Cardiovascular risk factor profiles in North and South Indian and Pakistani Americans: The MASALA Study

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South Asians in the United States have disproportionately high burden of cardiovascular disease compared to other race/ethnic groups but are a heterogenous population, so we evaluated differences in prevalence and adjusted odds of cardiovascular risk factors including diabetes, hypertension, dyslipidemia, and obesity between North Indian, South Indian, and Pakistani immigrants in the United States in the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study. Given cultural differences among residents of Indian regions, for example in dietary patterns, we categorized Indian participants as North or South Indian. In 1,018 participants (728 North Indian [47% women], 223 South Indian [43% women], 67 Pakistani [52% women]), unadjusted diabetes and obesity prevalence was highest in Pakistani participants (33% and 48%, respectively); hypertension prevalence was highest in North Indian participants (54%); dyslipidemia prevalence was highest in South Indian and Pakistani participants (55%); and South Indian participants had a higher odds of dyslipidemia (OR 1.77, 95% CI 1.27, 2.47) compared with North Indian participants in fully adjusted models. As differences in cardiovascular risk factors were observed across South Asian American subgroups, identifying the determinants of suboptimal cardiovascular health within South Asian American subgroups may help to better tailor cardiovascular disease prevention strategies. (Am Heart J 2022;244:14–18.)

South Asian Americans experience a higher proportional mortality and higher burden of premature mortality from atherosclerotic cardiovascular disease (ASCVD) compared to non-Hispanic White and other Asian American groups.[1-3] Furthermore, the prevalence of and risk for several cardiovascular risk factors is higher among South Asians compared with other groups. For example, South Asian adults have a 2-times higher prevalence of diabetes, higher levels of ectopic fat, and high prevalence of hypertriglyceridemia, compared with non-Hispanic White (NHW) adults. It has also been observed that South Asian adults with hypertension are younger, more likely to be male, and have lower mean BMI than NHW adults.[3,4] In the US, the 2 largest South Asian subgroups are Asian Indian and Pakistani Americans.[5] Health behaviors and social determinants related to ASCVD, such as diet and socioeconomic position, may differ between South Asian subgroups, leading to differences in ASCVD outcomes, but have not previously been described.[3,6-9] We evaluated differences in prevalence and relative odds of diabetes, hypertension, dyslipidemia, and obesity between North Indian, South Indian, and Pakistani immigrants in the US.

Methods

Participants

We used data from the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study, which included 1,018 South Asian immigrants in the San Francisco and Chicago metropolitan areas. Data were collected between October 2010-March 2018. MASALA participants were of South Asian ancestry (≥3 grandparents born in a South Asian country), age 40-84 years at enrollment, and spoke English, Hindi, or Urdu. Exclusion criteria are previously detailed, and include prevalent CVD and weight >300 pounds.[10]

Immigrant participants were categorized by region of origin: Pakistan, or North or South India (health differences between these Indian geographic regions are rec-

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Submitted May 2, 2021; accepted October 5, 2021

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0002-8703

https://doi.org/10.1016/j.ahj.2021.10.115

ognized and may be related to sociocultural and health-related behavior differences[9]). North Indian participants identified the following geographically northern states in response to "Which Indian state do you best identify with?": Haryana, Himachal Pradesh, Jammu and Kashmir, Orissa, Ladakh, Rajasthan, Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat, Maharashtra, West Bengal, Goa, Chandigarh, or the National Capital Territory of Delhi. South Indian participants were those who identified with the following geographically southern Indian states: Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.

Variable definitions

Methods for MASALA biospecimen data collection have previously been described.[10] ASCVD risk factors of interest were dyslipidemia, hypertension, diabetes, and obesity. Dyslipidemia was defined as elevated triglycerides $\geq$150 mg/dL, HDL < 40, or fibrate/niacin use. Hypertension was classified as a blood pressure $\geq$130/85 mmHg or use of anti-hypertensive medication. Type 2 diabetes was defined by plasma or serum glucose $\geq$200 mg/dL on 2-hour glucose tolerance test or use of diabetes medication. Obesity was defined as body-mass index (BMI) $\geq$27.5 kg/m^2.[11] Behavioral factors such as smoking, exercise, and dietary pattern were obtained by questionnaire. Carbohydrate, protein, and total fat intake were quantified as the percentage of total kilocalorie intake. Access to healthcare was defined as having any health insurance. Acculturation was defined as 1 of 3 categories: assimilation (preference for US culture), separation (preference for South Asian culture), and integration (similar preference for both cultures).[12] Details on other demographic factors (years in the US, education, family income) are previously described.[10]

