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CONTENTS

Awareness and prevalence of hypertension among educated Indians with internet access during COVID-19 and associated risk factors

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ABSTRACT: Hypertension is a risk factor for cardiovascular disease, which remains poorly controlled due to low awareness. The present study assessed the awareness and prevalence of hypertension and associated factors among Indian adults aged 18 years and above with a minimum of 12 years of education through an online cross-sectional survey based on convenience sampling. Out of 1933 respondents, 891 provided information on blood pressure. The mean age of the respondents was 32.2 ± 12.3 years, with the age range of 18 to 77 years. The respondents' average body mass index (BMI) and basal metabolic rate (BMR) were 23.9 ± 4.11 kg/m^2 and 1441 ± 279 kcal/day, respectively. BMI increased with age, while a decline in BMR with age was observed. Males had significantly higher BMI than females ($p < 0.001$). More than half of the respondents (55.9 %) are overweight or obese. About 46.1 % of the respondents were aware of their blood pressure profile. The prevalence of prehypertension and hypertension was 21.0 % and 5.1 %, respectively. Males are more likely to be prehypertensive and hypertensive than females. An increase in the prevalence of prehypertension and hypertension with age was observed. Hypertension was positively associated with age, BMI, BMR, urban residence, monthly per capita income, social class, and educational level. Family size was negatively correlated with hypertension. Individuals with higher BMI, income, upper social class, and those in the prehypertensive age group of 35 to 55 years can be targeted through nutritional awareness campaigns to sensitize them regarding modifiable risk factors.

Key words: Blood pressure, education, India, hypertension, health awareness, social class

Globally, 1.28 billion adults aged 30-79 years have hypertension. Hypertension is one of the major risk factors for cardiovascular disease (WHO, 2021). An increase in force with which the heart pumps blood around the body results in hypertension. Elevated blood pressure also increases the risk of brain and kidney diseases. Diet, physical activity, and tobacco or alcohol use are modifiable risk factors for high blood pressure. The COVID-19 pandemic has brought extreme distress to people's life. Pandemic has severely impacted academic, social life, and livelihoods of people around the world. The impact of social restrictions on psychological wellbeing, physical activity, diet pattern, and recreational and social activity was observed (Shukla *et al*., 2021; Park *et al*., 2021). The psychological impact of the COVID-19 outbreak has resulted in increased stress and anxiety levels (Salari *et al*., 2020). An observational study has reported an increase in systolic and diastolic blood pressure during the COVID-19 pandemic (Laffin *et al*., 2022).

Hypertension is highly prevalent in India, affecting one in every three Indian adults (Ramakrishnan *et al*., 2019). Research has shown a significant influence of sociodemographic factors on hypertension prevalence, with higher prevalence among older people, male sex, overweight/obesity, higher wealth status, and urban residence (Abariga *et al*., 2020). An inverse association was reported between hypertension and education in high-income countries (Liu *et al*., 2011). The prevalence of hypertension is higher among low socioeconomic status in developed countries (Leng *et al*., 2015). In contrast, an opposite trend was observed in South Asia, with an increasing prevalence of hypertension among higher social class and educated population (Rana *et al*., 2020; Harshfield *et al*., 2015; Van Minh *et al*., 2006). A recent review revealed that people in higher social classes consume more processed food and are less physically active than lower social classes in low-middle income countries (Allen *et al*., 2017).

Economic and social disruption due to the COVID-19 pandemic has severely impacted all spheres of life in India. Research exploring the awareness and prevalence of hypertension during COVID-19 and the association of elevated blood pressure with basal metabolic rate, family size, education, income, and social class is limited in the Indian context. As per WHO, an estimated 46 % of adults with hypertension are unaware of their condition (WHO, 2021). Early detection is essential for effective management and control of blood pressure. Thus, the

present study assesses the awareness and prevalence of hypertension among Indian adults during COVID-19 and its association with nutritional, sociodemographic, and socioeconomic variables.

MATERIALS AND METHODS

Sample and data collection

An online cross-sectional survey was conducted in June and July 2021 during the second wave of the COVID-19 pandemic in India, based on the convenience sampling technique to assess the blood pressure profile of Indian adults. Indian adults aged 18 years and above with internet access and a minimum of 12 years of education were included in the study. The survey proforma was designed in the Department of Food and Nutrition, College of Home Science, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. SurveyMonkey software was used to conduct the online survey.

The survey invitation was sent to university students, agribusiness and corporate companies executives, and faculties & heads of agriculture & allied universities and institutes. Participants were requested to share the survey link with family and friends based on snowballing technique. The survey was also posted to social media pages for broader dissemination.

Of the total 1933 responses, 891 respondents provided information on blood pressure, and the rest, 1042, chose the "Do not know" option and were therefore excluded from the analyses. Therefore, the total sample size of the present study was 891.

