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Sex differences in hypertension prevalence and risk factors in India – a comparative study based on National Family Health Survey IV and V

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ABSTRACT

Introduction and aim. Hypertension is increasing universally, mainly in developing countries like India. This study analyzed sex differences in hypertension using data from National Family Health Survey (NFHS) rounds IV and V, with a focus on prevalence trends and associated risk factors.

Material and methods. This study utilized data from NFHS rounds IV and V, focusing on males and females aged 15–49 years. The samples included 103,525 males and 667,258 females in NFHS-IV, and 93,267 males and 695,707 females in NFHS-V. Univariate, bivariate, and multivariate analytical techniques were employed to address the study's objectives.

Results. The NFHS-IV and V data revealed a notable increase in hypertension prevalence across India, with significantly higher odds observed among individuals in the older reproductive age group (45–49 years) for both sexes. Hypertension occurred 4.85 times higher among male in the age group 45–49 compared to 15-24 age group, which rose to 5.23 in NFHS-V. Among female, the odds increased from 5.39 in NFHS-IV to 6.40 in NFHS-V. Remarkably, illiterate male showed lower odds of hypertension linked to their educated peers in both survey rounds, while female with only primary education showed higher odds. Regional disparities were also evident, with both male and female from the Northeast showing elevated odds – particularly female, who had an odds ratio of 1.47 in NFHS-IV.

Conclusion. The observed sex-specific variations in hypertension and its risk factors indicate a need for public health strategies to designed for each gender. Tailored interventions addressing education,

lifestyle behaviors, and regional disparities are essential to effectively manage and prevent hypertension in India's diverse population.

Keywords. hypertension, prevalence, India, NFHS, risk Factors

Introduction

The global hypertension problem, often called high blood pressure (HBP), is responsible for many cases of cardiovascular disease, stroke, kidney failure, and premature death. HBP is repeatedly called the "silent killer" since it is not diagnosed until the condition develops very serious. Hypertension claims the lives of nearly 9.4 million individuals each year and most significant modifiable factors for both sickness and death around the globe.[1] In low- and middle-income countries, adult hypertension cases worldwide were expected to exceed 1.2 billion in 2021.[2] The prevalence of hypertension is rising steadily in India due to the country's aging population, stress, sedentary lifestyles, poor dietary habits, and speedy urbanization. The prevalence of high blood pressure in India is estimated at about 30%.[3] Factors such as access to healthcare, regional disparities, and socioeconomic status differences all contribute to this growing trend.[4]

Worldwide, there is growing interest in the disparities between male and female in the etiology, pathophysiology, and management of hypertension. Biological, hormonal, and behavioral factors manifest hypertension in both males and females. For example, due to the protective properties of estrogen, the premenopausal female usually has lower blood pressure than males of the same age. Based on previous studies in post-menopausal women, this condition is likely to opposite, and elderly females are more likely to have hypertension.[5] Some studies have shown that lifestyle factors like smoking and drinking affect hypertension in males compared to females, while females may face obstacles when it comes to accessing and receiving healthcare, particularly in rural areas.[6.7]

A study has shown that higher levels of salt sensitivity and arterial stiffness raise the risk of cardiovascular disease in postmenopausal females.[8] Research has demonstrated that sex hormones control endothelial, oxidative stress, and inflammation – all of which are important pathways in the etiology of hypertension.[9] Furthermore, sex-specific gene expression profiles that affect blood pressure regulation have been discovered by recent genetic and epigenetic research. This implies that the biological causes of hypertension differ between the sexes.[10]

Social and behavioral elements are just as significant as biological ones. Males are more likely than females to smoke, drink too much alcohol, and not exercise, all of which raise the risk of hypertension.[11] However, because of sociocultural norms, low health literacy, and gender bias in clinical settings, females – particularly those in low- and middle-income countries – frequently face a systemic lack of accessing health care, under-diagnosis, and undertreatment.[12.13]

A global review by Wang et al. showed that women are just as likely or more likely than males to have bad cardiovascular outcomes, but they are less likely to get antihypertensive treatment that follows guidelines, especially in older people.[14] The World Health Organization's INTERHEART study and the

STEPS survey also found that females in many areas, including South Asia and sub-Saharan Africa, are less likely to know about high blood pressure and how to treat and control it. This shows that health strategies need to be more gender-sensitive.[9,15]

Studies highlighted these gender-specific trends in hypertension, emphasizing the need for sex-specific strategies in prevention and management.[8,9] In the Indian context, socio-cultural factors, delayed childbearing, hormonal transitions, and rising obesity rates among urban female are influencing the shifting hypertension burden. Additionally, the combined effect of genetic predisposition and environmental exposures is now recognized as a critical driver of hypertension risk in both sexes.[16,17] Moreover, recent advancements in precision medicine and global health research highlight the importance of integrating sex as a biological variable in both epidemiological surveillance and clinical practice.[18-20] The Lancet Commission on Female and Cardiovascular Disease emphasized that the historical under representation of females in cardiovascular research has led to gaps in diagnostic accuracy and therapeutic effectiveness for female patients.[21] Tailored interventions, such as community-based blood pressure screening programs that address women's unique health needs –including reproductive health milestones like pregnancy-induced hypertension – are gaining importance. In India, initiatives such as the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS) offer a platform to incorporate such gender-sensitive approaches.[22] However, for these efforts to succeed, there must be a stronger emphasis on disaggregated data analysis, targeted health messaging, and improved access to antihypertensive care for females across diverse socio-economic backgrounds.

