.10), and non-significantly higher for ‘other Asian’ individuals in multi-variable adjusted models (aOR = 1.19, 0.97–1.46) when compared with White individuals. Compared with Chinese individuals (Supplementary Table 2), Asian Indians had higher likelihood of reporting hypertension among those younger than 40 years old in unadjusted (OR = 1.74, 1.18–2.57) and adjusted models (aOR = 1.73, 1.14–2.62). Among ‘other Asians’, the odds were non-significantly high in unadjusted (OR = 1.42, 0.99–2.04), and significantly higher in adjusted models (aOR = 1.66, 1.14–2.42).

Sensitivity analyses for predicting prevalence of overall hypertension regardless of age in both unadjusted and adjusted models with White race as the reference showed that Chinese individuals reported lower prevalence of overall hypertension compared with Whites. Similarly, Asian Indians (OR = 0.49, 0.43–0.55; aOR = 0.52, 0.46–0.58) and ‘other Asians’ (OR = 0.68, 0.63–0.73; aOR = 0.74, 0.68–0.79) reported lower likelihood of prevalent hypertension, which were different from those demonstrated by predicting models for premature hypertension.

Unadjusted and adjusted odds of hypertension reached statistical significance for Filipino individuals (OR = 1.13, 1.05–1.22; aOR = 1.18, 1.09–1.28) (Supplementary Table 3). Similar analyses by excluding Whites and with Chinese as the reference demonstrated higher likelihood of prevalent hypertension among Filipinos and ‘other Asians’, which was consistent with prior results for premature hypertension. However, Asian Indians showed lower likelihood of reporting hypertension compared with Chinese individuals (aOR = 0.81, 69–0.94), which was different from what was shown in the models for predicting premature hypertension (Supplementary Table 4). We performed a post-hoc analyses including a variable related to doctor visit within the past 12 months and did not observe any changes in our results (data not shown).

4. Discussion

Results from this study showed that Asian Indian and ‘other Asians’ individuals have higher prevalence of reported hypertension among individuals younger than 50 and 40 years old, when compared to White or Chinese populations. Overall results were consistent with higher likelihood of self-reported history of premature hypertension among Asian Indians, Filipinos, ‘other Asians’, but not Chinese, as compared with White individuals. Likelihood of premature hypertension was higher for Asian Indians, Filipinos, and ‘other Asians’ compared with Chinese individuals in models that did not include White individuals in the analyses. The models that estimated odds of overall hypertension showed different results for Asian Indian and ‘other Asian’ populations who both showed lower likelihood of hypertension, as compared with White and Chinese adults. These results indicate that although overall hypertension prevalence is lower in Asian Indian individuals, the burden of premature hypertension is especially high among Asian Indians compared with other groups.

This study is among the few reports that showed heterogeneity in premature hypertension among Asian Americans at a large scale while taking into account potential confounders of hypertension prevalence. A National Health and Nutrition Examination Survey (NHANES) study from 2015 to 2016 that included 5171 men and women (2,776) showed positive interaction between age and race/ethnicity. Asian Americans were not a distinct racial/ethnic group studied in this study, but they were included in the ‘other race’ group in the analyses [16]. Another NHANES study evaluated approximately 77 million US adults from 2013 to 2018 and reported a hypertension prevalence of 32% for both non-Hispanic Whites and Asian Americans, however results on subgroups of Asians were not reported [17]. A BRFSS study that combined data from 2013, 2015, and 2017 survey years showed that prevalence of self-reported hypertension was 21% among non-Hispanic Asians and 34% among non-Hispanic Whites [18], which is similar to our study. Discrepancy between NHANES and BRFSS regarding prevalence of hypertension among Asian Indians may be secondary to underestimation of hypertension prevalence among BRFSS and NHIS participants due to self-report, as has been shown in prior studies [19]. In addition, this underestimation of hypertension prevalence may stem from undiagnosed hypertension due to lack of access to care and health care visits. Our post-hoc analyses showed that including a variable related to doctor visit within the past 12 months did not change our results. However, more studies are needed to consider a broader range of sociodemographic variables and residual confounders pertaining to diagnosis and treatment of hypertension among Asian American populations.