Survey instrument

Sociodemographic profile of respondents

Information was collected on sociodemographic characteristics viz age, gender, marital status, religion, caste, education, occupation, family type, family size, number of children or adolescents in the family, number of old family members, educational status & occupation of family's head, house location, and residential state. Respondents were classified into residential zones using the Zonal Council's composition by the Ministry of Home Affairs, Government of India (2022) as follows: Northern zone: Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Delhi, Chandigarh; Central zone: Chhattisgarh, Uttarakhand, Uttar Pradesh, Madhya Pradesh; Eastern zone: Bihar, Jharkhand, Orissa, Sikkim, West Bengal; Western zone: Goa, Gujarat, Maharashtra, Daman & Diu, and Dadra & Nagar Haveli; Southern zone: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Puducherry; and North Eastern zone: Assam, Arunachal Pradesh, Manipur, Tripura, Mizoram, Meghalaya, Nagaland.

Socioeconomic profile of respondents

Information on the number of employed family members and monthly family income was collected. B. G. Prasad's socioeconomic classification (Prasad, 1961) was used to classify respondents into five social classes. Social classes were defined using the Multiplication factor, All India Consumer Price Index for Industrial Workers (CPI-IW), and monthly per capita income (MPCI). New income limits were obtained by applying the multiplication factor and the latest CPI-IW for March 2022 (base year = 2016) (Labour Bureau, Government of India, 2022). MPCI was calculated by dividing monthly family income by the number of family members. Social classes I, II, III, IV, and V were defined as per capita monthly income of 8201 and above, 4060-8200, 2403-4059, 1243-2402 and < 1242 Indian Rupees (INR), respectively. The respondents are then classified into five social classes based on their per capita monthly income.

Nutritional and health status of the respondents

Information on height (meters) and weight (kg) was collected to assess the nutritional status of the respondents in terms of body mass index and basal metabolic rate.

Systolic and diastolic blood pressure (mmHg)

Information on systolic blood pressure (SBP) and diastolic blood pressure (DBP) was collected from the respondents.

Respondents were provided with a range of systolic and diastolic blood pressure from which they could select the most appropriate range that matches their blood pressure by clicking on the drop-down menu. A response option of "Do not know" was also provided.

Classification of nutritional status based on body mass index

Body mass index (BMI) was calculated using body height and weight data. BMI is calculated by dividing weight in kilograms by height in meters squared (kg/m^2). BMI classification for Asian adults was used in the current study (WHO, IASO and IOTF, 2000). Underweight, normal, overweight, and obesity grade I and grade II were defined as adults with BMI < 18.5, 18.5-22.9, 23-24.9, 25-29.9, and30 kg/m^2 and above, respectively.

Calculation of basal metabolic rate

Body metabolic rate (BMR) (kcal/day) was calculated using the equations proposed by UNU and WHO (2004)

based on an individual's age, gender, and body weight (Table 1). Since the BMR of Indian males is 10% and females is 9% lower than the international values (ICMR-NIN, 2020), the resultant values were adjusted for the same.

Classification of blood pressure

Data on SBP and DBP was used to classify respondents into four classes of blood pressure based on the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of Hypertension in Adults (JNC7) (National High Blood Pressure Education Program, 2004). Normal, Prehypertension, Stage 1 Hypertension, and Stage 2 Hypertension were defined as adults with SBP/DBP (mmHg) < 120/80, 120-139/80-89, 140-159/90-99 and ≥ 160/≥ 100, respectively.

Data analysis

The data were downloaded from the SurveyMonkey software to Microsoft Excel and coded for statistical analysis using Jamovi software (Jamovi, 2021). Descriptive statistics were calculated as percentage, mean, median, and standard deviation. The chi-square test was used to compare categorical variables. Mann-Whitney U test was used to assess the difference in median values. The distribution of blood pressure across the four classifications was calculated across six mutually exclusive age groups (18–24, 25–34, 35–44, 45–54, 55–64, and ≥ 65 years) and gender. Spearman's rho correlation coefficient was calculated to examine the association between blood pressure and other variables. The significance level was fixed at *P*-value < 0.05.

Ethics

The study was approved by the University Ethics Committee for Human Research (UECHR) of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Approval No. CHS/Ethical Comm/319). Electronic informed consent was obtained from all participants.

Table 1: Equations for estimating basal metabolic rate (BMR) from body weight

Age (years)	BMR: kcal/day
Males	
18-30	15.057 x B.W. (kg) + 692.2
30-60	11.472 x B.W. (kg) + 873.1
≥ 60	11.711 x B.W. (kg) + 587.7
Females	
18-30	14.818 x B.W. (kg) + 486.6
30-60	8.126 x B.W. (kg) + 845.6
≥ 60	9.082 x B.W. (kg) + 658.5

Note: B.W.= Body weight

RESULTS AND DISCUSSION

Sociodemographic profile of the respondents

The average age of the respondent was 32.2 ± 12.3 years. Most respondents were in the age group of 25-34 years (43.4 %), followed by 18-24 years (29.2 %), as shown in Table 2. An equal proportion of respondents were in the age groups 35-44 years and 45-54 years, i.e., 9.3 % in each age group. The sample had an equal proportion of males (49.0 %) and females (51.0 %). As per the 2011 Census, the proportion of males and females in the Indian population was 51.47 % and 48.53 %, respectively (Census of India, 2011). Regarding marital status, 64.1 % and 34.6 % of the respondents were classified as never married and currently married, while a small proportion was classified as widower/widowed, divorced, or separated. Most of the respondents were Hindu (89.2 %).