Evaluating variations in hypertension prevalence in India can be done using surveys like the National Family Health Survey (NFHS). The latest datasets from 2015–2016 and 2019–2021 give the blood pressure levels and associated risk factors in male and female between the ages of 15 and 49. These datasets are strong, but there is not adequate research on the evaluation of hypertension prevalence and its risk factors in both rounds together by sex. Knowledge about these differences is necessary for making public health interventions that work for the targeted population. Both males and females come across different sets of problems, including the way they eat, stress, using tobacco or alcohol, and unequal healthcare. Moreover, gender can affect decisions about treatment and make it more difficult to manage high blood pressure.

Aim

This study aims to compare the occurrence of hypertension and hypertension linked factors in Indian males and females by using two rounds of NFHS-IV and V datasets to understand socio-demographic and behavioral factors and offer sex-sensitive strategies for hypertension prevention and management in an Indian context.

Material and methods

The NFHS data is a comprehensive, multi-phase survey implemented by the Ministry of Health and Family Welfare (MoHFW) in India and overseen by the International Institute of Population Sciences (IIPS), Mumbai. This analysis draws on data from the fourth (2015–2016) and fifth (2019–2021) rounds of the NFHS. As part of the Demographic and Health Survey (DHS) program, the NFHS gathers important data on health, fertility, family planning, mortality, and nutritional status across the Indian population.[23]

Sampling design

Both NFHS-IV and NFHS-V employed a two-stage stratified sampling method. Villages were in rural areas (primary sampling units (PSUs)), whereas census enumeration blocks (CEBs) were used in urban areas. In the primary stage, a predetermined number of PSUs were nominated from each stratum using probability proportional to size (PPS) sampling. In the second stage, 22 households were systematically and randomly selected from each PSU to join in the survey. NFHS-IV covered 640 districts in 29 states and 7 union territories, collecting data from 699,686 females aged between 15 and 49 years and 101,839 males aged 15 to 54 years. NFHS-V expanded the survey to 707 districts in 28 states and 8 union territories, surveying 724,115 females and 112,122 males in the same age group. The analysis used individual recoding files for males and females separately and combined them to examine sex differences. Only respondents with complete blood pressure measurements and valid demographic covariates were included in the final analysis. For this analysis, males aged 15–49 years were selected to match the female age group, enabling better age comparison between sexes. The samples comprised 103,525 males and 667,258 females in NFHS-IV, and 93,267 males and 695,707 females in NFHS-V (Fig. 1). Both surveys provide estimates at the state and district level, disaggregated by rural or urban residence and other key socio-demographic factors. Structured questionnaires were administered through computer-assisted personal interviews (CAPI) by trained enumerators. The NFHS tools include four core questionnaires: Household, Woman's, Man's, and Biomarker. More information refers to NFHS-IV and V reports.[23]

Blood pressure measurement and inclusion criteria

Blood pressure measurements were performed as part of the biomarker component of the survey using an Omron digital automated blood pressure monitor (model HEM-8712 in NFHS-IV and newer model in NFHS-V). Trained researchers followed a standardized protocol: respondents were asked to rest in a seated position for at least five minutes. Three measurements were then taken at approximately five-minute intervals. The average of the last two measurements was used for analysis, in accordance with WHO guidelines and the DHS protocol.[1,23] In particular, the NFHS measurement protocol also complies with the methodological standards of the International Society of Hypertension's "Measurement Month in May" initiative (2017–2019), which aims to standardize hypertension screening worldwide and improve data equivalence across populations.[24]

Variable descriptions

Outcome variable

For each participant, blood pressure (BP) was measured three times at five-minute intervals using an OMRON digital monitor by trained health personnel. The mean of the last two readings was taken as the ultimate BP value. Participants were considered hypertensive if their average systolic BP was ≥140 mmHg, their average diastolic BP was ≥90 mmHg, or if they reported current use of prescribed antihypertensive medication. For analytical purposes, a binary variable was generated, with hypertensive individuals coded as one and not a hypertensive individuals coded as zero in both NFHS-IV and NFHS-V.[23]

Independent variables

In this study, we included socio-demographic variables as covariates to categorize key risk factors related with hypertension. Age groups were divided into four groups: 15–24, 25–34, 35–44, and 45–49 for males and females in NFHS-IV and NFHS-V. Additional socio- demographic variables measured such as education level (primary, no education, secondary, or higher), place of residence (rural or urban) and occupation (unemployed, employed, or engaged in agriculture). Marital status was classified as unmarried or married, while religious affiliation included Hindus, Muslims, or others. Caste categories included Scheduled Castes/Scheduled Tribes (SC/ST), Other Backward Classes (OBC), and others. Wealth status was measured using the Wealth Index, categorized into five groups: poorest, poorer, middle, richer, and richest. Additionally, lifestyle factors incorporated into the analysis included alcohol consumption (yes or no), tobacco use (yes or no), and geographical region (central, north, east, northeast, west, and south).

Statistical analysis

The analysis incorporated univariate, bivariate, and multivariable logistic regression methods. Descriptive analysis was used to summarize participant appearances. Bivariate analyses assessed the relationship between explanatory variables and outcome variable, using Pearson's Chi-square test for associations and the z-test to compare differences between NFHS-IV and NFHS-V. To examine predictors of hypertension, a multivariable binary logistic regression model was applied, with results presented as adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Sampling weights were accounted for in all analyses, and statistical significance was set at a two-tailed p-value<0.05. Data analysis was performed using IBM SPSS version 19.0.

Bivariate technique

A cross-tabulation was projected to recognize the occurrence of prevalence of high blood pressure in each characteristic and Pearson's $\chi 2$ test was estimated to know the association of factors with hypertension. The following formula has been used to estimate Pearson's chi-square test in this study.