In this study, we showed higher likelihood of diagnosis of hypertension at an age younger than 50 years old among Asian American individuals with higher than college education and those with a known diagnosis of diabetes or CHD. This is consistent with a previous study including a Filipino American population from eight community-based organizations that showed higher education level was associated with a higher likelihood of diagnosis of hypertension in Filipino individuals, 80% of whom between the ages of 46–65 years were reported to have

hypertension [20]. However, a systematic review showed that lower socioeconomic status was associated with worse cardiometabolic risk factor profile among Asian American individuals [21]. Overall, findings from this study and prior literature support that higher health awareness is associated with higher likelihood of diagnosis of ASCVD risk factors, such as hypertension, at an earlier age. In addition, we found higher likelihood of hypertension among individuals younger than 50 years old with a known comorbidity (diabetes or CHD), which is likely due to higher rate of health care visits and screening tests among these populations. These results highlight the importance of targeting socially vulnerable individuals from high risk racial/ethnic groups who would benefit from primary preventive interventions prior to a diagnosis of clinically evident ASCVD. In this study, we were not able to perform stratified analyses by each sociodemographic factor for individual racial/ethnic groups due to insufficient sample size. Studies with a larger sample size including racial/ethnic minorities would help policy makers identify high risk social groups who would benefit from implementation of preventive strategies such as more intensive screening and ASCVD risk factor management.

In this study, results were different for prevalent hypertension for all participants versus individuals younger than 50 years old among Asian Indians and 'other Asians'. This is not the result of changing CVD trend inside each racial/ethnic population since annual variations in premature and total hypertension are insignificant as shown in [Supplementary Figure 1](#), but rather suggest that Asian Indians and 'other Asians' are high-risk racial/ethnic populations with increased risk of premature hypertension. Earlier onset of CVD risk factors, such as hypertension, among Asian Indians and 'other Asian' populations may drive the risk of future adverse CVD events if untreated. Prior studies have reported worse CHD risk factor profile among Asian Indians as compared to other racial/ethnic groups. Traditional and novel CVD risk factors and genetic markers indicate poorer risk factor profile among Asian Indian adults [5, 22]. Identifying high-risk racial/ethnic populations would help clinicians to screen for traditional and non-traditional risk factors at an early age to prevent premature CHD and CVD. More research would help identify CVD risk factors among specific racial/ethnic populations that contribute the most to their increased CVD risk.

'Other Asian' population in this study were found to be more likely to have premature hypertension than Whites and Chinese individuals. Secondary analyses also showed that results were significant for 'other Asian' adults younger than 40 years old. Confidentiality regulations on minimum samples size does not allow NHIS to publish race-specific data for 'other Asians' which include Japanese, Korean, and Vietnamese populations. An NHANES study reported a higher prevalence of hypertension among Korean and Vietnamese Americans compared to Chinese Americans [19]. A BFRSS using 2013, 2015, 2017 year data showed adjusted prevalence of hypertension was highest among Japanese (41%) than among any other studies Asian Americans [18]. Similarly, data on disaggregated Asian Indian subpopulations such as Indian, Pakistani, Bangladeshi, and Nepalese individuals are not available in NHIS [23]. Studying these racial/ethnic groups whose populations are rapidly growing in the US has important epidemiologic implications and would fill the knowledge gap with regard to identifying and controlling premature CVD risk factors.

This study has limitations. The cross-sectional nature of the NHIS survey limits the definition of premature hypertension using age of diagnosis due to recall bias. Selection bias due to survivorship bias and inclusion of non-institutionalized individuals would result in failure to capture data from deceased individuals or those with worse clinical conditions. The self-reported nature of the survey may also cause selection and information biases due to language barriers and poor health literacy. Under-representation and small sample size of some Asian populations did not allow for a more granular assessment of the racial/ethnic minorities that may be at higher risk of premature hypertension. Finally, definition of hypertension has changed across guidelines for the diagnosis of hypertension within the past years. Therefore,

interpretation of trends in the prevalence of hypertension should be made with caution. Differences in the thresholds of blood pressure for the diagnosis of hypertension along with increased awareness for undiagnosed hypertension may partly explain changes in trends of hypertension prevalence within the past years [24,25].

