Prevalence and associated risk factors of hypertension in India: Evidence from NFHS

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Prevalence and associated risk factors of hypertension in India: recent evidence from National Family Health Survey

Abstract

Objective

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. This is the first attempt to provide estimates on the prevalence of hypertension at the national, state and district level, a prerequisite for designing effective interventions.

Methods

We used data from the 4th round (2015-16) of National Family Health Survey (NFHS). In NFHS, all states were surveyed between 2015 and October 2016, gathering information from 811,918 persons. Hypertension was defined as systolic blood pressure (SBP) ≥140 mm Hg and/ or diastolic blood pressure (DBP) ≥90 mm Hg. The age standardised prevalence of hypertension was calculated for state comparison. Besides, multivariate logistic regression model was employed to assess the correlates of hypertension.

Results

The age-standardized prevalence of hypertension in India was 11.3% and was 4 percentage points higher amongst males (13.8%) than among females (10.9%). Notably, the hypertension prevalence among the urban adults (12.5%) was marginally higher than among rural adults (10.6%). The proportion of population suffering from hypertension varied greatly between states, with a prevalence of 8.2% in Kerala to 20.3% in Sikkim. Obesity, consumption of tobacco and alcohol were found to be the major predictors of hypertension.

Conclusions

The hypertension prevalence is now becoming more concentrated among the poor in both urban and rural areas. Policy measures should be taken to reduce the consumption of high calorie foods, tobacco and alcohol. On the other hand, a diet rich in fruits and vegetables, regular physical activity and weight control should be promoted.

Key words: Hypertension, prevalence, factors, state, district and India

Article summary

Strengths and limitations of the study

- Largest epidemiological study on hypertension based on the biomedical measurements in India
- First study to provide estimates on prevalence of hypertension at national, state and district level
- Multivariate analysis identified the key drivers of hypertension
- The use of cross-sectional data that does not allow for exploration of causal pathways underlying the reported associations
- The role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity could not be explored in this analysis
- Findings are limited to the adults aged between 15 and 54

Introduction

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. It is a leading risk factor for CVDs, which accounted for 23% of total deaths and 32% of adult deaths in 2010-2013 (RGI, 2015). India has committed to take an array of actions to meet the SDG target of reducing premature mortality from NCDs by one-third by 2030 (SDG declaration). However, much of the success in meeting this target hinges on its ability to check the rise of hypertension. The Global Burden of Hypertension study has highlighted that of the global burden of 212 million DALYs related to hypertension, 18% occurred in India in 2015 (Forouzanfar et al., 2017). The burden of hypertension in India is expected to rise considerably in the coming years due to rapid environmental and life style changes that follow urbanization.

Monitoring and evaluation for SDG

It is, therefore, imperative that blood pressure trends are monitored to evaluate the progress that the country makes vis-à-vis the SDG goal of reduction in NCD mortality. To do that, data on hypertension is needed so that stakeholders can design appropriate interventions and evaluate national programmes aimed at effectively addressing hypertension and associated NCDs. But there was a paucity of reliable information on the status of hypertension in India. As a result, to assess the magnitude of this problem, policy makers had to rely on community studies or surveys that provided self-reported data on hypertension (Roy et al., 2017; Devi et al., 2013; Agarwal, Bhalwar and Basannar 2008; Gupta, Gupta and Pednekar 2004). Further, data from small studies were extrapolated to obtain national level estimate on hypertension (Anchala R et al 2014). Although these studies were helpful and used as a key resource in the arsenal of health policy makers, in the absence of active surveillance or data from population based surveys, policy makers are unable to determine the true hypertension of the people of India.

The recent health surveys have measured blood pressure, providing an opportunity to explore the trends in prevalence of hypertension both at the national, sub-national (state) and district level. Given the heterogeneity in the demographic and socioeconomic conditions across states in India, there are considerable inter-state variations in hypertension prevalence. Besides that, socioeconomic disparities are widespread even within the state. Hence, estimates at the state and district levels are required for policy formulation, setting intervention priorities and to evaluate national programmes. This study is the first in India to provide estimates on the prevalence of hypertension at the national level and by state, district, rural and urban areas and individual characteristics such as age, sex and economic status using the most recent large scale survey data.

Methods

Data

The current study is mainly based on the data from the 4th round of National Family Health Survey (NFHS). NFHS is the Indian version of Demographic and Health Survey (DHS) and is the only source of data that provides estimates on the social and demographic indicators up to the district level. It is a multistage stratified random sample survey, which gathers data primarily on demographic, socioeconomic and reproductive and child health (RCH) parameters but in the latest round, the scope has been widened with the inclusion of clinical, anthropometric and bio-chemical (CAB) tests and measurements of blood glucose and blood pressure (BP) for assessing the prevalence of non-communicable diseases such as diabetes and hypertension in the population. Additionally, it also collected information on behavioural risk factors such as consumption of alcohol and smoking. NFHS 4 was conducted during the period between 2015 and 2016 across all 29 states and 7 Union Territories (UTs) in India. This data can be used for obtaining estimates for most indicators not only at the national and provincial level but also at the district level. Since the focus of this study is on hypertension, we provide the details regarding the BP measurement. For measuring BP for individuals, three blood pressure readings were recorded from men aged 15-54 years and women 15-49 years on the left arm, using a Ross Max AW BP monitor model.

Statistical analysis

In NFHS, three blood pressure readings were taken. Based on average of second and third readings of blood pressure, hypertension was defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg. The definition was based on the criteria given by WHO and American Heart Association (Pickering et al 2005). To make the prevalence of hypertension comparable, age adjusted prevalence rates were calculated for all states, UTs and districts. Apart from calculating the prevalence of hypertension, multivariate logistic regression model was employed to assess the correlates of hypertension.

Dependent variable

Hypertension for adults aged between 15 and 49 years. The dichotomous variable, hypertension, was defined as 1=hypertensive, else=0.

Explanatory variables

Predictors were selected based on their effects on hypertension.

Sociodemographic variables: Age, sex, marital status, caste, education, place of residence, wealth status. Besides sociodemographic variables, we included body mass index, smoking and alcohol consumption as proxy for behavioural risk factors.

Patient and Public Involvement

Patients and public were not involved in the analysis of this study.

Results

Sample characteristics

As seen in table 803,412 adults were included in this study. A little more than half of the sample population (51.3%) were aged between 15-29 years; 13% of males and 27% of females never went to school and 13% of both sexes attended school only up to primary level. Almost 64% of men and 73% of women were currently married. A third of the study population were urban residents and a quarter of them were either overweight or obese. While 45% of males were users of some form of tobacco, the prevalence of tobacco use was only 6% among the females. Similarly, a significantly greater proportion of men (30%) reported consuming alcohol either almost every day, about once a week or less than once a week as compared to just 1% amongst women.

Table1. Sample characteristics

Sample Characteristics		Total		Male		Female	
		N	%	N	%	N	%
Total		803,412	100	102,242	12.7	701,170	87.3
Hypertension	No	690,537	89.5	91,792	85.7	604,641	89.9
	Yes	80,946	10.5	15,359	14.3	67,857	10.1
Age group	15-19	140,987	17.5	18,676	16.7	122,305	17.5
	20-29	271,951	33.8	32,662	29.3	239,246	34.2
	30-39	215,399	26.8	28,156	25.2	187,230	26.7
	40-49	175,030	21.8	23,543	21.1	151,482	21.6
	50-54	803,412	100	8,618	7.7		
Marital Status	Not married	196,348	24.4	38,715	34.7	157,840	22.5
	Married	577,202	71.8	71,372	63.9	513,869	73.4
	Widow/separated/divorced	29,862	3.7	1,567	1.4	28,555	4.1
Caste	Others	180,047	23.5	25,360	23.9	156,759	23.5
	SC	165,867	21.6	22,385	21.1	145,127	21.7
	ST	73,723	9.6	10,099	9.5	64,365	9.6
	OBC	346,814	45.3	48,315	45.5	302,190	45.2
Education	No education	198,884	24.8	14,196	12.7	186,843	26.7
	Primary	106,737	13.3	14,304	12.8	94,102	13.4
	Secondary	392,853	48.9	64,093	57.4	332,438	47.5
	Higher	104,937	13.1	19,061	17.1	86,880	12.4
Place of residence	Urban	271,551	33.8	40,073	35.9	234,652	33.5
	Rural	531,861	66.2	71,581	64.1	465,611	66.5
Wealth quintile	Poorest	142,472	17.7	17,105	15.3	126,597	18.1
	Poorer	159,313	19.8	21,565	19.3	139,240	19.9
	Middle	166,795	20.8	23,800	21.3	144,657	20.7
	Richer	169,194	21.1	24,344	21.8	146,798	21.0
	Richest	165,638	20.6	24,840	22.3	142,971	20.4
BMI	Normal (18.5-24.9)	467,495	74.3	68,531	76.1	403,972	74.0
	Overweight (25.0-29.9)	123,473	19.6	18,082	20.1	107,254	19.6
	Obese (>=30)	38,057	6.1	3,490	3.9	34,965	6.4
Tobacco use	No	446,158	55.5	60,701	54.1	389,956	93.1
	Yes	357,254	44.5	50,953	45.9	310,307	6.9
Alcohol consumption	Never drinks	750,089	95.2	76,400	70.2	678,980	98.8
	Almost every day	4,909	0.6	4,026	3.7	1,497	0.2
	About once a week	14,945	1.9	13,204	12.1	2,953	0.4
	Less than once a week	17,948	2.3	15,192	14.0	3,994	0.6

Prevalence of hypertension at national, state and district level

Table1 shows crude and age standardized prevalence of hypertension amongst adults aged 15-49 years for the year 2015-16. The data shows that the age-standardized prevalence of hypertension in India was 11.3% and the prevalence was 4 percentage points higher amongst males (13.8%) as compared to females (10.9%). Notably, the hypertension prevalence among the urban adults (12.5%) was marginally higher than among rural adults (10.6%).

Table1. Prevalence of hypertension in India, 2015-2016

Prevalence	**Unadjusted**		**Adjusted**	
	%	**C.I.**	**%**	**C.I.**
Overall	**10.5**	**(10.37, 10.62)**	**11.3**	**(11.16, 11.43)**
Male	14.3	(13.97, 14.70)	13.8	(13.46, 14.19)
Female	10.1	(09.96, 10.22)	10.9	(10.79, 11.06)
Rural	9.8	(9.09, 9.94)	10.6	(10.50, 10.78)
Urban	11.8	(11.12, 12.12)	12.5	(12.25, 12.80)

Figure1 and 2 show the state variation in the age-adjusted prevalence of hypertension amongst adults aged between 15 and 54 years. The results reveal that the age-standardised prevalence of hypertension varied greatly between states and UTs, with a prevalence of 8.2% in Kerala to a prevalence of 20.2% in Sikkim. Quite intriguingly, the hypertension prevalence was greatest among the north-eastern states-Sikkim (20.3%), Nagaland (17.6%), Assam (17.6%), Arunachal Pradesh (16.6%) and Tripura (15.4%).

Figure1. Age-adjusted prevalence of hypertension across states, 2015-16 (in percent)

Hypertension prevalence was also very high in the following non-northeastern states-Jammu and Kashmir (15.8%), Punjab (14.8%), Himachal Pradesh (14.8%) and Telangana (14.2%). On the other hand, proportion of population suffering from hypertension was relatively low in states such as Kerala (8.2%), Bihar (8.8%), Delhi (8.6%), Rajasthan (9.1%), Uttar Pradesh (9.6%) and Jharkhand (9.6%).

Fig 2. Prevalence of hypertension across states, India, 2015-16

Figure 3 shows inter-district variation in hypertension prevalence. The proportion of hypertensive population varied tremendously, ranging between 3.5% in district Mahoba, Uttar Pradesh to 34.7% in district Dibang Valley, Arunachal Pradesh. A majority of districts across India recorded a high hypertension burden, with more than one-tenth of the adults aged 15-49 hypertensive in 427 districts. Only 10 districts had hypertension levels below 5% and all of them except one were in

EAG states. Several districts with alarmingly high prevalence of hypertension were clustered across north-eastern states. Five districts in Arunachal Pradesh, two districts in Punjab, one each in Sikkim, Assam and Andaman and Nicobar were among the top ten districts with the highest levels of hypertension. The results revealed that at least one in every five persons aged between 15 and 49 were having hypertension in as many as 28 districts across India.

The findings highlighted that the prevalence of hypertension was higher in men than in women in most states and UTs, except in Delhi, West Bengal, Meghalaya and J&K (Figure2). The sex difference in prevalence of hypertension was highest in Andaman and Nicobar Islands (12.4%), followed by Sikkim (8.4%), Himachal Pradesh (7.3%) and Manipur (7.2%). The results also suggest that in general, the gender differentials were relatively smaller in low prevalence states than in high prevalence states. Figure3 shows the weighted prevalence of hypertension in rural and urban areas of all states. As shown in the above figure, the prevalence rate of hypertension was found to be higher in urban than in rural areas for most of the states. However, there were a few exceptions. The prevalence of hypertension was relatively higher amongst the rural folks than their urban counterparts in Punjab, Goa and Kerala.

Fig 3. Prevalence of hypertension across districts, India, 2015-16

Another interesting pattern emerges while comparing the prevalence of hypertension between high and low socioeconomic status (SES) categories within rural and urban areas of each of these states (Figure 4). The results suggest hypertension is no longer a disease of the rich. In fact, the distribution of the condition is changing, disproportionately affecting the economically disadvantaged in urban areas of states such as Punjab, Haryana, Jammu and Kashmir and most of the NE states. Furthermore, the phenomenon of higher prevalence of hypertension among the poor appears to be not limited to only urban areas. In rural areas of Chhattisgarh, Kerala and Mizoram, poorer individuals had higher prevalence than their richer counterparts. Also, the differences in prevalence of hypertension by low vs high SES categories were generally marginal in urban areas of most states (<2 percentage points). The weak association between GDP per capita of states and hypertension prevalence (Figure 5) is also the confirmation of the growing convergence of rich-poor difference in prevalence of hypertension, particularly in the urban areas.