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \text{ with } (r-1)(c-1) \text{ degrees of freedom}$$

Where,

O_i=observed number of samples

E_i=expected number of samples

The z-test for two independent samples is estimated to know the change of prevalence from round 4 to round 5. The following formula has been used to estimate z-test for two independent samples in this study.

$$z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}} \text{ with } (n_1 + n_2 - 2) \text{ degrees of freedom}$$

Where,

$\bar{x}_1$=sample average of the first sample

$\bar{x}_2$=sample average of the second sample

SD_1^2=sample variance of the first sample

SD_2^2=sample variance of the second sample

n_1 =total number of observations in first samples

n_2=total number of observations in second samples

Multivariate technique

Binary logistic regression was employed to estimate the likelihood of hypertension across different categories of explanatory variables. In this model, the dependent variable was binary (hypertensive vs. non-hypertensive), while the independent variables included both categorical and continuous predictors. The following binary logistic regression framework was applied in this study.

$$log\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n$$

$$\text{Let } f(x) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n$$

Where,

$$p = \frac{e^{f(x)}}{1 + e^{f(x)}} \;\; \& \;\; q = 1 - p$$

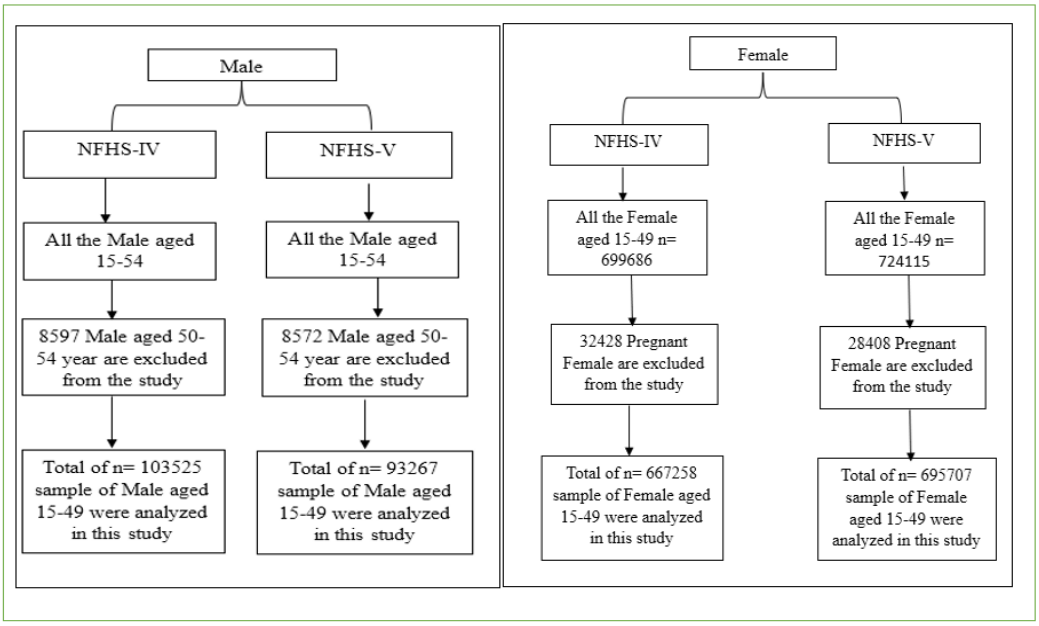

Fig. 1. Assortment of study participants from both NFHS IV and V for male and female samples

Results

The prevalence of hypertension in India has increased from NFHS-IV to NFHS-V for both males and females. In NFHS-IV, 15.5% of males and 12.2% of females had hypertension, which rose to 16.4% for males and 13.3% for females in NFHS-V (Fig. 2). Background characteristics of males and females from NFHS-IV and NFHS-V are presented in Table 1.

The highest increases were observed in the 35–44 and 45–49 age groups. Among females aged 35–44, the prevalence rose from 19.8% to 21.3%, while in the 45–49 age group, it increased from 28.1% to 31.0%. Similar patterns were observed among males in both rounds. For instance, in the 35–44 age group, the prevalence increased from 24.3% in Round IV to 26.7% in Round V; and in the 45–49 group, it rose from 30.2% to 33.7%. Hypertension prevalence also increased among both males and females in urban and rural areas. In urban areas, it rose from 13.4% to 14.6% among females and from 18.8% to 19.8% among males. In rural areas, it increased from 12.4% to 13.4% among females and from 15.5% to 17.3% among males. Increases were also observed across education levels and lifestyle factors. Among males with no formal education, the prevalence rose from 17.3% to 20.2%, while among females in the same category, it increased from 16.2% to 19.3% (Table 2 and Table 3).

The analysis of hypertension among males and females in India reveals significant associations with various demographic and socioeconomic characteristics. For males, age emerged as a critical factor, with those aged 45–49 displaying the highest adjusted odds ratio (AOR) of hypertension (AOR=4.85, p<0.001, 95% C.I: 4.47–5.25) in NFHS-IV and (AOR=5.23, p<0.001, 95% C.I 4.81–5.68) in NFHS-V. Education also played a role, as illiterate males had lower odds of hypertension (AOR=0.81, p<0.001, 95% C.I: 0.75–0.87in NFHS-IV and AOR=0.85, p<0.001, 95% C.I: 0.79–0.92 in NFHS-V) compared to their higher educated counterparts. Geographically, males in the Northeast exhibited higher odds (AOR=1.29, p<0.001, 95% C.I: 1.21–1.08 in NFHS-IV and AOR=1.08, p<0.001, 95% C.I: 1.01–1.16 in NFHS-V). Married males were more likely to have hypertension (AOR=1.22, p<0.001, 95% C.I: 1.15–1.30 in NFHS-IV and AOR=1.21, p<0.001, 95% C.I: 1.14–1.28 in NFHS-V). Additionally, unemployed and agriculture occupation of males showed lower odds (AOR=0.91, p<0.001, 95% C.I: 0.85–0.96 and AOR=0.89, p<0.001, 95% C.I: 0.86–0.93 in NFHS-IV and (AOR=0.81, p<0.001, 95% CI: 0.75–0.87 and AOR=0.88, p<0.001, 95% C.I: 0.84–0.92 in NFHS-V). Also, the poorest males had reduced odds of hypertension (AOR=0.63, p<0.001, 95% C.I: 0.58–0.68 in NFHS-IV and AOR: 0.72, p<0.001, 95% C.I: 0.66–0.77 in NFHS-V) compared to the richest. Alcohol consumption was significantly associated with increased odds of hypertension among males (AOR: 1.34, p<0.001, 95% C.I: 1.29–1.39 in NFHS-IV and AOR=1.44, p<0.001, 95% C.I: 1.38–1.50 in NFHS-V) (Table 4).

