Original Article

Hypertension and its association with body mass index among the Indian population. Findings from a nationwide survey (NFHS-4), 2015-16

Shailja Sharma[1], Harshvardhan Singh[1], Kedar Mehta[2], Madhur Verma[3], Sonu Goel[4]

[1]Department of Community Medicine, Dr. Rajendra Prasad Government Medical College, Kangra at Tanda, Himachal Pradesh, [2]Department of Community Medicine, GMERS Medical College, Gotri, Vadodara, Gujarat, [3]Department of Community and Family Medicine, All India Institute of Medical Sciences, Bathinda, Punjab, [4]Department of Community Medicine and School of Public Health, Post Graduate Institute of Medical Education and Research, Chandigarh, India

Abstract

Background: Globally, hypertension (HTN) and obesity are two cardinal causes of morbidity and mortality. The Asian population shows comorbidities associated with obesity at a much lower body mass index (BMI) than the western population. **Aim:** The primary objective of the present study was to evaluate the association between BMI and HTN among the adult population. **Material and Methods:** We did a cross-sectional secondary data analysis of the NFHS-4 datasets, conducted during 2015–16. We included the adult population, that is, ≥19 years of age (93,040 men and 5,46,066 women), and excluded adolescents and pregnant women from our analysis. HTN was the primary dependent variable, while BMI was the primary predictor variable. Other covariates included age, education, place of residence, wealth index, use of alcohol and tobacco, and diabetes. Weighted analysis was done to depict our results. **Results:** Around 18.7% of men and 13.5% of women were hypertensive, of which 53.86% of males and 38.7% females were either overweight or obese. The odds of living with HTN among obese men and women increased with age, wealth, use of alcohol and tobacco, and comorbidities such as diabetes. The prevalence of HTN was higher even among the underweight adults living with diabetes and those consuming alcohol and tobacco. **Conclusion:** We reaffirm the significant association between BMI and HTN among adults. The use of the Asian classification of BMI for India and its neighboring countries to assess the burden of obesity would help in planning better interventions. A community-based targeted approach would help in controlling and reducing the prevalence of HTN.

Keywords: BMI, HTN, India, NFHS-4, obesity, overweight

Introduction

Hypertension (HTN) is considered to be the most important cause of mortality and loss of disability-adjusted life years as per global burden of disease estimates.[1,2] Approximately 57% of deaths in patients with stroke and 24% deaths in patients with coronary artery disease (CAD) have been attributed to HTN.[3] Globally, an estimated 1.3 billion people suffer from HTN, with approximately two-thirds of them residing in lower- and middle-income countries (LMICs).[2] The prevalence

Address for correspondence: Dr. Sonu Goel, Professor of Health Management, Department of Community Medicine and School of Public Health Post Graduate Institute of Medical Education and Research, Chandigarh - 160 012, India. Adjunct Clinical Associate Professor, Public Health Masters Program School of Medicine and Health Research Institute (HRI), University of Limerick, Ireland.
E-mail: sonugoel007@yahoo.co.in

Received: 21-01-2022 **Revised:** 25-02-2022
Accepted: 08-03-2022 **Published:** 14-10-2022

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_168_22

How to cite this article: Sharma S, Singh H, Mehta K, Verma, Goel S. Hypertension and its association with body mass index among the Indian population. Findings from a nationwide survey (NFHS-4), 2015-16. J Family Med Prim Care 2022;11:5826-33.

of HTN in the LMICs has surpassed that in developed nations.[4] With multi-factorial causality, 90% of the patients suffer from primary HTN.[5] HTN forms a critical risk factor for several non-communicable diseases (NCDs), such as ischemic heart disease, stroke, and chronic kidney disease. It has been reported that the brain tissue in hypertensive patients is more susceptible to ischemic damage compared to its normal counterparts.[6] According to the NCD risk factor collaboration, the prevalence of HTN in India increased from 3.7% in 1980 to 9.1% in 2014 among men and from 4.6% to 8.3% among women.[3] The increase of prevalence in India from 2005 to 2012 was almost threefold and was the highest in the WHO's Southeast Asia region. HTN accounts for 5.1% of total deaths in India, and in the year 2016, approximately 1.6 million deaths in the country were attributed to HTN alone.[7]