Figure4. Prevalence of Hypertension amongst people with low and high socioeconomic status across rural and urban areas in all states in India, 2015-16.

Figure 5. Prevalence of hypertension and GDP per capita by state

Sociodemographic differentials in prevalence

Both bi-variate and multivariate analyses were carried out to understand the relative importance of socioeconomic and behavioural risk factors of hypertension. Since the bivariate (Table A1) and multivariate analyses yielded very similar results, we are only presenting the findings of multivariate analysis here. Table2 shows results for logistic regression of hypertension by its different covariates, separately for males and females. Not surprisingly, age was found to be an important predictor of hypertension. The likelihood of being hypertensive increased significantly with age. Odds Ratios suggest that men aged between 50 and 54 years and women aged 45-49 years were 9.1 and 7.1 times respectively more likely to have hypertension than the young adults (15-19 years). The differences in prevalence probabilities between married, widowed and single were statistically significant. Women who were widowed, separated and divorced were more likely to have hypertension than their 'single' counterparts (OR=1.15; $p<0.001$). Interestingly, married men were found to be at greater risk of hypertension than unmarried men (OR=1.18; $p<0.001$). Educational attainment seems to be inversely related with prevalence for women. While women with secondary (OR= 0.94; $p<0.001$) or tertiary education (OR=0.77; $p<0.001$) were less likely to be hypertensive as compared to their illiterate counterparts, we did not find any systematic relationship between education and hypertension in case of men.

We also looked at how economic status, proxied by asset index influences the risk of hypertension in males and females. Compared with those in poorest quintile, both men and women from middle and richer quintiles were having slightly higher likelihood of hypertension (≤0.52 percentage points). Place of residence was not found to be statistically significantly associated with hypertension for males. However, females residing in urban areas were more likely to be at risk of hypertension than their rural folks. Interestingly, even after controlling for socioeconomic status and demographic variables, differences in prevalence of hypertension by social groups remained statistically significant. Tribal men and women were more likely to have the condition (Males: OR=1.27; Females: 1.09; $p<0.001$) than their respective counterparts from advantaged social group.

Table2. Results of multivariate logistic regression on hypertension, India, 2015-16

	Category	Male		Female	
		Odds ratio	C.I. 95%	Odds ratio	C.I. 95%
Age group	15-19	1		1	
	20-29	2.578***	(2.14, 3.10)	1.819***	(1.67, 1.97)
	30-39	4.824***	(3.92, 5.93)	3.805***	(3.48, 4.15)
	40-49	8.255***	(6.71, 10.1)	7.064***	(6.46, 7.72)
	50-54[$]	9.113***	(7.32, 11.3)	-	-
Marital Status	Unmarried	1		1	
	Married	1.180***	(1.05, 1.32)	1.051	(0.98, 1.12)
	Widow/separated/divorced	1.191	(0.90, 1.57)	1.153***	(1.05, 1.26)
Caste	Others	1		1	
	SC	1.083	(0.98, 1.19)	0.943***	(0.90, 0.98)
	ST	1.275***	(1.14, 1.42)	1.093***	(1.03, 1.15)
	OBC	1.012	(0.93, 1.09)	0.908***	(0.87, 0.94)
Education	No education	1		1	
	Primary	1.226***	(1.09, 1.36)	1.037***	(0.99, 1.08)
	Secondary	1.162***	(1.05, 1.27)	0.941***	(0.90, 0.97)
	Higher	1.214***	(1.07, 1.36)	0.775***	(0.72, 0.82)
Place of residence	Urban	1		1	
	Rural	0.962	(0.89, 1.03)	1.029*	(0.99, 1.06)
Wealth Status	Poorest	1		1	
	Poorer	1.130**	(1.01, 1.25)	1.066***	(1.02, 1.11)
	Middle	1.346***	(1.21, 1.49)	1.088***	(1.04, 1.13)
	Richer	1.517***	(1.35, 1.69)	1.165***	(1.10, 1.22)
	Richest	1.410***	(1.24, 1.59)	1.104***	(1.04, 1.16)
BMI	Normal	1		1	
	Overweight (25.0-29.9)	2.035***	(1.89, 2.18)	1.942***	(1.87, 2.00)
	Obese (>=30)	3.135***	(2.73, 3.59)	3.149***	(3.00, 3.30)
Tobacco use	No	1		1	
	Yes	1.012	(0.94, 1.07)	1.071***	(1.02, 1.12)
Alcohol consumption	Never drinks	1		1	
	almost every day	1.769***	(1.56, 2.00)	1.402***	(1.08, 1.80)
	About once a week	1.275***	(1.16, 1.39)	1.572***	(1.36, 1.81)
	Less than once a week	1.183***	(1.08, 1.28)	1.162**	(1.01, 1.33)

$ - The data for the age group (50-54) is collected for males only. C.I. 95% - represents the 95 % confidence intervals. BMI – Body Mass Index -the *p<0.10, **p<0.05, ***p<0.01, ® - reference category

We also examined the association between hypertension and health and life-style practices of the men and women. The Odds Ratios (ORs) indicate that both men and women with overweight (Males: OR=2.03; Females: OR=1.94, p<0.001) or obesity issue (Males and Females: OR=3.1, p<0.001) had significantly higher probability of hypertension than those with 'normal' BMI. The differences in the probability of hypertension among women by tobacco use were small. Women who reported as tobacco users were more likely to be hypertensive (0.07 percentage points) than the non-users. Similarly, in case of men, the value of odds ratio suggests tobacco users had a higher likelihood of hypertension than the non-users but it was not statistically significant. Besides use of tobacco, alcohol consumption was also found to be positively related with hypertension. Both men and women who drank alcohol almost every day (Males: OR=1.76; Females: 1.40; $p<0.000$), about once a week (Males: OR=1.27; Females: 1.57; $p<0.001$) and less than once a week (Males: OR=1.18; Females: OR=1.16; $p<0.001$) were significantly more likely to suffer from hypertension than men or women without alcohol use habit.

Discussion

This article provides estimates on the prevalence of hypertension across different geographical areas in India and examines socioeconomic and life-style factors associated with this condition, by exploiting the latest data from the 4th round (2015-16) of NFHS. Although some previous research have attempted to understand the burden of hypertension in India (Geldsetzer P et al 2018; Bhansali et al 2015; Anchala R et al 2014), to the best of our knowledge, this study is the first comprehensive assessment of hypertension prevalence using high quality survey data of each state and district of India.

One of our key findings is that more than one-tenth of the adults in India are hypertensive. However, the estimated hypertension prevalence differ from the reported prevalence in Geldsetzer et al's (2018) study on hypertension. This is arising mainly because of the reason that our estimates of prevalence pertain to adults aged 15-54 years while the said study provided estimates for adults aged 18 and above. Besides that, their estimates can not be generalised nationally as several states and UTs such as Delhi, Gujarat, Jammu and Kashmir, A & N islands, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep were not covered in Annual Health Survey (AHS) and District Level Household Survey (DLHS) surveys[1] which they used for the estimation of hypertension

[1] Researchers have raised concerns about the quality of the data generated by DLHS and AHS (Borkotoky, Unisa 2014; Dandona, Pandey and Dandona 2016). Concerning the BP measurement, many factors including the number of measurements used can significantly affect the estimates of hypertension prevalence (Birkett NJ 1997, McAlister FA, Straus SE 2001). Studies show that three readings of BP as against one or two, is likely to provide a more accurate estimate of prevalence, especially in case of discrepancy in readings between the first two (Stevens, McManus and Stevens 2018). However, blood pressure was measured only twice in the left upper arm in both DLHS and AHS. Not surprisingly, only a handful of publications can be found using AHS (total 3 publications) and DLHS data (Dandona, Pandey and Dandona 2016).

prevalence. Further, it should be noted while the clinical and anthropometric data for AHS was collected in 2014[2], DLHS was carried out between 2012 and 2013. Hence, the pooled data may not provide true estimates of hypertension at the national level owing to inconsistencies between two surveys in terms of survey design, period of data collection (time gap) and non-inclusion of many states and UTs.

Hypertension was found to be more prevalent among males than among females. Although the prevalence of hypertension was relatively higher in urban than in rural areas at the national level, the rural-urban differences were not large, implying that hypertension epidemic is spreading very fast even in the rural population. This has serious implications for the rural people. The public health system through PHCs in rural areas is still focusing on infectious diseases, reproductive and child health and thus, has become too limited. So, people would have to rely on the private sector (wherever it is available) for the management of hypertension and its associated diseases, which would substantially add to their financial strain.

Considerable inter-state and inter-district differences were found in the prevalence of hypertension. It was more common in north-eastern states, Jammu & Kashmir, Himachal Pradesh, Punjab, and Telengana than in Kerala and EAG states. The inter-state differentials might have been caused by the differences in risk exposure such as rising affluence, urbanization, sedentary life style, changing dietary habits, obesity prevalence, social stress and possibly, genetic factors. The finding of relatively lower hypertension prevalence in EAG states is consistent with evidence from the latest burden of disease study that classified these states as having low epidemiological transition level (Dandona et al., 2017). But surprisingly, Kerala, where epidemiologic transition is most advanced among all states, had recorded the lowest prevalence of hypertension. This may be due to the non-inclusion of males and females aged more than 54 and 49 years in NFHS. It should be noted that Kerala has the highest proportion of elderly population (13%) in India. However, more research is needed to pinpoint the reasons for low prevalence in Kerala. Interestingly, in north-eastern states, despite their low per capita income, the prevalence was way higher than states with much higher level of socioeconomic development. The higher burden of hypertension amongst the population of north-east could be attributed to ethnicity and food habits. Hypertension

[2] Although AHS was conducted during 2013-2014, the biomarker component i.e., CAB data was collected only from a sub-sample of AHS in the year 2014. For details, see http://www.censusindia.gov.in/2011census/hh-series/HH-2/CAB-Introduction.pdf. In contrast, in DLHS, CAB tests were carried out in all selected households.

has emerged as a major epidemic in many districts. Examples being two districts of Arunachal Pradesh, where every third person was hypertensive and more than a fifth of the population had the condition in as many as 28 districts.

In majority of the states, hypertension prevalence was higher in urban than in rural areas, though the difference was small and at times, insignificant. However, in Goa, Punjab, Kerala and Nagaland, higher prevalence of hypertension was seen among rural people as compared to their urban counterparts. Such narrowing differentials may be the result of the factors mentioned in a recent study conducted in Punjab. Tripathy and others (2016) reported that there was no rural-urban differential in terms of dietary practices and prevalence of overweight and obesity barring the fact that a markedly higher proportion of individuals from rural areas always/often add salt before/when eating as compared to those from urban areas.

Another major finding was the weak link between economic growth (GDP per capita) and hypertension. Our study reveals that hypertension is affecting the people in poorer and not so poor states alike. Besides that, hypertension is not only affecting the affluent but is also widespread among the poor within states. Another salient finding is the increased proportion of poor suffering from hypertension in many states, particularly in the urban areas. This is in consonance with the findings from studies on non-communicable diseases (Anjana et al 2017). These findings paint a disturbing trend, indicating that it is just a matter of time when the less affluent segment of the population in other states would also face a disproportionately higher burden of hypertension. This would have a catastrophic impact on the poor as they do not have the means to cope up with the treatment costs associated with this chronic disease. Further, their productivity is also going to be significantly affected because of the delayed or no treatment for hypertension. This situation might have arisen due to factors such as the diffusion and adoption of 'modern' lifestyles (the changing dietary behaviour: smoking, drinking, unhealthy diets) across population groups (which is a result of urbanisation, aggressive push of junk food through advertising and marketing and related shifts in sociocultural practice), physical inactivity and high levels of depression and stress (linked to poverty and lack of equal opportunities) (Hawkes, 2006; Smit et al 2015).

Our study also corroborates the above observations as the evidences point to urban residence, obesity, tobacco and alcohol use as some of the key drivers of the hypertension epidemic in India. These were also supported by previous research in India (Tripathy et al 2016; Bhansali et al 2015;

Kaur et al 2012). Surprisingly, use of tobacco was not found to increase the risk of hypertension for men. While it is difficult to explain why use of tobacco did not display statistically significant association with hypertension in male population, past studies have also yielded conflicting findings with regards to the association between tobacco consumption and hypertension. Tripathy et al (2016) and Bhansali et al (2015) did not find smoking as an independent risk factor of hypertension. On the other hand, Bhadoria et al (2014) reported that tobacco chewing and tobacco smoking are significant predictors of hypertension. Hence, this deserves further investigation.

Conclusion

To conclude, hypertension epidemic is spreading alarmingly in India across rural and urban populations. More worryingly, the hypertension prevalence is now becoming more concentrated among the poor in both urban and rural areas. This phenomenon of rising hypertension prevalence among the least resourceful people has serious social and economic implications for the country and warrants immediate policy interventions to prevent the catastrophe. The district wise estimates on this condition should be used to plan for localised interventions so that the prevalence could be brought down significantly, which would help achieve the national target of 25% relative reduction in the prevalence of hypertension by 2025 (Ministry of Health and Family Welfare, 2013). We recommend universal blood pressure screening for high prevalence districts to track the progress of interventions. However, when it comes to interventions, the emphasis should be on primary prevention of hypertension. Policy measures should be taken to reduce the consumption of high calorie foods, tobacco and alcohol. On the other hand, a diet rich in fruits and vegetables, regular physical activity and weight control should be promoted.

Contributorship statement

While SG conceptualised the paper, partly analysed the data and wrote the manuscript, MK carried out the analysis of the data.

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Data sharing statement

The data used in this study came from the large scale surveys conducted by government agencies. All data are already in the public domain and can be accessed freely from the Government of

India's data sharing portals. Besides, NFHS data can also be obtained from the following website- www.iipsindia.org.

Conflicts of interest

The authors have none to declare.