Among females, those aged 45–49 had the highest odds of hypertension (AOR=5.39, p<0.001, 95% CI: 5.21–5.57 in NFHS-IV and AOR=6.40, p<0.001, 95% C.I: 1=6.18–6.63 in NFHS-V). Notably, rural females initially had higher odds (AOR=1.05, p<0.001, 95% C.I: 1.03–1.07 in NFHS-IV), but this trend reversed in NFHS-V (AOR=0.98, p<0.001, 95% C.I: 0.98–1.00). Muslim females showed increased odds in NFHS-IV (AOR=1.22, p<0.001, 95% C.I: 1.19–1.25), while females from other religious groups had higher odds in NFHS-V (AOR=1.22, p<0.001, 95% C.I: 1.22–1.25). Females who have a primary education exhibited elevated odds of hypertension (AOR=1.28, p<0.001, 95% C.I: 1.24–1.33 in NFHS-IV and AOR=1.42, p<0.001, 95% C.I: 1.29–1.39 in NFHS-V). Regionally, women in the Northeast had higher odds in NFHS-IV (AOR: 1.47, p<0.001, 95% C.I: 1.43–1.51), higher risk were shifted to the Central region in NFHS-V (AOR: 1.11, p<0.001, 95% C.I: 1.09–1.14). Married females also had significantly higher odds (AOR=1.16, p<0.001, 95% C.I: 1.12–1.19 in NFHS-IV and AOR=1.24, p<0.001, 95% C.I: 1.20-1.28 in NFHS-V). Alcohol consumption was consistently linked to a higher risk of hypertension (AOR=1.43, p<0.001, 95% C.I: 1.37–1.49 in NFHS-IV and AOR=1.41, p<0.001, 95% C.I: 1.35–1.48 in NFHS-V) (Table 5).

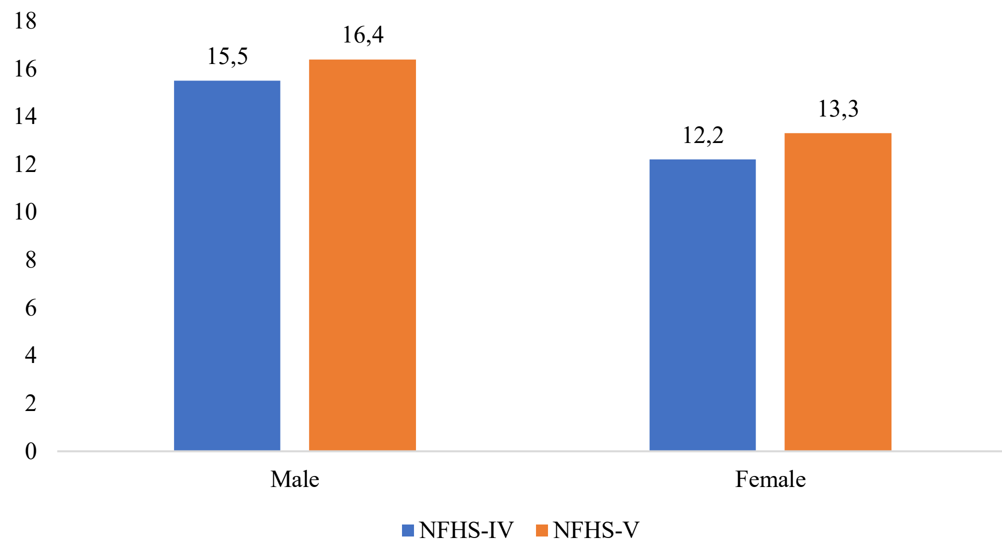

Fig. 2. Prevalence of hypertension among males and females in India, NHFS IV and V

Table 1. Background characteristics of males and females in NFHS-IV and NFHS-V

Variables	NFHS-IV		NFHS-V	
	Male	**Female**	**Male**	**Female**
	n (%)	**n (%)**	**n (%)**	**n (%)**
Age-group				
15–24	35712 (34.5)	230412 (34.5)	31070 (33.3)	227011 (32.6)
25–34	30791 (29.7)	198657 (29.8)	27652 (29.6)	206660 (29.7)
35–44	25851 (25)	165591 (24.8)	23712 (25.4)	178024 (25.6)
45–49	11171 (10.8)	72598 (10.9)	10833 (11.6)	84012 (12.1)
Residence				