The epidemiological transition has not only seen an increase in the prevalence of HTN but has also seen an increase in the overweight and obesity among the population. The prevalence of obesity doubled in the past 25 years in 73 countries, and the graph is escalating more in developing nations.[8] In 2016, about one-third of the adult population globally was overweight or obese.[9] Such people have a higher propensity to develop HTN later in their lives. The pathophysiological factors among the obese leading to increased risk of HTN include increased insulin resistance, inflammation, oxidative stress, the involvement of the sympathetic nervous system, and the renin-angiotensin system. Adiposity is strongly associated with endothelial dysfunction due to increased oxidative stress and a decrease in nitric oxide levels. There is increased circulation of inflammatory markers in the obese, finally resulting in HTN and causing end-organ damage.[8] The term "metabolically obese normal weight" (MONW), coined by Neil Ruderman, refers to an individual with a normal body mass index (BMI) but higher body fat. These individuals develop metabolic disorders at a much lower BMI.[10] This phenotype is prevalent in the Asian population as compared to the western and the Caucasian population. Thus, it presents comorbidities associated with an increase in overweight and obesity at much lower BMI cut-off values.[9]

The WHO member states in the year 2011 signed a global action plan for the prevention and control of NCDs. One of the primary objectives of the plan was to reduce the prevalence of HTN by 25%, thereby emphasizing the importance of controlling HTN to meet the challenges of the growing epidemic of NCDs.[11] In India, we already have the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases, and Stroke since October 2010, which aims to prevent and control NCDs[12] and achieve the SDG target of decreasing premature deaths due to NCDs by one-third.[13] This is a distant dream without addressing the risk factors for HTN, particularly obesity, which has been a proven risk factor. However, there is a lack of scientific evidence from India that relates HTN and BMI as per the modified criteria of overweight and obesity for the Asian population.[14] Existing literature on the association between the two involves sub-national small-scale analysis, which limits generalizability.[15] It was for the first time that the fourth round of the National Family Health Survey (NFHS-4) collected data on HTN, thereby giving researchers an opportunity to estimates the prevalence of HTN among the Indian population.[16] Therefore, this study aims to analyze the association between the prevalence of HTN with an increase in BMI among the Indian population.

Material and Methods

Data source and study design

We used the NFHS-4 (2015–16) datasets for this analysis. NFHS is a multi-round survey conducted throughout India. The survey was conducted under the Ministry of Health and family welfare leadership with the International Institute of Population Sciences (IIPS), Mumbai as the nodal agency. A stratified multistage sampling design was used. The questionnaires were administered at primary sampling units (PSUs) in rural areas and census enumeration blocks (CEBs) in urban areas. Three types of questionnaires translated into various languages were administered; a questionnaire for households, men, and women. In the fourth round of NFHS, 6,01,509 households were covered, wherein 6,99,686 women and 1,12,122 men were interviewed. It collected data on the household population, housing characteristics, basic demographics, socioeconomic characteristics, fertility, family planning, and several other emerging healthcare issues. The details of the survey methodology are given somewhere else.[17] We adopted a cross-sectional design to do this secondary data analysis.

Study sample

For the present study, we included the entire dataset for both men and women except pregnant women and adolescents (below 19 years of age) as the criteria for classifying overweight and obesity in adolescents is different.[18]

Study variables

HTN was our primary dependent variable. BP was measured using an OMRON BP instrument during the survey. Three consecutive readings were taken 5 min apart. The BP level was calculated using the average of the last two readings. We adopted the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), as per which HTN is defined as a systolic BP level of 140 mm Hg or higher or diastolic BP level of 90 mm Hg or higher.[19] Apart from this, any person taking medication to lower BP at the time of the survey was also considered hypertensive and included in our analysis.

BMI was considered as the primary predictor variable. BMI was calculated by dividing the weight (in kg) by the square of height (in m). For this, weight and height were obtained using standard methodology, where weight was measured using the Seca-874 digital scale, while the height was measured using the Seca-213 stadiometer.[18] The population was divided into four categories according to their BMI using

the modified criteria of overweight and obesity for Asian Indians, namely underweight (BMI <18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), and obese (>25 kg/m^2).[10,11]

Other covariates included in our analysis were based upon an extensive literature review. We included age (20–29, 30–39, and 40–49 years for women, and 50–54 years for men), level of education (no education, primary, secondary, and higher levels), place of residence (rural/urban), wealth index quintile (poor, middle, rich), tobacco consumption (ever tobacco users), and presence or absence of diabetes.

Statistical analysis

The statistical analysis was performed using STATA version 14 by using appropriate sampling weights. The prevalence of HTN among men and women was reported in percentages distributed to the BMI categories against covariates. After adjusting for these variables, a multivariate logistic regression analysis was performed to derive the adjusted odds ratio separately for both sexes. The results were calculated independently for each BMI category in both the sexes to see the dynamics of change in prevalence of HTN across these categories. $P < 0.05$ was considered to be statistically significant.

Ethical statement

The study was approved by the Ethics Committee of Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh (PGI/IEC/2021/001139).