The data was collected from an online survey designed in the English language with an inclusion criterion of a minimum of 12 years of education. Regarding educational status, 11.2 % were class 12th pass, 1.3 % were diploma holders, 20.8 % were graduates, 42.4 % were postgraduates, and 24.2 % were doctorates. Thus, the educational profile of the respondent was high. Students and those employed in the government or private sector responded enthusiastically (44.8 % and 42.4 %, respectively), while the response rate from unemployed respondents, business personnel, retired, and homemakers were less. More than half of the respondents reported living in nuclear families (69.9 %) with four or fewer family members (51.0 %) with no children or adolescents (57.4 %) and old members in their family (51.1 %). As per NFHS-5 2019-21, nuclear households are more prevalent in India, with a proportion of 58.2 % (IIPS and ICF, 2021). The respondent reported postgraduation (29.1 %) and working as an employee in the government or private sector (49.4 %) as the most prevalent educational and occupational statuses of the family head.

About 38.2 % of the respondents reported living in urban areas, followed by towns (33.70 %) and rural areas (28.2 %). Based on the report of the 2011 Census, the majority of the Indian population lives in rural areas (68.85 %), while 31.15 % live in urban areas (Census of India, 2011). Most of the respondents were from the Central zone (60.0 %). About 15.4 %, 8.8 %, and 7.5 % of the respondents were from the Northern, Southern, and Eastern zone, respectively. The proportion of respondents from the Western and North Eastern zone was 5.6 % and 2.7 %,

respectively.

Socioeconomic profile of the respondents

Most respondents reported one family member in regular employment (42.2 %), and 33.4 % reported two employed family members. About 5.7 % of the respondents reported that none of their family members was employed. The survey was conducted during the second wave of COVID-19, which might have resulted in the loss of jobs in the respondents' families.

876 out of 891 respondents provided information on monthly family income. The average MPCI was 33,338 ± 46,989 INR. Of the 876 respondents, 1.3 % reported MPCI less than 1,000 INR; 27.9 % reported MPCI between 1,000 to 10,000 INR; 28.3 % reported MPCI between 10,001 to 20,000 INR, and 12.0 % reported MPCI between 20,001 to 30,000 INR. MPCI of 30,001 to 40,000 INR, 40,001 to 50,000 INR, and > 50,000 INR was reported among 9.9 %, 5.1 %, and 15.5 % of the respondents.

Respondents were classified into five social classes based on MPCI. Most of the respondents were from social class I (upper class) (80.8 %), as shown in Table 2. About 12.0 % of respondents belong to social class II (upper-middle class); 3.2 % of respondents belong to social class III (middle class); 2.2 % and 1.8 % of respondents belong to social class IV (lower middle class) and social class V (lower class), respectively.

Body mass index

The male respondents' average height and weight were 1.71 ± 0.08 meters and 71.0 ± 11.1 kilograms, respectively. Female respondents' average height and weight were 1.58 ± 0.08 meters and 58.0 ± 10.6 kilograms, respectively. The proposed reference height and weight for adult males aged 19 39 are 1.77 meters and 65 kilograms, respectively. For females aged 19 39, the proposed reference for height is 1.62 meters, and the weight is 55 kilograms (ICMR-NIN, 2020).

The mean BMI of the respondents was 23.9 ± 4.11 kg/m^2 with a range of 12.4 to 40.3 kg/m^2. The average BMI of male and female respondents was 24.4 ± 3.64 kg/m^2 and 23.3 ± 4.45 kg/m^2, respectively. A similar value was reported by Rush *et al*. (2009), with an average BMI of 24 kg/m^2 for Indian males. A Mann-Whitney test indicated that BMI was significantly higher for males (Median = 24.1 kg/m^2) than females (Median = 22.9 kg/m^2), U (N_{males} = 437, $N_{females}$ = 454) = 79424, $p < 0.001$. A study conducted among undergraduate students in Bangalore, India, and Malaysia also reported higher BMI among males than females (Vijayalakshmi *et al*., 2017; Kuan *et al*., 2011).

Among respondents aged 18-24, the average BMI of males was 23.2 kg/m^2, which was higher than the normal BMI range of 18.5-22.9 kg/m^2. While, the average BMI of females was in the normal BMI range in the same age group, *i.e*., 21.6 kg/m^{2,} as shown in Figure 1. In the remaining five age groups from 25 to 65 years and above, the average BMI was higher than the normal BMI range in both male and female respondents. Male respondents aged 18 to 34 are more likely to have a higher BMI than females. After 34 years, the average BMI was higher among females than males. Average BMI increased from 21.6 kg/m^2 for females aged 18-24 to 29.2 kg/m^2 for females aged 65 years and above. Among males, BMI increased from 23.2 kg/m^2 for respondents aged 18-24 to 26.1 kg/m^2 among respondents aged 55-64. A similar increase in BMI with age among males and females was observed in NFHS-5, 2019-21 (IIPS and ICF, 2021).