5. Conclusions

The risk of total and premature hypertension varies across racial/ethnic populations, in particular Asian Americans. While all Asian populations, except Chinese, were shown to have higher risk for total and premature hypertension, Asian Indians and 'other Asians' had higher likelihood of reporting premature hypertension. This may suggest a more rapid increase in prevalence of hypertension among these populations as they age, if enough attention is not directed towards screening of Asian American populations at a younger age. Larger studies with enough sample size would be helpful to evaluate factors contributing to higher hypertension prevalence among these understudied minorities which could trigger targeted preventive strategies.

Funding disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Credit author statement

Sina Kianoush: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Visualization – **Mahmoud Al Rifai:** Conceptualization, Methodology, Writing – review & editing – **Anwar Y. Merchant:** Writing – Review & Editing – **Xiaoming Jia:** Writing – Review & Editing – **Zainab Samad:** Writing – Review & Editing – **Aneil Bhalla:** Writing – Review & Editing – **Aneysa Khan:** Writing – review & editing – **Dongshan Zhu:** Writing – Review & Editing – **Salim Virani:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

N/A.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijcrp.2022.200147>.

References

- [1] A.S. Volgman, L.S. Palaniappan, N.T. Aggarwal, M. Gupta, A. Khandelwal, A. V. Krishnan, J.H. Lichtman, L.S. Mehta, H.N. Patel, K.S. Shah, Atherosclerotic cardiovascular disease in South Asians in the United States: epidemiology, risk factors, and treatments: a scientific statement from the American Heart Association, *Circulation* 138 (2018) e1–e34.
- [2] J. Ye, G. Rust, P. Baltrus, E. Daniels, Cardiovascular risk factors among Asian Americans: results from a national health survey, *Ann. Epidemiol.* 19 (2009) 718–723.
- [3] Y. Commodore-Mensah, E. Selvin, J. Aboagye, R.-A. Turkson-Ocran, X. Li, C. D. Himmelfarb, R.S. Ahima, L.A. Cooper, Hypertension, overweight/obesity, and diabetes among immigrants in the United States: an analysis of the 2010–2016 National Health Interview Survey, *BMC Publ. Health* 18 (2018) 1–10.
- [4] Y. Chen, N.D. Freedman, P.S. Albert, R.R. Huxley, M.S. Shiels, D.R. Withrow, S. Spillane, T.M. Powell-Wiley, A.B. de González, Association of cardiovascular