Results

The total number of men and women included in the study was 93,040 and 5,46,066. The prevalence of HTN among men and women was found to be 18.7% and 13.5%, respectively. More than half (53.86%) of the male hypertensives and 38.69% of hypertensive females were overweight or obese [Table 1].

Association among men

Overall, the prevalence of hypertension in men ranged from 9.3% among underweight to 32.2% among obese, which was significantly lower ($P < 0.001$) and higher ($P < 0.001$) than that in the normotensive, respectively [Table 2]. We observed that the prevalence increased with age (aOR: 3.1; 95% CI: 2.8–3.5), with 43.5% and 33.7% hypertensive obese and overweight men over 50 years of age, respectively. The prevalence decreased with increasing levels of education (aOR: 1.2; 95% CI: 1.0–1.4 among overweight, and aOR: 1.1; 95% CI: 1.0–1.3 among obese), whereas an increase in prevalence was observed among alcohol consumers (aOR: 1.7; 95% CI: 1.5–1.9 among underweight; aOR: 1.2, 95% CI: 1.2–1.3 among obese), among tobacco users (aOR: 1.0, 95% CI: 0.9–1.0) and among diabetics (aOR: 1.1, 95% CI: 0.6–1.7 in underweight, and aOR: 1.5; 95% CI: 1.3–1.8 among obese) [Table 3].

Association among women

Overall, the prevalence of HTN in women ranged between 7.6% in underweight to 23.6% in obese women [Table 1]. Table 4 depicts the prevalence of HTN across various categories of HTN stratified as per different covariates. As in the male population, higher prevalence was associated with increased age and higher BMI among the women (aOR: 3.8; 95%CI: 3.6–4.0). The prevalence decreased with increasing levels of education (aOR: 0.8; 95%CI: 0.7–0.8) across all categories of BMI, increase among the rich obese women (aOR: 1.1; 95% CI: 1.0–1.1) among alcohol users across all BMI categories (aOR: 1.8; 95%CI: 1.6–2.0 among underweight, and aOR: 1.5; 95%CI: 1.3–1.6 among obese), and diabetics (aOR: 2.0; 95% CI: 1.6–2.5 among underweight and aOR: 1.8; 95%CI: 1.7–1.9). Type of residence (aOR: 1.0; 95% CI: 1.0–1.0) and tobacco usage (aOR: 1.0; 95% CI: 0.9–1.0) did not show a significant association among obese women. We also noted a significant association of age (aOR: 2.9; 95% CI: 2.7–3.1), higher education (aOR: 0.8; 95% CI: 0.7–0.9), middle class wealth status (aOR: 0.9; 95% CI: 0.9–1.1), type of residence (aOR: 1.2; 95% CI: 1.1–1.2), tobacco (aOR: 1.1; 95% CI: 1.1–1.2), alcohol (aOR: 1.8; 95% CI: 1.6–2.0), and comorbidities such as diabetes (aOR: 2.0; 95% CI: 1.6–2.5) even among underweight women [Table 5].

Discussion

The association between overweight/obesity and HTN is a well-established fact, and we reaffirm the same for our study population. The epidemic of obesity is escalating globally across all populations.[20] Evidence suggests that increased BMI is also associated with a higher prevalence of pre-HTN, which is also associated with an increased risk of cardiovascular morbidity and mortality.[21] Overweight and obesity can be considered independent risk factors for HTN as we see a consistent increase in prevalence with an increase in BMI across all covariates in our

Table 1: Prevalence of hypertension in the adult respondents of the fourth round of National Family Health Survey- India (2015-16) as per their BMI

Body Mass Index	HTN in men			HTN in women		
	Normal Hyper. %	Pre-Hyper. %	HTN %	Normal Hyper. %	Pre-Hyper. %	HTN %
Underweight	78.87	39.82	9.37	86.26	27.85	7.65
Normal BMI	65.65	56.07	13.85	80.04	37.15	9.81
Overweight	53.06	69.4	21.29	71.21	48.23	15.01
Obese	43.87	75.31	32.27	62.72	57.18	23.68
Total	60.43	59.99	18.68	75.77	41.57	13.49

Table 2: Bivariate analysis showing association of socio-demographic characteristics with BMI among male participants from the fourth round of National Family Health Survey-India (2015-16)