Statistical analysis

Sociodemographic and clinical characteristics are presented as mean or geometric mean where skewed (standard deviation), median (interquartile range), or frequency. Chi-square and independent sample t-tests compared characteristics between North Indian, South Indian, and Pakistani participants. Multivariable logistic regression was used to determine the adjusted odds of hypertension, diabetes, dyslipidemia, and obesity. Odds ratios were adjusted first for age and sex, then additionally for years in the US, education, family income, health insurance, BMI (for hypertension, diabetes, and dyslipidemia outcomes), and statin medication use (for dyslipidemia outcome). Analyses for each outcome were also adjusted for the other clinical factors (i.e. odds of hypertension adjusted for dyslipidemia and diabetes). Analyses were conducted in SPSS v.26 in 2021. The MASALA study was approved by the Institutional Review Boards at the University of California San Francisco and Northwestern University, participants provided written informed consent. This study was supported by the National Institutes of Health (grant numbers R01HL093009, UL1RR024131, UL1TR001872, F32HL149187, K23HL157766). The authors are solely responsible for the study design and conduct, all study analyses, the drafting and editing of the paper and its final contents.

Results

There were 728 North Indian (mean age 58 [SD 9] years, 47% women), 223 South Indian (mean age 54 [9] years, 43% women), and 67 Pakistani (mean age 57 [9] years, 52% women) participants (**Table 1**). North and South Indian participants had higher income (66% and 84% family income $\geq$\$75,000/year) compared with Pakistani participants (33%, $P<$ .01 compared with both). Education $\geq$ Bachelor's degree varied by region of birth (66% North Indian, 84% South Indian, versus 70% Pakistani, $P<$ .01), as did health insurance (92% North Indian, 95% South Indian, versus 70% Pakistani, $P<$ .01). Differences in total calorie, carbohydrate, and total fat intake were observed.

Unadjusted hypertension prevalence was 56% in North Indian, 45% in South Indian, and 54% in Pakistani participants. Diabetes prevalence was 27% in North Indian, 29% in South Indian, and 33% in Pakistani participants. Dyslipidemia prevalence was 40% in North Indian, 55% in South Indian, and 55% in Pakistani participants. Obesity prevalence was 32% in North Indian, 27% in South Indian, and 48% in Pakistani. Additional cardiovascular health characteristics are shown in the *Table*.

Adjusted relative odds of hypertension, diabetes, dyslipidemia, and obesity in South Asian American subgroups are shown in the **Figure 1**. Adjusted for age and sex, the odds of dyslipidemia relative to North Indian were higher in South Indians. The odds of obesity were higher in Pakistanis relative to North Indian participants. After further adjustment for sociodemographic and clinical variables, only the odds of dyslipidemia in South Indian participants were significantly elevated relative to North Indian participants.

Discussion

In this sample of immigrant South Asian Americans, we observed a high prevalence of cardiovascular risk factors in North Indian, South Indian, and Pakistani participants, with some differences in adjusted odds between subgroups, particularly in dyslipidemia. While South Asians in aggregate have high risk for developing cardiovascular disease, understanding differences within this group may help better target clinical and public health prevention.

A combination of multilevel structural, sociocultural, and behavioral factors related to ethnicity and regional affiliation – such as dietary pattern, physical activity norms, immigration factors, health care access, language barriers, and socioeconomic position, among others – likely influence the development of heart disease in South

