

# BMJ Open Sex differences in the risk profile of hypertension: a cross-sectional study

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## ABSTRACT

**Objective:** To assess the socioeconomic and behavioural risk factors associated with hypertension among a sample male and female population in India.

**Setting:** Cross-sectional survey data from a Health and Demographic Surveillance System (HDSS) of rural West Bengal, India was used.

**Participants:** 27 589 adult individuals (13 994 males and 13 595 females), aged  $\geq 18$  years, were included in the study.

## Primary and secondary outcome measures:

Hypertension was defined as mean systolic blood pressure (SBP)  $\geq 140$  mm Hg or diastolic blood pressure (DBP)  $\geq 90$  mm Hg, or if the subject was undergoing regular antihypertensive therapy. Prehypertension was defined as SBP 120–139 mm Hg and DBP 80–89 mm Hg. Individuals were categorised as non-normotensives, which includes both the prehypertensives and hypertensives. Generalised ordered logit model (GOLM) was deployed to fulfil the study objective.

**Results:** Over 39% of the men and 25% of the women were prehypertensives. Almost 12.5% of the men and 11.3% of the women were diagnosed as hypertensives. Women were less likely to be non-normotensive compared to males. Odds ratios estimated from GOLM indicate that women were less likely to be hypertensive or prehypertensive, and age (OR 1.04, 95% CI 1.03 to 1.05; and OR 1.08, 95% CI 1.07 to 1.09 for males and females, respectively) and body mass index (OR 1.64, 95% CI 1.38 to 1.97 for males; and OR 1.32, 95% CI 1.08 to 1.60 for females) are associated with hypertension.

**Conclusions:** An elevated level of hypertension exists among a select group of the rural Indian population. Focusing on men, an intervention could be designed for lifestyle modification to curb the prevalence of hypertension.

## INTRODUCTION

On 25 September 2015, India endorsed the Sustainable Development Goal for health to set a target to decrease premature deaths from non-communicable diseases (NCDs) by one-third by 2030.<sup>1</sup> Globally, NCDs are estimated to be the leading cause of mortality.<sup>2</sup> Among NCDs, hypertension (high blood pressure (BP) or arterial hypertension)

## Strengths and limitations of this study

- Non-communicable diseases are an impending epidemic in developing countries. In light of this trend, the current study throws substantial light on the prevalence of hypertension in rural India which is poorly understood.
- The uniqueness and strength of the study lies in the study site as it is based on a demographic surveillance site and has a significantly large sample size.
- The study is based on cross-sectional data, which does not allow determination of causal relationships between hypertension and its risk factors.
- Information on the known risk factors of hypertension such as dietary intake, salt consumption, family history of hypertension, duration of diabetes, and physical activity were not available in the dataset. Also other unmeasured factors like genetic, social and sex-specific characteristics may have affected the results obtained in the present study.

affects one in four individuals globally, making it the single most important risk factor for mortality and the third highest cause of morbidity.<sup>3</sup> With a population of over 1.25 billion people, hypertension in India is responsible for 57% of all stroke deaths and 24% of coronary heart disease deaths.<sup>4</sup> According to the 2008 estimates of the WHO, the prevalence of high BP among Indians is 21.1%, with 21.3% among males and 21% among females.<sup>5</sup> A systematic review on the prevalence of hypertension in India reported ranges of 13.9–46.3% and 4.5–58.8% in urban and rural areas of India, respectively.<sup>6</sup>

Coupled with the potential determinants of hypertension, sex differences in hypertension—which exist in human populations—are attributed to both biological and behavioural factors. The biological factors include sex hormones, chromosomal differences, and other biological sex differences that are protective against hypertension in women.<sup>7</sup> These factors become prominent in adolescence and persist through adulthood until

women reach menopause.<sup>8</sup> Behavioural risk factors for hypertension include high body mass index (BMI), smoking, and low physical activity. Affluence is growing in rural India, thus raising the risky sociodemographic and lifestyle factors contributing to the burden of hypertension.