Background characteristics	Underweight		Normal		Overweight		Obese	
	Total (*n*)	%	Total (*n*)	%	Total (*n*)	%	Total (*n*)	%
Age (in years)		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
20-29	5640	4.7	15,362	7.4	4,580	12.2	4551	19.3
30-39	3171	10.0	11,376	13.6	5184	19.1	6638	29.5
40-49	2756	14.0	8828	20.9	4162	29.6	6168	40.9
50-54	1167	18.9	3238	26.4	1500	33.7	2220	43.5
Level of education		*P*<0.001		*P*<0.001		*P*=0.448		*P*=0.022
No education	2732	13.9	6664	15.1	1849	23.5	1702	30.9
Primary	2309	8.4	5791	15.8	1882	22.4	2216	39.1
Secondary	6229	8.4	20,030	13.3	8135	21.2	10,570	32.9
Higher S. & above	1465	6.4	6319	12.6	3560	19.8	5090	28.6
Wealth status		*P*=0.725		*P*<0.001		*P*=0.013		*P*<0.001
Poor	6777	9.2	15,710	12.7	3490	19.3	2678	28.3
Middle	2747	9.6	8705	13.9	3299	21.0	3619	33.8
Rich	3210	9.7	14,389	15.1	8637	22.2	13,280	32.7
Type of residence		*P*=0.220		*P*<0.001		*P*=0.269		*P*=0.223
Urban	3310	9.7	12,185	14.5	6757	21.2	10,263	32.3
Rural	9425	9.3	26,619	13.5	8670	21.4	9,314	32.2
Use any tobacco		*P*<0.001		*P*<0.001		*P*=0.002		*P*=0.285
No	5196	7.8	18,435	12.8	8450	20.7	12,096	31.5
Yes	7538	10.5	20,368	14.8	6976	22.0	7481	33.5
Drinking alcohol		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
No	8520	7.4	25,519	12.6	10,194	19.8	13,089	30.4
Yes	4214	13.4	13,285	16.2	5232	24.2	6487	36.1
Diabetes*		*P*=0.147		*P*<0.001		*P*<0.001		*P*<0.001
No	12,487	9.3	37,931	13.5	14,908	21.1	18,504	31.3
Yes	162	19.6	610	32.0	406	30.2	955	50.8
Total	12,734	9.4	38,803	13.8	15,426	21.3	19,577	32.3

*Cases may not equal due to missing value and don't know; S - Secondary; *P : P*

study. This can be understood better by the pathophysiological changes in the obese that cause HTN as described earlier.[9]

The epidemiological transition in the country is attributed to sedentary lifestyle, obesity, rapid urbanization, tobacco usage, and alcohol consumption.[22] In our study, the prevalence of HTN was inversely proportional to the years of education among the overweight and obese but not among the underweight. These results corroborate findings from previous studies that report less prevalence of HTN with increased levels of education.[23] This inverse relationship has been attributed to the effect of education on lifestyle and dietary habits. Less education relates to an unhealthy diet, less physical activity, and increased substance abuse. Further, education increases awareness about the harmful effects of HTN and the benefits of adopting a healthy lifestyle. Lastly, higher education leads to better occupational opportunities and their subsequent health care benefit packages.[24] We observed only a moderate association between wealth index and HTN.[25] A study from our neighboring country Nepal did not find any association between the two.[26] We noted a significantly higher prevalence of HTN among the middle-income obese and the rich obese in males and females. Better economic status can contribute to increased access to health services and other amenities and hence more awareness about an individual's health status. However, we observed no significant urban-rural differences in HTN in different BMI categories, except for people with BMI in the normal range. There have been mixed reports about variations in the prevalence of hypertension in urban and rural areas.[23] The data from NFHS-4 suggest that the disparity in the prevalence is gradually narrowing. This can be explained by the urbanization of the rural areas in India, which is accompanied by less physical activity, more consumption of energy-dense food, substance abuse, and their existing risk factors such as poverty and less education. Besides the above-mentioned factors adjusted for different covariates, a significant association of hypertension with BMI was also observed among participants living with diabetes, among those belonging to the rich- and middle-income groups, and those consuming tobacco and alcohol. The findings are consistent with previous studies that have assessed the role of these factors in HTN.[27,28]

The consistent gradient in the prevalence of HTN with higher BMI even on an adjusted analysis incorporates the need to recognize obesity as an independent risk factor for HTN and adopt strategies to check the increase in BMI among the general population. Although there has been an emphasis on lifestyle modifications in the national health program for NCDs in different countries, much remains to be done on this front.[29]

Table 3: Binary regression analysis to explore factors associated with hypertension in different BMI categories among men from the fourth round of National Family Health Survey-India (2015-16)