Table 1. Characteristics of MASALA participants

	North Indian N = 728	South Indian N = 223	P[a]	Pakistani N= 67	P*	P†
Socio-demographic Characteristics						
Female, N (%)	354 (47%)	96 (43%)	.14	35 (52%)	.57	.19
Age in years, mean (SD)	57.7 (9.3)	54.0 (9.1)	<.01	57.4 (9.0)	.77	.01
Years in the U.S., mean (SD)	28.1 (11.5)	25.9 (11.7)	.01	28.8 (11.9)	.61	.07
Family income ≥ $75,000/year, N (%)	481 (66%)	187 (84%)	<.01	22 (33%)	<.01	<.01
Education ≥ Bachelor's, N (%)	629 (86%)	214 (96%)	<.01	47 (70%)	.01	<.01
Health insurance, N (%)	667 (92%)	212 (95%)	.05	47 (70%)	<.01	<.01
Acculturation category, N (%)			.53		.25	.52
Assimilation strategy	189 (26%)	72 (32%)		15 (22%)		
Separation strategy	169 (23%)	33 (15%)		28 (42%)		
Integration strategy	370 (51%)	118 (53%)		24 (36%)		
Cardiovascular Health Characteristics						
Never smoker, N (%)	619 (85%)	182 (82%)	.48	12 (18%)	.47	.79
Alcohol use (≥1 drink/week), N (%)	224 (31%)	70 (31%)	.86	13 (19%)	.03	.04
Exercise (MET-min/week), median (IQR)	945 (315, 1806)	1125 (473, 2048)	.08	420 (0, 1470)	.02	<.01
Diet						
Total daily calorie intake, mean (SD)	1627 (502)	1728 (486)	.01	1660 (635)	.68	.44
Carbohydrates, % of intake, mean (SD)	56.2 (5.7)	57.4 (6.0)	.02	55.2 (4.1)	.32	.01
Protein, % of intake, mean (SD)	14.6 (2.1)	14.9 (2.2)	.06	15.2 (2.1)	.09	.50
Total Fat, % intake, mean (SD)	29.6 (4.9)	27.6 (5.3)	<.01	30.4 (3.4)	.23	<.01
Vegetarian diet, N (%)	236 (32%)	76 (34%)	.47	1 (2%)	<.01	<.01
AHEI score, mean (SD)	70.5 (6.2)	70.0 (6.8)	.30	68.5 (7.8)	.02	.06
Body Composition						
Obesity (BMI ≥27.5 kg/m^2), N (%)	231 (32%)	59 (27%)	.125	32 (48%)	.01	.02
BMI, kg/m^2, mean (SD)‡	25.8 (4.0)	25.6 (3.6)	.382	27.7 (4.9)	<.01	.01
Waist circumference, cm, mean (SD)	93.7 (10.1)	93.0 (9.6)	.374	98.3 (11.6)	<.01	<.01
Blood Pressure						
Systolic, mmHg, mean (SD)	126 (17)	124 (15.)	.21	123 (15)	.14	.44
Diastolic, mmHg, mean (SD)	74 (10)	75 (10)	.29	73 (11)	.50	.23
Hypertension, N *(%)*	410 (56%)	101 (45%)	.04	36 (54%)	.68	.23
Lipids						
Total Cholesterol, mg/dL, mean (SD)‡	181 (37)	182 (38)	.84	193 (42)	.01	.04
HDL, mg/dL, mean (SD)	51.1 (14.0)	47 (11.8)	<.01	48 (12)	.05	.70
LDL, mg/dL, mean (SD)	109.3 (32.6)	111 (32.1)	.49	120 (34)	.02	.06
Triglycerides, mg/dL, (Median, IQR)	116 (86, 152.3)	124 (96, 166)	.01	137 (97, 202)	.01	.12
Statin use, N (%)	213 (29%)	56 (25%)	.22	24 (36%)	.26	.11
Fibrate or niacin use, N (%)	31 (4%)	10 (5%)	.89	2 (3%)	.62	.59
Dyslipidemia, N (%)	288 (40%)	123 (55%)	<.01	37 (55%)	.01	.98
Glucose						
Fasting glucose, mg/dL, mean (SD)‡	103 (23%)	102 (24%)	.41	112 (39%)	.02	.01
Diabetes, N (%)	196 (27%)	64 (29%)	.75	22 (33%)	.14	.14
10-year ASCVD risk, N (%)			.01		.99	.21
Low (<5%)	277 (38%)	112 (50%)		18 (27%)		
Intermediate (5%-20%)	229 (31%)	63 (28%)		24 (36%)		
High (>20%)	83 (11 %)	18 (8 %)		4 (6 %)		
Prevalence of ≥2 risk factors, N (%)	568 (78 %)	180 (81%)	.41	56 (84%)	.26	.56

ASCVD: Atherosclerotic cardiovascular disease. Prevalence of ≥2 risk factors indicates presence of two or more of: current/former smoking, exercise < median, diet quality score < median, obesity, hypertension, dyslipidemia, or diabetes. [a]P for comparison of North Indian with South Indian

