Socio-demographic factors, overweight/obesity and nutrients associated with hypertension among rural adults (≥18 years): Findings from National Nutrition Monitoring Bureau survey

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1. Introduction

With rapid economic growth, demographic transition and changes in lifestyle and dietary habits, the prevalence of chronic non-communicable diseases (NCDs) are increasing globally. The nutrition transition has accompanied a rise in the prevalence of overweight and obesity in India with an estimated 166 million adults overweight or obese in 2016. The overweight and obesity is an important factor for increase in prevalence of other chronic diseases such as cardiovascular diseases, hypertension, diabetes, dyslipidaemia and some types of cancers. NCDs typically occurs among individuals aged 55 years or older in many developed countries, but in India it occurs a decade earlier (≥45 years of age).

The prevalence of overweight and obesity (ranging from 26% to 3%, respectively) and associated deaths (6.5%) in adults are rising rapidly in several countries including India. The 2016 World Health Organization (WHO) has reported overweight/obesity as a pandemic in India as it increased from 16% during 2006 to 11.8% in 2016.

Cardiovascular diseases (CVDs) are estimated to be responsible for 17.9 million attributed deaths globally and 1.5 million deaths in India annually in 2016. Hypertension (HTN) is one of the...
important modifiable risk factors for cardiovascular diseases and is leading cause of death throughout the world and third most important risk factor for attributable burden of disease in South Asia.11 HTN is directly responsible for 57% of all stroke deaths and 24% of all coronary heart disease (CHD) deaths in India.10 In India, HTN is a major public health problem and its prevalence is rapidly increasing among both urban and rural populations.11 The prevalence of hypertension ranges from 20 to 40% in urban adults and 12–17% among rural adults.12

Global Burden of Disease (GBD) Study has estimated that hypertension leads to 1.63 million deaths as compared to 0.78 million in 1990 and 33.9 million disability adjusted life (DALYs) years in 2015 and is most important cause of disease burden in India.11,12

Under Sustainable Development Goal (SDGs 3), the United Nations (UN) member states has set the target of reducing premature mortality from non-communicable diseases (NCDs) by one-third by 2030 (UNDP).14

The present study was carried out by National Nutrition Monitoring Bureau (NNMB) in 10 major states representing 80% of total population in India. Nutrient intakes, nutritional status and prevalence of hypertension among rural adult population in India is presented in this communication.

2. Methods

Ethical approval

The study was approved by the Scientific Advisory Committee (NIN-SAC) of the ICMR-National Institute of Nutrition (ICMR-NIN). Institutional Ethical Committee (IEC) approval was also obtained. Written informed consent was obtained from head of the HHs included in the study.

2.1. Study design

It was a community-based, cross-sectional study carried out by NNMB in 10 states (Andhra Pradesh, Gujarat, Kerala, Karnataka, Maharashtra, Madhya Pradesh, Odisha, Tamil Nadu, West Bengal and Uttar Pradesh) of India, between February 2010 and February 2012 by adopting multistage random sampling procedure.

2.2. Sample size and sampling procedures

Considering lowest (10%) prevalence of hypertension11 from earlier NNMB study carried out in 2006, with 95% confidence interval, 20% relative precision, and design effect of 2, sample size required was 1728 for each gender in each state.

In order to get representative to entire state, 120 villages were covered from each State. Detail methodology is already published.15 In the selected household, all the adults ≥18 years of age and above were covered. Total 2400 HHs were covered from each state.

2.3. Inclusion & exclusion criteria

All the available adults (≥18 years) and given informed written consent.

The subjects who were suffering from debilitating/terminal illness, kyphosis/scoliosis, mentally and physically challenged and those who did not provide consent were excluded from the study.

2.4. Data collection

Data was collected by trained staff recruited locally and trained and standardized for 3 weeks at NIN, Hyderabad. Information on the household socio-economic and demographic particulars were collected using a pre-tested and validated questionnaire. A one day 24-h dietary recall was carried out in every alternate household (HH) using standard diet survey methods.16

Body weight (accuracy of 100 g) was measured using SECA electronic digital weighing scale and height (accuracy of 0.2 cm) using stadio-meter using standard procedures.17 In addition, waist circumference (WC) and hip circumferences (HC) were also measured for all the participants,18 except pregnant women using a fibre reinforced tape as per the standard operating procedures.

