Original Article

# Diet and lifestyle risk factors associated with young adult hypertensives in India – Analysis of National Family Health Survey IV

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## Abstract

**Background:** Young adults with hypertension have a higher lifetime risk of cardiovascular diseases. Global evidence suggests a significant role of diet and lifestyle risk factors on hypertension among the young adult (aged 18–39 years) hypertensive population. **Aim:** The purpose of this study was to look for the association of diet and lifestyle risk factors with young adult hypertensives. **Results:** This study reports the prevalence of young adult hypertension based on a national representative sample based on the National Family Health Survey (NFHS-4) data and the association of behavioral risk factors with young adult hypertension. The survey adopted a two-stage stratified random sampling. The outcome variable was hypertension, whereas the exposure variables were various diet and lifestyle factors. The prevalence of young adult hypertension in India was 12.4% among men and 8.2% among women. Sikkim had the highest prevalence among both sexes. Lower prevalence was seen in the states of Delhi and Kerala. Marital status, body mass index, eating meat, alcohol intake, and taking coffee or tobacco 30 min before BP measurement were found to be associated factors that put both the sexes at risk of developing hypertension. The wealth index was concluded as a risk factor only in men while the level of education came out to be a risk factor only in females. **Conclusion:** This study is the first from India which gives a recent estimate of prevalence of young adult hypertension by state and individual level characteristics in addition to national level estimates for India.

**Keywords:** India, NFHS4, prevalence, risk factors, survey analysis, young adult hypertension

## Introduction

Non-communicable diseases (NCDs) cost millions of people every year and attributes to 67% of DALYs (Global health estimates, 2019).[1] Globally, around 1.13 billion people are estimated to have hypertension, two-thirds of which are from low- and middle-income countries.[2] The Global Action Plan for the Prevention and Control of Non-communicable Diseases and Target 3.4 of the sustainable development goals (SDGs) aims to bring down the mortality due to NCDs by 25% by 2025.[3] According to the World Health Organization (WHO), a combined national and individual effort to reduce the burden of NCDs can bring down more than half of the deaths and disabilities from cardiovascular diseases.[4] Hypertension is a major public health problem in India. The prevalence is increasing

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over time and varies across regions. The disease burden (DALYs) attributable to hypertension increased tremendously over the past three decades.[5] The current prevalence of hypertension in India is 29.8% (33.8% in urban and 27.6% in rural areas).[6] The WHO member nations, including India, have kept a target of reducing the prevalence of hypertension to 25% by 2025.[3]

Young adults (18–39-years old) with hypertension have a higher lifetime risk for cardiovascular disease.[7] Recent evidence suggests that Indians have a higher risk of cardiovascular diseases at an earlier age than western cohorts.[8] Although young adults (18–39 years old) with hypertension are being increasingly reported in the country, the health system in India mainly focuses on screening the older adult population. The risk factors and determinants of young adult hypertension should be promptly identified for planning an early detection and adequate management. According to WHO, unhealthy diets (excessive salt intake, diet low in fruits and vegetables, diet high in fat and trans fats), physical inactivity, consumption of tobacco and alcohol, obesity or being overweight are some of the modifiable risk factors of hypertension.[2] These dietary and lifestyle risk factors are also found to be associated with young adult hypertension.[9-12] Young adults with these risk factors are prone to developing prehypertension, dyslipidemia, metabolic derangements, and even raised blood sugar values, putting them at a higher risk of developing diabetes mellitus, cardiovascular diseases, and stroke.[13] The National Institute for Health and Care Excellence (NICE) guidelines for hypertension recommends specialist review of young adults with hypertension as there may be an early risk of heart disease among them.[14]

There are various multi-site surveys that studied the prevalence and risk factors of young hypertension in India, but population-specific information on determinants is required to update the policy recommendations on hypertension control. More evidence is needed based on a nationally representative sample to develop guidelines for prevention, early detection, and optimal management of hypertension in young adults. This study reports the prevalence of young adult hypertension based on a national representative sample based on the NFHS-4 data and the association of behavioral and dietary risk factors with young adult hypertension.

## Material and Methods

### Data

The NFHS is a nationally representative survey of the general population that has a wide range of information on sociodemographic and other lifestyle-related factors.[15] We used data from NFHS-4 between January 2015 and December 2016. NFHS-4 has data on fertility, maternal and child health, anemia, nutrition, family planning, and infant mortality using three different questionnaires, namely household questionnaire, women's questionnaire, and village questionnaire, covering over 29 states and 6 union territories. Also, blood glucose and blood pressure were measured for the first time in NFHS-4. The age group involved was randomly selected with women aged 15-49 years and men aged 15-54 years. The Ministry of Health and Family Welfare (MOHFW), Government of India, designated the International Institute for Population Sciences (IIPS) Mumbai, as the nodal agency, responsible for providing coordination and technical guidance for the survey. IIPS collaborated with a number of field organizations (FO) for survey implementation. Each FO was responsible for conducting survey activities in one or more states covered by the NFHS. Technical assistance for the NFHS was provided mainly by ICF (USA) and other organizations on specific issues. The funding for different rounds of NFHS has been provided by USAID, DFID, the Bill and Melinda Gates Foundation, UNICEF, UNFPA, and MOHFW, GOI.[16]

The survey adopted a two-stage stratified random sampling. The first stage involved the selection of primary sampling units (PSUs), i.e., villages, with probability proportional to population size (PPS) and census enumeration blocks in urban areas; the second stage involved the systematic selection of households within each PSU. The survey team consisted of one field supervisor, three female interviewers, one male interviewer, and two health investigators for drawing blood for testing. We merged Household Member Recode (PR) and individual dataset, and men's data (Male Recode or MR) and Household PR datasets. Then, men and individual recode were appended to each other. Those observations with valid blood pressure recording were included in the current analysis.