Nutritional status of the respondents

About 37.8 % of the respondents were in the normal BMI range (Figure 2). The proportion of respondents in the underweight category was 6.3 %. About 21.3 % were overweight, and 25.8 % and 8.8 % were in the category of obesity grade I and II, respectively. The total prevalence of obesity was 34.6 % in the present study. A nationwide cross-sectional survey in 2017 revealed that 40.3 % of Indian adults are obese (Venkatrao *et al*., 2020). Recent data shows that the prevalence of obesity ranges from 13.0 to 50.0 % in urban areas and 8.0 % to 38.0 % in rural areas (Behl and Misra, 2017).

A significant difference was observed in the proportion of underweight, normal, overweight, obese grade I, and obese grade II among male and female respondents as per the chi-square test ($p < 0.001$). The prevalence of underweight was higher among females (9.7 %) than males (2.7 %), as shown in Figure 2. A greater proportion of females (41.0 %) were in the normal BMI range than males (34.6 %). About 22.0 % and 20.7 % of the males and females were overweight, respectively. The prevalence of obesity grade I was higher among males (32.3 %) than females (19.6 %). The proportion of males and females categorized as obesity grade II were 8.5 % and 9 %, respectively. The prevalence of obesity among males and females was 40.8 % and 28.6 %, respectively. The prevalence of obesity reported among males in the present study is similar to that of Venkatrao *et al*. (2020), which was 38.67 %. However, a higher prevalence was reported among females (41.88 %).

Table 2: Sociodemographic characteristics of sample (n = 891)

Variable	Category	Frequency	%
Age (years)	18-24	260	29.2 %
Mean ± SD = 32.2 ± 12.3	25-34	387	43.4 %
	35-44	83	9.3 %
	45-54	83	9.3 %
	55-64	64	7.2 %
	65 and above	14	1.6 %
Gender	Male	437	49.0 %
	Female	454	51.0 %
Marital status	Never married	571	64.1 %
	Currently married	308	34.6 %
	Widower/ Widowed	4	0.4 %
	Divorced	3	0.3 %
	Separated	5	0.6 %
Religion	Hindu	795	89.2 %
	Muslim	35	3.9 %
	Christian	24	2.7 %
	Sikh	28	3.1 %
	Buddhist	4	0.4 %
	Jain	3	0.3 %
	Atheist	2	0.2 %
Caste	General	642	72.1 %
	Other Backward Class	153	17.2 %
	Scheduled Caste	72	8.1 %
	Scheduled Tribe	24	2.7 %
Education	Class 12^{th} pass	100	11.2 %
	Diploma	12	1.3 %
	Graduate	185	20.8 %
	Postgraduate	378	42.4 %
	Doctorate	216	24.2 %
Occupation of the respondent	Unemployed	46	5.2 %
	Homemaker	14	1.6 %
	Student	399	44.8 %
	Employee (government sector, teaching, private company, NGO)	378	42.4 %
	Business/Self-employed	30	3.4 %
	Retired	24	2.7 %
Family type	Joint	268	30.1 %
	Nuclear	623	69.9 %
Family size	≤ 4	454	51.0 %
	5 to 6	295	33.1 %
	≥ 7	142	15.9 %
No. of children or adolescents in the family ($\leq$ 18 years)	None	511	57.4 %
	1	207	23.2 %
	2	123	13.8 %
	≥ 3	50	5.6 %
No. of old family members ($\geq$60 years)	None	455	51.1 %
	1	240	26.9 %
	2	170	19.1 %
	≥ 3	26	2.9 %
Education (head of the family)	No formal education	27	3.0 %
	Fifth grade	17	1.9 %
	Highschool	84	9.4 %
	Intermediate	91	10.2 %

	Diploma	52	5.8 %
	Graduate	245	27.5 %
	Postgraduate	259	29.1 %
	Doctorate	116	13.0 %
Occupation (head of the family)	Unemployed	31	3.5 %
	Homemaker	42	4.7 %
	Student	5	0.6 %
	Employee (government sector, teaching, private company, NGO)	440	49.4 %
	Business/Self-employed	188	21.1 %
	Retired	185	20.8 %
House location	Rural	251	28.2 %
	Town	300	33.7 %
	Urban	340	38.2 %
Residential zone	Northern	137	15.4 %
	Central	535	60.0 %
	Eastern	67	7.5 %
	Western	50	5.6 %
	Southern	78	8.8 %
	North Eastern	24	2.7 %
Employed family members	None	51	5.7 %
	1	376	42.2 %
	2	298	33.4 %
	3	105	11.8 %
	4	43	4.8 %
	5	11	1.2 %
	> 5	7	0.8 %
Monthly per capita income (Indian Rupees)	< 1,000	11	1.3 %
Mean ± SD = 33,338 ± 46,989	1,000-10,000	244	27.9 %
	10,001-20,000	248	28.3 %
	20,001-30,000	105	12.0 %
	30,001-40,000	87	9.9 %
	40,001-50,000	45	5.1 %
	> 50,000	136	15.5 %
Social class based on MPCI (INR)			
8201 and above	Uupper class	708	80.8 %
4060-8200	Upper-middle class	105	12.0 %
2403-4059	Middle class	28	3.2 %
1243-2402	Lower middle class	19	2.2 %
1242 and below	Llower class	16	1.8 %