Three measurements of Blood pressure (BP) were recorded at 5 min interval using sphygmomanometer in supine position and the average was used for classifying subject in different stage of hypertension as per the Joint National Committee-7 (JNC-7) classification in which only incident cases were included19 as well American Society for hypertension.20

2.4.1. Definition of hypertension

BP was categorized as normal if systolic BP is < 120 mmHg and diastolic BP < 80 mmHg; pre-hypertension as, either systolic BP 120–139 mmHg and/or diastolic BP between 80 and 89 mmHg, and HTN, if systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg and those on medication for high BP.

Food consumption (g/person/day) levels were assessed by one day 24-h recall method. Nutrient intakes were computed by using ‘Nutritive values of Indian foods published by ICMR 1989. Foods and Nutrients were compared against the Recommended Dietary Intakes for Indians prescribed by the Indian Council of Medical Research.21,22 Data on knowledge and practices about hypertension, its signs and symptoms and risk behaviors like alcohol and tobacco consumption and health seeking behavior of the subjects were also collected.

2.5. Quality control

Scientists from NIN had done quality checks of anthropometric and blood pressure measurements carried out by the project staff on a sub-sample of subjects and the variations observed were at acceptable levels (99% agreement).

2.6. Data analysis

The data was entered in the computer after scrutiny was done by the staff of NIN to check consistency and database was prepared. Data analysis was carried out using SPSS Windows version 22.0. Age-standardized prevalence estimates were weighted to the age distribution of the WHO’s standard population.23 Age-sex adjusted prevalence was estimated using Census 2011 population.

Per capita monthly income (PCI/month) was calculated by dividing total family income with number of family members in that household and then by 12 months. The PCI was divided into quartiles, 1st tertile indicates low-income group (LIG), 2nd tertile = middle income group (MiG), 3rd tertile = high income group (HiG). Body mass index (BMI) was computed using formula weight (kg)/height (m)², and subjects were categorized as chronic energy deficiency (BMI: <18.5), normal (BMI ≥18.5 to <23.0) and overweight & obesity (BMI ≥23.0).24

WC ≥ 90 cm among men and ≥80 cm women were considered as cut off for abdominal obesity and waist hip ratio (WHR = waist circumference divided by hip circumference) is ≥ 0.90 among men and ≥0.80 among women were categorized as truncal obesity as per the Asian cut-off levels.25

Proportion tests were used to compare prevalence in different age groups and Chi square analysis was done to study associations between different socio-economic and demographic factors and HTN. Stepwise multivariate logistic regression analysis was carried
out to examine the strength of associations between hypertension as dependent and socio-demographic, physical activity, overweight/obesity as independent variables. WHO age standardized prevalence and age standardized prevalence using 2011 Census population for estimating the weighted prevalence of HTN based on the age and sex was done.

3. Results

A total of 22,075 men (44.7%) and 27,248 women (55.3%) were covered for blood pressure measurements. Mean age of the subjects was 41.4 ± 15.1 years. Height and weight measurements are available for all those covered for BP measurements, while waist and hip circumference was measured in 21,942 men and 27,074 women.

About half (49%) of them were below 40 years of age, majority were Hindus, 35% belonged to backward communities and 29% were from forward community. Only 26% were living in pucca houses, while 58% were living in semi pucca houses. Half (50%) of HHs were nuclear families and 30% were joint families. About 32% were engaged in labour, 21% were owner cultivators, 5% were engaged in service, 4% were in business and 38% were either housewife or dependant. About 46% were engaged in sedentary type of work, 54% in moderate work while only 0.3% were engaged in heavy work.

3.1. Prevalence of HTN as per American society for HTN

Age, sex and state-wise & age standardized prevalence is presented in Table 1. The prevalence of HTN increases as the age advances and was higher among elderly (44–54%) as compared to middle age (7–13%). The overall prevalence of HTN was 22% (CI = 21.5–22.3) and was similar among both the genders. The prevalence was observed high in Kerala and West Bengal (30% each among men & 28–29% among women) and low in Uttar Pradesh (15–17%) (Table 1).