### Variables to be used in the main analysis

#### *Outcome variables*

High blood pressure was defined as mean systolic blood pressure ≥140 mm Hg or mean diastolic blood pressure ≥90 mm Hg, or current use of antihypertensive medication

#### *Exposure variables*

Diet and lifestyle-related factors [Supplementary Table 1]

Table 1: Characteristics of sample population by gender, NFHS-4 2015–2016

Table 2: Predictors of young adult hypertension in India (multivariable model)

*Supplementary Table 1*: Details of the exposure variables and subgroups used in the analysis

*Supplementary Table 2*: Percentage of individuals with young adult hypertension in India and its association with sociodemographic characteristics and biochemical characteristics.

### Statistical analysis

We estimated the overall prevalence (95% CI) of hypertension among young adults both at the national and state levels. The baseline characteristics were described using proportions and 95% confidence intervals (CI) for categorical variables. The age group considered for young adults were considered as 18–39 years.[17] To identify the risk factors of young adult

**Table 1: Characteristics of the sample population of young adults (18-39 years) by gender, NFHS-4 2015-2016**

| Characteristics | Male *n*=1,22,122 | % | Female *n*=6,99,886 | % | Total *n*=8,22,008 | % |
|---|---|---|---|---|---|---|
| Place of residence | | | | | | |
| Rural | 46,835 | 61.2 | 3,35,728 | 65.2 | 3,82,563 | 70.3 |
| Urban | 22,045 | 38.8 | 1,39,589 | 34.8 | 1,61,634 | 29.7 |
| Religion | | | | | | |
| Muslims | 9647 | 13.2 | 64,655 | 13.8 | 74,302 | 13.6 |
| Hindu | 50,744 | 80.8 | 3,50,009 | 80.1 | 4,00,753 | 73.6 |
| Christians | 4829 | 2.5 | 35,997 | 2.5 | 40,826 | 7.5 |
| Others | 3660 | 3.5 | 24,656 | 3.6 | 28,316 | 5.2 |
| Caste | | | | | | |
| Scheduled Caste | 11,107 | 96.5 | 77,111 | 96.2 | 88,218 | 98.5 |
| Scheduled Tribe | 155 | 3.1 | 1097 | 3.2 | 1252 | 1.4 |
| Others | 10 | 0.3 | 102 | 0.5 | 112 | 0.1 |
| Wealth Index | | | | | | |
| Poorest | 11,005 | 14.2 | 89,335 | 17.5 | 1,00,340 | 18.4 |
| Poor | 14,198 | 18.6 | 1,00,560 | 19.4 | 1,14,758 | 21.1 |
| Middle | 15,296 | 21.8 | 1,00,508 | 20.7 | 1,15,804 | 21.3 |
| Rich | 14,470 | 22.6 | 95,504 | 21.5 | 1,09,974 | 20.2 |
| Richest | 13,911 | 22.9 | 89,410 | 21.0 | 1,03,321 | 19.0 |
| Education | | | | | | |
| No formal education | 7100 | 9.9 | 1,16,000 | 23.7 | 1,23,100 | 22.6 |
| Up to primary | 8144 | 11.5 | 60,377 | 12.6 | 68,521 | 12.6 |
| Upton secondary | 40,009 | 56.5 | 2,27,520 | 47.0 | 2,67,529 | 49.3 |
| Higher secondary and above | 13,627 | 22.1 | 71,420 | 16.7 | 85,047 | 15.6 |
| Marital status | | | | | | |
| Never | 28,118 | 40.7 | 98,093 | 18.8 | 1,26,211 | 23.2 |
| Married | 40,049 | 58.4 | 3,64,343 | 78.5 | 4,04,392 | 74.3 |
| Others | 713 | 0.9 | 12,881 | 2.6 | 13,594 | 2.5 |
| BMI | | | | | | |
| Undernourished | 12,161 | 18.9 | 99,149 | 21.8 | 1,11,310 | 20.8 |
| Normal | 44,414 | 63.2 | 2,89,249 | 59.4 | 3,33,663 | 62.3 |
| Obese/Overweight | 10,986 | 17.9 | 79,016 | 18.8 | 90,002 | 16.8 |
| History of diabetes | | | | | | |
| No | 67,428 | 98.4 | 4,64,640 | 98.2 | 5,32,068 | 97.8 |
| Yes | 730 | 1.0 | 3947 | 1.0 | 4677 | 0.9 |
| Don't know | 722 | 0.6 | 6730 | 0.8 | 7452 | 1.4 |
| Blood glucose level | | | | | | |
| <99 | 32,260 | 50.1 | 2,40,930 | 53.0 | 2,73,190 | 51.4 |
| Normal (100-126) | 25,028 | 36.3 | 1,77,184 | 36.9 | 2,02,212 | 38.0 |
| High (>126 mg/dL) | 9204 | 13.6 | 47,254 | 10.1 | 56,458 | 10.6 |
| Dietary intake | | | | | | |
| i) Green leafy vegetable | | | | | | |
| Non-frequent | 8422 | 11.7 | 68,824 | 14.2 | 77,246 | 14.2 |
| Frequent | 60,458 | 88.3 | 4,06,493 | 85.8 | 4,66,951 | 85.8 |
| ii) Fruits | | | | | | |
| Inadequate | 34,847 | 49.1 | 2,67,810 | 53.3 | 3,02,657 | 55.6 |
| Adequate | 34,033 | 50.9 | 2,07,507 | 46.7 | 2,41,540 | 44.4 |
| iii) Fish | | | | | | |
| Non fish eaters | 19,248 | 27.0 | 1,69,935 | 34.8 | 1,89,183 | 34.8 |
| Fish eaters | 49,632 | 73.0 | 3,05,382 | 65.2 | 3,55,014 | 65.2 |
| iv) Meat | | | | | | |
| Non meat eaters | 15,741 | 22.6 | 1,52,644 | 31.3 | 1,68,385 | 30.9 |
| Meat eaters | 53,139 | 77.4 | 3,22,673 | 68.7 | 3,75,812 | 69.1 |
| v) Mixed diet | | | | | | |
| No | 14,791 | 21.2 | 1,44,864 | 29.5 | 1,59,655 | 29.3 |
| Yes | 54,089 | 78.8 | 3,30,453 | 70.5 | 3,84,542 | 70.7 |
| vi) Coffee* | | | | | | |