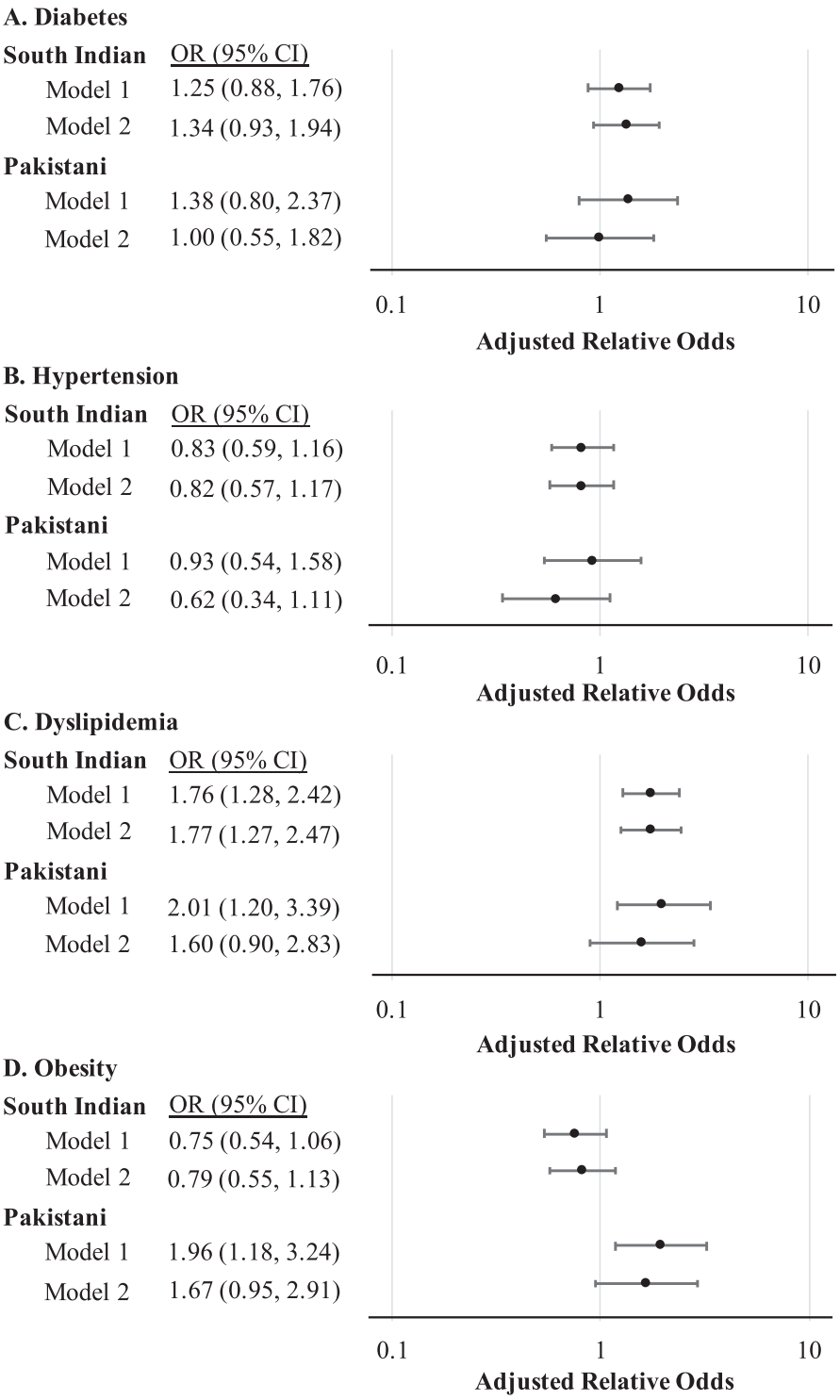
*P for comparison of Pakistani with North Indian

†P for comparison of Pakistani with South Indian

‡Geometric mean

Asians.[3,6] The Center for Cardiometabolic Risk Reduction in South Asia (CARRS) Study identified the role of socioeconomic position in India and Pakistan in predisposing to cardiovascular disease.[13] Whether any biological difference related to ancestry predisposes the South Asian population to ASCVD remains an active area of study.[14,15] Differences in ASCVD risk factor prevalence in South Asian American immigrants compared with adults in their countries of origin may reflect the influence of acculturation on cardiovascular health behaviors, socioeconomic position and access to care among immigrants, discrimination, and neighborhood and food environments, among other social and structural determinants.

Figure



Adjusted relative odds of cardiovascular risk factors in South Indian and Pakistani participants relative to North Indian participants in the MASALA study CI: Confidence interval, OR: Odds ratio. ORs displayed are relative to North Indian participants. Model 1 adjusted for sex and age, Model 2 additionally adjusted for years in the US, education, family income, health insurance, statin medication use (for dyslipidemia), BMI (for diabetes, dyslipidemia and hypertension), and the other cardiovascular risk factors (e.g., diabetes adjusted for hypertension and dyslipidemia).

Limitations of our study include relatively fewer South Indian and Pakistani compared with North Indian participants, limiting power to detect differences in cardiovascular risk factors between groups. Selection bias may have influenced enrollment of participants from various South Asian regions, particularly among the Pakistani American population. Also, these data may not reflect estimates among South Asian individuals in US regions outside of MASALA enrollment. However, as South Asians are among the most rapidly growing populations in the US, these findings provide important initial data about the distribution of cardiovascular risk factors in South Asian Americans. Given MASALA eligibility and exclusion criteria (i.e., prevalent CVD, weight >300 lbs) that may be differentially prevalent in South Asian subgroups, the potential for selection bias is acknowledged, and our findings represent a relatively heathier subset of South Asian Americans that may underestimate risk factor burden in this population. Further exploration of the contribution of social and structural determinants, advanced biomarkers such as lipoprotein(a) and coronary artery calcium, and genetics across South Asian American subgroups may valuably inform development and implementation of preventive strategies that address multi-level determinants of ASCVD in South Asian Americans.

Disclosure

The authors report no disclosures of financial conflicts of interest.

Acknowledgements

The authors thank the other investigators, the staff, and the participants of the MASALA study for their valuable contributions. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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