As per NFHS-5 2019-21, more females aged 15-49 years (19.0 %) are underweight than males (16.0 %). The prevalence of overweight was higher among males (19.0 %) than females (18.0 %) by one percentage point. The overall prevalence of overweight or obesity was 24.4 % among females and 23.0 % among males (IIPS and ICF, 2021). The above variation in the percentage of respondents across various categories of BMI in the present study compared to NFHS-5 is due to the use of different classification criteria. The present study used BMI classification for Asians, while in NFHS-5, WHO International BMI classification was employed with different cut-off ranges.

Basal metabolic rate

BMR of the respondents ranged from 915 to 2250 kcal/day with a mean value of 1441 ± 279 kcal/day. Average BMR of 1688 ± 156 kcal/day and 1203 ± 118 kcal/day were reported among male and female respondents, respectively. BMR of the males (Median = 1684 kcal/day) was significantly higher than the females (Median = 1198 kcal/day) [Mann Whitney U ($N_{\text{males}} = 437$, $N_{\text{females}} = 454$) = 1824, $p < 0.001$]. Gender is one of the significant determinants of BMR (Lazzer *et al.*, 2010), which correlates with higher lean tissues among males and higher fat tissues among females (Jensen, 2020).

Among males, BMR was fairly uniform over the age group of 18 to 54 years. After 54 years, BMR decreased from 1723 kcal/day for males aged 45-54 years to 1417 kcal/day for males aged 65 years and above, as shown in Figure 3. Among females, BMR increased from 1175 kcal/day for respondents aged 18-24 to 1249 kcal/day for those aged 45-54. After 54 years, BMR decreased to 1095 kcal/day among females aged 65 and above. The above trend of decline in BMR indicates fat mass accumulation and muscle mass reduction in the body with aging (Jensen, 2020). BMR decreases at the rate of 1.0 to 2.0 % per decade after 50 years of age (UNU and WHO, 2004).

Blood pressure awareness among respondents

Of the 1933 surveyed respondents, only 46.1 % were aware of their blood pressure; 46.4 % were males, and 45.8 % were females. More than half (53.9 %) of the respondents were unaware of their blood pressure profile and had poor information about their health. Blood pressure awareness among respondents aged 18-24 years was 43.4 %, 25-34 years 45.5 %, 35-44 years 33.7 %, 45-54 years 58.0 %, 55-64 years 82.1 %, and $\geq$ 65 years 82.4 %. Thus, blood pressure awareness was highest in older age groups and lowest in younger age groups. The results are consistent with the finding of the meta-analysis, which reported that 42.0 % of urban and 25.0 % of rural Indians are aware of their hypertensive status (Anchala *et al*., 2014). A systematic review reported that awareness of hypertension in India ranged from 20.0 to 54.0 % (Devi *et al*., 2013). Awareness of hypertension was 44.7 % in a study among the adult population in Kerala. The study also reported higher awareness among older adults aged 40-79 years (61.2 %) than younger adults aged 20-39 years (27.3 %) (Geevar *et al*., 2022). At the same time, others have reported that 38.7 % to 51.0 % of Indian adults are aware of their blood pressure profile (Roy *et al*., 2017; Ramakrishnan *et al*., 2019). The above studies have assessed the awareness rate of hypertension among Indian adults before COVID-19. The results of the present study indicate that the awareness rate of blood pressure profiles remains the same before and during COVID-19 among Indian adults.

Blood pressure level

Table 3 shows the systolic and diastolic blood pressure of the respondents. Half of the respondents (55.4 %) reported SBP in the 110 119 mmHg range. Most respondents reported a DBP of 70-79 mmHg (64.6 %). Figure 4 shows the blood pressure level of the respondents based on self-reported systolic and diastolic blood pressure. Most respondents (74.0 %) reported normal blood pressure of <120/80 mmHg. The prevalence of prehypertension (120-139/80-89 mmHg) was 21.0 %. About 5.1 % of the respondents were in Stage 1 of Hypertension (140-159/90-99 mmHg). None of the respondents were found in the category of Stage 2 Hypertension. Based on the JNC7 guidelines (National High Blood Pressure Education Program, 2004), the prevalence of hypertension among Indian adults was 13.0 % (Abariga *et al*., 2020). The great Indian blood pressure survey conducted in 2015 revealed that the overall prevalence of hypertension was 30.7 % assessed through one-day blood pressure measurement camps. The study also reported that the prevalence of self-reported hypertension was 15.9 % among Indian adults (Ramakrishnan *et al*., 2019). In the present study, the self-reported hypertension prevalence was less than those of Ramakrishnan *et al*. (2019) by 10.8 percentage points. The above difference was due to more proportion of males (66.8 %) and higher average age (40.6 ± 14.9 years) of the respondents in the study by Ramakrishnan *et al*. (2019) as compared to the present study.

