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

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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. Approximately 57% of deaths in patients with stroke and 24% deaths in patients with coronary artery disease (CAD) have been attributed to HTN. Globally, an estimated 1.3 billion people suffer from HTN, with approximately two-thirds of them residing in lower- and middle-income countries (LMICs). The prevalence...
of HTN in the LMICs has surpassed that in developed nations.\[^{10}\] With multi-factorial causality, 90% of the patients suffer from primary HTN.\[^{11}\] 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.\[^{12}\] 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.\[^{13}\] 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.\[^{14}\]

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.\[^{15}\] In 2016, about one-third of the adult population globally was overweight or obese.\[^{16}\] 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.\[^{17}\] 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.\[^{18}\] 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.\[^{19}\]

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.\[^{20}\] 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\[^{21}\] and achieve the SDG target of decreasing premature deaths due to NCDs by one-third.\[^{22}\] 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.\[^{23}\] Existing literature on the association between the two involves sub-national small-scale analysis, which limits generalizability.\[^{24}\] 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 estimate the prevalence of HTN among the Indian population.\[^{25}\] 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.\[^{26}\] 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.\[^{27}\]

#### 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.\[^{28}\] 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.\[^{29}\] 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/m²), normal weight (18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), and obese (>25 kg/m²).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 overweight; 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

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### 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 |
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. 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. We observed only a moderate association between wealth index and HTN. A study from our neighboring country Nepal did not find any association between the two. 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. 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.

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       |                               |
| 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 = 0.448       |                               | 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 < 0.001       |                               |
| 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 < 0.022                     |                 |                               | 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 < 0.002       |                               | 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       |                               |
| 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       |                               |
| 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

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.

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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    |
| Age (in years)            |             |        |            |       |            |       |
| 20-29                     | 1.0         | [1.0‑1.0] | 1.0        | [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] |
| 40-49                     | 3.5***      | [2.9‑4.1] | 3.0***     | [2.8‑3.2] | 2.8***     | [2.5‑3.1] |
| 50-54                     | 4.4***      | [3.6‑5.4] | 4.1***     | [3.7‑4.6] | 3.4***     | [2.9‑3.9] |
| Level of education        |             |        |            |       |            |       |
| No education              | 1.0         | [1.0‑1.0] | 1.0        | [1.0‑1.0] | 1.0        | [1.0‑1.0] |
| Primary                   | 0.9         | [0.7‑1.0] | 1.1        | [1.0‑1.2] | 1.0        | [0.8‑1.2] |
| Secondary                 | 1.0         | [0.9‑1.2] | 1.1        | [1.0‑1.1] | 1.10       | [1.0‑1.3] |
| Higher Secondary & above  | 1.0         | [0.8‑1.3] | 1.1        | [1.0‑1.2] | 1.2*       | [1.0‑1.4] |
| Wealth status             |             |        |            |       |            |       |
| Poor                      | 1.0         | [1.0‑1.0] | 1.0        | [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] |
| Rich                      | 1.1         | [1.0‑1.4] | 1.3***     | [1.2‑1.4] | 1.1*       | [1.0‑1.3] |
| Type of residence         |             |        |            |       |            |       |
| Urban                     | 1.0         | [1.0‑1.0] | 1.0        | [1.0‑1.0] | 1.00       | [1.0‑1.0] |
| Rural                     | 0.9         | [0.8‑1.0] | 0.9        | [0.9‑1.0] | 1.00       | [0.9‑1.1] |
| Used any tobacco          |             |        |            |       |            |       |
| No                        | 1.0         | [1.0‑1.0] | 1.0        | [1.0‑1.0] | 1.00       | [1.0‑1.0] |
| Yes                       | 0.9         | [0.8‑1.0] | 1.0        | [0.9‑1.0] | 1.00       | [0.9‑1.1] |
| Drinking alcohol          |             |        |            |       |            |       |
| No                        | 1.0         | [1.0‑1.0] | 1.0        | [1.0‑1.0] | 1.00       | [1.0‑1.0] |
| Yes                       | 1.7***      | [1.5‑1.9] | 1.3***     | [1.3‑1.4] | 1.4***     | [1.3‑1.5] |
| Diabetes                  |             |        |            |       |            |       |
| No                        | 1.0         | [1.0‑1.0] | 1.0        | [1.0‑1.0] | 1.00       | [1.0‑1.0] |
| Yes                       | 1.1         | [0.6‑1.7] | 1.6***     | [1.3‑1.9] | 1.10       | [0.9‑1.4] |

P<0.05; **P<0.01; ***P<0.001; OR - Odds ratio; CI - 95% Confidence interval; R - 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.[31]

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.[32] 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.[32] Cigarette smoking also exerts a hypertensive effect, mainly through the stimulation of the sympathetic nervous system.[33] Similarly, patients with diabetes mellitus experience increased peripheral artery resistance caused by vascular
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    |
| Age (in years)             |             |        |            |       |
| 20-29<sup>a</sup>          | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| 30-39                      | 1.7***      | [1.6-1.8] | 1.9***     | [1.8-2.0] |
| 40-49                      | 2.9***      | [2.7-3.1] | 3.3***     | [3.2-3.4] |
| Level of education         |             |        |            |       |
| No education<sup>a</sup>   | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Primary                    | 1.0         | [0.9-1.1] | 1.1***     | [1.0-1.1] |
| Secondary                  | 1.0         | [0.9-1.0] | 1.0        | [1.0-1.1] |
| Higher Secondary & above   | 0.8***      | [0.7-0.9] | 0.9***     | [0.8-0.9] |
| Wealth status              |             |        |            |       |
| Poor<sup>a</sup>           | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Middle                     | 0.9**       | [0.9-1.1] | 1.0*       | [0.9-1.0] |
| Rich                       | 0.9         | [0.9-1.0] | 1.0        | [1.0-1.0] |
| Type of residence          |             |        |            |       |
| Urban<sup>a</sup>          | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Rural                      | 1.2***      | [1.1-1.2] | 1.1***     | [1.0-1.1] |
| Use any tobacco            |             |        |            |       |
| No<sup>a</sup>             | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Yes                        | 1.1*        | [1.1-1.2] | 1.0        | [1.0-1.1] |
| Drinking alcohol           |             |        |            |       |
| No<sup>a</sup>             | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Yes                        | 1.8***      | [1.6-2.0] | 1.6***     | [1.5-1.7] |
| Diabetes                   |             |        |            |       |
| No<sup>a</sup>             | 1.0         | [1.0-1.0] | 1.0        | [1.0-1.0] |
| Yes                        | 2.0***      | [1.6-2.5] | 1.7***     | [1.6-1.9] |

<sup>a</sup>P<0.05, **P<0.01, ***P<0.001; OR - Odds ratio; CI - 95% Confidence interval; <sup>a</sup> - 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.

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### Conflicts of interest

There are no conflicts of interest.

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