*Contd...*

**Table 1: Contd...**

| Characteristics | Male *n*=1,22,122 | % | Female *n*=6,99,886 | % | Total *n*=8,22,008 | % |
|---|---|---|---|---|---|---|
| No | 83,851 | 77.9 | 3,68,471 | 79.5 | 4,52,322 | 79.2 |
| Yes | 23,773 | 22.1 | 94,977 | 20.5 | 1,18,750 | 20.8 |
| Addiction history | | | | | | |
| a) Alcohol | | | | | | |
| i) Alcohol intake | | | | | | |
| No intake | 46,349 | 69.5 | 4,64,121 | 98.9 | 5,10,470 | 93.8 |
| Alcohol intake present | 22,531 | 30.5 | 11,196 | 1.1 | 33,727 | 6.2 |
| ii) Frequency of alcohol intake | | | | | | |
| Frequent | 11,817 | 49.60 | 5501 | 50.8 | 17,318 | 51.4 |
| Occasional | 10,714 | 50.4 | 5695 | 49.2 | 16,409 | 48.7 |
| b) Smoking | | | | | | |
| No | 50,796 | 76.9 | 4,68,503 | 99.1 | 5,19,299 | 95.4 |
| Yes | 18,084 | 23.1 | 6814 | 0.9 | 24,898 | 4.6 |
| c) Secondary smoke | | | | | | |
| No | 18,156 | 30.6 | 2,23,692 | 47.1 | 2,41,848 | 44.5 |
| Yes | 50,724 | 69.4 | 2,51,172 | 52.8 | 3,01,896 | 55.5 |
| d) Tobacco* | | | | | | |
| No | 95,856 | 89.1 | 4,50,469 | 97.2 | 5,56,325 | 95.7 |
| Yes | 11,769 | 11.0 | 12,975 | 2.8 | 24,744 | 4.3 |

*Taken 30 min before BP measurement

**Table 2: Risk factors of young adult hypertension among males and females in India, NFHS4 2015-16**

| Risk factors | Categories | Males | | Female | |
|---|---|---|---|---|---|
| | | *P* | aOR | *P* | aOR |
| Marital status | Unmarried | | Reference | | Reference |
| | Married | <0.01 | 1.80 (1.57-2.07) | 0.05 | 1.58 (1.00-2.50) |
| | Separated/Widowed | <0.01 | 2.66 (1.58-4.49) | 0.06 | 1.75 (0.98-3.14) |
| Education | No education | | | | Reference |
| | primary | | | <0.01 | 0.66 (0.50-0.88) |
| | secondary | | | 0.13 | 0.77 (0.55-1.08) |
| | Higher | | | 0.03 | 0.49 (0.26-0.94) |
| Wealth index | Poorest | | Reference | | - |
| | Poor | 0.44 | 0.93 (0.78-1.11) | | |
| | Middle | 0.16 | 1.14 (0.95-1.38) | | |
| | Rich | 0.01 | 1.29 (1.04-1.59) | | |
| | Richest | 0.75 | 1.04 (0.82-1.33) | | |
| BMI | Normal | | Reference | | Reference |
| | Undernutrition | <0.01 | 1.40 (1.16-1.69) | 0.05 | 1.28 (0.99-1.65) |
| | Overweight/Obese | <0.01 | 3.70 (2.93-4.66) | <0.01 | 2.36 (1.58-3.53) |
| Meat eaters | No | | Reference | | Reference |
| | Yes | 0.04 | 1.24 (1.01-1.52) | 0.64 | 0.90 (0.57-1.41) |
| Coffee taken 30 min before BP measurement | No | | Reference | | Reference |
| | Yes | <0.01 | 1.26 (1.09-1.45) | 0.40 | 0.89 (0.68-1.17) |
| Tobacco taken 30 min before BP measurement | No | | Reference | | Reference |
| | Yes | <0.01 | 1.28 (1.10-1.49) | 0.04 | 1.47 (1.02-2.11) |
| Alcohol intake | Frequent | | Reference | | Reference |
| | Occasional | <0.01 | 0.83 (0.73-0.93) | 0.52 | 0.93 (0.75-1.16) |

hypertension, bivariable and multivariable logistic regression were used. Exposure variables for multivariable logistic regression were selected based on $P \leq 0.2$ in bivariable logistic regression analysis and contextually important variables. Separate models were run for men and women, and risk factor association was done separately. National estimates were determined using sample weights in all analyses. The STATA 16.1 software was used for conducting analysis, and adjustment for sampling weight, cluster, and strata were done using the "svyset" command.