Urban	32771 (31.7)	196917 (29.5)	24211 (26)	173942 (25)
Rural	70754 (68.3)	470341 (70.5)	69056 (74)	521765 (75)
Religion				
Hindu	77115 (74.5)	496025 (74.3)	70608 (75.7)	525869 (75.6)
Muslim	14437 (13.9)	89340 (13.4)	11317 (12.1)	86140 (12.4)
Others	11973 (11.6)	81893 (12.3)	11342 (12.2)	83698 (12)
Caste				
SC/ST	36883 (37.7)	239513 (35.9)	35496 (40)	263550 (40)
OBC	40181 (41.1)	260754 (39.1)	35991 (40.6)	266321 (40.4)
Others	20666 (21.1)	166991 (25)	17230 (19.4)	128850 (19.6)
Education				
No education	12593 (12.2)	188407 (28.2)	9980 (10.7)	162651 (23.4)
Primary	12684 (12.3)	84010 (12.6)	10169 (10.9)	81896 (11.8)
Secondary	61706 (59.6)	318853 (47.8)	56197 (60.3)	354007 (50.9)
Higher	16542 (16)	75988 (11.4)	16921 (18.1)	97153 (14)
Region				
North	22855 (22.1)	134495 (20.2)	19565 (21)	142028 (20.4)
Central	25964 (25.1)	175810 (26.3)	21452 (23)	163067 (23.4)
East	15864 (15.3)	119723 (17.9)	13887 (14.9)	112963 (16.2)
Northeast	13360 (12.9)	94145 (14.1)	13540 (14.5)	98754 (14.2)
West	11434 (11)	54157 (8.1)	10606 (11.4)	69481 (10)
South	14048 (13.6)	88928 (13.3)	14217 (15.2)	109414 (15.7)
Marital status				
Unmarried	39869 (38.5)	171704 (25.7)	36754 (39.4)	181211 (26)
Married	63656 (61.5)	495554 (74.3)	56513 (60.6)	514496 (74)
Wealth index				
Poorest	17035 (16.5)	125566 (18.8)	18151 (19.5)	142912 (20.5)
Poorer	21584 (20.8)	141850 (21.3)	20823 (22.3)	153749 (22.1)
Middle	22604 (21.8)	140571 (21.1)	19928 (21.4)	145760 (21)
Richer	21516 (20.8)	132927 (19.9)	18494 (19.8)	134521 (19.3)
Richest	20786 (20.1)	126344 (18.9)	15871 (17)	118765 (17.1)
Consumes tobacco				
No	67173 (64.9)	610220 (91.5)	57234 (61.4)	651086 (93.6)
Yes	36352 (35.1)	57038 (8.5)	36033 (38.6)	44621 (6.4)

Consumes alcohol				
No	71296 (68.9)	650548 (97.5)	69552 (74.6)	682532 (98.1)
Yes	32229 (31.1)	16710 (2.5)	23715 (25.4)	13175 (1.9)
Occupation				
Unemployed	24170 (23.4)	24170 (23.4)	18870 (20.3)	18870 (20.3)
Employee	49916 (48.3)	49916 (48.3)	45411 (48.8)	45411 (48.8)
Agriculture	29242 (28.3)	29242 (28.3)	28758 (30.9)	28758 (30.9)
Body mass index				
Normal	59880 (61.2)	387734 (59.2)	24253 (57.4)	401557 (59.8)
Underweight	19166 (19.6)	146439 (22.4)	8903 (21.1)	121992 (18.2)
Overweight and obese	18751 (19.2)	120983 (18.5)	42269 (21.5)	148195 (22.1)

Table 2. Prevalence of hypertension and its association with selected background characteristics of male in NFHS-IV and NFHS-V[a]

Variables	NFHS-IV		NFHS-V		z-test
	Prevalence (%)	χ^2 (p-value)	Prevalence (%)	χ^2 (p-value)	
Age group					
15–24	6.7	5217.1	6.9		1.024
25–34*	15.7	(<0.05)	16.6	5688.5	2.95
35–44*	24.3		26.7	(<0.05)	6.122
45–49*	30.2		33.7		5.569
Type of place of residence					
Urban*	18	99.9	19.8	74.2	5.412
Rural*	15.5	-0.05	17.3	(<0.05)	9.088
Religion					
Hindu*	16	241.4	17.8	326.9	9.216
Muslim	14.2	(<0.05)	13.6	(<0.05)	1.383
Other*	20.9		22.8		3.509
Caste					
SC/ST*	16.7	107.9	18.8	48.8	7.391
OBC*	15	(<0.05)	16.9	(<0.05)	7.143
Others	18.2		18.8		1.497
Educational level					

No education*	17.3	150	20.2	132.8	5.529
Primary*	17.4	(<0.05)	20.9	(<0.05)	6.664
Secondary*	15.2		16.9		7.937
Higher	18.9		18.1		1.884
Region					
North	18.2	825	18.3		0.266
Central*	12.8	(<0.05)	17.3		13.588
East*	12.8		14.3	381.0	3.766
North East*	22.3		21.3	(<0.05)	1.986
West*	16.2		15		2.455
South*	18.1		20.9		5.945
Marital status					
Unmarried*	8.7	2723.3	9.1	3192.7	1.942
Married*	21.1	(<0.05)	23.7	(<0.05)	10.782
Occupation					
Unemployed*	9.4	1172.7	8.2	1578.9	4.378
Employed*	19.3	(<0.05)	21.1	(<0.05)	6.91
Agriculture*	16.8		19.2		7.524
Wealth index combined					
Poorest*	12.3	609.1	15.3	233	8.173
Poorer*	13.7	(<0.05)	16.7	(<0.05)	8.604
Middle*	16.2		18.1		5.182
Richer	18.5		19.1		1.531
Richest*	20.2		21.1		2.107
Consumes tobacco					
No*	15.7	59.9	16.4	249.0	3.35
Yes*	17.5	(<0.05)	20.4	(<0.05)	9.96
Consumes alcohol					
No*	14.1	806.2	15.3	1288.7	6.358
Yes*	21.2	(<0.05)	25.7	(<0.05)	12.369
Body mass index$					
Normal	14.2	609.1	21.9	796.6	-25.544
Underweight	6.7	(<0.05)	17.3	(<0.05)	-24.109