Most of the earlier studies conducted in India focused on the increasing burden of hypertension and associated cardiovascular disease and stroke in urbanised populations.<sup>9</sup> A study conducted in a rural disadvantaged community in India revealed that in addition to traditional risk factors such as age and obesity, men from relatively socioeconomically advantaged groups are more prone to hypertension compared to women.<sup>9</sup> This pattern was similar to a study in Vietnam<sup>10</sup> but contrary to a study carried out in Indonesia in 2000.<sup>11</sup> A recent study among urban Chinese adults showed that the prevalence of prehypertension was greater in males than females.<sup>12</sup> Although the prevalence of hypertension among the rural population was found to be the highest in eastern India,<sup>3</sup> little research has been conducted in this region using large-scale survey data. To bridge this gap, the present study attempts to identify risk factors of hypertension among a selected male and female population, using data from a rural Health and Demographic Surveillance System (HDSS) site of West Bengal, India.

## METHODS

### Data

Data were used from the Birbhum HDSS, covering 351 villages in four administrative blocks in rural areas of the Birbhum district of West Bengal, India. The HDSS is a longitudinal cohort study, which was designed to study demographic changes, population health and epidemiology, and healthcare utilisation. A multi-stage sampling design was adopted to select sample households.<sup>13</sup> First, administrative blocks were selected based on sociodemographic characteristics of the population. Then villages were selected from the administrative blocks according to probability proportional to size sampling, followed by households within villages by stratified sampling. Thus the sample households are self-weighted. Besides collecting data on vital statistics, antenatal and postnatal tracking, and conducting verbal autopsies, periodic surveys capturing sociodemographic and economic conditions were conducted twice.<sup>13</sup> Causes of death data, according to International Classification of Diseases (ICD), from verbal autopsies collected for the years 2012 and 2013 showed that approximately 25% of the deaths were attributed to hypertensive heart diseases.<sup>13</sup>

The present study uses data from a combination of four surveys of the Birbhum HDSS, namely, a hypertension survey (measurement of BP of individuals aged  $\geq 18$  years) in 2012, the second wave of socioeconomic survey (conducted in 2012–2013), a lifestyle survey (conducted in 2012), and a survey of physical or anthropometric measures (conducted in 2011–2012). Indicators

of socioeconomic status and cultural characteristics were obtained from the socioeconomic survey, while data on tobacco usage and alcohol consumption were obtained from the lifestyle survey. Data obtained from these four separate surveys were matched through a unique identification number. Although BP was measured for 28 455 individuals (14 414 males and 14 041 females), analysis was restricted to 27 589 individuals (13 994 males and 13 595 females) for whom complete information was available. Upon compilation of data used in the study, the consistency was checked rigorously.

### BP measurements: inclusion and exclusion criteria

BP of each participant was measured using a digital sphygmomanometer (OMRON, Model- HEM-7111) after participants had been sitting quietly for at least 10 min. Three consecutive measurements were taken 5 min apart on the right arm, with the person in a sitting position. The measurement was taken by the field surveyors (who were undergraduates with at least 3 years' experience of large scale survey data collection) after 2 days of training. The study included HDSS residents aged  $\geq 18$  years, whose BP was measured at least twice. The exclusion criteria were: non-residents of HDSS; individuals  $< 18$  years of age; residents who were absent during the survey; persons with disability; and those whose BP was not measured twice. All values of BP measurements were checked and randomly cross-verified for consistency. Using international standards,<sup>14</sup> a hypertensive condition was identified when the mean systolic blood pressure (SBP) was  $\geq 140$  mm Hg, the diastolic blood pressure (DBP) was  $\geq 90$  mm Hg, or if the respondent was undergoing regular antihypertensive therapy. Hypertension was divided into two stages of severity: stage 1 (SBP 140–159 mm Hg/DBP 90–99 mm Hg); and stage 2 (SBP  $\geq 160$  mm Hg/DBP  $\geq 100$  mm Hg). Also, prehypertension was diagnosed when SBP was between 120–139 mm Hg and DBP was between 80–89 mm Hg. We have introduced a broad term called 'non-normotension' which includes both the prehypertensives and hypertensives, irrespective of the stage of hypertension.