Table 1
Prevalence of HTN according to age, gender, states and standardized population.

| Age groups (yrs) | Male | Female | Pooled | Age adjusted |
|------------------|------|--------|--------|--------------|
|                  | N    | % (CI) | N      | % (CI)       | N       | % (CI)       |
| 18–29            | 5613 | 8.6 (7.9–9.3) | 6833 | 5.3 (4.8–5.8) | 12,446 | 6.8 (6.4–7.2) |
| 30–39            | 5056 | 15.6 (14.6–16.6) | 6853 | 11.9 (11.1–12.7) | 11,909 | 13.4 (12.8–14.0) |
| 40–49            | 4183 | 23.2 (21.9–24.4) | 5719 | 24.0 (22.9–25.1) | 10,102 | 23.7 (22.8–24.5) |
| 50–59            | 3186 | 30.8 (29.2–32.4) | 3890 | 35.7 (34.2–37.2) | 7,676 | 33.5 (32.4–34.6) |
| 60–69            | 2533 | 39.5 (37.6–41.4) | 2784 | 46.6 (44.7–48.5) | 5,317 | 43.3 (41.9–44.6) |
| ≥70              | 1304 | 48.4 (45.7–51.11) | 1169 | 57.7 (54.8–60.5) | 2,473 | 52.8 (50.8–54.7) |

States

Kerala 2176 30.4 (28.5–32.3) 3233 28.0 (26.4–29.5) 5410 28.9 (27.3–30.1) Tamil Nadu 2170 21.4 (19.7–23.1) 2898 20.3 (18.8–21.8) 5068 20.8 (19.7–21.9) Karnataka 2479 19.6 (18.0–21.2) 2904 19.5 (18.1–20.9) 5383 19.6 (18.5–20.7) Andhra Pradesh 1904 17.4 (15.7–19.1) 2497 16.9 (15.4–18.4) 4401 17.1 (16.0–18.2) Maharashtra 2387 26.2 (24.4–28.0) 2666 24.8 (23.2–26.4) 5053 25.4 (24.2–26.6) Madhya Pradesh 2689 20.7 (19.2–22.2) 3028 17.1 (15.8–18.4) 5717 18.8 (17.8–19.8) Gujarat 1973 14.0 (12.5–15.5) 2167 16.5 (14.9–18.1) 4141 15.3 (14.2–16.4) Odisha 2069 24.3 (22.4–26.1) 2648 27.8 (26.1–29.5) 4718 26.2 (24.9–27.4) West Bengal 2071 30.0 (28.0–32.0) 2769 29.1 (27.4–30.8) 4840 29.5 (28.2–30.8) Uttar Pradesh 2157 17.2 (15.6–18.8) 2435 14.6 (13.2–16.0) 4592 15.9 (14.8–16.9) Pooled 22,075 22.2 (21.6–22.7) 27,248 21.7 (21.2–22.2) 49,323 21.9 (21.5–22.3) Census 2011 age standardized – 20.1 – 20.3 – – – WHO age standardized – 22.5 – 22.0 – – –

CI-confidence interval.

3.2. Prevalence of pre-hypertension and hypertension as per JNC 7 criteria-states wise

The prevalence of pre-hypertension was 50% among men and 42% among women. The prevalence of pre-hypertension was more in Gujarat (67% and 55%) followed by Odisha (53% & 48%) among men and women respectively (Fig. 1). Overall prevalence of hypertension was 19% among men and 17.5% among women. The prevalence was observed high in Maharashtra (23.2%) and West Bengal (28.1%) among men, while among women, it was more in Odisha (25.2%) and West Bengal (26.6%) (Fig. 2).

3.3. Prevalence of overweight/obesity

The prevalence of overweight/obesity as per Asian criteria (BMI≥23) was 23%, while as per WHO criteria (BMI≥25), it was 13%. The prevalence was higher among women (24.5%) as compared to men (20.3%). The prevalence was higher in Kerala (35% & 48% respectively and low in Madhya Pradesh (10% & 14% respectively) (Fig 3).

3.4. Association between socio-demographic variables, overweight/obesity, behavior and hypertension

The prevalence of hypertension significantly increases as the age increased. The prevalence of hypertension was 7% among less than 30-year and was 53% among ≥70-year subjects. The association between HTN and socio-demographic factors are presented in Table 2. The prevalence was also higher among overweight/obese (39.7%), abdominal obesity (39%) and truncal obesity (27.8%). The association between HTN and behaviour risk factors are presented in Table 2.

The prevalence of hypertension was observed high among subjects with BMI, WC, WHR in third tertile (39.7%, 32% & 29% respectively) as compared to subject belonging to 1st tertile group (14.7%, 13.2% & 11.8% respectively) Fig 4.
Fig. 1. Prevalence of pre-hypertension as per JNC-7 among men and women.