Overweight and obese	31.6	34.2	-4.320

[a] * – significant change in proportion variations among NFHS-IV and NFHS-V (using z-test) at 5% level of significance, % – indicates percentage change from NFHS-IV to V, χ^2 – indicate Chi-square value, ST – Scheduled Tribe, SC – Scheduled Caste and OBC – Other Backward Class, $ – based on the matched cases in NFHS-V dataset

Table 3. Prevalence of hypertension and its association with selected background characteristics of female in NFHS-IV and NFHS-V[a]

Variables	NFHS-IV		NFHS-V		z-test
	Prevalence		Prevalence		
Age-group					
15–24*	4.7		4.20		8.20
25–34	10.4	37404.4	10.40	49379.4	0
35–44*	19.8	(<0.05)	21.30	(<0.05)	10.88
45–49*	28.1		31.00		12.56
Place of residence					
Urban*	13.4	131.3	14.60	166.5	10.50
Rural*	12.4	(<0.05)	13.40	(<0.05)	14.85
Religion					
Hindu*	11.9		13.20	741.4	19.84
Muslim*	14.1	1054.2	13.40	(<0.05)	4.25
Other*	15.6	(<0.05)	16.70		6.08
Caste					
SC/ST*	12.7	610.1	13.70	207	10.47
OBC*	11.6	(<0.05)	13.00	(<0.05)	15.47
Other*	14.2		14.70		3.83
Education					
No education*	16.2	4315.7	19.30	8790.9	23.93
Primary*	15	(<0.05)	17.80	(<0.05)	15.40
Secondary*	10.8		11.40		7.82
Higher*	9.4		9.00		2.85
Region					
North*	13.3	2807.1	14.40	662.9	8.37

Central*	10.8	(<0.05)	13.50	(<0.05)	24.01
East*	11.1		12.00		6.78
North East*	17.4		15.50		11.24
West	12.4		12.60		1.05
South*	12.8		13.70		5.88
Marital status					
Unmarried*	5.1	11870.9	04.50	17248.9	8.32
Married*	15.3	(<0.05)	16.90	(<0.05)	21.88
Wealth index					
Poorest*	11.1	744.2	12.10	678.3	8.08
Poorer*	12	(<0.05)	13. 00	(<0.05)	8.21
Middle*	12.5		13.90		11.07
Richer*	13.8		14.50		5.19
Richest*	14.1		15.20		7.69
Consumes tobacco					
No*	12.3	845.6	13.30	1267.9	16.81
Yes*	16.5	(<0.05)	19.30	(<0.05)	11.52
Consumes alcohol					
No*	12.4	1182.7	13.50	1036.5	18.91
Yes*	21.4	(<0.05)	23.20	(<0.05)	3.70
Body mass index					
Normal*	11.1	23490.2	11.80	23797.7	9.76
Underweight	7	(<0.05)	7	(<0.05)	0
Overweight	25.7		25.80		0.59

[a] * – significant difference in percentage change between NFHS-IV and NFHS-V (using z-test) at 5% level of significance, % – indicates percentage change from NFHS-IV to V, χ^2 – indicate Chi-square value, SC – Scheduled Caste, ST – Scheduled Tribe, OBC – Other Backward Class, $ – based on the matched cases in NFHS-V dataset

Table 4. Results of multivariable logistic regression to measure the effect of covariates on hypertension among Indian males, NFHS-IV and NFHS-V[a]

Variables	Male			
	NFHS–IV		NFHS–V	
	Exp(B) (95% CI)	p	Exp(B) (95% CI)	p
Age group				
15–24	1		1	
25–34	2.08 (1.94–2.22)	<0.05	2.08 (1.94–2.24)	<0.05
35–44	3.55 (3.3–3.82)	<0.05	3.63 (3.37–3.92)	<0.05
45–49	4.85 (4.47–5.25)	<0.05	5.23 (4.81–5.68)	<0.05
Place of residence				
Urban	1		1	
Rural	1.03 (0.98–1.07)	0.26	0.97 (0.92–1.01)	0.15
Religion				
Hindu	1		1	
Muslim	0.95 (0.9–1.02)	0.14	0.8 (0.75–0.86)	<0.05
Other	1 .00 (0.94–1.07)	0.90	1.24 (1.17–1.32)	<0.05
Caste				
SC/ST	1		1	
OBC	0.93 (0.89–0.97)	<0.05	0.93 (0.89–0.97)	<0.05
Other	1.00 (0.95–1.05)	0.93	1.00(0.95–1.05)	0.93
Education				
Higher	1		1	
No education	0.81 (0.75–0.87)	<0.05	0.85 (0.79–0.92)	<0.05
Primary	0.86 (0.8–0.92)	<0.05	0.94 (0.87–1.01)	0.09
Secondary	0.87 (0.82–0.91)	<0.05	0.96 (0.91–1.01)	0.13
Region				
North	1		1	
Central	0.73 (0.69–0.77)	<0.05	1.07 (1.01–1.13)	<0.05
East	0.71 (0.67–0.76)	<0.05	0.79 (0.74–0.84)	<0.05
North East	1.29 (1.21–1.38)	<0.05	1.08 (1.01–1.16)	<0.05
West	0.86 (0.81–0.92)	<0.05	0.81 (0.76–0.87)	<0.05
South	0.89 (0.84–0.95)	<0.05	1.07 (1.01–1.14)	<0.05
Marital status				