## Ethical approval

The study was ethically approved by the Ethical Committee, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh (PGI/IEC/2019/002357).

# Results

## Sample characteristics

A total of 6,22,437 respondents [Figure 1] in the age group 18–39 years (young adults) with 14.8% males and 85.14% females were included in this study. The mean age of the participants was 31.73 (± 11.08) years for males and 29.83 (± 9.76) years for females. The majority of the respondents were from the rural area (70.2%) and belonged to the Hindu religion (73.6%). More than half of men (58.4%) and 78.5% of women were currently married. The socioeconomic background (based on the wealth quintile) had almost equal representation from both sexes in all five quintiles, though the "poorest" background was comparatively lesser than others (14.2% in men and 17.2% of women). Primary education was received by 12%–13% of both sexes, while 23.7% of women and 9.8% of men had not received any formal education. Around 18% of men and women were obese or overweight, and 18.9% of men and 21.8% of women were undernourished. Raised blood sugar levels (>126 mg/dL) were recorded in 13.6% of men and 10.1% of women. The majority of the population follows a mixed diet (70.6%), with men having adequate fruit intake (50.9%) and more frequent green leafy vegetable intake (88.3%) than women (46.7% and 85.8%, respectively) [For details of categorization, refer to Supplementary Table 1]. Alcohol consumption and smoking habits were considerably higher in men (30.5% and 23.1%, respectively) than in women (1.1% and 0.9%, respectively), and 69.4% of men and 53.4% of women had exposure to secondary smoke. The prevalence of young adult hypertension in India among men was found to be 12.4% (95% CI: 12.1–12.7) and women 8.2% (95% CI: 8.1–8.3). Among the states, Sikkim had the highest prevalence among both sexes. Lower prevalence was seen in the states of Delhi and Kerala [Figure 2]. The characteristics of included participants are shown in Table 1.

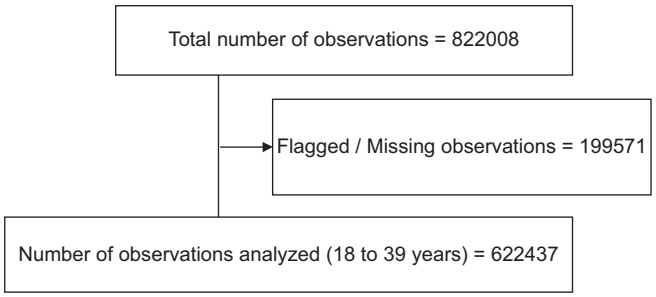


**Figure 1:** Flowchart showing number of observations analyzed and reasons for exclusion

All the exposure variables from the bivariable model had a *P* value of <0.2 in both sexes except secondary smoke in males and caste in both sexes. Secondary smoke was considered as a contextually important variable; thus, all exposure variables except caste were considered for multivariable logistic regression.

## Sociodemographic factors associated with young adult hypertension

Table 2 shows the adjusted odds ratio (aOR) estimated from the multivariable logistic regression analysis of young adult males and females separately. For men, as per AHA and JNC7 rules, the odds for hypertension were significantly higher for those belonging to the rich socio-economic category (based on wealth quintile, aOR: 1.29 (1.04–1.59). It has been also observed that married men (aOR: 1.80, CI: 1.57–2.07) and separated men compared to unmarried men had higher odds of having hypertension (aOR: 2.66, CI: 1.58–4.49). Among females, respondents having primary (aOR: 0.66, CI: 0.50–0.88) and higher education (aOR: 0.49, CI: 0.26–0.94) were significantly less likely to be hypertensive than those who had no education.

## Diet-related factors associated with young adult hypertension

There was a significant association between meat consumption and risk of hypertension among those who were young (aOR: 1.24, CI: 1.01–1.52). Those who consumed coffee 30 min