Fig. 2. Prevalence of HTN as per JNC-7 among men & women.

Fig. 3. Prevalence of overweight/obesity as per Asian classification among men & women.
3.5. Mean blood pressure

Age-wise mean and standard deviation (SD) for SBP and DBP are provided in Table 3. The age standardized mean SBP was 123.0 mmHg in men and 121.2 mmHg in women, while the age standardized mean DBP was 79.6 mmHg and 78.2 mmHg among men and women, respectively. The mean systolic BP significantly \((p < 0.001)\) increased with increase of age. Regression analysis showed a significant association between BP and age. It was evident that the decadal increase in age showing significant increase of 3.41 \((2.8–4.0)\) units in SBP and 0.88 \((0.2–1.6)\) units in DBP among men.

Similarly, there was increase of 5.31 \((4.9–5.7)\) units in SBP and 1.76 \((1.1–2.4)\) units in DBP among women for every ten years (Table 3).

3.6. Association between foods, nutrient intakes and hypertension

The odds of hypertension was significantly higher among those consuming lower tertile of carbohydrates, lower tertile of energy, protein, folic acid and zinc. On multivariate analysis, the odds of hypertension was 1.2 times women who consumed lower tertile of carbohydrates \((95\% \text{ CI: } 1.02–1.41)\) and zinc \((95\% \text{ CI: } 1.11–1.42)\). The odds of hypertension was lower among those consuming lower tertile of fat \((OR 0.84, CI = 0.74–0.96)\), sugar \((OR 0.88, 95\% \text{ CI: } 0.81–0.96)\), etc.

Table 2

| Particulars | N (%) | HTN (%) | \(\chi^2, P\) value |
|-------------|-------|---------|------------------|
| Religion    |       |         |                  |
| Hindu       | 43,736 (89.0) | 21.5 | 518, 0.000       |
| Muslim      | 2871 (5.8)    | 25.0 |                  |
| Christian   | 1692 (3.4)    | 27.2 |                  |
| Others      | 844 (1.7)     | 24.6 |                  |
| Community   |       |         |                  |
| Scheduled Tribe | 6491 (13.2) | 19.1 | 194.1, 0.000     |
| Scheduled Caste | 11,188 (22.8) | 19.8 |                  |
| Backward Caste | 17,238 (35.1) | 21.1 |                  |
| Others      | 14,226 (28.9) | 25.8 |                  |
| Type of house |       |         |                  |
| Kutchia     | 8348 (17.0)   | 19.0 | 969.0, 0.000     |
| Semi Pucca  | 28,260 (57.5) | 21.6 |                  |
| Pucca       | 12,535 (25.5) | 24.6 |                  |
| Type of Family |       |         |                  |
| Nuclear     | 24,564 (50.0) | 19.4 | 188.5, 0.000     |
| Extended Nuclear | 9872 (20.1) | 24.7 |                  |
| Joint       | 14,707 (29.9) | 24.3 |                  |
| Education   |       |         |                  |
| Illiterate/R&W | 19,230 (39.1) | 24.8 | 307.9, 0.000     |
| 1–8         | 14,962 (30.4) | 23.0 | 0.000            |
| 9th & above | 14,951 (30.4) | 17.1 |                  |
| Occupation  |       |         |                  |
| Labour      | 9343 (19.0)   | 18.1 | 162.92, 0.00     |
| Agriculture/tenant cultivation | 10,178 (20.7) | 21.2 |                  |
| Service     | 2404 (4.9)    | 20.8 |                  |
| Business    | 1966 (4.0)    | 28.7 |                  |
| HW + Others | 25,252 (51.4) | 23.2 |                  |
| Activity status |       |         |                  |
| Sedentary   | 22,737 (46.3) | 25.6 | 327.8, 0.000     |
| Moderate    | 26,274 (53.5) | 18.8 |                  |
| Heavy       | 132 (0.3)     | 16.7 |                  |
| PCI_tertile |       |         |                  |
| 1.00        | 16,280 (33.2) | 20.6 | 818.0, 0.000     |
| 2.00        | 16,268 (33.1) | 20.8 |                  |
| 3.00        | 16,540 (33.7) | 24.3 |                  |
| BMI         |       |         |                  |
| <18.5       | 16,713 (34.7) | 14.8 | 1854.7, 0.000    |
| 18.5–22.9   | 21,080 (43.7) | 20.4 |                  |
| 23.0–24.9   | 5011 (9.6)    | 29.6 |                  |
| ≥25.0       | 6245 (12.0)   | 39.7 |                  |
| WC (Asian cut off) |       |         |                  |
| Normal      | 39,804 (81.2) | 17.9 | 1950.1, 0.000    |
| Abdominal adiposity | 9216 (18.8) | 39.0 |                  |
| WHR (Asian cut off) |       |         |                  |
| Normal      | 20,497 (41.8) | 13.6 | 1399.7, 0.000    |
| Adiposity   | 28,517 (58.2) | 27.8 |                  |
| Regular exercise |       |         |                  |
| Yes         | 1192 (2.4)    | 28.7 | 32.7, 0.000      |
| No          | 47,951 (97.6) | 21.7 |                  |
| Tobacco use |       |         |                  |
| Yes         | 15,231 (31.1) | 25.5 | 162.9, 0.000     |
| No          | 33,912 (69.9) | 20.3 |                  |
| Smoking     |       |         |                  |
| Yes         | 5278 (10)    | 23.9 | 13.7, 0.001      |
| No          | 43,865 (89.3) | 21.7 |                  |
| Smoking duration (Years) |       |         |                  |
| ≤20         | 3658 (7.4)    | 20.8 | 81.0, 0.000      |
| >20         | 1620 (3.3)    | 30.9 |                  |
| NA          | 43,865 (89.3) | 21.7 |                  |
| Tobacco Cheewing |       |         |                  |
| Yes         | 93,851 (20)  | 25.3 | 819.0, 0.000     |
| No          | 39,292 (80)  | 21.1 |                  |
| Chewing duration (Years) |       |         |                  |
| ≤20         | 7888 (16.1)   | 21.7 | 387.5, 0.000     |
| >20         | 1953 (4.0)    | 39.9 |                  |
| NA          | 39,292 (80.0) | 21.1 |                  |
| Alcohol consumption |       |         |                  |
| Daily/weekly | 3007 (6.1)   | 25.4 | 23.2, 0.000      |
| Not consuming | 46,136 (93.9) | 21.7 |                  |
| Diabetes    |       |         |                  |
| No          | 30,273 (92.6) | 20.4 | 6419.0, 0.001    |
| Yes         | 2411 (7.4)    | 42.7 |                  |