Unmarried	1		1	
Married	1.22 (1.15–1.3)	<0.05	1.21 (1.14–1.28)	<0.05
Occupation				
Employed	1		1	
Unemployed	0.91 (0.85–0.96)	<0.05	0.81 (0.75–0.87)	<0.05
Agriculture	0.89 (0.86–0.93)	<0.05	0.88 (0.84–0.92)	<0.05
Wealth index				
Richest	1		1	
Poorest	0.63 (0.58–0.68)	<0.05	0.72 (0.66–0.77)	<0.05
Poorer	0.68 (0.63–0.72)	<0.05	0.79 (0.73–0.84)	<0.05
Middle	0.81 (0.76–0.86)	<0.05	0.85 (0.8–0.9)	<0.05
Richer	0.95 (0.9–1)	<0.05	0.91 (0.86–0.97)	<0.05
Consumes tobacco				
No	1		1	
Yes	0.95 (0.92–0.99)	0.02	0.97 (0.93–1.01)	0.11
Consumes alcohol				
No	1		1	
Yes	1.34 (1.29–1.39)	<0.05	1.44 (1.38–1.5)	<0.05

[a] CI – confidence interval, ST – Scheduled Tribe, SC – Scheduled Caste, OBC – Other Backward Class

Table 5. Results of multivariable logistic regression to measure the effect of covariates on hypertension among Indian females in India, NFHS-IV and NFHS-V[a]

Variables	NFHS–IV		NFHS–V	
	Exp(B) (95% CI)	p	Exp(B) (95% CI)	p
Age group				
15–24	1		1	
25–34	1.78 (1.73–1.84)	<0.05	1.91 (1.85-1.98)	<0.05
35–44	3.46 (3.35–3.56)	<0.05	3.93 (3.8-4.06)	<0.05
45–49	5.39 (5.21–5.57)	<0.05	6.4 (6.18-6.63)	<0.05
Place of residence				
Urban	1		1	
Rural	1.05 (1.03–1.07)	<0.05	0.98 (0.96-1)	0.05
Religion				
Hindu	1		1	

Muslim	1.22 (1.19–1.25)	<0.05	1.06 (1.03-1.08)	<0.05
Other	0.99 (0.96–1.01)	0.37	1.22 (1.19-1.25)	<0.05
Caste				
SC/ST	1		1	
OBC	0.94 (0.92–0.96)	<0.05	0.95 (0.94-0.97)	<0.05
GM	1.02 (1–1.04)	0.07	0.99 (0.97-1.01)	0.28
Education				
Higher	1		1	
No education	1.26 (1.22–1.3)	<0.05	1.38 (1.33-1.42)	<0.05
Primary	1.28 (1.24–1.33)	<0.05	1.42 (1.37-1.47)	<0.05
Secondary	1.16 (1.12–1.19)	<0.05	1.23 (1.19-1.26)	<0.05
Region				
North	1		1	
Central	0.88 (0.86–0.91)	<0.05	1.11 (1.09-1.14)	<0.05
East	0.91 (0.89–0.94)	<0.05	0.93 (0.9-0.95)	<0.05
North East	1.47 (1.43–1.51)	<0.05	1.03 (1-1.06)	0.08
West	0.96 (0.93–0.99)	<0.05	0.89 (0.86-0.91)	<0.05
South	0.87 (0.85–0.89)	<0.05	0.82 (0.8-0.84)	<0.05
Marital status				
Unmarried	1		1	
Married	1.16 (1.12–1.19)	<0.05	1.24 (1.2-1.28)	<0.05
Wealth index				
Richest	1		1	
Poorest	0.99 (0.96–1.03)	0.72	0.88 (0.86-0.91)	<0.05
Poorer	0.98 (0.95–1.01)	0.15	0.94 (0.91-0.97)	<0.05
Middle	0.96 (0.94–0.99)	0.01	0.98 (0.95-1)	0.1
Richer	1.02 (1–1.05)	0.12	1 (0.97-1.03)	0.98
Consumes tobacco				
No	1		1	
Yes	0.93 (0.91–0.95)	<0.05	1.06 (1.03-1.09)	<0.05
Consumes alcohol				
No	1		1	
Yes	1.43 (1.37–1.49)	<0.05	1.41 (1.35-1.48)	<0.05
Body mass index				

Normal	1		1	
Underweight	0.75 (0.73–0.77)	<0.05	0.79 (0.77-0.81)	<0.05
Obese	2.19 (2.16–2.23)	<0.05	2.05 (2.02–2.09)	<0.05

[a] CI – confidence interval, ST – Scheduled Tribe, SC – Scheduled Caste, OBC – Other Backward Class

Discussion

The findings from NFHS-IV and NFHS-V about hypertension trends in India highlight a concerning public health issue, with significant rises in prevalence among both males and females. Hypertension rates increased from 12.2% in NFHS-IV to 13.3% in NFHS-V, highlighting a broader trend that reflects the growing global concern over non-communicable diseases (NCDs) in developing countries.[1,24] Hypertension, a leading risk factor for cardiovascular diseases (CVDs), stroke, and kidney disease, has reached alarming levels – particularly in older populations. These findings align with global patterns, where hypertension prevalence increased with age, especially among individuals aged 35–49 years, as seen in both this study and existing worldwide literature.[1,24] This trend reflects deeper societal changes that are influencing lifestyle and health behaviors.

The rising prevalence of hypertension across all age groups is particularly concerning, with a notable increase among individuals aged 35–44 and 45–49 years. Our findings, consistent with existing literature, reveal that middle-aged adults are more susceptible to hypertension due to a combination of factors such as psychological stress, unhealthy dietary habits, physical inactivity, and environmental conditions.[25-28] However, these trends are not even across the sexes. Men in these age groups often exhibit higher hypertension rates, potentially related to more alcohol consumption, tobacco use, and occupational stress. In contrast, women – particularly those in the post-reproductive age group—may experience increased hypertension risk due to hormonal changes, rising obesity, and limited access to preventive healthcare.