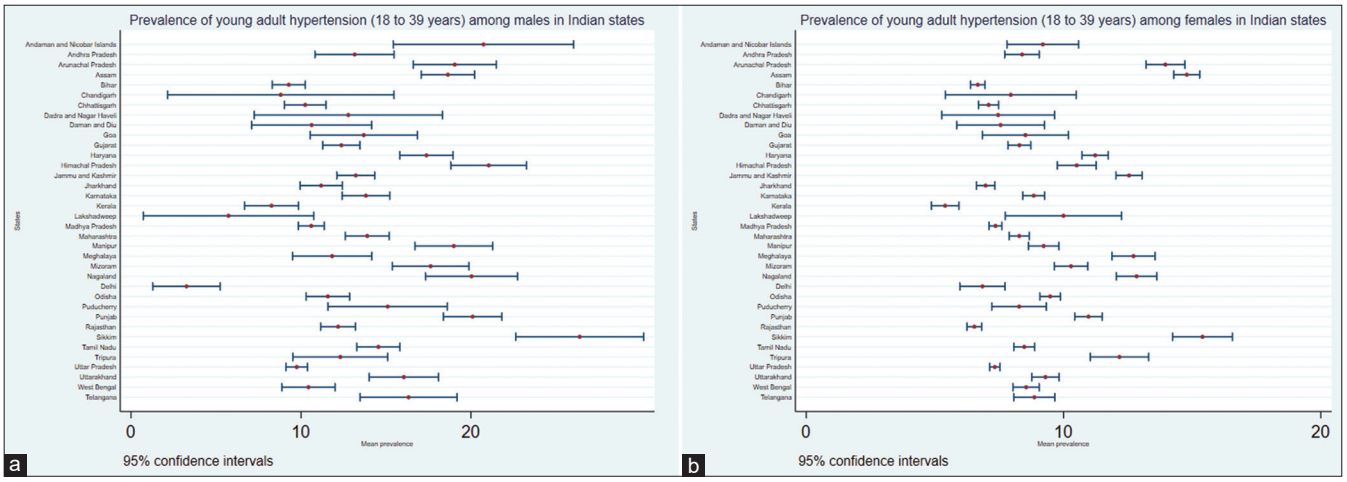


**Figure 2:** (a) Prevalence of young adult hypertension (18–39 years) among males in Indian states (b) Prevalence of young adult hypertension (18–39 years) among males in Indian states

before blood pressure measurement had higher odds of having hypertension compared to those who did not consume coffee (aOR: 1.26, CI: 1.09–1.45).

### Lifestyle-related factors associated with young adult hypertension

Men who were malnourished based on BMI (undernourished- aOR: 1.40, CI: 1.16–1.69; overweight/obese- aOR: 3.70, CI: 2.93–4.66), were found to have higher odds of having hypertension compared to those with normal BMI. Among young females too, overweight/obesity (aOR: 2.36, CI: 1.58–3.53) were found to have a higher association with risk of hypertension compared to those with normal BMI. The magnitude of association of blood pressure with tobacco use 30 min before blood pressure measurement was stronger among men (aOR: 1.28, CI: 1.10–1.49) and women (aOR: 1.47, CI: 1.02–2.11) compared to those who did not consume. Among young men, those with occasional drinking had lesser odds of having hypertension (aOR: 0.83, CI: 0.73–0.93) compared to those who reported frequent alcohol drinking.

Overall, the place of residence, religion, caste, history of diabetes, blood glucose levels, intake of green leafy vegetables or fish, mixed diet, and fruit intake had no significant association with hypertension.

## Discussion

This study aims to find out the prevalence of young adult (18–39 years old) hypertension (national and state-wise) and associated diet and lifestyle factors in a nationally representative sample of 6,22,437 individuals by using the NFHS 4 (2015–2016) data. The overall prevalence of young adult hypertension in India was higher in males (12.39%) as compared to females (8.21%). Among the state-wise prevalence, Sikkim had the highest prevalence in both sexes. Kerala had the lowest prevalence among women and Delhi among men. Factors such as marital status, body mass index, eating meat, alcohol intake, and taking coffee or tobacco 30 min before BP measurement were found to be associated with the risk of developing hypertension in both sexes. The wealth index was concluded as a risk factor only in men, while the level of education came out to be a risk factor only in females.

The overall prevalence of hypertension among young males was higher compared to females. Although the prevalence is lower compared to existing subnational surveys and regional studies, it is still higher considering the risk associated with it.[18,19] Overall, in the NFHS-4 survey, Madhya Pradesh, Maharashtra, and Uttar Pradesh had a high prevalence of hypertension.[20] However, in our analysis, northeastern states had a high prevalence of young adult hypertension. The higher prevalence can be attributed to the existing cultural diversities and socioeconomic differences, which play a role in the dietary and lifestyle practices of that area as well as highlights the need for understanding the social determinants of hypertension.[8] This is an important finding and has implications in the early diagnosis and management of young hypertension in this region.

Existing literature has found positive associations between abnormal BMI and hypertension conducted among different ethnic groups.[21,22] Obesity or overweight induced hypertension is a known concept, one of the cited reasons being impaired renal pressure natriuresis and other being the activation of the renin–angiotensin–aldosterone system (RAAS)[23] The reasons for the association between underweight and hypertensive is uncertain. Although some studies point to low body muscle mass and lack of nutrients in underweight individuals as reasons, these are not proven to be directly involved in causing hypertension.[24] The findings of our study were also similar and suggested an increased risk of hypertension for those who were obese or overweight and underweight. These malnourished young adults tend to have metabolic variations, which may be also associated with hypertension. Thus, at policy and programmatic levels, focus is required for young adults on either spectrum of BMI (low or high) as it is one of the most important primary prevention strategies of hypertension.