BMI-body mass index, WC-waist circumference, WHR-waist hip ratio, PCI-per capita income.
belonging to scheduled caste and backward caste community. The 95% CI: 1.05–1.49) and was significantly lower among those belonging to scheduled caste and backward caste community. The odds of hypertension were 1.3 times higher among other religion (95% CI: 1.05–1.49) and was significantly lower among those belonging to scheduled caste and backward caste community. The odd of hypertension was 1.2 times higher among those engaged in business as compared to laborers (Table 5).

Similarly, the odds of hypertension were 3 times higher among overweight (95% CI: 2.65–3.23), 1.3 times higher among women with abdominal obesity (95% CI: 1.26–1.47) and with truncal obesity (95% CI = 1.20–1.34). The odds of hypertension was 1.4 times higher among tobacco users (95% CI = 1.26–1.60) and alcohol consumers (CI = 1.11–1.35).

3.8. Knowledge and practices about hypertension

Knowledge about the disease, its symptoms, current status of hypertension and if known hypertensive, whether on treatment was assessed among the subjects. Among hypertensive, about 79% were aware of hypertension and only 9–38% were aware of its signs and symptoms such as headache, breathlessness, and palpitation. Among those interviewed, only 5% were suffering from hypertension and most of them were taking treatment regularly.

4. Discussion

The study observed that the prevalence of overweight/obesity as per Asian criteria (BMI $\geq$23) was 23% while as per WHO criteria (BMI $\geq$25), it was 13%. The prevalence of overweight/obesity was high among female as compared to men. The study also observed that the prevalence of pre-hypertension was 50% among men and 42% among women, while age standardized prevalence of hypertension was 20% among both the gender. The prevalence of hypertension was observed high in Kerala, Odisha and West Bengal and low in Uttar Pradesh and Madhya Pradesh.

Logistic regression analysis showed that the odds of hypertension was significantly higher among elderly, those engaged in service, business or doing sedentary work such as housewives or dependant. The risk was also higher among overweight and with abdominal or truncal obesity. Use of tobacco in any form and alcohol consumption was associated with risk of hypertension.