Background characteristics	Underweight		Normal		Overweight		Obese	
	OR	CI	OR	CI	OR	CI	OR	CI
Age (in years)								
20-29®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
30-39	2.2***	[1.9-2.6]	1.8***	[1.7-2.0]	1.6***	[1.5-1.8]	1.6***	[1.5-1.8]
40-49	3.5***	[2.9-4.1]	3.0***	[2.8-3.2]	2.8***	[2.5-3.1]	2.6***	[2.3-2.8]
50-54	4.4***	[3.6-5.4]	4.1***	[3.7-4.6]	3.4***	[2.9-3.9]	3.1***	[2.8-3.5]
Level of education								
No education®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Primary	0.9	[0.7-,1.0]	1.1	[1.0-1.2]	1.00	[0.8-1.2]	1.1	[1.0-1.3]
Secondary	1.0	[0.9-1.2]	1.1	[1.0-1.1]	1.10	[1.0-1.3]	1.1	[1.0-1.2]
Higher Secondary & above	1.0	[0.8-1.3]	1.1	[1.0-1.2]	1.2*	[1.0-1.4]	1.1	[1.0-1.3]
Wealth status								
Poor®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Middle	1.1	[1.0-1.3]	1.1**	[1.0-1.2]	1.00	[0.9-1.2]	1.2***	[1.1-1.4]
Rich	1.1	[1.0-1.4]	1.3***	[1.2-1.4]	1.1*	[1.0-1.3]	1.3***	[1.2-1.4]
Type of residence								
Urban®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Rural	0.9	[0.8-1.0]	0.9	[0.9-1.0]	1.00	[0.9-1.1]	1.0	[1.0-1.1]
Used any tobacco								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	0.9	[0.8-1.0]	1.0	[0.9-1.0]	1.00	[0.9-1.1]	1.0	[0.9-1.0]
Drinking alcohol								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	1.7***	[1.5-1.9]	1.3***	[1.3-1.4]	1.4***	[1.3-1.5]	1.2***	[1.2-1.3]
Diabetes								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	1.1	[0.6-1.7]	1.6***	[1.3-1.9]	1.10	[0.9-1.4]	1.5***	[1.3-1.8]

P<0.05, **P*<0.01, ***P*<0.001; OR - Odds ratio; CI - 95% Confidence interval; ® - reference category

The National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, And Stroke in India is an evolving healthcare program with a definite NCD-care model. Still, it lacks an appropriate physical activity promotion strategy as a low level of physical activity is not considered a serious risk factor.[30] Specific monitoring and interventions strategies to prevent and control overweight and obesity need to be prioritized. To mitigate the looming epidemic, tried and tested population and individual-based approaches that are tailor-made as per our local requirements should be adopted at the earliest.[31] The capacity of ground-level workers, including the community health officers at the health and wellness centers, auxiliary nurse midwives, and accredited social health activists (ASHA) regarding screening for high BMI, needs to be strengthened to gain maximum leverage from the well-established primary health care system in the country. We also need to thoroughly adopt the Asian classification of BMI for our obesity-based estimates as comorbidities set in at a much lower BMI among the Indian population compared to the western world.[9]

As we observed that the prevalence of overweight and obesity increases with age, it is imperative to address childhood obesity. A review aimed at gathering evidence about best practices to reduce obesity and chronic disease risk in children reported that schools are critical in positively impacting the health status indicators such as body composition, chronic disease risk factors, and fitness.[32] Efforts toward primordial prevention by involving schools can add a new dimension to the ongoing measures to reduce NCDs. Such actions can include training peer educators from among the school children, just as is being done for adolescent care in India.[25] Efforts can be directed toward training healthcare workers in identifying overweight and obese children and planning relevant interventions, as well as counseling parents to encourage parenting strategies targeted at healthy diet and lifestyle.

In the present study, the odds of HTN were found to be higher even among underweight alcohol consumers and diabetics. Alcohol may cause hypertension by an imbalance of the central nervous system, altered baroreceptors functioning, sympathetic overactivity, stimulation of the renin-angiotensin-aldosterone system, higher cortisol levels, enhanced vascular reactivity due to increase in intracellular calcium levels, stimulation of the endothelium to release vasoconstrictors, and loss of relaxation due to inflammation and oxidative injury of the endothelium leading to inhibition of endothelium-dependent nitric oxide production.[28] Cigarette smoking also exerts a hypertensive effect, mainly through the stimulation of the sympathetic nervous system.[27] Similarly, patients with diabetes mellitus experience increased peripheral artery resistance caused by vascular

Table 4: Bivariate analysis showing association of sociodemographic characteristics with BMI among female participants from the fourth round of National Family Health Survey-India (2015-16)