The increase in hypertension prevalence in both urban and rural populations is a significant finding. In urban areas, prevalence rose from 13.4% in NFHS-IV to 14.6% in NFHS-V, while in rural areas, it increased from 12.4% to 13.4% over the same period. This urban-rural disparity reflects complex lifestyle and environmental dynamics and gender-related dynamics. Although urbanization often improves access to healthcare, it also brings lifestyle deviations such as increased consumption of processed foods, decreased physical activity, and elevated stress levels – all of which contribute to the increasing prevalence of hypertension.[28,29] However, the influence of these factors can vary by gender; for example, urban women may face unique challenges balancing work, household responsibilities, and limited opportunities for physical activity, increasing their vulnerability to hypertension. In contrast, rural populations – especially women – often confront additional barriers, including lower health literacy, limited autonomy in health decision-making, inadequate hypertension management, and insufficient healthcare infrastructure. Studies show that individuals in rural areas often experience delayed diagnosis and poor treatment adherence, with women disproportionately affected by these challenges, exacerbating hypertension-related health outcomes.[23,26.30]

The increasing prevalence of hypertension is strongly influenced by socioeconomic factors, such as income and educational attainment, with notable sex differences in how these factors affect hypertension risk. Hypertension prevalence was significantly higher among individuals with lower education levels, for both males and females; however, the impact tends to be more pronounced among women. For instance, the prevalence of hypertension among females with no education rose from 16.2% in NFHS-IV to 19.3% in NFHS-V, representing a strong correlation between education, awareness, and the prevention of hypertension. Lower educational attainment in women often limits their access to health information, decision-making autonomy, and healthcare utilization, thereby increasing their vulnerability to undiagnosed and poorly managed hypertension. In contrast, men with low education levels may experience higher hypertension prevalence partially due to increased occupational stress and lifestyle factors such as tobacco and alcohol use. Hypertension prevalence also increased among males with only primary education or no education, underscoring the importance of community outreach and tailored health education initiatives that address the different needs and challenges faced by men and women in managing hypertension.[24,31]

Higher rates of hypertension in both males and females were closely associated with lifestyle choices, particularly alcohol and tobacco use. Tobacco uses significantly raises blood pressure levels, as reflected in the data showing an increase in hypertension prevalence from 16.5% in NFHS-IV to 19.3% in NFHS-V.[4] Smoking accelerates the onset of hypertension by increasing vascular resistance and causing endothelial damage.[32] The importance of addressing modifiable risk factors is further underscored by the positive correlation between alcohol consumption and hypertension, which rose from 21.4% in NFHS-IV to 23.2% in NFHS-V. Research consistently shows that reducing alcohol and tobacco use through lifestyle interventions can substantially lower hypertension prevalence and improve public health outcomes.[28]

Regional variations in hypertension prevalence also interact with sex differences, influencing risk patterns differently for males and females. For example, lifestyle, dietary habits, and healthcare access can vary significantly by region and gender, affecting hypertension rates. In some regions, cultural norms and gender roles may limit women's access to healthcare or healthy food options, increasing their vulnerability to hypertension. Conversely, men in certain areas might face higher occupational stress or greater exposure to risk behaviors such as tobacco and alcohol use, which elevate hypertension risk. These regional and gender-specific dynamics highlight the necessity for tailored interventions that consider both geographic and sex-based factors to effectively address hypertension across India.[29,30]

Urgent public health action is required due to the rising prevalence of hypertension in India, especially among older adults, people living in rural areas, and those with certain lifestyle factors like obesity, alcoholism, and tobacco use. Early detection, lifestyle modification, and improved access to treatment should be the main goals of interventions, particularly in underprivileged rural areas. Public health initiatives that highlight the importance of routine health screenings and hypertension prevention can play a crucial role in reducing its burden on the Indian population. While biological sex is a key factor in hypertension risk, it is equally important to recognize that sex often intersects with gender-based disparities in healthcare access and health-seeking behavior. These sociocultural barriers, particularly affecting female, may influence awareness, diagnosis, and management of hypertension, and must be measured in designing inclusive and equitable intervention strategies.

Conclusion

The NFHS-IV and NFHS-V data show that the prevalence of hypertension is rising in India, especially among middle-aged people, those living in rural areas, and those with certain risk factors like obesity, tobacco use, and low levels of education Notably, educational status influences hypertension risk differently for males and females—while illiterate males show lower odds, females with primary education are at greater risk, suggesting possible gaps in awareness and health-seeking behavior. Additionally, regional disparities, such as higher odds among individuals from the Northeast – especially females – indicate the importance of region-specific and gender-sensitive public health responses. These findings call for differentiated hypertension prevention and management strategies that address the unique social, educational, and regional determinants across genders.

Declarations

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Author contributions

Conceptualization J.B.P., R.A.B. and G.S.; Methodology, J.B.P.; Software, J.B.P; Validation, J.B.P., G.S and R.A.B.; Formal Analysis, G.S Investigation, R.A.B.; Resources, G.S.; Data Curation, J.B.P.; Writing – Original Draft Preparation, R.A.B.; Writing – Review & Editing, G.S.; Visualization, G.S.; Supervision, R.A.B.; Project Administration, J.B.P.; Funding Acquisition, R.A.B.

Conflicts of interest

The authors have no conflicts of interest to declare.

Data availability

The datasets analyzed during the current study are available in the Demographic and Health Survey repository (https://dhsprogram.com/data/).

Ethics approval

The study performed a secondary analysis and there was no identifiable information about the respondents. Hence, ethical approval was not required.

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