Table 3: Self-reported systolic and diastolic blood pressure of the respondents (n = 891)

Systolic blood pressure (mmHg)	Frequency	%
70-79	27	3.0 %
80-89	38	4.3 %
90-99	35	3.9 %
100-109	122	13.7 %
110-119	494	55.4 %
120-129	115	12.9 %
130-139	46	5.2 %
140-149	12	1.3 %
150-159	2	0.2 %
Diastolic blood pressure (mmHg)	**Frequency**	**%**
40-49	11	1.2 %
50-59	23	2.6 %
60-69	60	6.7 %
70-79	576	64.6 %
80-89	180	20.2 %
90-99	41	4.6 %

Females are more likely to have normal blood pressure than males (80.8 % and 66.8 %, respectively) (Figure 4). Prehypertension prevalence was higher among males (25.9 %) than females (16.3 %). The overall prevalence of hypertension stage 1 was higher among males (7.3 %) than females (2.9 %). Males and females significantly differed in distribution across three classes of blood pressure as per the chi-square test ($p < 0.001$). A study by Ramakrishnan and colleagues (2019) showed that Indian males are more likely to be hypertensive than females (34.2 % and 23.7 %, respectively). A higher prevalence of hypertension in males (24.0 %) than females (21.0) was also reported in NFHS-5, 2019-21 (IIPS and ICF, 2021).

Table 4: Blood pressure by gender and age

Age (years)	Gender	Blood pressure (mmHg)		
		Normal (< 120/80)	Prehypertension (120 139/80 89)	Stage 1 Hypertension (140 159/90 99)
18-24 (n = 260)	Male (n = 99)	36.9 %	1.2 %	0.0 %
	Female (n = 161)	60.4 %	1.5 %	0.0 %
	Total	97.3 %	2.7 %	0.0 %
25-34 (n = 387)	Male (n = 196)	41.1 %	7.5 %	2.1 %
	Female (n = 191)	43.9 %	4.7 %	0.8 %
	Total	85.0 %	12.1 %	2.8 %
35-44 (n = 83)	Male (n = 44)	22.9 %	28.9 %	1.2 %
	Female (n = 39)	28.9 %	15.7 %	2.4 %
	Total	51.8 %	44.6 %	3.6 %
45-54 (n = 83)	Male (n = 44)	6.0 %	31.3 %	15.7 %
	Female (n = 39)	13.3 %	26.5 %	7.2 %
	Total	19.3 %	57.8 %	22.9 %
55-64 (n = 64)	Male (n = 44)	15.6 %	40.6 %	12.5 %
	Female (n = 20)	7.8 %	21.9 %	1.6 %
	Total	23.4 %	62.5 %	14.1 %
65 years and above (n = 14)	Male (n = 10)	21.4%	35.7 %	14.3 %
	Female (n = 4)	0.0 %	21.4 %	7.1 %
	Total	21.4 %	57.1 %	21.4 %

As earlier reported by Ramakrishnan *et al*. (2019), the self-reported prevalence of hypertension was 15.0 % less than the measured value. The present study also reported less hypertension prevalence based on self-reported data.

Choi *et al*. (2017) investigated the prevalence of hypertension among Korean adults and reported a higher prevalence among males than females. A study by Shirani *et al*. (2011) reported that females are more aware of their blood pressure changes, and hypertension is more controlled among them. It is suggested that the female hormone plays a protective role in regulating blood pressure (Reckelhoff, 2001).

The distribution of blood pressure levels across six age categories and gender were also assessed, as shown in Table 4. The prevalence of prehypertension increased with age from 2.7 % for respondents aged 18-24 years to 62.5 % for respondents aged 55-64 years. A decline of 5 percentage points was observed in the prevalence of prehypertension after 64 years of age. The prevalence was higher among males than females across all age groups, except in those aged 18-24 years, where an almost equal percentage of males and females had prehypertension. The prehypertensive population aged 35 to 55 indicates that they may become hypertensive with age. The age group, 35 to 55, represents critical age for educational, exercise, and dietary interventions to control modifiable risk factors. Therefore, early diagnosis and intervention at the prehypertensive stage are essential.