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TableA1. Results of bi-variate analysis

Age group	Category	Male No n (%)	Male Yes n (%)	Male Total n (%)	Male P-value	Female No n (%)	Female Yes n (%)	Female Total n (%)	Female P-value
	15-19	17,490 (97.5)	436 (2.5)	17,926 (100)		1,14,037 (97.5)	2,980 (2.5)	1,17,017 (100)	
	20-29	28,746 (91.9)	2,526 (8.1)	31,272 (100)		2,17,394 (94.7)	12,122 (5.3)	2,29,516 (100)	0.000
	30-39	22,552 (83.4)	4,470 (16.6)	27,022 (100)	0.000	1,58,186 (87.9)	21,745 (12.1)	1,79,931 (100)	
	40-49	16,971 (74.9)	5,669 (25.1)	22,640 (100)		1,15,024 (78.7)	31,011 (21.3)	1,46,035 (100)	
	50-54*	6,033 (72.8)	2,259 (27.2)	8,292 (100)		-	-	-	
Marital Status	Not married	34,885 (94.2)	2,124 (5.8)	37,009 (100)		1,45,177 (96.5)	5,189 (3.5)	1,50,366 (100)	
	Married	55,673 (81.1)	12,954 (18.9)	68,627 (100)	0.000	4,36,671 (88.2)	58,055 (11.8)	4,94,726 (100)	0.000
	Widow/separated/divorced	1,233 (81.4)	281 (18.6)	1,514 (100)		22,793 (83.1)	4,613 (16.9)	27,406 (100)	
Caste	Others	20,636 (84.6)	3,738 (15.4)	24,374 (100)		1,33,916 (88.7)	17,012 (11.3)	1,50,928 (100)	
	SC	18,587 (86.3)	2,938 (13.7)	21,525 (100)	0.000	1,26,328 (90.6)	12,988 (9.4)	1,39,316 (100)	0.000
	ST	8,221 (85.4)	1,404 (14.6)	9,625 (100)		55,331 (90.1)	6,026 (9.9)	61,357 (100)	
	OBC	39,883 (85.8)	6,587 (14.2)	46,470 (100)		2,62,845 (90.3)	27,988 (9.7)	2,90,833 (100)	
Education	No education	11,607 (84.7)	2,092 (15.3)	13,699 (100)		1,57,470 (87.1)	23,191 (12.9)	1,80,661 (100)	
	Primary	11,513 (83.5)	2,261 (16.5)	13,774 (100)	0.000	79,746 (87.9)	10,910 (12.1)	90,656 (100)	0.000
	Secondary	53,347 (86.8)	8,122 (13.2)	61,469 (100)		2,90,869 (91.3)	27,534 (8.7)	3,18,403 (100)	
	Higher	15,325 (84.2)	2,885 (15.8)	18,210 (100)		76,555 (92.5)	6,222 (7.5)	82,777 (100)	
Place of residence	Urban	31,872 (83.2)	6,416 (16.8)	38,288 (100)	0.000	1,98,965 (88.7)	25,318 (11.3)	2,24,283 (100)	0.000
	Rural	59,920 (87.0)	8,943 (13.0)	68,863 (100)		4,05,676 (90.5)	42,539 (9.5)	4,48,215 (100)	
Wealth Status	Poorest	14,876 (90.1)	1,631 (9.9)	16,507 (100)		1,11,787 (91.6)	10,125 (8.4)	1,21,912 (100)	
	Poorer	18,478 (89.1)	2,258 (10.9)	20,736 (100)		1,21,661 (91.1)	12,023 (8.9)	1,33,684 (100)	
	Middle	19,635 (85.9)	3,214 (14.1)	22,849 (100)	0.000	1,25,615 (90.4)	13,392 (9.6)	1,39,007 (100)	0.000
	Richer	19,316 (82.9)	3,980 (17.1)	23,296 (100)		1,24,961 (88.6)	16,075 (11.4)	1,41,036 (100)	
	Richest	19,486 (82.0)	4,276 (18.0)	23,762 (100)		1,20,618 (88.1)	16,242 (11.9)	1,36,860 (100)	
BMI	Normal (18.5-24.9)	57,404 (87.5)	8,208 (12.5)	65,612 (100)		3,55,267 (91.7)	32,039 (8.3)	3,87,306 (100)	
	Overweight (25.0-29.9	12,566 (72.5)	4,761 (27.5)	17,327 (100)	0.000	84,012 (81.5)	18,994 (18.5)	1,03,006 (100)	0.000
	Obese (>=30)	2,131 (63.8)	1,209 (36.2)	3,340 (100)		24,163 (71.9)	9,408 (28.1)	33,571 (100)	
Use of tobacco	No	48,879 (86.9)	7,334 (13.1)	56,213 (100)	0.000	5,54,543 (90.1)	60,722 (9.9)	6,15,265 (100)	0.000
	Yes	40,599 (84.1)	7,659 (15.9)	48,258 (100)		38,769 (86.1)	6,239 (13.9)	45,008 (100)	
Alcohol consumption	No	64,287 (87.5)	9,175 (12.5)	73,462 (100)	0.000	5,86,690 (89.9)	65,665 (10.1)	6,52,355 (100)	0.000
	yes	25,191 (81.2)	5,818 (18.8)	31,009 (100)		6,623 (83.6)	1,296 (16.4)	7,919 (100)	
Frequency of alcohol consumption	Never drinks	64,287 (87.5)	9,175 (12.5)	73,462 (100)		5,86,690 (89.9)	65,665 (10.1)	6,52,355 (100)	
	almost every day	2,800 (73.3)	1,020 (26.7)	3,820 (100)	0.000	1,122 (81.5)	254 (18.5)	1,376 (100)	0.000
	About once a week	10,138 (80.7)	2,424 (19.3)	12,562 (100)		2,287 (81.8)	507 (18.2)	2,794 (100)	
	Less than once a week	12,253 (83.8)	2,374 (16.2)	14,627 (100)		3,214 (85.7)	535 (14.3)	3,749 (100)	
Overall	Total	91,792 (85.7)	15,359 (14.3)	1,07,151 (100)		6,04641 (89.9)	67,857 (10.1)	6,72,498 (100)	

*The data for the age group (15-54) is collected for males only. BMI – Body Mass Index

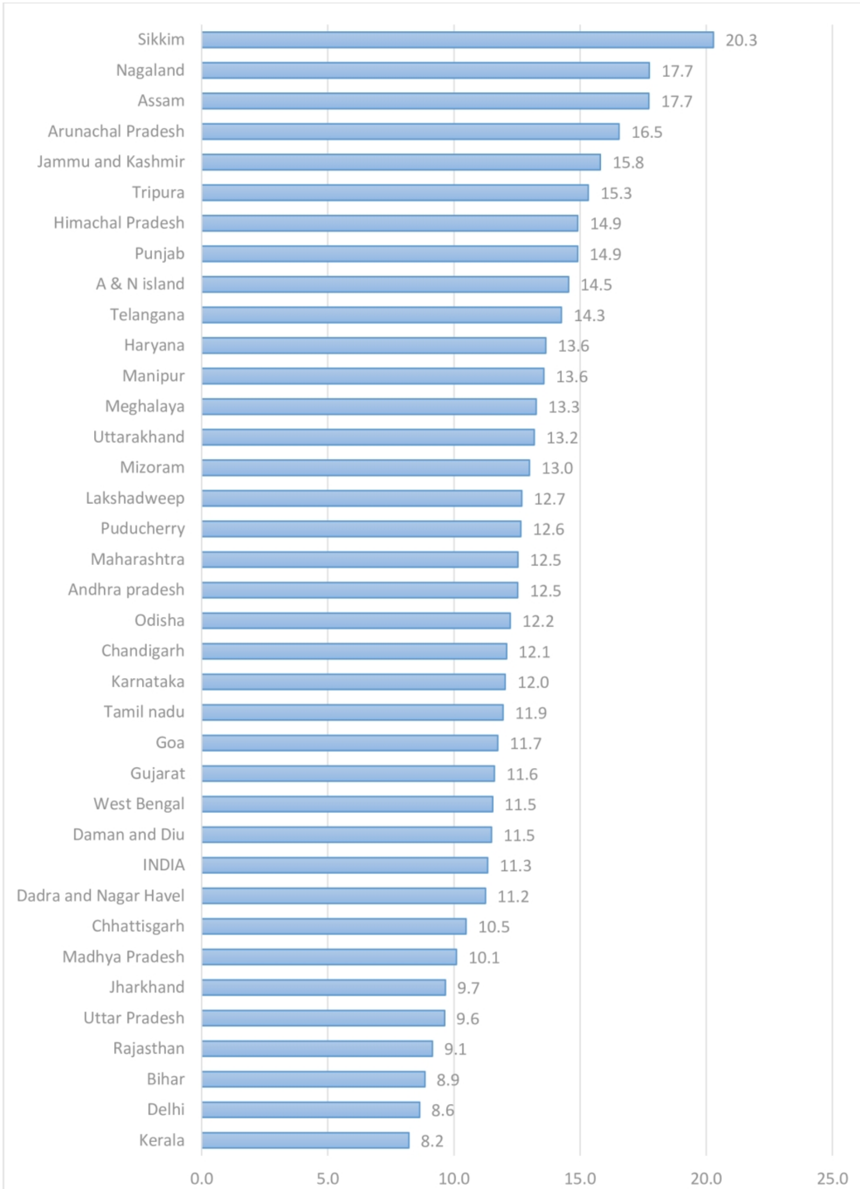

Figure1. Age-adjusted prevalence of hypertension across states, 2015-16 (in percent)

153x211mm (300 x 300 DPI)

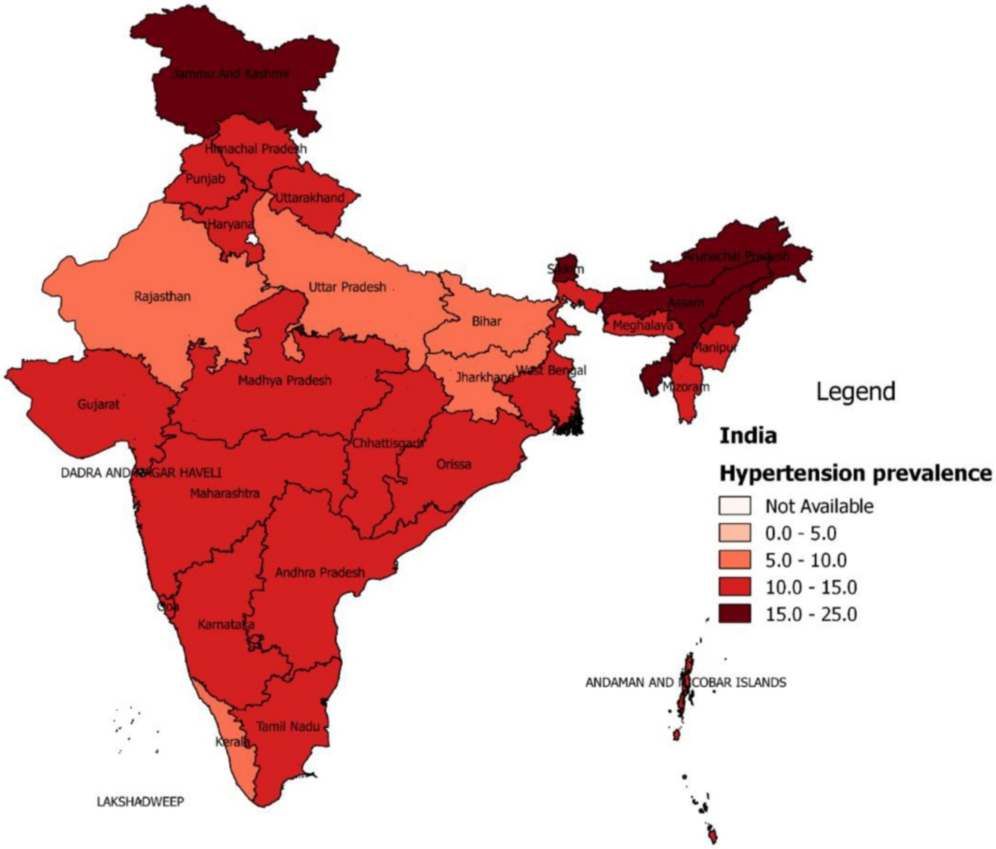

Fig 2. Prevalence of hypertension across states, India, 2015-16

123x106mm (300 x 300 DPI)

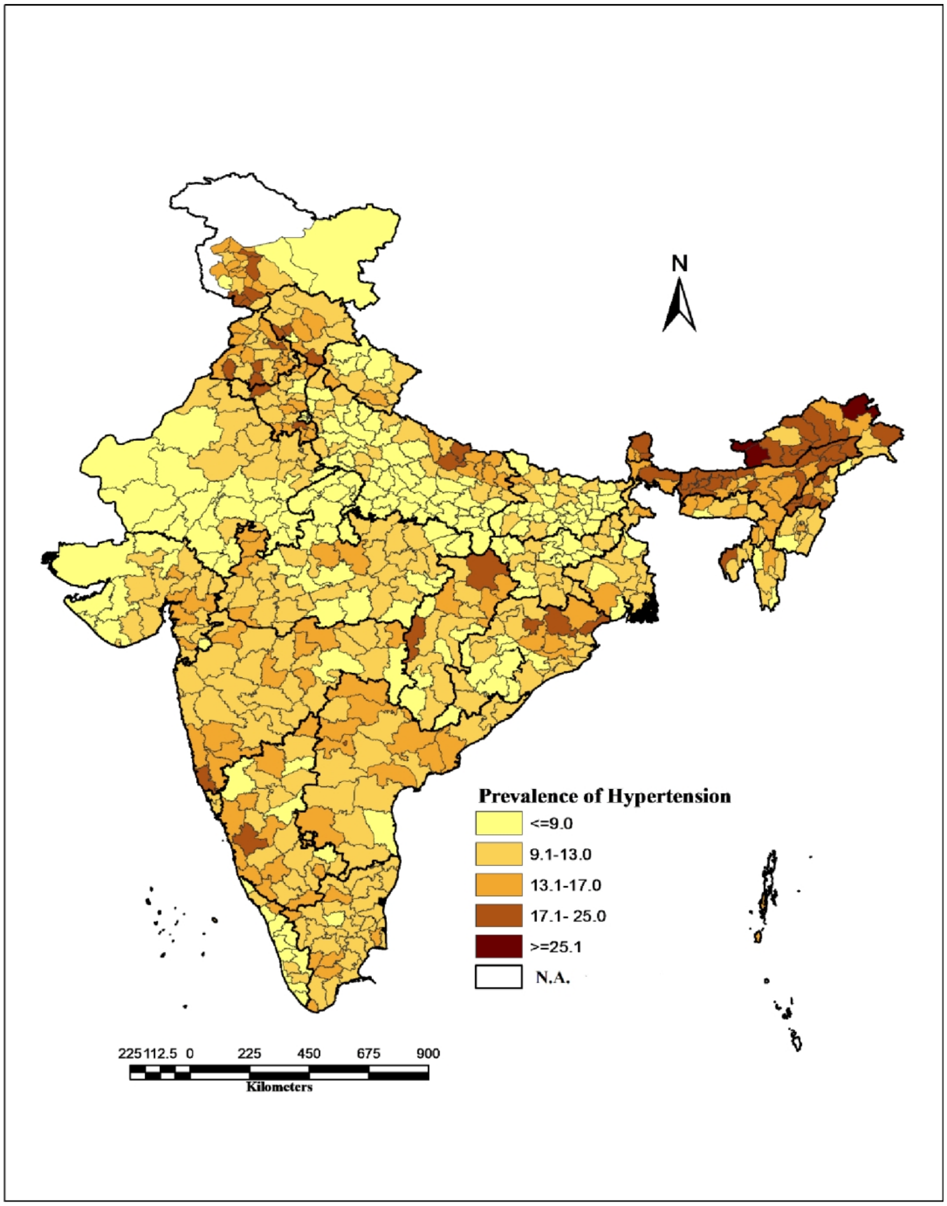

Figure2. Prevalence of hypertension across districts, India, 2015-16

145x185mm (300 x 300 DPI)