Being rich (based on household wealth index) has emerged as an important determinant of hypertension among young males compared to those who belong to poor economic status. This may be due to a sedentary lifestyle and consumption of readymade food, which contains more salt among those with higher economic background. Similar national survey data in the South Asian region has found that inequalities in wealth indices had a higher association of having hypertension.[25]

Our study found that higher education among females aged 18–39 years had a significantly lower risk of being hypertensive. The reason might be that educated individuals will have better awareness about hypertension compared to those who are not formally educated.[26] Awareness leads to better self-care regarding the prevention of hypertension and better health-seeking behavior.[27] They are more likely to undergo regular screening as well as be more compliant in treatment once diagnosed. Further, the use of technology to get the right information regarding hypertension might be seen in the educated group. This also highlights the importance of delivering health promotion messages through technologies such as mobile apps , websites, and television.

In our analysis, meat consumption had a significant higher risk of being hypertensive in young males. This supports the existing evidence of risk factors of young adult hypertension in larger surveys. Although meat has a higher amount of protein and minerals compared to a vegetarian diet, it is known to alter the metabolic functions of the body, which results in hypertension.[28,29]

Tobacco consumption was found to be significantly associated with higher odds of being hypertensive among young adults in both males and females. This is in sharp contradiction to

the finding of the NFHS-4 survey among the adult population where tobacco consumption was not found to be significantly associated with hypertension.[30] Smoking is proved to be associated with cardiovascular events, but the association of smoking and hypertension is inconclusive.[31] Longitudinal data may be required to confirm this finding. In accordance with the existing literature, the association between alcohol consumption and hypertension among young males was found to be significant.[32]

The India Hypertension Management Initiative (IHMI) was recently introduced in a few selected Indian sites by ICMR, Central government, state government, and WHO to reduce mortality and morbidity related to NCDs by improving the control of hypertension, reducing salt consumption, and eliminating artificial trans-fats, which are the leading risk factors for CVD.[33] The strength of the current study is that it gives a recent estimate of the prevalence of young adult hypertension by state- and individual-level characteristics in addition to a national-level estimate for India. The existing estimates are based on multiple cross-sectional studies and surveys. The National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke focuses on all aspects of hypertension, including diagnosis and management. However, a holistic approach toward hypertension management is required, including a focus on young adults especially in improving diet and lifestyle factors.

## Conclusions

The current study provides nationally representative data about the risk factors associated with young adult hypertension. More dietary factors, including consumption of salt, trans fat, and other junk foods, need to be captured in national surveys to understand the risk factors at the population level. At the policy level, taxing of salt and sugar along with subsidizing fiber-rich food needs to be considered to reduce excess consumption.

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## Conflicts of interest

There are no conflicts of interest.

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**Supplementary Table 1: Details of the exposure variables and subgroups used in the analysis**

| Variable Description | Sub-groups |
|---|---|
| Socioeconomic characteristics | |
| Place of residence | Rural |
| | Urban |
| Wealth index | Poorest |
| | Poor |
| | Middle |
| | Rich |
| | Richest |
| Religion | Muslim |
| | Hindu |
| | Christians |
| | Others (Sikh, Buddhist/neo-Buddhist, Jain, Jewish, Parsi/Zoroastrian, no religion, Other (not defined)) |
| Caste | Scheduled caste |
| | Scheduled tribe |
| | Other backward class |
| Education | No formal education |
| | Upto Primary (≤ 5 years of schooling) |
| | Upto Secondary (>5 and≤10 years of schooling) |
| | Higher Secondary and above (≥ 10 years of schooling) |
| BMI (kg/m2) | Undernourished (<18.5) |
| | Normal (18.4-24.9) |
| | Overweight or Obese (≥25.0) |
| History of Diabetes | No |
| | Yes |
| | Don't know |
| Blood Glucose level | <99 |
| | Normal (100-126) |
| | High(>126mg/dl) |
| Dietary Intake | |
| i) Green leafy Vegetable | Non frequent (Occasional/Never) |
| | Frequent (Daily/Weekly) |
| ii) Fruits | Inadequate (Occasional/Never) |
| | Adequate (Daily/weekly) |
| iii) Fish | Non fish eaters (Never) |
| | Fish eaters (Daily/Weekly/Occasional) |
| iv) Meat | Non Meat eaters (Never) |
| | Meat eaters (Daily/Weekly/Occasional) |
| v) Mixed diet | No (Non fish and Non meat eater) |
| | Yes( fish or meat eater) |
| vi) Coffee taken 30 min before BP measurement | No |
| | Yes |
| Addiction History | |
| a) Alcohol | |
| i) Alcohol intake | No |
| | Yes |
| ii) Frequency of alcohol intake | Frequent (Almost everyday/about once a week) |
| | Occasional (less than once a week) |
| b) Smoking | No |
| | Yes (Cigarette, Pipes, Cigars, Others, bidi) |
| c) Secondary Smoke | No |
| | Yes (Someone other than respondent smokes in his residence or smokes when respondent is present ) |
| d) Tobacco usage 30 minutes before BP measurement | No |
| | Yes |