### Predictor variables

We have included the predictor variables guided by the studies conducted in India and developing countries. Predictor variables used in the analysis primarily fall into four categories: individual level (age, sex, and educational attainment); household level (religion, ethnicity, and economic status); substance use (tobacco usage and alcohol consumption); and BMI. Studies conducted in India have included BMI, family history of hypertension, smoking, and alcohol use as the risk factors of hypertension.<sup>15 16</sup> The proxy indicators for socioeconomic status, education, food habits, and occupation were included as predictor variables in studies conducted in similar settings.<sup>17</sup> A study conducted in Vietnam (using data from a Vietnam HDSS site) used education, occupation, and

economic conditions as the (only) indicators explaining the determinants of hypertension.<sup>18</sup> However, to our knowledge, no single study conducted to date has used a comprehensive set of all possible variables affecting hypertension.

Monthly per capita household expenditure was first calculated from total monthly household expenditure and number of household members. This was then divided into five quintiles representing the richest, richer, middle, poorer and poorest, which act as a proxy for household economic status. Religion and ethnicity affiliation were pooled to form a single categorised variable as non-scheduled caste (SC)/scheduled tribe (ST) Hindu, Hindu SC, Hindu ST, and non-Hindu. BMI was calculated from the information on weight (kg) and height (m) of the respondents measured.

### Analytical model

Bivariate and multivariate analyses were performed to attain the study objective. The  $\chi^2$  test was used to identify the difference in proportion. To identify the determinants of hypertension status, generalised ordered logit models (GOLMs) were used. The primary outcome variable in

the analysis was created from the BP measurement. Accordingly, we have four ordered groups of respondents: normal, prehypertension, stage 1 hypertension, and stage 2 hypertension. However, <4% of adults were classified as being at stage 2 hypertension. For the purpose of regression modelling (more precisely to avoid problems with zero cell counts while estimating models), stage 1 and stage 2 groups were combined to create a stage 1/2 category and defined as hypertension as defined earlier (SBP  $\geq 140$  mm Hg/DBP  $\geq 90$  mm Hg diastolic).

Altogether three multivariate models—one for males only, another for females only, and one for males and females combined—were estimated. The variable alcohol consumption was dropped from the multivariate model for females due to an extremely skewed distribution (only 2.1% of surveyed females were found to consume alcohol during the month preceding the survey). Data were analysed using a statistical software (Stata V.13).

## RESULTS

### Sample characteristics

Table 1 presents the sample characteristics of the study population, where 44% of the population was found to

**Table 1** Sample characteristics

Variables	Total number or percentage
Total population	28, 455
% of male respondents	50.7
% of female respondents	49.3
% of respondents with normal blood pressure	56.0
% of respondents with prehypertension	32.1
% of respondents with stage 1 hypertension	8.4
% of respondents with stage 2 hypertension	3.5
% of respondents belonging to 18–29 age group	26.4
% of respondents belonging to 30–44 age group	36.2
% of respondents belonging to 45–59 age group	25.9
% of respondents belonging to 60 and above age group	11.5
Median age of the respondents (in years)	38
Religion and ethnicity (%)	
Hindu SC	34.2
Hindu ST	7.7
Hindu non-SC/ST	31.0
Non-Hindu	27.1
Educational attainment (%)	
Non-literate	39.1
Primary	21.0
Secondary	29.1
Higher	10.8
Current tobacco user (smoked or used any tobacco related products in last 7 days)	41.1
Alcohol user (at least one standard drink * in 30 days preceding the survey)	10.9
BMI (kg/m <sup>2</sup> )	
<18.5	42.8
18.5–22.9	43.5
23.0–24.9	7.5
$\geq 25.0$	6.2
Mean monthly per capita expenditure (in Indian rupees)	Rs. 980 (Rs. 175, Rs. 19, 825)

\*Refers to 30 mL of spirits, 285 mL of beer or 120 mL of wine; ( ) denotes range.

BMI, body mass index; SC, scheduled caste; ST, scheduled tribe.

be non-normotensive, consisting mainly of prehypertensives. The majority of the respondents (36%) were in the age group 30–44 years. Over one-third of the selected population was non-literate. Employment in the primary and secondary sectors together constituted nearly half of the work force in the study site; however, mean monthly per capita expenditure was less than 1000 Indian rupees (about US\$16) with substantial variation.