Among food and nutrients, lower tertile intake of carbohydrates and zinc was observed to be associated with increased risk of hypertension while lower tertile intakes of sugar, calcium, fat and vitamin C was associated with lower risk of hypertension.

The increase in prevalence of hypertension among rural population is not only attributed to overweight/obesity, but increasing mechanization of farm work, decreased manual labour and physical activity as well as consumption of junk food and beverages. The increased prevalence of diabetes was also associated with risk of hypertension. High prevalence of hypertension among men till 5th decades of life may be attributed to high level of exposure to environmental stress along with other factors such as tobacco and alcohol use.

Geldsetzer et al$^{26}$ reported 20% & 24.5% age standardized prevalence of hypertension among women and men respectively in India which are similar to present study. The prevalence was more among elderly population and odds of hypertension was low among high income which is similar to our study.

Non-Communicable Disease Risk Factor Collaboration (NCDRiSC) study reported 26.5% (95% CI, 21.2%–32.4%) prevalence of hypertension among men and 24.7% (95% CI, 19.9%–29.9%) among women in India in 2015 which is marginally higher than the present study.$^{2}$

### Table 3

| Age   | 18–29 | 30–39 | 40–49 | 50–59 | 60–69 | $\geq$70 | Total |
|-------|-------|-------|-------|-------|-------|---------|-------|
| N     | 5588  | 5037  | 4372  | 3172  | 2523  | 1294    | 21,986|
| Mean  | 74.8  | 79.2  | 80.7  | 81.6  | 81.6  | 81.4    | 79.6  |
| Std. Deviation | 8.2 | 8.9   | 10.4  | 10.6  | 11.3  | 12.0    | 10.0  |
| Median | 78.7  | 80.0  | 80.0  | 80.0  | 80.0  | 80.0    | 80.0  |

### Table 4

| Age   | 18–29 | 30–39 | 40–49 | 50–59 | 60–69 | $\geq$70 | Total |
|-------|-------|-------|-------|-------|-------|---------|-------|
| N     | 5588  | 5037  | 4372  | 3172  | 2523  | 1294    | 21,986|
| Mean  | 7.6   | 9.0   | 9.2   | 9.5   | 9.8   | 10.0    | 9.7   |
| Std. Deviation | 1.7 | 1.8   | 1.9   | 2.0   | 2.2   | 2.3     | 2.1   |
| Median | 7.4   | 7.6   | 7.8   | 8.0   | 8.3   | 8.5     | 8.0   |

### Table 5

| Age   | 18–29 | 30–39 | 40–49 | 50–59 | 60–69 | $\geq$70 | Total |
|-------|-------|-------|-------|-------|-------|---------|-------|
| N     | 5588  | 5037  | 4372  | 3172  | 2523  | 1294    | 21,986|
| Mean  | 6.6   | 7.0   | 7.2   | 7.5   | 7.8   | 8.0     | 7.8   |
| Std. Deviation | 1.2 | 1.3   | 1.5   | 1.7   | 1.9   | 2.1     | 1.9   |
| Median | 6.4   | 6.6   | 6.8   | 7.0   | 7.3   | 7.5     | 7.0   |

0.81–0.95), calcium (OR 0.85, 95% CI = 0.78–0.92) and vitamin C (OR 0.89, 95% CI = 0.82–0.97) (Table 4).
Ramakrishnan et al\textsuperscript{27} reported 30.7% prevalence of hypertension (95% CI: 30.5, 30.9) and the prevalence was higher among men (34.2%) as compared to women (23.7%), which was higher as compared to our study as it was carried out in clinics. The prevalence of pre-hypertension was 45% which is similar to our study.

District Level Household Survey carried out in 2012–13 reported 25.3% prevalence of hypertension with higher prevalence among men (27.4%) as compared to women (20.0%).\textsuperscript{28} It was also high in Kerala (33% female vs 27.4%) as compared to women (23.7%), which was higher as compared to our study as it was carried out in clinics. The prevalence of hypertension and pre-hypertension was 27% and 45% which is similar to the present study.\textsuperscript{29}

Prenissl et al in their nationally representative survey (NFHS 4) among 15–49-year adults reported 18.1% prevalence of hypertension, which is lower than our study findings.\textsuperscript{30}

The WHO age-standardized prevalence was more (22.5%) for India as compared to age adjusted prevalence (20%) in present study and was 15.5% & 10.8% among men and women in United States (NCDRISC).\textsuperscript{9}

Nuepane et al in their meta-analysis observed that the overall prevalence of hypertension and pre-hypertension was 27% and 29.6%, respectively, while in rural areas, the prevalence of HTN was 22% and 21% among men and women respectively which is similar to our study.\textsuperscript{30} Significant association was also observed between HTN and education with higher risk among illiterates.