Background characteristics	Prevalence of HTN with body mass index among women							
	Underweight		Normal		Overweight		Obese	
	Total (*n*)	%	Total (*n*)	%	Total (*n*)	%	Total (*n*)	%
Age (in years)		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
20-29	51,135	4.7	99,607	5.5	23,476	6.8	28,944	10.5
30-39	27,435	8.5	71,370	10.1	27,220	13.9	48,325	20.6
40-49	19,763	14.0	52,377	17.5	23,724	24.3	49,007	34.5
Level of education		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
No education	40,546	9.8	78,451	12.2	21,317	18.9	29,885	29.0
Primary	14,061	7.7	30,460	10.9	9,867	18.1	16,967	26.6
Secondary	26,505	6.3	64,954	9.1	24,901	14.3	46,774	23.5
Higher S. & above	17,223	4.6	49,489	6.3	18,335	9.8	32,649	17.6
Wealth status		*P*<0.001		*P*<0.001		*P*<0.001		*P*=0.228
Poor	54,878	8.7	93,890	10.7	19,791	16.0	20,096	23.6
Middle	19,881	6.7	47,520	9.4	15,980	15.3	23,707	24.0
Rich	23,575	5.9	81,944	9.0	38,649	14.4	82,472	23.6
Type of residence		*P*<0.001		*P*<0.001		*P*<0.001		*P*=0.135
Urban	20,794	5.9	66,426	8.8	30,210	14.2	65,446	23.4
Rural	77,540	8.1	1,56,928	10.2	44,210	15.5	60,830	24.0
Use any tobacco		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
No	90,053	7.2	2,10,751	9.6	71,199	14.8	1,22,243	23.6
Yes	8281	12.2	12,603	13.8	3221	20.2	4033	26.7
Drinking alcohol		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
No	96,524	7.5	2,19,903	9.7	73,519	14.9	1,25,160	23.6
Yes	1810	17.1	3452	17.6	901	21.5	1115	29.1
Diabetes*		*P*<0.001		*P*<0.001		*P*<0.001		*P*<0.001
No	96,613	7.6	2,18,651	9.7	72,050	14.6	1,19,444	22.9
Yes	701	14.9	2626	20.0	1663	30.9	5527	40.4
Total	98,334	7.7	2,23,354	9.8	74,420	15.0	1,26,275	23.7

remodeling and increased body fluid volume associated with insulin resistance-induced hyperinsulinemia and hyperglycemia. Both of these mechanisms elevate systemic blood pressure.[33] The explained pathophysiology holds true irrespective of the BMI status as we see higher odds of HTN among alcohol users, even among the underweight participants and the population with normal BMI. Among people with diabetes too, the chances of suffering from HTN are twice as high, even among those with low BMI.

There are several strengths in this study. Being a secondary analysis performed on a national level dataset collected following a robust sampling methodology makes the results generalizable. Complex statistical analysis used in the study overcomes the limitations of the cluster sampling method used in NFHS-4. Finally, among the first studies from India, it reinforces the independent association of BMI and HTN through a nationwide sample. However, there are also a few limitations in our study that should be acknowledged. Being a cross-sectional study, we could not comment on the temporality of association between BMI and HTN. Second, the secondary data analysis is limited by the availability of specific variables, and the effect of some other pertinent variables that affect BMI could not be analyzed. Lastly, the limited diagnostic accuracy of BMI to diagnose obesity should not be ignored, particularly for individuals in the intermediate BMI ranges. Not many studies have elucidated the effect of BMI improvement on HTN and hence needs to be studied further. Further studies are required to explore the temporality of the association between BMI and HTN and see the effect of specific interventions decrease on BMI and the prevalence of HTN.

We strongly need to implement community and individual-based approaches, more specifically at the level of schools and *Anganwadis*. This would go a step further in halting the burden of increased BMI among children, thereby reducing the future risk of HTN and other NCDs in later life. Implementation of strategies to increase physical activities is the need of the hour and can be adopted as per our local needs. In our study, we also need to integrate the efforts to contain tobacco and alcohol use as they have emerged as independent risk factors for HTN among both overweight and underweight individuals.

Conclusion

To conclude, we observed a gradient and distinctly positive association between BMI and HTN that holds for different socioeconomic variables. Several factors, such as tobacco and alcohol

Table 5: Binary regression analysis to explore factors associated with hypertension in different BMI categories among females from the fourth round of National Family Health Survey- India (2015-16)