### Bivariate analysis of the sex differences in prevalence of hypertension

Table 2 represents sex differences in the prevalence of hypertension by background characteristics. More than half of the adult males and more than one-third of adult females were non-normotensives. Prehypertension was found to be substantially higher among males than females. The prevalence of hypertension significantly increased with age irrespective of sex, though disproportionately, particularly after 45 years of age. The prevalence of hypertension for females was lower than that for males at a younger age and then crossed over and exceeded that for males. While non-SC/ST Hindu

respondents were more prone to prehypertension and hypertension, the non-Hindus were the least likely to be affected by hypertension. Household affluence was found to be positively related with non-normotension among both males and females. Current tobacco usage was significantly associated ( $\chi^2$  test) with increased risk of hypertension irrespective of sex (males 14.1%, females 16.7%). Being overweight and obese was found to have a positive, significant relation ( $\chi^2$  test) with hypertension for both sexes, but the prevalence was higher among males in this category.

### Multivariate analysis

The ORs with 95% CI estimated from the generalised ordered logit regression model, explaining the risk factors of hypertension, is presented in table 3. Sex was found to be a significant covariate, with females having a lower likelihood for non-normotension and hypertension (OR 0.50, 95% CI 0.47 to 0.53; and OR 0.88, 95% CI 0.80 to 0.96, respectively). Of the total population, the likelihood of non-normotension and hypertension increased significantly as age increased, and the

**Table 2** Prevalence of hypertension by background characteristics, stratified by sex (N=27 589)

Background characteristics	Males			Females		
	Normal	Prehypertension	Hypertension	Normal	Prehypertension	Hypertension
Age (years)***						
15–24	55.2	41.2	3.7	82.5	16.4	1.2
25–34	54.8	39.6	5.6	80.7	16.9	2.5
35–44	51.6	39.0	9.4	66.7	25.5	7.8
45–60	44.4	38.2	17.4	45.2	34.6	20.2
60+	29.0	37.3	33.8	25.1	35.5	39.4
Religion and ethnicity**						
Hindu SC	49.9	38.0	12.1	67.2	22.8	10.1
Hindu ST	47.9	40.5	11.6	63.6	26.1	10.3
Hindu non-SC/ST	44.2	40.6	15.2	56.7	29.7	13.6
Non-Hindu	51.5	38.2	10.3	67.8	21.9	10.3
Expenditure class***						
Poorest	53.1	36.6	10.3	69.7	21.0	9.3
Poorer	50.4	38.4	11.2	67.0	23.4	9.6
Middle	49.1	39.3	11.5	65.5	24.0	10.6
Richer	47.8	39.5	12.7	62.7	25.0	12.3
Richest	41.2	41.9	17.0	53.7	31.5	14.9
Tobacco use***						
Non-user	49.1	40.7	10.1	65.9	24.4	9.7
User	48.0	38.0	14.1	56.2	27.1	16.7
Alcohol consumption**						
Non-user	48.9	38.8	12.3	–	–	–
User	46.5	40.2	13.3	–	–	–
BMI (kg/m <sup>2</sup> )***						
<18.5	58.3	32.4	9.4	70.9	19.5	9.6
18.5–22.9	44.8	42.3	13.0	63.2	26.2	10.7
23.0–24.9	26.7	52.4	20.9	49.9	35.2	15.0
≥25.0	23.5	51.8	24.7	43.8	36.7	19.4
Total	48.4	39.1	12.5	63.8	24.9	11.3

Significance levels from  $\chi^2$  tests are identical for males and females (\*\*\*p<0.001; \*\*p<0.01).

BMI, body mass index; SC, scheduled caste; ST, scheduled tribe.

– Information of alcohol consumption for females is not applicable.