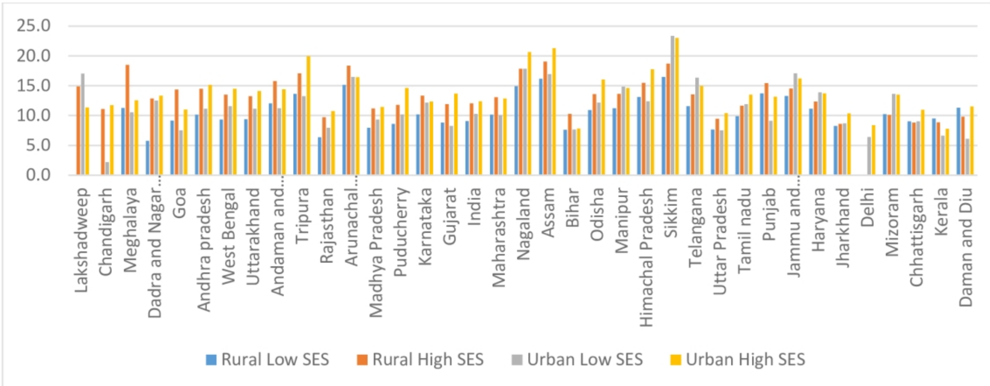

Figure4. Prevalence of Hypertension amongst people with low and high socioeconomic status across rural and urban areas in all states in India, 2015-16.

165x64mm (300 x 300 DPI)

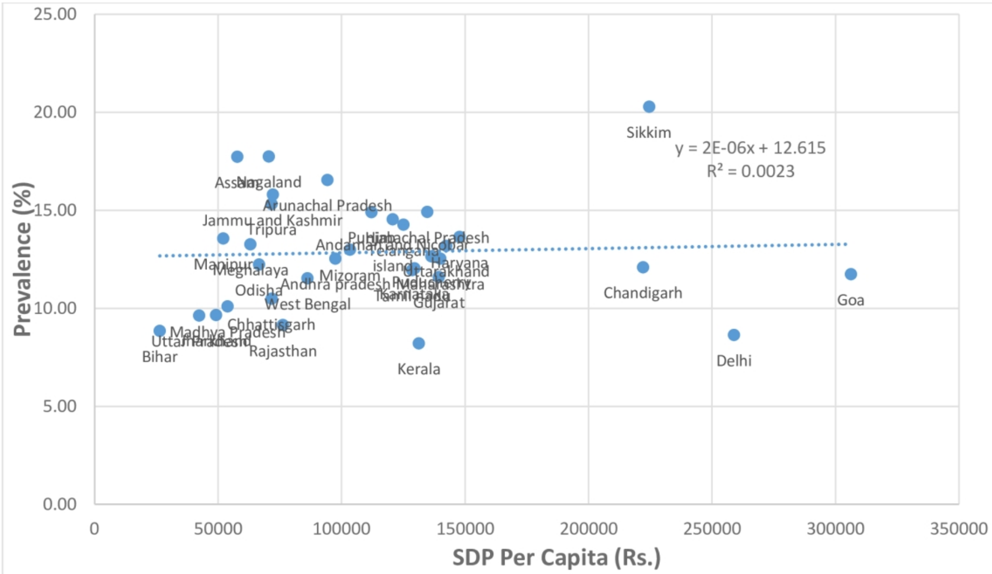

Figure 5. Prevalence of hypertension and GDP per capita by state

165x95mm (300 x 300 DPI)

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Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross sectional study

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Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross sectional study

Abstract

Objective

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. This is the first attempt to provide estimates on the prevalence of hypertension at the national, state and district level, a prerequisite for designing effective interventions. Besides, the study aims to identify the risk factors of hypertension.

Methods

We used data from the 4th round (2015-16) of National Family Health Survey (NFHS). In NFHS, all states were surveyed between January 2015 and December 2016, gathering information on a range of indicators including blood pressure from 811,918 persons. Hypertension was defined as systolic blood pressure (SBP) ≥140 mm Hg and/ or diastolic blood pressure (DBP) ≥90 mm Hg. The age adjusted prevalence of hypertension was calculated for state comparison, while multilevel logistic regression analysis was done to assess the correlates of hypertension.

Results

The age-adjusted prevalence of hypertension in India was 11.3% (95% CI 11.16 to 11.43) among persons aged between 15 and 49 years and was 4 percentage points higher amongst males-13.8% (95% CI 13.46 to 14.19) than among females-10.9% (95% CI 10.79 to 11.06). Persons in the urban location (12.5%, 95% CI 12.25 to 12.80) had a marginally higher prevalence than persons in rural location-(10.6%, 95% CI 10.50 to 10.78). The proportion of population suffering from hypertension varied greatly between states, with a prevalence of 8.2% (95% CI 7.58, 8.85) in Kerala to 20.3% (95% CI 18.81, 21.77) in Sikkim. Advancing age, obesity/overweight, male sex, socioeconomic status and consumption of alcohol were found to be the major predictors of hypertension.

Conclusions

Hypertension prevalence is now becoming more concentrated amongst the poor. Policy measures should be taken to improve the hazardous working conditions and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol.

Key words: Hypertension, prevalence, factors, state, district and India

Article summary

Strengths and limitations of the study

- First epidemiological study to provide estimates on prevalence of hypertension at national, state and district level
- Multivariate analysis identified the key drivers of hypertension
- The use of cross-sectional data that does not allow for exploration of causal pathways underlying the reported associations
- The role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity could not be explored in this analysis
- Findings are limited to the persons aged between 15 and 49

Introduction

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. It is a leading risk factor for cardiovascular disease, which accounted for 23% of total deaths and 32% of adult deaths in 2010-2013[1]. India has committed to take an array of actions to meet the Sustainable Development Goals (SDG) target of reducing premature mortality from non-communicable diseases (NCDs) by one-third by 2030. However, much of the success in meeting this target hinges on its ability to check the rise of hypertension. The Global Burden of Hypertension study has highlighted that of the global burden of 212 million DALYs related to hypertension, 18% occurred in India in 2015[2]. The burden of hypertension in India is expected to rise considerably in the coming years due to rapid environmental and 'life-style' changes that emanate from hazardous working conditions and growing social pressures of survival [3, 4].

Monitoring and evaluation for SDG

It is, therefore, imperative that blood pressure trends are monitored to evaluate the progress that the country makes vis-à-vis the SDG goal of reduction in NCD mortality. To do that, data on hypertension is needed so that stakeholders can design appropriate interventions and evaluate national programmes aimed at effectively addressing hypertension and associated NCDs. But there was a paucity of reliable information on the status of hypertension in India. As a result, to assess the magnitude of this problem, policy makers had to rely on community studies or surveys that provided self-reported data on hypertension [5, 6, 7, 8]. Further, data from small studies were extrapolated to obtain national level estimate on hypertension [9]. Although these studies were helpful and used as a key resource in the arsenal of health policy makers, in the absence of active surveillance or data from population based surveys, policy makers are unable to determine the true hypertension of the people of India.

The recent health surveys have measured blood pressure, providing an opportunity to explore the trends in prevalence of hypertension both at the national, sub-national (state) and district level. Given the heterogeneity in the demographic and socioeconomic conditions across states in India, it is very likely that there would be considerable inter-state variations in hypertension prevalence. Moreover, the socioeconomic disparities are widespread even within the state. Hence, estimates at the state and district levels are required for policy formulation, setting intervention priorities and to evaluate national programmes. This study is the first in India to provide estimates on the prevalence of hypertension at the national level and for each state, district, and by rural and urban areas and individual characteristics such as age, sex and economic status using the most recent large scale survey data. Aside from providing estimates on hypertension prevalence, an attempt was also made to identify the correlates of hypertension.

Methods

Data

The current study is mainly based on the data from the 4th round of National Family Health Survey (NFHS). NFHS is the Indian version of Demographic and Health Survey (DHS) carried out periodically in over 90 countries across the globe.

It is a multistage stratified random sample survey, which gathers data primarily on demographic, socioeconomic and reproductive and child health (RCH) parameters but in the latest round, the scope has been widened with the inclusion of clinical, anthropometric and bio-chemical (CAB) tests and measurements of blood glucose and blood pressure (BP) for assessing the prevalence of non-communicable diseases such as diabetes and hypertension in the population. Additionally, it also collected information on behavioural risk factors such as consumption of alcohol and smoking. NFHS 4 was conducted during the period between 2015 and 2016 across all 29 states and 7 Union Territories (UTs) in India. This data can be used for obtaining estimates for many vital indicators not only at the national and provincial level but also at the district level. The household level questionnaire of NFHS collects details on the possession of certain assets and access to certain utilities. The information on assets and utilisation of utilities are used for constructing wealth index, which reflects the standard of living of households. The wealth index categorises the households into 5 wealth quintiles: ‘poorest’, ‘poor’, ‘middle’, ‘rich’ and richest.

Statistical analysis

Hypertension was considered as the outcome variable of this study. Three blood pressure readings were taken in NFHS. The first measurement was discarded and then, based on the average of second and third readings of blood pressure, it was decided whether a participant was hypertensive or not. Hypertension was defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg. The definition was based on the criteria given by WHO and American Heart Association [10]. In addition, an individual is classified as having hypertension if she/he is currently taking antihypertensive medication to lower his or her blood pressure. The analysis was restricted to women and men age 15-49, after excluding men aged 49-54 (n=8,618) and missing values (n=32,268). Data were weighted prior to analysis.

To make the prevalence of hypertension comparable, age adjusted prevalence rates were calculated for all states, UTs and districts using the direct standardization method. The national population, as per 2011 Census, was used as a reference population for carrying out the standardization technique. To understand how hypertension prevalence varies by socioeconomic status (SES), the wealth index was converted into a dichotomous variable; where the bottom 60% i.e., 'poorest', 'poor' and 'middle' were combined into one group (low SES), the remaining two categories were clubbed into the other category (high SES). Besides conducting bivariate analyses, multi-level (first level: individual; second level: district; third level: state) logistic regression model with random intercepts and fixed slopes were employed to calculate multilevel odds ratios (OR) with corresponding 95% confidence intervals (CI).

Dependent variable

Hypertension for persons aged between 15 and 49 years. The dichotomous variable, hypertension, was defined as 1=hypertensive, else=0.

Explanatory variables

Predictors were selected based on their effects on hypertension.

Sociodemographic variables: Age, sex, marital status, caste[1], education, place of residence, wealth status. Besides sociodemographic variables, we included body mass index, tobacco use and alcohol consumption as proxy for behavioural risk factors. The education categories are defined based on number of years of education completed by an individual: 0 year as "no education"; 1 to 5 years as "primary education"; 6 to 12 years as "secondary education"; and more than 12 years of education attainment categorised as "higher studies".

All statistical analyses were performed using STATA 14.

[1] Indian society is mainly divided into four castes within the framework of the Hindu caste system. The castes used to be classified according to occupation. Historically, many sub-castes have faced discrimination, deprivation and social exclusion on account of their assigned 'low status'. Recognising the marginalisation of certain communities and socioeconomic differences among different population groups, the constitution of India categorised the Indian population into four major groups: Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Class (OBC) and General. ST is the most socio-economically disadvantaged group, followed by the SC and OBC and together they comprise 69% of India's population, with SC at 19.7%, ST at 8.5% and OBC at 41.1%.

Patient and Public Involvement

Patients and public were not involved in the analysis of this study.

Results

Sample characteristics

As seen in table1, of the total 779,649 persons who participated in the survey, a little more than half of them (51.3%) were aged between 15-29 years; 13% of males and 27% of females never went to school and 13% of both sexes attended school only up to primary level. Almost 64% of men and 73% of women were currently married. A third of the study population were urban residents and a quarter of them were either overweight or obese. While 45% of males were users of some form of tobacco, the prevalence of tobacco use was only 6% among the females. Similarly, a significantly greater proportion of men (30%) reported consuming alcohol either almost every day, about once a week or less than once a week as compared to just 1% amongst women.

Prevalence of hypertension at national, state and district level

Table2 shows crude and age adjusted prevalence of hypertension amongst persons aged 15-49 years for the year 2015-16. The data shows that the age-adjusted prevalence of hypertension in India was 11.3% and the prevalence was 4 percentage points higher amongst males (13.8%) as compared to females (10.9%). Persons in the urban location (12.5%) had a marginally higher prevalence than persons in rural location-(10.6%).