Islam et al observed that the prevalence of hypertension as per JNC–7 criteria was 17.9% (95% CI: 16.2–19.7) in Bangladesh during 2015, while it was 15% in rural area which is lower than our study.\textsuperscript{32}

It was also observed that the risk of hypertension was more among elderly, sedentary workers, among tobacco users, among overweight/obese and with abdominal obesity which is similar to our study.

Gupta et al\textsuperscript{33} in their study observed association between HTN and alcohol use (OR 1.42) low fruit intakes (OR 1.74) and with high fat intakes (OR 1.33), while we observed low carbohydrate and low zinc intake associated with HTN in the present study.

Huang et al in their meta-analysis reported 24.4% prevalence of hypertension among rural population of Nepal in 2010,\textsuperscript{34} while Mehta et al reported 18% prevalence of hypertension in Nepal.\textsuperscript{35}

Although awareness about hypertension was good; but knowledge about symptoms/sign was very poor. Previous studies carried out in India also reported similar findings on awareness and knowledge about hypertension.\textsuperscript{13,29,31}

### 5. Conclusions

Prevalence of hypertension and pre-hypertension is high in India even among rural population. Major investments targeted hypertension prevention, detection, and treatment programs are needed across the country to avert negative health, social, and economic consequences of these conditions and their sequelae.

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**Table 4**

Bivariate and multivariate logistic regression analysis of hypertension with food and nutrient intakes.

| Food                                      | Tertile | N    | Crude OR | 95% CI     | OR  | 95% CI     |
|-------------------------------------------|---------|------|----------|------------|-----|------------|
| Carbohydrates                             | 1st     | 7884 | 1.32     | 1.22–1.43  | 1.20*| 1.02–1.41  |
|                                           | 2nd     | 7922 | 1.15     | 1.07–1.25  | 1.08| 0.97–1.22  |
|                                           | 3rd     | 7897 | 1.0      |            |     | 1          |
|                                           | 2nd     | 7862 | 1.13     | 1.05–1.23  | 1.03| 0.91–1.17  |
|                                           | 3rd     | 7830 | 1.0      |            |     | 1          |
| Energy                                    | 1st     | 7851 | 1.28     | 1.19–1.39  | 1.05| 0.87–1.27  |
|                                           | 2nd     | 7862 | 1.13     | 1.05–1.23  | 1.03| 0.91–1.17  |
|                                           | 3rd     | 7830 | 1.0      |            |     | 1          |
| Total fat                                 | 1st     | 7833 | 1.03     | 0.96–1.12  | 0.84*| 0.74–0.96  |
|                                           | 2nd     | 7840 | 0.91     | 0.84–0.99  | 0.85*| 0.77–0.94  |
|                                           | 3rd     | 7870 | 1.0      |            |     | 1          |
| Proteins                                  | 1st     | 7842 | 1.22*    | 1.14–1.32  | 0.95| 0.82–1.10  |
|                                           | 2nd     | 7849 | 1.08     | 1.00–1.17  | 0.93| 0.84–1.04  |
|                                           | 3rd     | 7852 | 1.0      |            |     | 1          |
| Sugar                                     | 1st     | 7598 | 0.90     | 0.83–0.97  | 0.88*| 0.81–0.95  |
|                                           | 2nd     | 8085 | 0.93     | 0.86–1.01  | 0.92| 0.85–1.00  |
|                                           | 3rd     | 7860 | 1.0      |            |     | 1          |
| Milk & milk products                      | 1st     | 8534 | 0.98     | 0.91–1.05  | 1.07| 0.96–1.18  |
|                                           | 2nd     | 7170 | 0.86*    | 0.79–0.93  | 0.91| 0.83–1.00  |
|                                           | 3rd     | 7839 | 1.0      |            |     | 1          |
| Vitamin A                                 | 1st     | 7896 | 0.98     | 0.91–1.06  | 1.03| 0.93–1.14  |
|                                           | 2nd     | 7910 | 0.88*    | 0.82–0.95  | 0.95| 0.87–1.03  |
|                                           | 3rd     | 7897 | 1.0      |            |     | 1          |
| Calcium                                   | 1st     | 7845 | 0.94     | 0.87–1.01  | 0.85*| 0.78–0.92  |
|                                           | 2nd     | 7686 | 0.93     | 0.86–1.00  | 0.93| 0.86–1.07  |
|                                           | 3rd     | 7830 | 1.0      |            |     | 1          |
| Folic acid                                | 1st     | 7898 | 0.93     | 0.86–1.01  | 0.89*| 0.82–0.97  |
|                                           | 2nd     | 7856 | 0.89     | 0.82–0.96  | 0.88*| 0.81–0.95  |
|                                           | 3rd     | 7839 | 1.0      |            |     | 1          |
| Zinc                                      | 1st     | 7982 | 1.35*    | 1.25–1.46  | 1.26*| 1.11–1.42  |
|                                           | 2nd     | 7926 | 1.22*    | 1.13–1.32  | 1.22*| 1.12–1.34  |
|                                           | 3rd     | 7885 | 1.0      |            |     | 1          |