**Table 3** Adjusted OR (with 95% CI) of generalised logit regression for males and females

	Total		Males		Females	
Background characteristics	Non-normotension†	Hypertension	Non-normotension†	Hypertension	Non-normotension†	Hypertension
Sex (ref: male)						
Female	0.50 (0.47 to 0.53)***	0.88 (0.80 to 0.96)***				
Age	1.04 (1.04 to 1.04)***	1.06 (1.06 to 1.06)***	1.03 (1.01 to 1.03)***	1.04 (1.03 to 1.05)***	1.06 (1.05 to 1.07)***	1.08 (1.07 to 1.09)***
Education (ref: non-literate)						
Up to primary	1.04 (0.96 to 1.11)	0.98 (0.88 to 1.10)	1.11 (1.01 to 1.23)**	1.10 (0.95 to 1.28)	0.99 (0.89 to 1.10)	0.92 (0.79 to 1.08)
Up to secondary	1.00 (0.93 to 1.08)	0.96 (0.86 to 1.07)	1.16 (1.05 to 1.28)***	1.04 (0.90 to 1.21)	0.97 (0.86 to 1.09)	1.03 (0.86 to 1.23)
>Secondary	1.06 (0.95 to 1.18)	0.91 (0.78 to 1.07)	1.31 (1.15 to 1.50)***	1.00 (0.83 to 1.22)	0.66 (0.54 to 0.82)***	0.76 (0.52 to 1.10)
Religion and ethnicity (ref: Hindu non-SC/ST)						
Hindu-SC	0.96 (0.89 to 1.03)	1.03 (0.92 to 1.14)	1.07 (0.96 to 1.18)	1.04 (0.90 to 1.21)	0.84 (0.76 to 0.94)***	1.05 (0.90 to 1.23)
Hindu-ST	1.05 (0.93 to 1.17)	0.98 (0.82 to 1.17)	1.10 (0.94 to 1.29)	0.98 (0.77 to 1.26)	0.99 (0.83 to 1.18)	1.07 (0.82 to 1.40)
Non-Hindu	0.83 (0.77 to 0.89) ***	(0.88 (0.79 to 0.97)**	0.95 (0.86 to 1.04)	0.77 (0.67 to 0.89)***	0.73 (0.66 to 0.82)***	1.03 (0.88 to 1.20)
Economic status (ref: poorest)						
Poorer	1.09 (1.01 to 1.18) **	0.99 (0.88 to 1.13)	1.11 (1.00 to 1.24)*	0.98 (0.83 to 1.17)	1.05 (0.93 to 1.19)	1.01 (0.83 to 1.22)
Middle	1.09 (1.00 to 1.18)*	1.05 (0.93 to 1.19)	1.11 (0.99 to 1.23)*	1.06 (0.90 to 1.26)	1.04 (0.92 to 1.17)	1.03 (0.85 to 1.24)
Richer	1.08 (1.00 to 1.18)*	1.10 (0.97 to 1.25)	1.09 (0.97 to 1.21)*	1.09 (0.91 to 1.29)	1.05 (0.93 to 1.20)	1.11 (0.92 to 1.34)
Richest	1.18 (1.08 to 1.29)***	1.14 (1.00 to 1.29)*	1.16 (1.02 to 1.31)**	1.21 (1.01 to 1.45)**	1.15 (1.01 to 1.31)**	1.04 (0.86 to 1.26)
Tobacco use (ref: non-user)						
Current user	0.91 (0.86 to 0.97)***	1.08 (0.99 to 1.18)	0.90 (0.84 to 0.98)**	1.16 (1.03 to 1.30)**	0.98 (0.89 to 1.08)	1.04 (0.91 to 1.19)
Alcohol (ref: non-user)						
User	1.15 (1.05 to 1.26)***	1.19 (1.04 to 1.36)**	1.24 (1.12 to 1.38)***	1.16 (0.99 to 1.35)*	–	–
BMI (ref: normal)						
Underweight	0.59 (0.56 to 0.62)***	0.68 (0.63 to 0.74)***	0.57 (0.53 to 0.61)***	0.65 (0.58 to 0.73)***	0.60 (0.55 to 0.65)***	0.69 (0.61 to 0.79)***
Overweight	1.70 (1.54 to 1.87)***	1.48 (1.30 to 1.69)***	2.00 (1.71 to 2.33)***	1.64 (1.38 to 1.97)***	1.54 (1.34 to 1.76)***	1.32 (1.08 to 1.60)***
Obese	1.15 (1.01 to 1.32)**	1.25 (1.06 to 1.47)***	2.28 (1.89 to 2.76)***	1.93 (1.58 to 2.37)***	1.87 (1.62 to 2.15)***	1.81 (1.50 to 2.18)***
Pseudo R <sup>2</sup>	0.095		0.062		0.128	
Number of cases	27 589		13 994		13 595	

Level of significance: \*\*\*p&lt;0.001; \*\*p&lt;0.01; \*p&lt;0.05.