The results reveal that the age-adjusted prevalence of hypertension varied greatly between states and UTs, with a prevalence of 8.2% in Kerala to a prevalence of 20.2% in Sikkim (See figures 1 and S1). Quite intriguingly, the hypertension prevalence was greatest among the north-eastern states-Sikkim (20.3%), Nagaland (17.6%), Assam (17.6%), Arunachal Pradesh (16.6%) and Tripura (15.4%). Hypertension prevalence was also very high in the following non-northeastern states-Jammu and Kashmir (15.8%), Punjab (14.8%), Himachal Pradesh (14.8%) and Telangana (14.2%). On the other hand, proportion of population suffering from hypertension was relatively low in states such as Kerala (8.2%), Bihar (8.8%), Delhi (8.6%), Rajasthan (9.1%), Uttar Pradesh (9.6%) and Jharkhand (9.6%).

Table1. Characteristics of sample population by gender, National Family Health Survey, India, 2015-16

Sample Characteristics		Total		Female		Male	
		N	%	N	%	N	%
Hypertension	No	693,875	85.5	602,609	86.1	91,266	81.7
	Yes	85,774	10.6	69,889	10.0	15,885	14.2
	No response	32,268	4.0	27,765	4.0	4,503	4.0
Age group	15-19	144,277	17.8	125,282	17.9	18,995	17.0
	20-29	272,054	33.5	239,307	34.2	32,747	29.3
	30-39	215,796	26.6	187,459	26.8	28,337	25.4
	40-49	171,285	21.1	148,215	21.2	23,070	20.7
Marital Status	Not married	210,107	25.9	170,691	24.4	39,416	35.3
	Married	572,676	70.5	502,074	71.7	70,602	63.2
	Widow/separated/divorced	29,134	3.6	27,498	3.9	1,636	1.5
Caste	Others	165,234	20.4	142,244	20.3	22,990	20.6
	SC	146,969	18.1	126,804	18.1	20,165	18.1
	ST	147,737	18.2	127,661	18.2	20,076	18.0
	OBC	314,661	38.8	271,733	38.8	42,928	38.5
	No response	37,316	4.6	31,821	4.5	5,495	4.9
Education	No education	204,922	25.2	190,537	27.2	14,385	12.9
	Primary	109,102	13.4	94,563	13.5	14,539	13.0
	Secondary	401,720	49.5	336,381	48.0	65,339	58.5
	Higher	96,173	11.8	78,782	11.3	17,391	15.6
Place of residence	Urban	237,105	29.2	202,358	28.9	34,747	31.1
	Rural	574,812	70.8	497,905	71.1	76,907	68.9
Wealth quintile	poorest	152,942	18.8	134,330	19.2	18,612	16.7
	poorer	173,813	21.4	150,489	21.5	23,324	20.9
	middle	171,866	21.2	147,612	21.1	24,254	21.7
	richer	161,338	19.9	138,213	19.7	23,125	20.7
	richest	151,958	18.7	129,619	18.5	22,339	20.0
BMI	Normal (18.5-24.9)	488,801	60.2	418,369	59.7	70,432	63.1
	Overweight (25.0-29.9)	114,970	14.2	98,306	14.0	16,664	14.9
	Obese (>=30)	32,523	4.0	29,516	4.2	3,007	2.7
	No Response	175,623	21.6	154,072	22.0	21,551	19.3
Tobacco use	No	670,194	82.5	615,197	87.9	54,997	49.3
	Yes	126,050	15.5	72,226	10.3	53,824	48.2
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Alcohol consumption	never drinks	744,838	91.7	670,364	95.7	74,474	66.7
	almost every day	6,898	0.8	2,172	0.3	4,726	4.2
	About once a week	20,939	2.6	6,674	1.0	14,265	12.8
	Less than once a week	23,569	2.9	8,213	1.2	15,356	13.8
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Total		**811,917**	**100**	**700,263**	**100**	**111,654**	**100**

Figure 2 shows inter-district variation in hypertension prevalence. The proportion of hypertensive population varied tremendously, ranging between 3.5% in district Mahoba, Uttar Pradesh and 34.7% in district Dibang Valley, Arunachal Pradesh. A majority of districts across India recorded a high hypertension burden, with more than one-tenth of the persons aged 15-49 hypertensive in 427 districts. Only 10 districts had hypertension levels below 5% and all of them except one were in EAG states. Several districts with alarmingly high prevalence of hypertension were clustered across north-eastern states. Five districts in Arunachal Pradesh, two districts in Punjab, one each in Sikkim, Assam and Andaman and Nicobar were among the top ten districts with the highest levels of hypertension. The results revealed that at least one in every five persons aged between 15 and 49 were having hypertension in as many as 28 districts across India.

The findings highlighted that the prevalence of hypertension was higher in men than in women in most states and UTs, except in Delhi, West Bengal, Meghalaya and Jammu and Kashmir J & K (Figure S2). The sex difference in prevalence of hypertension was highest in Andaman and Nicobar Islands (12.4%), followed by Sikkim (8.4%), Himachal Pradesh (7.3%) and Manipur (7.2%). The results also suggest that, in general, the gender differentials were relatively smaller in low prevalence states than in high prevalence states. Figure3 shows the weighted prevalence of hypertension in rural and urban areas of all states. As shown in the above figure, the prevalence rate of hypertension was found to be higher in urban than in rural areas for most of the states. However, there were a few exceptions. The prevalence of hypertension was relatively higher amongst the rural folks than their urban counterparts in Punjab, Goa and Kerala. Another interesting pattern emerges while comparing the prevalence of hypertension between high and low SES categories within rural and urban areas of each of these states (Figure S3). The results suggest hypertension is no longer a disease of the rich. In fact, the distribution of the condition is changing, disproportionately affecting the economically disadvantaged in urban areas of states such as Punjab, Haryana, Jammu and Kashmir and most of the NE states. Furthermore, the phenomenon of higher prevalence of hypertension among the poor appears to be not limited to only urban areas. In rural areas of Chhattisgarh, Kerala and Mizoram, poorer individuals had higher prevalence than their richer counterparts.

Table2. Prevalence of hypertension in India, 2015-2016

Prevalence	**Unadjusted**		**Adjusted**	
	%	**C.I.**	**%**	**C.I.**
Overall	**10.5**	**(10.37, 10.62)**	**11.3**	**(11.16, 11.43)**
Male	14.3	(13.97, 14.70)	13.8	(13.46, 14.19)
Female	10.1	(09.96, 10.22)	10.9	(10.79, 11.06)
Rural	9.8	(9.09, 9.94)	10.6	(10.50, 10.78)
Urban	11.8	(11.12, 12.12)	12.5	(12.25, 12.80)

Also, the differences in prevalence of hypertension by low vs high SES categories were generally marginal in urban areas of most states (<2 percentage points). The weak association between GDP per capita of states and hypertension prevalence (Figure S4) is also the confirmation of the growing convergence of rich-poor difference in prevalence of hypertension, particularly in the urban areas.

Sociodemographic differentials in prevalence

The bi-variate and multivariate analyses were carried out to understand the relative importance of socioeconomic and behavioural risk factors of hypertension. Since the bi-variate and multivariate analyses yielded very similar results, we are only presenting the findings of multivariate analysis here. Table3 shows results for multilevel logistic regression of hypertension by its different covariates. Expectedly, age was found to be an important predictor of hypertension. The likelihood of being hypertensive increased significantly with age. Odds Ratios suggest that older persons (45-49 years) were 6.7 times more likely to have hypertension than the younger individuals (15-19 years). The differences in prevalence probabilities between married, widowed and single were statistically significant. Those who were widowed, separated and divorced were more likely to have hypertension than their 'single' counterparts (OR=1.19; p<0.001). Interestingly, married persons were also found to be at greater risk of hypertension than unmarried ones (OR=1.08; p<0.001). Educational attainment seems to be inversely related with prevalence, though the effect of education was not significant among those who studied only up to primary level. But persons with secondary (OR=0.92; p<0.001) or higher education (OR=0.81; p<0.001) were less likely to be hypertensive as compared to their illiterate counterparts.

We also looked at how economic status, proxied by asset index influences the risk of hypertension in individuals. The ORs suggest a positive association between economic status and hypertension.

Compared with those in poorest quintile, people from richest quintile were having considerably higher likelihood of hypertension (0.21 percentage points). Place of residence was also found to be statistically significantly associated with hypertension. However, persons residing in rural areas (OR=0.96; p<0.01) were marginally less likely to be at risk of hypertension than their urban folks. Interestingly, caste differences in prevalence of hypertension were not much, except that persons belonging to OBC were less likely to have the condition (OR=0.96; p<0.001) as compared to those from 'others'.

We also examined the association between hypertension and health and life-style practices of the men and women. The ORs indicate that persons with overweight (OR=2.02; p<0.001) or obesity issue (OR=3.22, p<0.001) had significantly higher probability of hypertension than those with 'normal' BMI. Alcohol consumption was found to be positively related with hypertension; however, no statistically significant association was found between tobacco use and hypertension. Those who drank alcohol almost every day (OR=1.45; p<0.000), about once a week (OR=1.25; p<0.001) and less than once a week (OR=1.17; p<0.001) were significantly more likely to suffer from hypertension than individuals without alcohol use habit.

We have explored the regional and sub-regional disparities in the prevalence of hypertension in India. Median odds ratio, MOR, indicates geographical heterogeneity in the prevalence of hypertension across India. Overall, the variation in the prevalence of hypertension was of greater magnitude at the district level (MOR= 1.32; p<0.001) than at the state level (MOR= 1.28; p<0.001). While the MOR was 1.28 and 1.32, ORs for most individual level characteristics were relatively higher, suggesting that unexplained between-district and between-state variations are not as relevant as individual level characteristics for understanding the prevalence of hypertension.

Table3. Results of multilevel logistic regression on hypertension, India, 2015-16

		Odds Ratio	P value	95% CI
Age group	15-19	1		
	20-29	1.86	0.000	(1.77, 1.96)
	30-39	3.80	0.000	(3.60, 4.01)
	40-49	6.71	0.000	(6.36, 7.09)
Marital Status	Unmarried	1		
	Married	1.08	0.000	(1.04, 1.12)
	Widow/separated/divorced	1.19	0.000	(1.13, 1.25)
Caste	Others	1		
	SC	0.98	0.214	(0.96, 1.01)
	ST	1.02	0.312	(0.98, 1.06)
	OBC	0.96	0.001	(0.94, 0.98)
Education	No education	1		
	Primary	1.00	0.914	(0.97, 1.03)
	Secondary	0.92	0.000	(0.90, 0.94)
	Higher	0.81	0.000	(0.78, 0.84)
Place of residence	Urban			
	Rural	0.96	0.001	(0.94, 0.98)
Wealth Status	Poorest	1		
	Poorer	1.08	0.000	(1.04, 1.11)
	Middle	1.13	0.000	(1.09, 1.16)
	Richer	1.22	0.000	(1.18, 1.26)
	Richest	1.21	0.000	(1.17, 1.26)
BMI	Normal	1		
	Overweight (25.0-29.9)	2.02	0.000	(1.98, 2.06)
	Obese (>=30)	3.22	0.000	(3.13, 3.32)
Tobacco use	No			
	Yes	1.01	0.395	(0.99, 1.04)
Alcohol consumption	Never drinks	1	1	
	almost every day	1.45	0.000	(1.34, 1.56)
	About once a week	1.25	0.000	(1.19, 1.31)
	Less than once a week	1.17	0.000	(1.11, 1.22)
Random Effect Part				
Variance (SE)#	State	0.066	0.000	(0.04, 0.11)
	District	0.084	0.000	(0.07, 0.09)
Median Odds Ratio (MOR)	State	1.28		
	District	1.32		

Note. # variance expressed in standard error

Discussion

This article provides estimates on the prevalence of hypertension across different geographical areas in India and examines socioeconomic and life-style factors associated with this condition, by exploiting the latest data from the 4th round (2015-16) of NFHS. Although some previous research have attempted to understand the burden of hypertension in India [9, 11, 12], to the best of our knowledge, this study is the first comprehensive assessment of hypertension prevalence using high quality survey data of each state and district of India.

One of our key findings is that more than 11% of the population age 15-49 in India are hypertensive. However, our estimate on the age-adjusted hypertension prevalence differ considerably from the reported crude prevalence (25%) in Geldsetzer et al's (2018) study on hypertension. This is arising partly because of the reason that our estimates of prevalence pertain to those aged 15-49 years while the said study provided estimates for adults aged 18 and above. Besides the differences in age composition between two samples, their estimates can not be generalised nationally as several states and UTs were not covered in Annual Health Survey (AHS) and District Level Household Survey (DLHS) surveys, which were used for assessing hypertension prevalence in Geldsetzer et al's study. Furthermore, it should be noted while the clinical and anthropometric data for AHS were collected in 2014[2], DLHS was carried out between 2012 and 2013. Hence, the pooled data may not provide true estimates of hypertension at the national level owing to inconsistencies between two surveys in terms of survey design, period of data collection (time gap) and non-inclusion of many states and UTs.

Hypertension was found to be more prevalent among males than among females. Although the prevalence of hypertension was relatively higher in urban than in rural areas at the national level, the rural-urban differences were not large, implying that hypertension epidemic is spreading very fast even in the rural population. This has serious implications for the rural people. The public health system through PHCs in rural areas is still focusing on infectious diseases, reproductive and child health and thus, has become too limited. So, people would have to rely on the private sector

[2] Although AHS was conducted during 2013-2014, the biomarker component i.e., CAB data were collected only from a sub-sample of AHS in the year 2014. For details, see http://www.censusindia.gov.in/2011census/hh-series/HH-2/CAB-Introduction.pdf. In contrast, in DLHS, CAB tests were carried out in all selected households.

for the management of hypertension and its associated diseases, which would substantially add to their financial strain.