*Contd...*

**Supplementary Table 2: Percentage of individuals with young adult hypertension in India and its association with sociodemographic characteristics and biochemical characteristics**

| Characteristics | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Normal *n*(%) | Hypertension *n*(%) | *P* | uOR (95% CI) | Normal *n*(%) | Hypertension *n*(%) | *P* | uOR (95% CI) |
| Place of residence | | | | | | | | |
| Rural | 39271 (88.3) | 5643 (11.7) | <0.01 | Reference | 298599 (92) | 28059 (8.0) | <0.01 | Reference |
| Urban | 17698 (86.5) | 3072 (13.5) | | 1.17 (1.08-1.27) | 121794 (91.5) | 12024 (8.5) | | 1.07 (1.02-1.11) |
| Religion | | | | | | | | |
| Muslims | 8048 (88.4) | 1069 (11.6) | <0.01 | Reference | 56321 (90.4) | 6331 (9.6) | <0.01 | Reference |
| Hindu | 42343 (87.7) | 6269 (12.3) | | 1.07 (0.95-1.20) | 312728 (92.1) | 27213 (7.9) | | 0.81 (0.77-0.85) |
| Christians | 3771 (88.1) | 710 (11.9) | | 1.03 (0.82-1.29) | 30554 (90.8) | 3718 (9.25) | | 0.96 (0.87-1.07) |
| Others | 2807 (83.4) | 667 (16.6) | | 1.51 (1.25-1.84) | 20790 (90.1) | 2821 (9.91) | | 1.04 (0.95-1.14) |
| Caste | | | | | | | | |
| Scheduled Tribe | 8916 (87.4) | 1533 (12.6) | 0.73 | Reference | 66249 (91.2) | 7508 (8.8) | 0.57 | Reference |
| Scheduled Caste | 131 (88.5) | 17 (11.5) | | 0.89 (0.44-1.81) | 927 (92.2) | 97 (7.8) | | 0.88 (0.64-1.20) |
| Others | 8 (100) | 0 | | 0.14 (0.13-0.15) | 79 (93.5) | 8 (6.5) | | 0.72 (0.27-1.91) |
| Wealth Index | | | | | | | | |
| Poorest | 9566 (90.6) | 1035 (9.4) | <0.01 | Reference | 80258 (92.2) | 6892 (7.8) | <0.01 | Reference |
| Poor | 12135 (90.3) | 1493 (9.7) | | 1.09 (0.91-1.16) | 89653 (92.3) | 8228 (7.7) | | 0.99 (0.95-1.04) |
| Middle | 12666 (87.6) | 1931 (12.4) | | 1.36 (1.22-1.52) | 89029 (92.2) | 8449 (7.8) | | 1.009 (0.96-1.06) |
| Rich | 11626 (85.6) | 2080 (14.4) | | 1.62 (1.44-1.82) | 83778 (91) | 8575 (9.0) | | 1.17 (1.11-1.23) |
| Richest | 10976 (85.5) | 2176 (14.5) | | 1.63 (1.45-1.84) | 77675 (91.3) | 7939 (8.7) | | 1.13 (1.07-1.91) |
| Education | | | | | | | | |
| No formal education | 5929 (88.1) | 848 (11.9) | 0.13 | Reference | 101868 (90.4) | 11209 (9.58) | <0.01 | Reference |
| Upto Primary | 6833 (87.4) | 964 (12.6) | | 1.06 (0.91-1.24) | 53058 (90.6) | 5810 (9.4) | | 0.98 (0.93-1.03) |
| Upto Secondary | 33218 (87.9) | 4988 (12.1) | | 1.01 (0.90-1.13) | 201729 (92.1) | 18510 (7.9) | | 0.81 (0.78-0.84) |
| Higher secondary and above | 10989 (86.8) | 1915 (13.2) | | 1.12 (0.98-1.28) | 63738 (93.9) | 4554 (6.1) | | 0.62 (0.58-0.65) |
| Marital Status | | | | | | | | |
| Never | 24095 (91.7) | 2506 (8.3) | <0.01 | Reference | 89052 (95.7) | 4702 (4.3) | <0.01 | Reference |
| Married | 32312 (84.9) | 6089 (15.1) | | 1.95 (1.80-2.11) | 320380 (91) | 33918 (9.0) | | 2.21 (2.1-2.33) |
| Others | 562 (82.4) | 120 (17.6) | | 2.35 (1.67-3.30) | 10961 (88.7) | 1463 (11.3) | | 2.85 (2.59-3.13) |
| History of Diabetes | | | | | | | | |
| no history | 55826 (87.7) | 8479 (12.3) | <0.01 | Reference | 411763 (91.9) | 38503 (8.1) | <0.01 | Reference |
| Yes | 559 (80.6) | 135 (19.4) | | 1.71 (1.29-2.27) | 3007 (80.6) | 803 (19.4) | | 2.74 (2.4-3.13) |
| No | 584 (87.9) | 101 (12.1) | | 0.97 (0.66-1.44) | 5623 (88.9) | 777 (11.1) | | 1.42 (1.22-1.65) |
| Blood Glucose level | | | | | | | | |
| <99 | 27769 (88.3) | 3993 (11.7) | <0.01 | Reference | 218955 (92.7) | 18502 (7.4) | <0.01 | Reference |
| Normal (100-126) | 21552 (88.4) | 3047 (11.6) | | 0.98 (0.91-1.07) | 159441 (91.9) | 15111 (8.1) | | 1.11 (1.07-1.15) |
| High(>126mg/dl) | 7392 (82.9) | 1636 (17.1) | | 1.56 (1.42-1.71) | 40251 (86.9) | 6251 (13.1) | | 1.90 (1.81-1.99) |
| BMI | | | | | | | | |
| Undernourished | 10592 (94) | 736 (6.0) | <0.01 | Reference | 92539 (95) | 5265 (5.0) | <0.01 | Reference |
| Normal | 38503 (89.3) | 5091 (10.7) | | 1.86 (1.66-2.08) | 262849 (93) | 21572 (7.0) | | 1.42 (1.36-1.48) |
| Obese/Overweight | 7870 (75.4) | 2888 (24.6) | | 5.07 (4.46-5.75) | 64579 (84.3) | 13186 (15.7) | | 3.5 (3.34-3.68) |
| Dietary Intake | | | | | | | | |
| i) Green leafy Vegetable | | | | | | | | |
| Non frequent | 7098 (88.8) | 917 (11.2) | 0.04 | Reference | 62204 (92.8) | 4939 (7.2) | <0.01 | Reference |
| Frequent | 49871 (87.5) | 7798 (12.5) | | 1.13 (1.005-1.28) | 358189 (91.6) | 35144 (8.4) | | 1.18 (1.13-1.24) |
| ii) Fruits | | | | | | | | |
| Inadequate | 29323 (88.9) | 4003 (11.1) | <0.01 | Reference | 238515 (91.9) | 21971 (8.1) | 0.03 | Reference |
| Adequate | 27646 (86.4) | 4712 (13.6) | | 1.25 (1.16-1.35) | 181878 (91.6) | 18112 (8.4) | | 1.03 (1.00-1.07) |
| iii) Fish | | | | | | | | |
| Non fish eaters | 16227 (88.2) | 2373 (11.8) | 0.04 | Reference | 153156 (92.3) | 13054 (7.7) | <0.01 | Reference |
| Fish eaters | 40742 (87.4) | 6342 (12.6) | | 1.08 (1.003-1.17) | 267237 (91.5) | 27029 (8.5) | | 1.1 (1.07-1.15) |
| iv) Meat | | | | | | | | |