†Non-normotensives include pre-hypertensives and hypertensives.

– Information of alcohol consumption for female is not applicable.

BMI, body mass index; SC, scheduled caste; ST, scheduled tribe.



direction of association was the same for male and female respondents.

Level of education was not found to be significantly associated with non-normotension and hypertension, whereas with increasing education level, non-normotension was likely to be higher among males. While non-Hindus were significantly less likely to be affected by non-normotension and hypertension compared to Hindu non-SC/ST respondents (OR 0.83, 95% CI 0.77 to 0.89; and OR 0.88, 95% CI 0.79 to 0.97, respectively), the risks of non-normotension and hypertension did not differ significantly by social group affiliation among Hindus. Risk of non-normotension significantly increased with economic class (OR 1.09, 95% CI 1.01 to 1.18 among poorer; OR 1.09, 95% CI 1.00 to 1.18 among middle; OR 1.08, 95% CI 1.00 to 1.18 among richer; OR 1.18, 95% CI 1.08 to 1.29 among richest). Furthermore, respondents belonging to the highest economic class were significantly more likely to be affected by hypertension compared to the poorest (OR 1.14, 95% CI 1.00 to 1.29). The direction of association was similar when studied separately for males and females.

While tobacco use was negatively associated with non-normotension (OR 0.91, 95% CI 0.86 to 0.97), it did not significantly increase the risk of hypertension. Alcohol usage had positive and significant effects on non-normotension and hypertension (OR 1.15, 95% CI 1.05 to 1.26; and OR 1.19, 95% CI 1.04 to 1.36, respectively).

While being underweight significantly reduced the risk of non-normotension and hypertension (OR 0.59, 95% CI 0.56 to 0.62; and OR 0.68, 95% CI 0.63 to 0.74, respectively), overweight persons were significantly more likely to suffer from non-normotension and hypertension (OR 1.70, 95% CI 1.54 to 1.87; and OR 1.48, 95% CI 1.30 to 1.69, respectively). Obese respondents were significantly more likely to be affected by non-normotension as well as hypertension compared to respondents with normal BMI (OR 1.15, 95% CI 1.01 to 1.32; and OR 1.25, 95% CI 1.06 to 1.47, respectively). Though analysed separately for males and females, the direction is the same.

## DISCUSSION

Using data from a Health and Demographic Surveillance site of West Bengal, India, this study assesses the sex differences in hypertension. While past studies on sex differences in the prevalence of hypertension in India have been inconclusive,<sup>19–21</sup> this study reveals a higher likelihood of hypertension among men compared to women. A large-scale study conducted in Haryana also observed that more men experienced hypertension than women.<sup>4</sup> In confirmation of an earlier study conducted in rural areas of West Bengal, prehypertension was more common than hypertension among the respondents.<sup>22</sup> Additionally, in line with the findings of other developed and developing societies,

traditional risk factors such as age and BMI were found to be most strongly associated with non-normotension and hypertension, irrespective of sex even after controlling for other potential confounders.<sup>9 22–26</sup>

The prevalence of hypertension for females in this study is lower than males at a younger age but exceeds males when older, which corroborates the literature indicating the role of oestrogen as a protective factor until menopause.<sup>8</sup> Experimental and clinical data reveal that oestrogen exerts different cardiovascular effects, including vasorelaxation, sympatho-inhibition, prevention of vascular remodelling, and subsequently decreased aortic stiffness through activity on the endothelium and smooth muscle cells,<sup>27</sup> which all act as a protective factor against hypertension. Oestrogen values fall abruptly in postmenopausal women, leading to hypertension. Arterial stiffness becomes more pronounced in postmenopausal women than men, contributing to BP enhancement.<sup>28</sup>

We hypothesised that observed sex differences in hypertension may be in part due to differences in risk factors, such as BMI, smoking, and physical activity.<sup>7 29</sup> However, taking these factors into account had virtually no effect on the sex differences in hypertension. This suggests that the sex differences among young adults may be partly due to biological sex differences, but more research is needed to investigate other behavioural factors that may explain this early disparity.