Considerable inter-state and inter-district differences were found in the prevalence of hypertension. It was more common in north-eastern states, Jammu & Kashmir, Himachal Pradesh, Punjab, and Telengana than in Kerala and EAG states. The inter-state differentials might have been caused by the differences in risk exposure such as rising affluence, urbanization, sedentary life style, changing dietary habits, obesity prevalence, social stress and possibly, genetic factors. The finding of relatively lower hypertension prevalence in EAG states is consistent with evidence from the latest burden of disease study that classified these states as having low epidemiological transition level [13]. But surprisingly, Kerala, where epidemiologic transition is most advanced among all states, had recorded the lowest prevalence of hypertension. This may be due to the non-inclusion of older persons in NFHS. It should be noted that Kerala has the highest proportion of elderly population (13%) in India. However, more research is needed to pinpoint the reasons for low prevalence in Kerala. Interestingly, in north-eastern states, despite their low per capita income, the prevalence was way higher than states with much higher level of socioeconomic development. The higher burden of hypertension amongst the population of north-east could be attributed to ethnicity and food habits. Hypertension has emerged as a major epidemic in many districts. Examples being two districts of Arunachal Pradesh, where every third person was hypertensive and more than a fifth of the population had the condition in as many as 28 districts.

In majority of the states, hypertension prevalence was higher in urban than in rural areas, though the difference was small and at times, insignificant. However, in Goa, Punjab, Kerala and Nagaland, higher prevalence of hypertension was seen among rural people as compared to their urban counterparts. Such narrowing differentials may be the result of the factors mentioned in a recent study conducted in Punjab. Tripathy and others (2016) reported that there was no rural-urban differential in terms of dietary practices and prevalence of overweight and obesity barring the fact that a markedly higher proportion of individuals from rural areas always/often add salt before/when eating as compared to those from urban areas [14].

Another major finding was the weak link between economic growth (GDP per capita) and hypertension. Our study reveals that hypertension is affecting the people in poorer and not so poor states alike. Furthermore, hypertension is not only affecting the affluent but is also widespread among the poor within states. Another salient finding is the increased proportion of poor suffering from hypertension in many states, particularly in the urban areas. This is in consonance with the findings from studies on non-communicable diseases [15]. These findings paint a disturbing trend, indicating that it is just a matter of time when the less affluent segment of the population in other states would also face a disproportionately higher burden of hypertension. This situation might have arisen due to factors such as the diffusion and adoption of 'modern' lifestyles (the changing dietary behaviour: smoking, drinking, unhealthy diets) across population groups (which is a result of urbanisation, aggressive push of junk food through advertising and marketing and related shifts in sociocultural practice), physical inactivity and high levels of depression and stress (linked to poverty and lack of equal opportunities) [16, 17].

Our study also corroborates the above observations as the evidences point to urban residence, obesity, and alcohol use as some of the key drivers of the hypertension epidemic in India. These were also supported by previous research in India [12, 14, 18]. Surprisingly, use of tobacco was not found to increase the risk of hypertension. While it is difficult to explain why use of tobacco did not display statistically significant association with hypertension, one plausible reason could be the young population of our sample. According to a recent study which examined the life-course impact of smoking on hypertension, found no statistically significant relationship between smoking and the risk of hypertension in the age-group younger than 35; though smoking was found to be significantly associated with hypertension in the later ages[19].

Our study has several notable strengths. This is the first study that used the recently released NFHS data, which is based on a sample of households that is representative at the national, state and district levels, thereby, allowing us to provide estimates of the prevalence of hypertension across administrative regions. Further, multivariate analysis identified the key drivers of hypertension in India.

Aside from the above mentioned strengths, the study has a few limitations, which merit discussion. The findings of this study are limited to the persons aged between 15 and 49 in India. Further, NFHS provides cross-sectional data. This prevents exploration of causal pathways underlying the reported associations. We could not investigate the role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity in this analysis due to the non-availability of such information in the dataset.

Conclusion

To conclude, hypertension epidemic is spreading alarmingly in India across rural and urban populations. Disturbingly, the hypertension prevalence is now becoming more concentrated among the poor in both urban and rural areas. This phenomenon of rising hypertension prevalence among the least resourceful people has serious social and economic implications for the country and warrants immediate policy interventions to prevent the catastrophe. The district wise estimates on this condition should be used to plan for localised interventions so that the prevalence could be brought down significantly, which would help achieve the national target of 25% relative reduction in the prevalence of hypertension by 2025 [20]. We recommend universal blood pressure screening for high prevalence districts to track the progress of interventions. However, when it comes to interventions, the emphasis should be on primary prevention of hypertension. Policy measures should be taken to improve hazardous working conditions of the poor and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol. On the other hand, a diet rich in fruits and vegetables, regular physical activity and weight control should be promoted.

Contributorship statement

While SG conceptualised the paper, partly analysed the data and wrote the manuscript, MK carried out the analysis of the data. Both SG and MK participated in editing of the paper. The authors discussed the results and approved the revision of the final manuscript.

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Data sharing statement

The data used in this study came from the large scale surveys conducted by government agencies. All data are already in the public domain and can be accessed freely from the Government of India's data sharing portals. Besides, NFHS data can also be obtained from the following website- www.iipsindia.org.

Conflicts of interest

The authors have none to declare.

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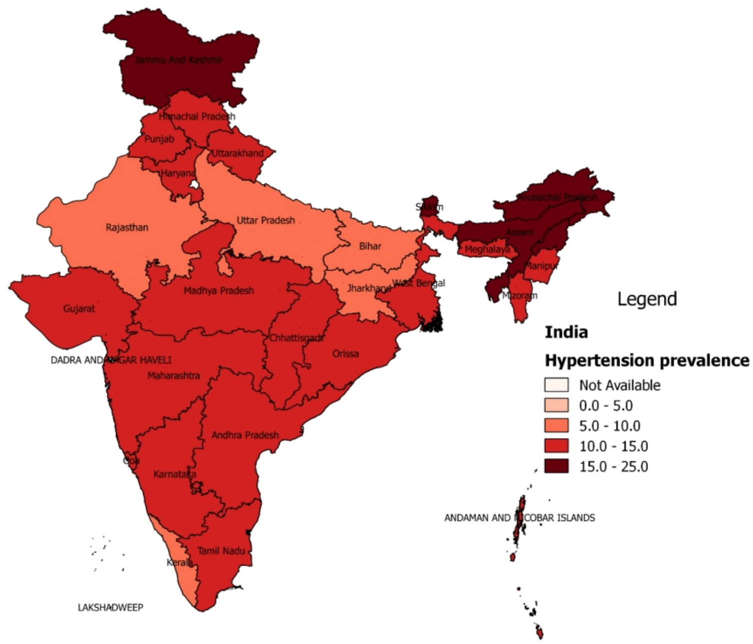

Fig 1. Prevalence of hypertension across states, India, 2015-16

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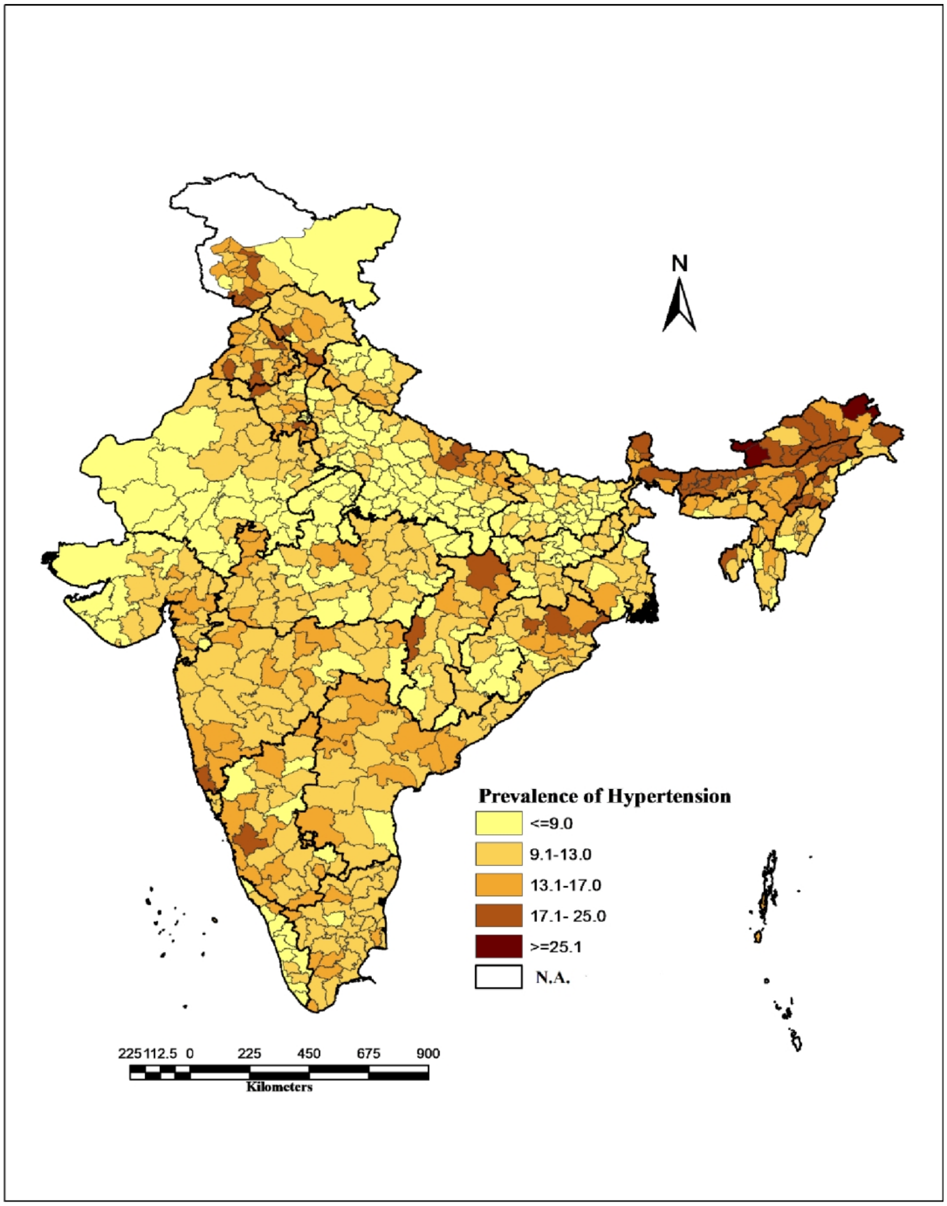

Figure2. Prevalence of hypertension across districts, India, 2015-16

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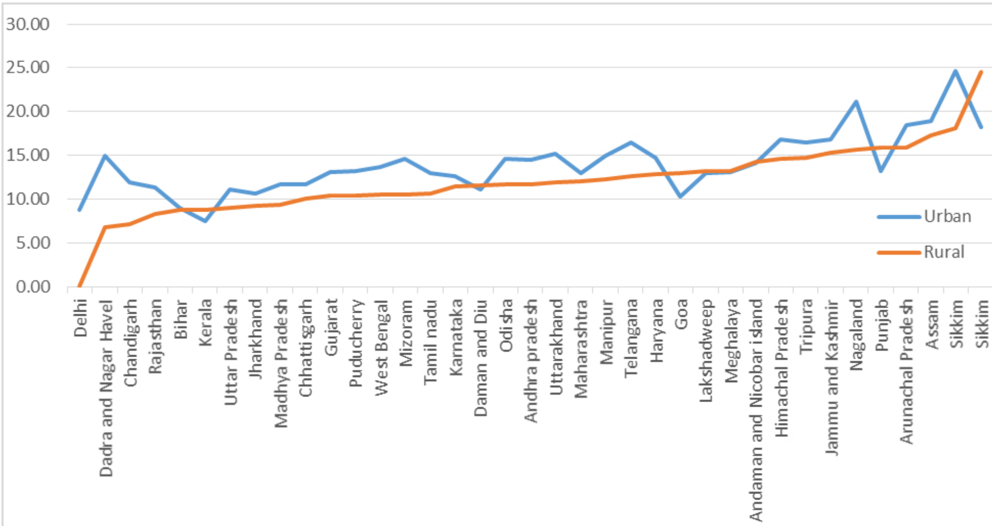

Figure3. Prevalence of hypertension by sector across selected states, 2015-16

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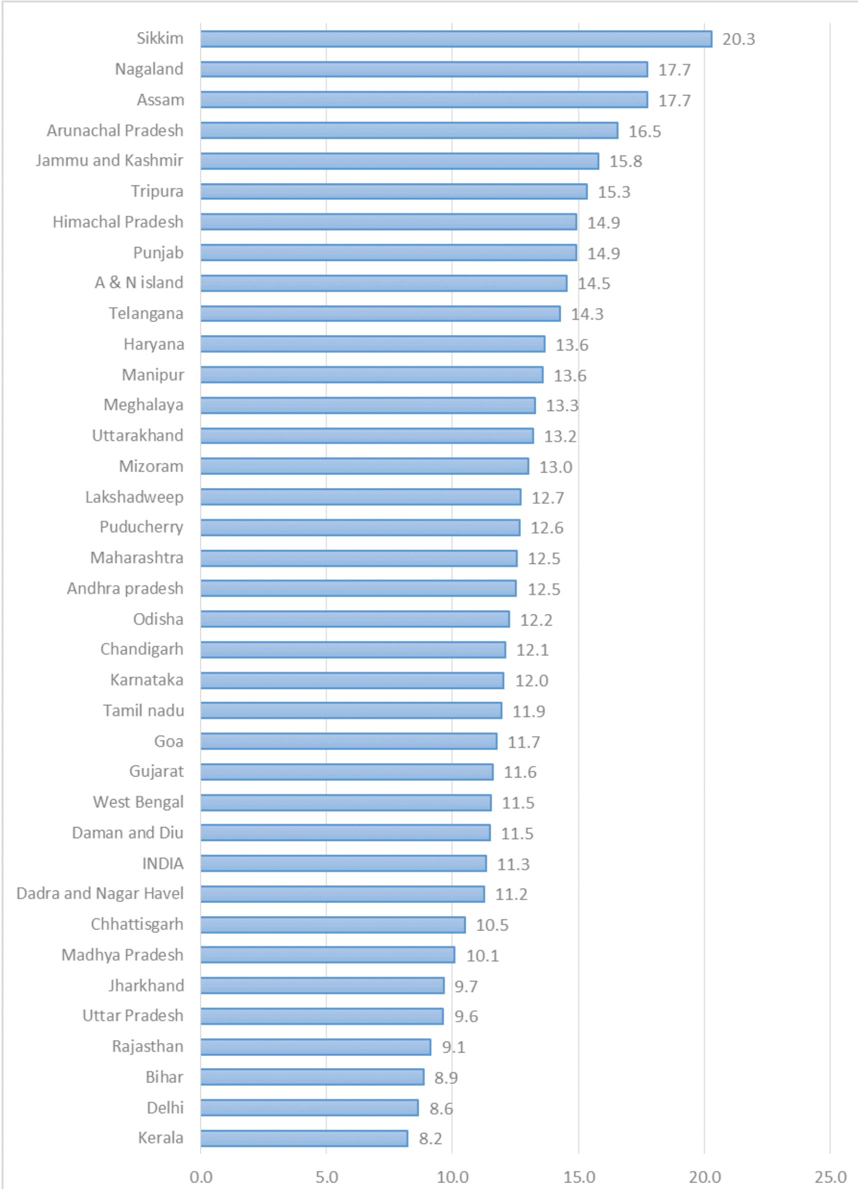