- disease with premature mortality in the United States, *JAMA cardiology* 4 (2019) 1230–1238.
- [5] S.T. Ahmed, H. Rehman, J.M. Akeroyd, M. Alam, T. Shah, A. Kalra, S.S. Virani, Premature coronary heart disease in South Asians: burden and determinants, *Curr. Atherosclerosis Rep.* 20 (2018) 1–8.
- [6] D. Zhao, Epidemiological features of cardiovascular disease in Asia, *JACC (J. Am. Coll. Cardiol.): Asia* 1 (2021) 1–13.
- [7] P.O. Jose, A.T. Frank, K.I. Kapphahn, B.A. Goldstein, K. Eggleston, K.G. Hastings, M.R. Cullen, L.P. Palaniappan, Cardiovascular disease mortality in Asian Americans, *J. Am. Coll. Cardiol.* 64 (2014) 2486–2494.
- [8] G.A. Roth, G.A. Mensah, C.O. Johnson, G. Addolorato, E. Ammirati, L.M. Baddour, N.C. Barengo, A.Z. Beaton, E.J. Benjamin, C.P. Benziger, Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study, *J. Am. Coll. Cardiol.* 76 (2020) 2982–3021.
- [9] S.S. Yi, L.E. Thorpe, J.M. Zanowski, C. Trinh-Shevrin, N.S. Islam, Clinical characteristics and lifestyle behaviors in a population-based sample of Chinese and South Asian immigrants with hypertension, *Am. J. Hypertens.* 29 (2016) 941–947.
- [10] S. Kianoush, M. Al Rifai, V. Jain, Z. Samad, J. Rana, S. Dodani, X. Jia, M. Lee, S. U. Khan, K. Gupta, Prevalence and predictors of premature coronary heart disease among Asians in the United States: a national health interview survey study, *Curr. Probl. Cardiol.* (2022), 101152.
- [11] M.D. Ritchey, H.K. Wall, M.G. George, J.S. Wright, US trends in premature heart disease mortality over the past 50 years: where do we go from here? *Trends Cardiovasc. Med.* 30 (2020) 364–374.
- [12] P.C. Balfour, C.J. Rodriguez, K.C. Ferdinand, The role of hypertension in race-ethnic disparities in cardiovascular disease, *Curr. Cardiovasc. Risk Rep.* 9 (2015) 18.
- [13] J.A. Leigh, M. Alvarez, C.J. Rodriguez, Ethnic minorities and coronary heart disease: an update and future directions, *Curr. Atherosclerosis Rep.* 18 (2016) 9.
- [14] Centers for Disease Control & Prevention. National center for health Statistics: about the national health interview survey. Accessed. 2021 [Available from: https://www.cdc.gov/nchs/nhis/about_nhis.htm].
- [15] D.E. Nelson, E. Powell-Griner, M. Town, M.G. Kovar, A comparison of national estimates from the national health interview survey and the behavioral risk factor surveillance system, *Am. J. Publ. Health* 93 (2003) 1335–1341.
- [16] Z. Zhang, Q. Wang, T. Zhang, E. Zhao, S. Ding, X. Kang, W. Zhang, B. Liu, H. Liu, A. Cheng, Interaction of Sex, Age, Body Mass Index and Race on Hypertension Prevalence in the American Population: A Cross-Sectional Study, 2020.
- [17] R. Aggarwal, N. Chiu, R.K. Wadhera, A.E. Moran, I. Raber, C. Shen, R.W. Yeh, D. S. Kazi, Racial/ethnic disparities in hypertension prevalence, awareness, treatment, and Control in the United States, 2013 to 2018, *Hypertension* 78 (2021) 1719–1726.
- [18] J. Fang, C. Luncheon, A. Patel, C. Ayala, C. Gillespie, K.J. Greenlund, F. Loustalot, Self-reported prevalence of hypertension and Antihypertensive medication use among Asian Americans: behavioral risk factor surveillance system 2013, 2015 and 2017, *J. Immigr. Minority Health* 23 (2021) 26–34.
- [19] M.Y. Jung, S. Lee, S.B. Thomas, H.-S. Juon, Hypertension prevalence, treatment, and related behaviors among Asian Americans: an examination by method of measurement and disaggregated subgroups, *J. Racial Ethnic Health Dispar.* 6 (2019) 584–593.
- [20] G.X. Ma, M. Lee, A. Bhimla, Y. Tan, C.A. Gadegbeku, M.C. Yeh, H. Aczon, Risk assessment and prevention of hypertension in Filipino Americans, *J. Community Health* 42 (2017) 797–805.
- [21] L.Y. Min, R.B. Islam, N. Gandrakota, M.K. Shah, The social determinants of health associated with cardiometabolic diseases among Asian American subgroups: a systematic review, *BMC Health Serv. Res.* 22 (2022) 1–16.
- [22] G. Koulaouzidis, P. Jenkins, T. McArthur, Comparison of coronary calcification among South Asians and caucasians in the UK, *Int. J. Cardiol.* 168 (2013) 1647–1648.
- [23] P. Satish, E. Vela, U. Bilal, M. Cleries, A.M. Kanaya, N. Kandula, S.S. Virani, N. Islam, J. Valero-Elizondo, T. Yahya, Burden of cardiovascular risk factors and disease in five Asian groups in Catalonia: a disaggregated, population-based analysis of 121 000 first-generation Asian immigrants, *Eur. J. Prev. Cardiol.* 29 (2021) 916–924.
- [24] P.K. Whelton, R.M. Carey, W.S. Aronow, D.E. Casey, K.J. Collins, C. Dennison Himmelfarb, S.M. DePalma, S. Gidding, K.A. Jamerson, D.W. Jones, 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines, *J. Am. Coll. Cardiol.* 71 (2018) e127–e248.
- [25] J.P. Ioannidis, Diagnosis and treatment of hypertension in the 2017 ACC/AHA guidelines and in the real world, *JAMA* 319 (2018) 115–116.