Importantly, a strong effect of education on non-normotension is evident in men even after adjustment for confounding factors, but not among women. This may be because with enhancement of educational attainment men are more likely to engage in high paid sedentary occupations, thus are more likely to be physically inactive and stressed, which could lead to hypertension. Educated women, however, are less likely to be engaged in such occupations due to less working opportunity in this rural area; instead they are more likely to be engaged in daily household chores, farming, and other physical activities.

Additionally, our study found that economic affluence, although associated with hypertension among males, showed no association among females even after controlling for potential confounders. It seems that other unmeasured factors related to sex differentials in socio-economic status may come into play in explaining the occurrence of hypertension. In addition, longstanding stress linked to the larger social environment is an important contributor to hypertension risk,<sup>30</sup> and the residential environment can also contribute to the development of hypertension.<sup>31</sup> In the current study set up, commenting on the effect of the neighbourhood would be difficult as it is homogeneous throughout the study area.

Similarly some effect of socio-religious affiliation on non-normotension or hypertension was evident in both men and women, even after adjusting for other potential confounders associated with higher social class (ie, affluence, education and BMI). In an underdeveloped rural

region in India, ethnicity provides some measure of socio-economic status.<sup>9</sup> In the study region the majority of people who belonged to the SC, ST, and minority communities are generally engaged in labour-intensive agriculture and related activities. Furthermore, diet composition could also vary in different socio-religious groups. However, we do not have data to support this speculation.

Although a number of studies have pointed to the cardiovascular system as being one of the major targets for the damaging effects of smoking and other forms of tobacco use,<sup>26 32–36</sup> some findings identified that tobacco use, particularly smoking among males, is inversely related to systolic BP.<sup>37 38</sup> In our study we found that although tobacco use was inversely related to prehypertension, tobacco use had a positive and significant effect on hypertension even after controlling for other confounders. According to Leone,<sup>39</sup> vasoconstriction mediated by nicotine causes an acute but transient increase in systolic BP initially, then a decrease in BP as a consequence of depressant effects caused chronically by nicotine itself. Although smokeless tobacco use was high among surveyed women, we did not find any significant association between tobacco use among women and increased hypertension, even after controlling for other confounders, implying the existence of some unknown mechanisms. In confirmation of other studies, we found alcohol consumption among males had a positive and significant effect on hypertension.<sup>26 39</sup> Alcohol intake was virtually non-existent in surveyed women so it can be dismissed as a potential causal factor for hypertension among female respondents.

Men and women differ in these key risk factors in complex ways. Smoking prevalence is lower among women than men, whereas overweight and obesity tend to be lower among men than women.<sup>40 41</sup> However, these risk factors cannot fully explain the sex differences in hypertension, suggesting possibly that either their effects nullify each other (higher rates of obesity in women and current smoking in men) or the sex differentials in these behaviours cannot adequately explain the differences in hypertension. This implies that there is a different pathway by which unknown behavioural and socio-cultural factors come into play.

The pathways and factors that yield the sex differences for hypertension in such communities clearly deserve further study. We urge public initiatives are undertaken to generate awareness about NCDs like hypertension, as our dataset reveals that 74% of respondents with stage 1 hypertension and 56% of those with stage 2 hypertension were not receiving antihypertensive medication. Health promotion programmes, awareness generation, and reorientation of primary health care could be the strategies for early detection of hypertension and its management.<sup>42</sup>

### Limitations of the study

Some limitations of the present study must be acknowledged. First, the study is based on cross-sectional data,

which ideally does not allow for determining temporal relationships between hypertension and its risk factors. Secondly, since information on the known risk factors of hypertension, such as salt consumption, family history of hypertension, and duration of diabetes, were not available in the dataset, we could not determine their effect on hypertension in the current population. Other unmeasured factors may include genetic, social, and sex-specific characteristics. It is unclear how these factors may have affected the odds ratios obtained in the present study. Therefore it is possible that our findings may not be applicable universally to a larger population, although they may be generalised within the HDSS area.

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**Competing interests** None declared.

**Ethics approval** The study conducted was in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975 (in its most recently amended version). An independent Ethical Review Board appointed by the chairman of the Society for Health and Demographic Surveillance, Government of West Bengal approved the study. Informed consent from the participants was taken before the survey. The information was anonymised. Further information on the ethical committee may be obtained from the website <http://www.shds.in>

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