The prevalence of stage I hypertension increased with age, from 2.8 % among respondents aged 25-34 to 21.40 % among respondents aged 65 years and above. The highest prevalence of stage 1 hypertension was reported in the age group of 45-54 years (22.9 %). In each group, more males had hypertension than females, except in those aged 35-44 years, where more females (2.4 %) were hypertensive than males (1.2 %). Among females, hypertension increased from 2.4 % to 7.2 % among respondents aged 35 to 54 years, which might be attributed to hormonal changes after menopause (Coylewright *et al*., 2008). The great Indian blood pressure survey also observed a similar trend of increase in the prevalence of hypertension with age, with more males being hypertensive than females in each age group (Ramakrishnan *et al*., 2019). Structural changes in arteries are associated with

Table 5: Correlation coefficient between blood pressure level and study variables

Variables	Blood pressure level
Age	0.589***
BMI (kg/m^2)	0.439***
BMR (kcal/day)	0.233***
Education	0.345***
Family size	-0.151***
House location	0.178***
MPCI	0.283***
Social class	0.184***

Note: MPCI (monthly per capita income, INR); * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

increased blood pressure with age (Pinto, 2007), which increases the risk of type-2 diabetes, stroke, renal, and cardiovascular diseases.

A longitudinal study conducted among US adults observed an increase in systolic and diastolic blood pressure among males and females and across age groups during the COVID-19 pandemic. Mean changes in blood pressure were higher for systolic than diastolic blood pressure (Laffin *et al*., 2022). To our knowledge, no study reports awareness and prevalence of hypertension among Indian adults during COVID-19.

Association of blood pressure with nutritional, sociodemographic, and socioeconomic variables

A Spearman's rank-order correlation was run to determine the relationship between blood pressure, age, BMI, BMR, education, family size, house location, monthly per capita income (MPCI), and social class (Table 5). A strong, positive correlation was reported between blood pressure and age, which was statistically significant ($r_s = 0.589$, $p < 0.001$). The correlation coefficient ($r_s = 0.439$) showed a strong, positive relation between blood pressure and BMI, which was significant at a p-value < 0.001. The above result showed increased blood pressure with an increase in age and BMI. However, the magnitude of blood pressure's association with age was greater than that of blood pressure with BMI. A study conducted among adult males of Northeast India also reported that blood pressure was positively associated with BMI and age (Mungreiphy *et al*., 2011).

A positive association was reported between blood pressure and BMR ($r_s = 0.233$, $p < 0.001$). The present study results were consistent with previous findings of Ali *et al*. (2017) and Snodgrass *et al*. (2008), which also reported a positive association between BMR and blood pressure. The educational status of the respondents was moderately associated with blood pressure in a positive direction, which showed an increase in blood pressure with a higher degree of attainment ($r_s = 0.345$, $p < 0.001$). The above positive association might be due to the higher prevalence of obesity among the more educated population in India, as reported by Venkatrao *et al*. (2020) and Verma *et al.* (2021). A similar result was reported in a study conducted in Nepal, which showed a higher likelihood of being hypertensive among individuals from the higher educational group (Rana *et al*., 2020). A study conducted in Bangladesh also reported a positive association between hypertension and the highest educational level attained (Harshfield *et al*., 2015). In contrast, another study reported that graduates have a lower blood pressure than

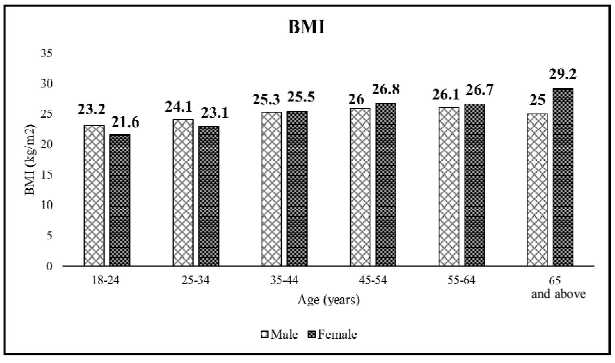

Fig. 1: Trends in body mass index with gender and age

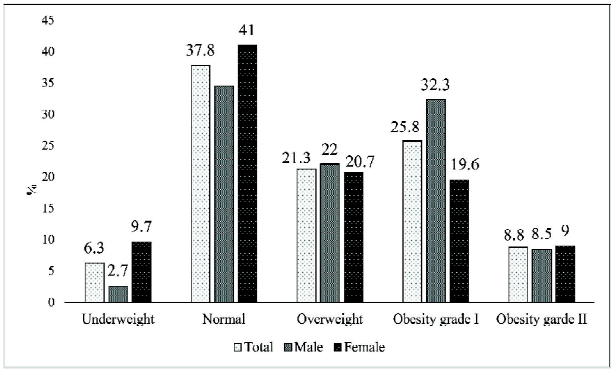

Fig. 2: Nutritional status of the respondents (n = 891)