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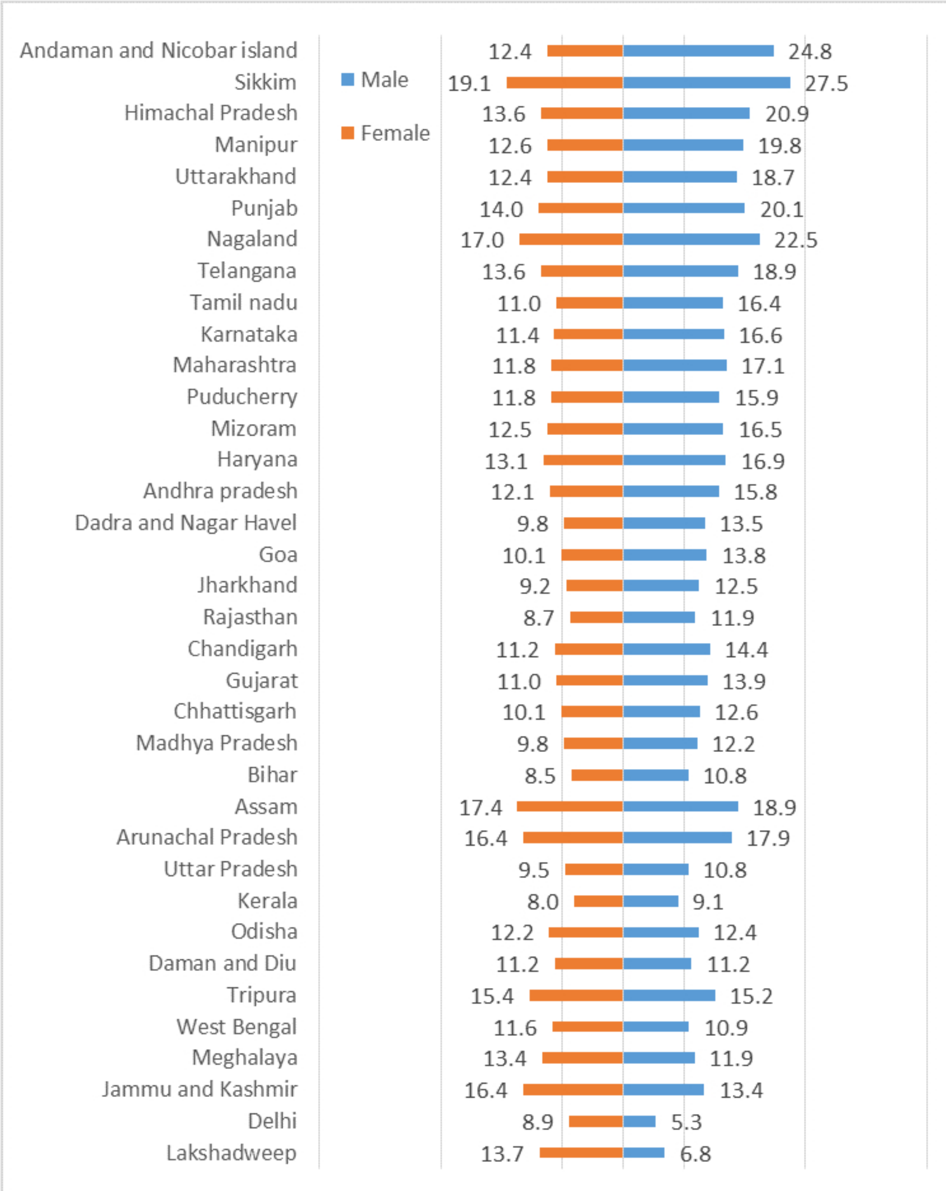

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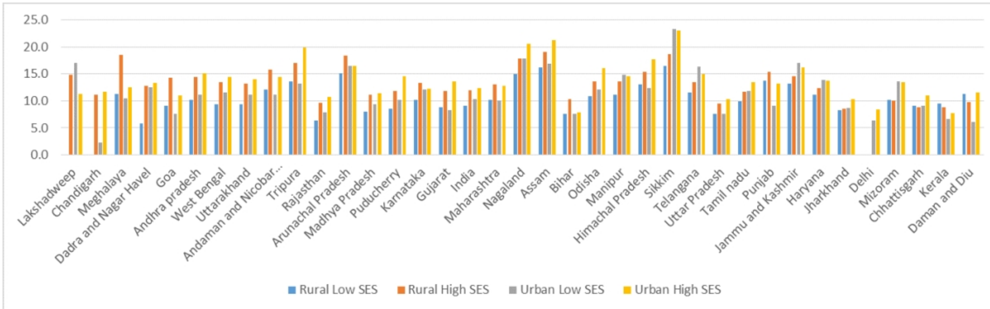

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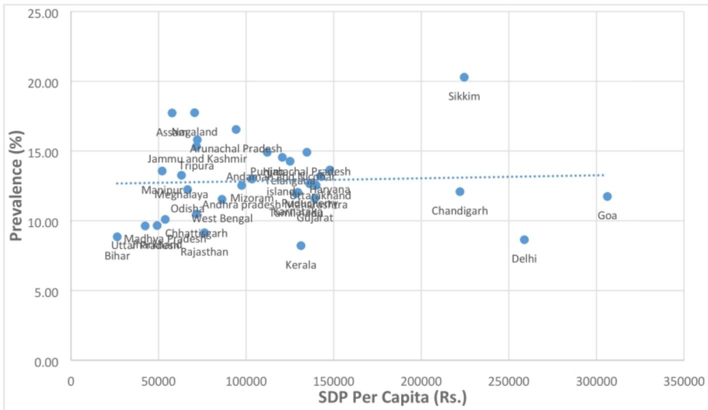

Note: The source of GDP data is Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India

215x279mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	*6*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross sectional study

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Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross-sectional study

Abstract

Objectives This is the first attempt to provide estimates on the prevalence of hypertension at the national, state and district level, a prerequisite for designing effective interventions. Besides, the study aims to identify the risk factors of hypertension.

Design We analysed cross-sectional survey data from the 4th round (2015-16) of National Family Health Survey (NFHS). NFHS was conducted between January 2015 and December 2016, gathering information on a range of indicators including blood pressure. The age adjusted prevalence of hypertension was calculated for state comparison, while multilevel logistic regression analysis was done to assess the correlates of hypertension.

Setting and participants India (2015-16 n=811,917) aged 15-49 years.

Primary and secondary outcome measures The primary outcome is hypertension, which has been defined as systolic blood pressure (SBP) ≥140 mm Hg and/ or diastolic blood pressure (DBP) ≥90 mm Hg.

Results The age-adjusted prevalence of hypertension in India was 11.3% (95% CI 11.16 to 11.43) among persons aged between 15 and 49 years and was 4 percentage points higher amongst males-13.8% (95% CI 13.46 to 14.19) than among females-10.9% (95% CI 10.79 to 11.06). Persons in the urban location (12.5%, 95% CI 12.25 to 12.80) had a marginally higher prevalence than persons in rural location-(10.6%, 95% CI 10.50 to 10.78). The proportion of population suffering from hypertension varied greatly between states, with a prevalence of 8.2% (95% CI 7.58, 8.85) in Kerala to 20.3% (95% CI 18.81, 21.77) in Sikkim. Advancing age, obesity/overweight, male sex, socioeconomic status and consumption of alcohol were found to be the major predictors of hypertension.

Conclusions Hypertension prevalence is now becoming more concentrated amongst the poor. Policy measures should be taken to improve the hazardous working conditions and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol.

Key words: Hypertension, prevalence, factors, state, district and India

Article summary

Strengths and limitations of the study

- First epidemiological study to provide estimates on prevalence of hypertension at national, state and district level
- Multivariate analysis identified the key drivers of hypertension
- The use of cross-sectional data that does not allow for exploration of causal pathways underlying the reported associations
- The role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity could not be explored in this analysis
- Findings are limited to the persons aged between 15 and 49

Introduction

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. It is a leading risk factor for cardiovascular disease, which accounted for 23% of total deaths and 32% of adult deaths in 2010-2013[1]. India has committed to take an array of actions to meet the Sustainable Development Goals (SDG) target of reducing premature mortality from non-communicable diseases (NCDs) by one-third by 2030. However, much of the success in meeting this target hinges on its ability to check the rise of hypertension. The Global Burden of Hypertension study has highlighted that of the global burden of 212 million DALYs related to hypertension, 18% occurred in India in 2015[2]. The burden of hypertension in India is expected to rise considerably in the coming years due to rapid environmental and 'life-style' changes that emanate from hazardous working conditions and growing social pressures of survival [3, 4].

Monitoring and evaluation for SDG

It is, therefore, imperative that blood pressure trends are monitored to evaluate the progress that the country makes vis-à-vis the SDG goal of reduction in NCD mortality. To do that, data on hypertension is needed so that stakeholders can design appropriate interventions and evaluate national programmes aimed at effectively addressing hypertension and associated NCDs. But there was a paucity of reliable information on the status of hypertension in India. As a result, to assess the magnitude of this problem, policy makers had to rely on community studies or surveys that provided self-reported data on hypertension [5, 6, 7, 8]. Further, data from small studies were extrapolated to obtain national level estimate on hypertension [9]. Although these studies were helpful and used as a key resource in the arsenal of health policy makers, in the absence of active surveillance or data from population based surveys, policy makers are unable to determine the true hypertension of the people of India.

The recent health surveys have measured blood pressure, providing an opportunity to explore the trends in prevalence of hypertension both at the national, sub-national (state) and district level. Given the heterogeneity in the demographic and socioeconomic conditions across states in India, it is very likely that there would be considerable inter-state variations in hypertension prevalence [9]. Moreover, the socioeconomic disparities are widespread even within the state. Hence, estimates at the state and district levels are required for policy formulation, setting intervention priorities and to evaluate national programmes. This study is the first in India to provide estimates on the prevalence of hypertension at the national level and for each state, district, and by rural and urban areas and individual characteristics such as age, sex and economic status using the most recent large scale survey data. Aside from providing estimates on hypertension prevalence, an attempt was also made to identify the correlates of hypertension.

Methods

Data

The current study is based on the data from the 4th wave of National Family Health Survey (NFHS), which is the Indian version of Demographic and Health Survey (DHS) carried out periodically in over 90 countries across the globe. NFHS 4 was conducted under the stewardship of the Ministry of Health and Family Welfare (MOH&FW) and led by International Institute for Population Sciences. The survey was a collaborative effort of 14 research organisations, including three Population Research Centres (under MOH&FW). ICF International provided technical assistance at all stages of NFHS project. NFHS 4 began on 20th January 2015 and ended on 4th December 2016. The survey was conducted across all 29 states and 7 Union Territories (UTs) in India. The survey is representative not only at the national and state level but also at the district level.

NFHS adopted a 2-stage stratified random sampling approach by selecting primary sampling units (PSUs) [villages in rural areas and census enumeration blocks in urban areas] with probability proportional to population size at the first stage and subsequently, picking the same number of households from each of selected PSUs through systematic random sampling. Both male and female interviewers were recruited by field agencies to interview respondents of the same sex. The data collection team made up to 3 visits in case no body was present in the chosen household or any eligible member was not available at the time of the household visit.

The household level questionnaire of NFHS covered the details on possession of certain assets and access to certain utilities. The information on assets and utilisation of utilities were used for constructing wealth index, which reflects the standard of living of households. The wealth index categorises households into 5 wealth quintiles: 'poorest', 'poor', 'middle', 'rich' and richest. In NFHS, the Biomarker Questionnaire collected details on height, weight, and haemoglobin for children, and measurements of height, weight, haemoglobin, blood pressure, and random blood glucose for women aged 15-49 years and men aged 15-54 years. The different age ranges for men and women were chosen, considering the average spousal age gap of 5 years in India. The survey used same questionnaires, field procedures and procedures for biomarker measurements across the country to ensure comparability across states and to ensure the highest possible data quality. The response rate for BP measurements was 97% among women and 92% among men. Apart from taking BP measurements, all participants irrespective of their BP were asked, "Were you told on two or more different occasions by a doctor or other health professional that you had hypertension or high blood pressure?" If they responded in affirmative, they faced a follow-on question, "To lower your blood pressure, are you taking a prescribed medicine?"

The analysis was restricted to women and men age 15-49, after excluding men aged 49-54 (n=8,618) to ensure an equal age range among women and men. Missing values (n=32,268) were also excluded from analysis. Data were weighted prior to analysis.

Ethics approval

The study is based on an anonymous publicly available dataset with no identifiable information on the survey participants; therefore, no ethics statement is required for this work.