*Contd...*

**Supplementary Table 2: Contd...**

| Characteristics | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Normal *n*(%) | Hypertension *n*(%) | *P* | uOR (95% CI) | Normal *n*(%) | Hypertension *n*(%) | *P* | uOR (95% CI) |
| Non Meat eaters | 13355 (88.6) | 1865 (11.4) | <0.01 | Reference | 137671 (92.3) | 11667 (7.7) | <0.01 | Reference |
| Meat Eaters | 43614 (87.3) | 6850 (12.7) | | 1.13 (1.04-1.23) | 282722 (91.5) | 28416 (8.5) | | 1.10 (1.07-1.15) |
| v) Mixed Diet | | | | | | | | |
| No | 12540 (88.5) | 1768 (11.5) | <0.01 | Reference | 130785 (92.3) | 11022 (7.7) | <0.01 | Reference |
| Yes | 44429 (87.4) | 6947 (12.6) | | 1.11 (1.02-1.21) | 289608 (91.6) | 29061 (8.5) | | 1.11 (1.07-1.15) |
| vi) Coffee* | | | | | | | | |
| No | 44070 (88.5) | 6158 (11.5) | <0.01 | Reference | 330047 (92.2) | 29321 (7.9) | <0.01 | Reference |
| Yes | 12898 (84.2) | 2557 (15.8) | | 1.44 (1.32-1.58) | 90343 (90.3) | 10761 (9.68) | | 1.26 (1.21-1.31) |
| Addiction History | | | | | | | | |
| a) Alcohol | | | | | | | | |
| i) Alcohol intake | | | | | | | | |
| no intake | 39006 (88.9) | 5187 (11.1) | <0.01 | Reference | 411483 (91.8) | 38484 (8.1) | <0.01 | Reference |
| Alcohol intake present | 17963 (84.7) | 3528 (15.3) | | 1.45 (1.34-1.57) | 8910 (86.6) | 1599 (13.4) | | 1.74 (1.57-1.94) |
| ii) Frequency of alcohol intake | | | | | | | | |
| Frequent | 9139 (82.9) | 2079 (17.1) | <0.01 | Reference | 4310 (85.5) | 834 (14.5) | <0.01 | Reference |
| Occasional | 8824 (86.3) | 1449 (13.7) | | 0.76 (0.68-0.87) | 4600 (87.7) | 765 (12.3) | | 0.82 (0.67-1.02) |
| b) Smoking | | | | | | | | |
| No | 42092 (87.8) | 6286 (12.2) | 0.07 | Reference | 414392 (91.8) | 39406 (8.2) | <0.01 | Reference |
| Yes | 14877 (87) | 2429 (13) | | 1.08 (0.99-1.17) | 6001 (90.2) | 677 (9.8) | | 1.21 (1.06-1.38) |
| c) Secondary Smoke | | | | | | | | |
| No | 14714 (87.3) | 2334 (12.7) | 0.36 | Reference | 180541 (91.4) | 18021 (8.6) | <0.01 | Reference |
| Yes | 42255 (87.7) | 6381 (12.3) | | 0.96 (0.88-1.04) | 239582 (92.1) | 22062 (7.9) | | 0.90 (087-0.93) |
| d) Tobacco usage* | | | | | | | | |
| No | 48408 (88) | 7084 (12) | <0.01 | Reference | 400780 (91.9) | 37371 (8.1) | <0.01 | Reference |
| Yes | 8560 (84.9) | 1631 (15.1) | | 1.31 (1.20-1.43) | 19604 (87.8) | 2712 (12.2) | | 1.58 (1.46-1.70) |

*30 minutes before Blood pressure measurement