OR-odds ratio, CI-confidence interval.
Table 5
Step wise logistic regression analysis for hypertension with socio-demographic variables, overweight/obesity, physical activity and behaviour among adults.

| Particulars       | N      | OR     | 95% CI     |
|-------------------|--------|--------|------------|
| **Religion**      |        |        |            |
| Hindu             | 43,541 | 1.0    |            |
| Muslim            | 2851   | 1.07   | 0.98–1.20  |
| Christian         | 1677   | 0.94   | 0.83–1.06  |
| Others            | 842    | 1.25***| 1.05–1.49  |
| **Community**     |        |        |            |
| Scheduled Tribe   | 6475   | 1.0    |            |
| Scheduled Caste   | 11,144 | 0.88** | 0.81–0.97  |
| Backward Caste    | 17,153 | 0.85** | 0.78–0.92  |
| Others            | 14,139 | 1.00   | 0.92–1.09  |
| **Education**     |        |        |            |
| Illiterate        | 19,115 | 0.97   | 0.91–1.04  |
| 1–8 class         | 14,989 | 1.05   | 0.98–1.12  |
| 9th & above       | 14,989 | 1.0    |            |
| **Occupation**    |        |        |            |
| Labour            | 9330   | 1.0    |            |
| Agriculture/tenant| 10,162 | 1.0    | 0.92–1.07  |
| Service           | 2399   | 1.09   | 0.96–1.24  |
| Business          | 1958   | 1.20***| 1.06–1.36  |
| Housewife/dependant| 25,062| 1.00   | 0.92–1.05  |
| **BMI tertile**   |        |        |            |
| 1st               | 16,229 | 1.20** | 1.13–1.28  |
| 2nd               | 16,210 | 1.03   | 0.98–1.10  |
| 3rd               | 16,472 | 1.0    |            |
| **WHR**           |        |        |            |
| Normal            | 9186   | 1.36***| 1.26–1.47  |
| Abdominal obesity | 39,725 | 1.0    |            |
| **Normal exercise**|      |        |            |
| Yes               | 1189   | 1.23** | 1.07–1.43  |
| No                | 47,722 | 1.0    |            |
| **Tobacco use**   |        |        |            |
| Yes               | 15,178 | 1.42***| 1.26–1.60  |
| No                | 33,733 | 1.0    |            |
| **Alcohol consumption**|     |        |            |
| Yes               | 3003   | 1.23** | 1.11–1.35  |
| No                | 45,908 | 1.0    |            |

Notes: BMI-body mass index, WHR-waist hip ratio, PCI-per capita income, ***p < 0.01, **p < 0.05.

Given the size, growth, and aging of India’s population the country’s success in tackling hypertension epidemic will be crucial to achieving Sustainable Development Goals globally.

The strength of the study lies in its uniform methodology, sampling techniques and large sample size. Locally recruited trained staff including medical officer, social worker and Nutritionist carried out study. Quality controls were carried out by scientist from the Institute from time to time.

6. Limitation

As this is cross-sectional study, we are unable to assess causality between the observed associations with hypertension. Questions regarding history of hypertension and treatment of hypertension are vulnerable to recall bias; however, when available, doctor’s prescription or medicine labels were checked from the subjects.

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