Background characteristics	Underweight		Normal		Overweight		Obese	
	OR	CI	OR	CI	OR	CI	OR	CI
Age (in years)								
20-29®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
30-39	1.7***	[1.6-1.8]	1.9***	[1.8-2.0]	2.0***	[1.9-2.1]	2.0***	[1.9-2.1]
40-49	2.9***	[2.7-3.1]	3.3***	[3.2-3.4]	3.6***	[3.4-3.8]	3.8***	[3.6-4.0]
Level of education								
No education®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Primary	1.0	[0.9-1.1]	1.1***	[1.0-1.1]	1.00	[1.0-1.1]	1.0	[1.0-1.1]
Secondary	1.0	[0.9-1.0]	1.0	[1.0-1.1]	1.00	[0.9-1.0]	1.0*	[0.9-1.0]
Higher Secondary & above	0.8***	[0.7-0.9]	0.9***	[0.8-0.9]	0.8***	[0.7-0.8]	0.8***	[0.7-0.8]
Wealth status								
Poor®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Middle	0.9**	[0.9-1.1]	1.0*	[0.9-1.0]	1.10	[1.0-1.1]	1.1***	[1.0-1.1]
Rich	0.9	[0.9-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.1]	1.1***	[1.0-1.1]
Type of residence								
Urban®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Rural	1.2***	[1.1-1.2]	1.1***	[1.0-1.1]	1.00	[1.0-1.1]	1.0	[1.0-1.0]
Use any tobacco								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	1.1*	[1.1-1.2]	1.0	[1.0-1.1]	1.00	[0.9-1.1]	1.0	[0.9-1.0]
Drinking alcohol								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	1.8***	[1.6-2.0]	1.6***	[1.5-1.7]	1.6***	[1.4-1.7]	1.5***	[1.3-1.6]
Diabetes								
No®	1.0	[1.0-1.0]	1.0	[1.0-1.0]	1.00	[1.0-1.0]	1.0	[1.0-1.0]
Yes	2.0***	[1.6-2.5]	1.7***	[1.6-1.9]	1.9***	[1.6-2.1]	1.8***	[1.7-1.9]

*P<0.05, **P<0.01, ***P<0.001; OR - Odds ratio; CI - 95% Confidence interval; ® - Reference category

use and the presence of diabetes, were seen as significant modifiable risk factors. We need to take aggressive measures to curtail the increase in the burden of these risk factors, including overweight and obesity, that will limit the morbidity and mortality due to the rising menace of HTN and associated cardiovascular events. We call for the use of the Asian classification of BMI for framing obesity-based estimates in India and its neighboring countries.

Acknowledgement

The authors would like to acknowledge and thank Resource Center for Cardiovascular Health (RCCVH) established under Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh for providing technical support towards writing the manuscript. We are also grateful to Global Health Advocacy Incubator (GHAI) for supporting the study (Grant number-INDIA-RIIR-20) and Demographic and Health Surveys (DHS) Program for providing the data set (survey ref no. 155509 downloaded on June 3, 2021) which helped in the development of the manuscript.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Naghavi M, Abajobir AA, Abbafati C, Abbas KM, Abd-Allah F, Abera SF, *et al.* Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: A systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390:1151-210.
2. World Health Organisation. Hypertension. Fact Sheet. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension. [Last accessed on 2021 Sep 01].
3. Ramakrishnan S, Zachariah G, Gupta K, Shivkumar Rao J, Mohanan PP, Venugopal K, *et al.* Prevalence of hypertension among Indian adults: Results from the great India blood pressure survey. Indian Heart J 2019;71:309-13.
4. Thrift AG, Ragavan RS, Riddell MA, Joshi R, Thankappan KR, Chow C, *et al.* Hypertension in rural India: The contribution of socio-economicsocio-economic position. J Am Heart Assoc 2020;9:e014486.
5. Rossier BC, Bochud M, Devuyst O. The hypertension pandemic: An evolutionary perspective. Physiology (Bethesda) 2017;32:112-25.
6. Cipolla MJ, Liebeskind DS, Chan S-L. The importance of comorbidities in ischemic stroke: Impact of hypertension on the cerebral circulation. J Cereb Blood Flow Metab 2018;38:2129-49.
7. Geldsetzer P, Manne-Goehler J, Theilmann M, Davies JI, Awasthi A, Vollmer S, *et al.* Diabetes and hypertension in India a nationally representative study of 1.3 million adults. JAMA Intern Med 2018;178:363-72.