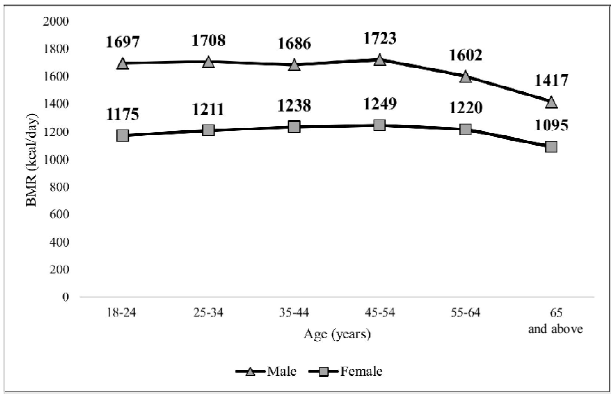

Fig. 3: Basal metabolic rate by gender and age

high school pass (Liu *et al*., 2011). However, the impact of a higher workload with a higher degree cannot be ignored.

A larger family size was negatively associated with blood pressure ($r_s = -0.151$, $p < 0.001$). A study conducted among female students reported a significant correlation between family size and systolic blood pressure (Khan and Manzoor, 2002). Family members are the primary source of care and support and have shown protective effects on an individual's psychological and physical health (Widmer *et al*., 2018). Blood pressure prevalence was higher among

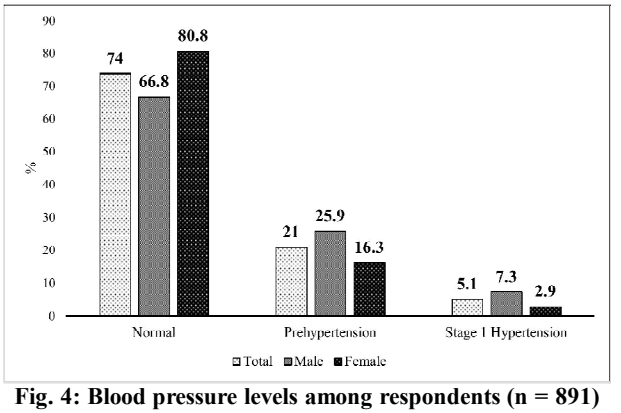

Fig. 4: Blood pressure levels among respondents (n = 891)

urban areas ($r_s = 0.178$, $p < 0.001$). A recent review found a significant difference in hypertension prevalence in urban and rural India (33.8 % *vs.* 27.6 %) (Anchala *et al*., 2014). Also, obesity, one of the risk factors for hypertension, is higher in urban than rural areas (Venkatrao *et al*., 2020; Verma *et al.,* 2021). MPCI was positively associated with social class ($r_s = 0.686$, $p < 0.001$) and education ($r_s = 0.329$, $p < 0.001$). Social class and education were positively associated ($r_s = 0.199$, $p < 0.001$).

A positive correlation was reported between blood pressure and MPCI, which was statistically significant ($r_s = 0.283$, $p < 0.001$). It showed that blood pressure increased with an increase in MPCI. Higher income increases the purchasing power and consumption of processed food and animal products. The above change in dietary preferences results in obesity, as evident in the richest wealth quintiles (Verma *et al.,* 2021). A study conducted in Japan showed that the odds of high blood pressure were twice among males in the high-income category than males in the low-income group (Antipolis, 2020). A study conducted in Vietnam reported that richer males are more likely to be hypertensive than males with lower economic status (Van Minh *et al*., 2006). A positive association was reported between blood pressure and social class ($r_s = 0.184$, $p < 0.001$). Thus, individuals in higher social classes had higher blood pressure. The result of the present study is consistent with the previous research conducted in Nepal, which showed that higher income and higher socioeconomic status are positively associated with hypertension (Rana *et al*., 2020). A study conducted in Bangladesh also reported that individuals in the highest wealth quintile had higher odds of being hypertensive than those in the lowest (Harshfield *et al*., 2015).

CONCLUSION

More than half of the Indian adults were overweight or obese in the present study. Body mass index increased with age, highlighting the importance of weight management. The prevalence of prehypertension and hypertension increased with age, with a higher prevalence among males than females. Thus, age and male gender were identified as significant risk factors for high blood pressure. The study concluded a positive association between blood pressure and age, BMI, BMR, and urban residence. Blood pressure was negatively associated with family size, as family members are the primary source of care and support. The increasing monthly per capita income, social class, and educational level are positively associated with elevated blood pressure among Indian adults.

Blood pressure is one significant risk factor for several non-communicable diseases; awareness about the blood pressure profile and subsequent control holds significant potential. The awareness rate of blood pressure among Indian adults during COVID-19 was similar to pre-COVID-19 levels. Half of the Indian adults are unaware of their blood pressure profile. Health awareness campaigns can sensitize the masses about the consequences of high blood pressure and subsequent testing. Quarterly or bi-annual health camps can be organized to help citizens monitor their blood pressure. Individuals with higher BMI, income, upper social class, and those in the prehypertensive age group of 35 to 55 years can be targeted through nutritional awareness campaigns to sensitize them to weight management, physical activity, and healthy dietary choices. Besides, living with family members must be promoted as far as possible.

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