8. Cohen JB. Hypertension in obesity and the impact of weight loss. Curr Cardiol Rep 2017;19:98.
9. Verma M, Rajput M, Kishore K, Kathirvel S. Asian BMI criteria are better than WHO criteria in predicting Hypertension: A cross-sectional study from rural India. J Fam Med Prim Care 2019;8:2095-100.
10. Misra A. Ethnic-specific criteria for classification of body mass index: A perspective for Asian Indians and American Diabetes Association position statement. Diabetes Technol Ther 2015;17:667-71.
11. 66th World Health Assembly. Follow-up to the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases. World Health Organisation. 2013. Available from: https://apps.who.int/iris/bitstream/handle/10665/150161/A66_R10-en.pdf?sequence=1&isAllowed=y.
12. Govt. Of India, Ministry of Health and Family Welafare; National Programme for prevention and control of cancer, diabetes, CVD and Stroke. Available from: www.nhp.gov.in/national-programme-for-prevention-and-control-of-c_pg.
13. World Health Organzation. Sustainable Development Goals. Available from: www.undp.org/sustainable-development-goals#good-health.
14. Kumar K, Misra S. Sex differences in prevalence and risk factors of hypertension in India: Evidence from the National Family Health Survey-4. PLoS One 2021;16:e0247956.
15. Verma M, Rajput M, Sahoo SS, Kaur N, Rohilla R, Sharma R. Prevalence of hypertension and its association with different anthropometric variables among adults in rural areas of north India of hypertension and its association with different. Int J Res Dev Pharm Life Sci 2015;4:1775-83.
16. Ghosh S, Kumar M. Prevalence and associated risk factors of hypertension among persons aged 15–49 in India: A cross-sectional study. BMJ Open 2019;9:e029714.
17. International Institute for Population Sciences (IIPS). National Family Health Survey (NFHS-3), 2005–06: India. Volume I. Mumbai: IIPS; 2007. Available from: http://rchiips.org/nfhs/report.shtml. [Last accessed on 2020 Nov 18].
18. Ministry of Health and Family Welfare, UNICEF, Population Council. Comprehensive national nutrition Survey. New Delhi; 2019. p. 290. Available from: https://www.popcouncil.org/uploads/pdfs/2019RH_CNNSreport.pdf.
19. Textor SC, Schwartz GL, Frye RL. The new hypertension guidelines from JNC 7: Is the devil in the details? Mayo Clin Proc 2003;78:1078-81.
20. The GBD 2015 Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med 2017;377:13-27.
21. Rahmanian K, Shojaie M. The prevalence of pre-hypertension and its association to established cardiovascular risk factors in the south of Iran. BMC Res Notes 2012;5:386.
22. Verma M, Kalra S. Epidemiological transition in South -East Asia and it's public health implications. J Pak Med Assoc 2020;70:1661-3.
23. Wang Y, Chen J, Wang K, Edwards CL. Education as an important risk factor for the prevalence of hypertension and elevated blood pressure in Chinese men and women. J Hum Hypertens 2006;20:898-900.
24. Yamori Y, Liu L, Mu L, Zhao H, Pen Y, Hu Z, *et al.* Diet-related factors, educational levels and blood pressure in a Chinese population sample: Findings from the Japan-China Cooperative Research Project. Hypertens Res 2002;25:559-64.
25. Gupta R, Kaur M, Islam S, Mohan V, Mony P, Kumar R, *et al.* Association of household wealth index, educational status, and social capital with hypertension awareness, treatment, and control in South Asia. Am J Hypertens 2017;30:373-81.
26. Das Gupta R, Bin Zaman S, Wagle K, Crispen R, Hashan MR, Al Kibria GM. Factors associated with hypertension among adults in Nepal as per the Joint National Committee 7 and 2017 American College of Cardiology/American Heart Association hypertension guidelines: A cross-sectional analysis of the demographic and health survey 2016. BMJ Open 2019;9:e030206.
27. Virdis A, Giannarelli C, Neves MF, Taddei S, Ghiadoni L. Cigarette smoking and hypertension. Curr Pharm Des 2010;16:2518-25.
28. Husain K, Ansari RA, Ferder L. Alcohol-induced hypertension: Mechanism and prevention. World J Cardiol 2014;6:245-52.
29. Allen LN, Nicholson BD, Yeung BYT, Goiana-da-Silva F. Implementation of non-communicable disease policies: A geopolitical analysis of 151 countries. Lancet Glob Health 2020;8 e50-8.
30. Mohanty S, Venkatarao E, Yasobant S. Non-communicable disease care and physical activity promotion in India: Analysis of recent policies, guidelines, and workplans. Fam Med Community Health 2020;8:e000206.
31. World Health Organization. A guide for population-based approaches to increasing levels of physical activity: Implementation of the who global strategy on a diet, physical activity and health. Implementation of the Who Global Strategy on Diet, Physical Activity, and Health 2007. p. 24. Available from: https://www.who.int/dietphysicalactivity/physical-activity-promotion-2007.pdf.
32. Ells LJ, Rees K, Brown T, Mead E, Al-Khudairy L, Azevedo L, *et al.* Interventions for treating children and adolescents with overweight and obesity: An overview of Cochrane reviews. Int J Obes (Lond) 2018;42:1823-33.
33. Ohishi M. Hypertension with diabetes mellitus: Physiology and pathology review-article. Hypertens Res 2018;41:389-93.