Statistical analysis

Hypertension was considered as the outcome variable of this study. Three blood pressure readings were taken in NFHS. The first measurement was discarded and then, based on the average of second and third readings of blood pressure, it was decided whether a participant was hypertensive or not. Hypertension was defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg. The definition was based on the criteria given by WHO and American Heart Association [10]. In addition, an individual is classified as having hypertension if she/he is currently taking antihypertensive medication to lower his or her blood pressure. To make the prevalence of hypertension comparable, age adjusted prevalence rates were calculated for all states, UTs and districts using the direct standardization method. The national population, as per 2011 Census, was used as a reference population for carrying out the standardization technique. To understand how hypertension prevalence varies by socioeconomic status (SES), the wealth index was converted into a dichotomous variable; where the bottom 60% i.e., 'poorest', 'poor' and 'middle' were combined into one group (low SES), the remaining two categories were clubbed into the other category (high SES). Besides conducting bivariate analyses, multi-level (first level:

individual; second level: district; third level: state) logistic regression model with random intercepts and fixed slopes were employed to calculate multilevel odds ratios (OR) with corresponding 95% confidence intervals (CI).

Dependent variable

Hypertension for persons aged between 15 and 49 years. The dichotomous variable, hypertension, was defined as 1=hypertensive, else=0.

Explanatory variables

Predictors were selected based on their effects on hypertension.

Sociodemographic variables: Age, sex, marital status, caste[1], education, place of residence, wealth status. Besides sociodemographic variables, we included body mass index, tobacco use and alcohol consumption as proxy for behavioural risk factors. The education categories are defined based on number of years of education completed by an individual: 0 year as "no education"; 1 to 5 years as "primary education"; 6 to 12 years as "secondary education"; and more than 12 years of education attainment categorised as "higher studies".

All statistical analyses were performed using STATA 14.

Patient and Public Involvement

Patients and public were not involved in the analysis of this study.

Results

Sample characteristics

As seen in table1, of the total 779,649 persons who participated in the survey, a little more than half of them (51.3%) were aged between 15-29 years. This is in line with the Census figures, according to which, the median age was 24 years in 2011. The results suggest that 13% of males

[1] Indian society is mainly divided into four castes within the framework of the Hindu caste system. The castes used to be classified according to occupation. Historically, many sub-castes have faced discrimination, deprivation and social exclusion on account of their assigned 'low-status'. Recognising the marginalisation of certain communities and socioeconomic differences among different population groups, the constitution of India categorised the Indian population into four major groups: Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Class (OBC) and General. ST is the most socio-economically disadvantaged group, followed by the SC and OBC and together they comprise 69% of India's population, with SC at 19.7%, ST at 8.5% and OBC at 41.1%.

and 27% of females never went to school and 13% of both sexes attended school only up to primary level. Almost 64% of men and 73% of women were currently married. A third of the study population were urban residents and a quarter of them were either overweight or obese. While 45% of males were users of some form of tobacco, the prevalence of tobacco use was only 6% among the females. The significant disparity in tobacco use between men and women, as revealed by NFHS data, is not typical. In fact, it is in consonance with results of other nationally representative household surveys. For instance, as per Global Adult Tobacco Survey (2016-17), 19% of men and 2% of women smoke tobacco in India [11]. It may be pointed out that, traditionally, the prevalence of tobacco consumption among males is much higher than that among females in the Indian sub-continent. This may be because of cultural disapproval, prohibiting women from smoking in India. Also, this could be partly due to under-reporting of tobacco-use by women because of social non-acceptance.

Like use of tobacco, a significantly greater proportion of men (30%) reported consuming alcohol either almost every day, about once a week or less than once a week as compared to just 1% amongst women.

Prevalence of hypertension at national, state and district level

Table 2 shows crude and age adjusted prevalence of hypertension amongst persons aged 15-49 years for the year 2015-16. The data shows that the age-adjusted prevalence of hypertension in India was 11.3% and the prevalence was 4 percentage points higher amongst males (13.8%) as compared to females (10.9%). Persons in the urban location (12.5%) had a marginally higher prevalence than persons in rural location-(10.6%).

The results reveal that the age-adjusted prevalence of hypertension varied greatly between states and UTs, with a prevalence of 8.2% in Kerala to a prevalence of 20.2% in Sikkim (See figures 1 and S1). Quite intriguingly, the hypertension prevalence was greatest among the north-eastern states-Sikkim (20.3%), Nagaland (17.6%), Assam (17.6%), Arunachal Pradesh (16.6%) and Tripura (15.4%). Hypertension prevalence was also very high in the following non-northeastern states-Jammu and Kashmir (15.8%), Punjab (14.8%), Himachal Pradesh (14.8%) and Telangana (14.2%). On the other hand, proportion of population suffering from hypertension was relatively low in states such as Kerala (8.2%), Bihar (8.8%), Delhi (8.6%), Rajasthan (9.1%), Uttar Pradesh (9.6%) and Jharkhand (9.6%).

Table1. Characteristics of sample population by gender, National Family Health Survey, India, 2015-16

Sample Characteristics		**Total**		**Female**		**Male**	
		N	**%**	**N**	**%**	**N**	**%**
Hypertension	No	693,875	85.5	602,609	86.1	91,266	81.7
	Yes	85,774	10.6	69,889	10.0	15,885	14.2
	No response	32,268	4.0	27,765	4.0	4,503	4.0
Age group	15-19	144,277	17.8	125,282	17.9	18,995	17.0
	20-29	272,054	33.5	239,307	34.2	32,747	29.3
	30-39	215,796	26.6	187,459	26.8	28,337	25.4
	40-49	171,285	21.1	148,215	21.2	23,070	20.7
Marital Status	Not married	210,107	25.9	170,691	24.4	39,416	35.3
	Married	572,676	70.5	502,074	71.7	70,602	63.2
	Widow/separated/divorced	29,134	3.6	27,498	3.9	1,636	1.5
Caste	Others	165,234	20.4	142,244	20.3	22,990	20.6
	SC	146,969	18.1	126,804	18.1	20,165	18.1
	ST	147,737	18.2	127,661	18.2	20,076	18.0
	OBC	314,661	38.8	271,733	38.8	42,928	38.5
	No response	37,316	4.6	31,821	4.5	5,495	4.9
Education	No education	204,922	25.2	190,537	27.2	14,385	12.9
	Primary	109,102	13.4	94,563	13.5	14,539	13.0
	Secondary	401,720	49.5	336,381	48.0	65,339	58.5
	Higher	96,173	11.8	78,782	11.3	17,391	15.6
Place of residence	Urban	237,105	29.2	202,358	28.9	34,747	31.1
	Rural	574,812	70.8	497,905	71.1	76,907	68.9
Wealth quintile	poorest	152,942	18.8	134,330	19.2	18,612	16.7
	poorer	173,813	21.4	150,489	21.5	23,324	20.9
	middle	171,866	21.2	147,612	21.1	24,254	21.7
	richer	161,338	19.9	138,213	19.7	23,125	20.7
	richest	151,958	18.7	129,619	18.5	22,339	20.0
BMI	Normal (18.5-24.9)	488,801	60.2	418,369	59.7	70,432	63.1
	Overweight (25.0-29.9)	114,970	14.2	98,306	14.0	16,664	14.9
	Obese (>=30)	32,523	4.0	29,516	4.2	3,007	2.7
	No Response	175,623	21.6	154,072	22.0	21,551	19.3
Tobacco use	No	670,194	82.5	615,197	87.9	54,997	49.3
	Yes	126,050	15.5	72,226	10.3	53,824	48.2
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Alcohol consumption	never drinks	744,838	91.7	670,364	95.7	74,474	66.7
	almost every day	6,898	0.8	2,172	0.3	4,726	4.2
	About once a week	20,939	2.6	6,674	1.0	14,265	12.8
	Less than once a week	23,569	2.9	8,213	1.2	15,356	13.8
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Total		**811,917**	**100**	**700,263**	**100**	**111,654**	**100**

Figure 2 shows inter-district variation in hypertension prevalence. The proportion of hypertensive population varied tremendously, ranging between 3.5% in district Mahoba, Uttar Pradesh and 34.7% in district Dibang Valley, Arunachal Pradesh. A majority of districts across India recorded a high hypertension burden, with more than one-tenth of the persons aged 15-49 hypertensive in 427 districts. Only 10 districts had hypertension levels below 5% and all of them except one were in EAG states. Several districts with alarmingly high prevalence of hypertension were clustered across north-eastern states. Five districts in Arunachal Pradesh, two districts in Punjab, one each in Sikkim, Assam and Andaman and Nicobar were among the top ten districts with the highest levels of hypertension. The results revealed that at least one in every five persons aged between 15 and 49 were having hypertension in as many as 28 districts across India.

The findings highlighted that the prevalence of hypertension was higher in men than in women in most states and UTs, except in Delhi, West Bengal, Meghalaya and Jammu and Kashmir J & K (Figure S2). The sex difference in prevalence of hypertension was highest in Andaman and Nicobar Islands (12.4%), followed by Sikkim (8.4%), Himachal Pradesh (7.3%) and Manipur (7.2%). The results also suggest that, in general, the gender differentials were relatively smaller in low prevalence states than in high prevalence states. Figure3 shows the weighted prevalence of hypertension in rural and urban areas of all states. As shown in the above figure, the prevalence rate of hypertension was found to be higher in urban than in rural areas for most of the states. However, there were a few exceptions. The prevalence of hypertension was relatively higher amongst the rural folks than their urban counterparts in Punjab, Goa and Kerala. Another interesting pattern emerges while comparing the prevalence of hypertension between high and low SES categories within rural and urban areas of each of these states (Figure S3). The results suggest hypertension is no longer a disease of the rich. In fact, the distribution of the condition is changing, disproportionately affecting the economically disadvantaged in urban areas of states such as Punjab, Haryana, Jammu and Kashmir and most of the NE states. Furthermore, the phenomenon of higher prevalence of hypertension among the poor appears to be not limited to only urban areas. In rural areas of Chhattisgarh, Kerala and Mizoram, poorer individuals had higher prevalence than their richer counterparts.

Table2. Prevalence of hypertension in India, 2015-2016

Prevalence	Unadjusted		Adjusted	
	%	C.I.	%	C.I.
Overall	**10.5**	**(10.37, 10.62)**	**11.3**	**(11.16, 11.43)**
Male	14.3	(13.97, 14.70)	13.8	(13.46, 14.19)
Female	10.1	(09.96, 10.22)	10.9	(10.79, 11.06)
Rural	9.8	(9.09, 9.94)	10.6	(10.50, 10.78)
Urban	11.8	(11.12, 12.12)	12.5	(12.25, 12.80)

Also, the differences in prevalence of hypertension by low vs high SES categories were generally marginal in urban areas of most states (<2 percentage points). The weak association between GDP per capita of states and hypertension prevalence (Figure S4) is also the confirmation of the growing convergence of rich-poor difference in prevalence of hypertension, particularly in the urban areas.

Sociodemographic differentials in prevalence

The bi-variate and multivariate analyses were carried out to understand the relative importance of socioeconomic and behavioural risk factors of hypertension. Since the bi-variate and multivariate analyses yielded very similar results, we are only presenting the findings of multivariate analysis here. Table3 shows results for multilevel logistic regression of hypertension by its different covariates. Expectedly, age was found to be an important predictor of hypertension. The likelihood of being hypertensive increased significantly with age. Odds Ratios suggest that older persons (45-49 years) were 6.7 times more likely to have hypertension than the younger individuals (15-19 years). The differences in prevalence probabilities between married, widowed and single were statistically significant. Those who were widowed, separated and divorced were more likely to have hypertension than their 'single' counterparts (OR=1.19; p<0.001). Interestingly, married persons were also found to be at greater risk of hypertension than unmarried ones (OR=1.08; p<0.001). Educational attainment seems to be inversely related with prevalence, though the effect of education was not significant among those who studied only up to primary level. But persons with secondary (OR=0.92; p<0.001) or higher education (OR=0.81; p<0.001) were less likely to be hypertensive as compared to their illiterate counterparts.

We also looked at how economic status, proxied by asset index influences the risk of hypertension in individuals. The ORs suggest a positive association between economic status and hypertension.

Compared with those in poorest quintile, people from richest quintile were having considerably higher likelihood of hypertension (0.21 percentage points). Place of residence was also found to be statistically significantly associated with hypertension. However, persons residing in rural areas (OR=0.96; $p<0.01$) were marginally less likely to be at risk of hypertension than their urban folks. Interestingly, caste differences in prevalence of hypertension were not much, except that persons belonging to OBC were less likely to have the condition (OR=0.96; $p<0.001$) as compared to those from 'others'.

We also examined the association between hypertension and health and life-style practices of the men and women. The ORs indicate that persons with overweight (OR=2.02; $p<0.001$) or obesity issue (OR=3.22, $p<0.001$) had significantly higher probability of hypertension than those with 'normal' BMI. Alcohol consumption was found to be positively related with hypertension; however, no statistically significant association was found between tobacco use and hypertension. Those who drank alcohol almost every day (OR=1.45; $p<0.000$), about once a week (OR=1.25; $p<0.001$) and less than once a week (OR=1.17; $p<0.001$) were significantly more likely to suffer from hypertension than individuals without alcohol use habit.

We have explored the regional and sub-regional disparities in the prevalence of hypertension in India. Median odds ratio, MOR, indicates geographical heterogeneity in the prevalence of hypertension across India. Overall, the variation in the prevalence of hypertension was of greater magnitude at the district level (MOR= 1.32; $p<0.001$) than at the state level (MOR= 1.28; $p<0.001$). While the MOR was 1.28 and 1.32, ORs for most individual level characteristics were relatively higher, suggesting that unexplained between-district and between-state variations are not as relevant as individual level characteristics for understanding the prevalence of hypertension.

Table3. Results of multilevel logistic regression on hypertension, India, 2015-16

		Odds Ratio	P value	95% CI
Age group	15-19	1		
	20-29	1.86	0.000	(1.77, 1.96)
	30-39	3.80	0.000	(3.60, 4.01)
	40-49	6.71	0.000	(6.36, 7.09)
Marital Status	Unmarried	1		
	Married	1.08	0.000	(1.04, 1.12)
	Widow/separated/divorced	1.19	0.000	(1.13, 1.25)
Caste	Others	1		
	SC	0.98	0.214	(0.96, 1.01)
	ST	1.02	0.312	(0.98, 1.06)
	OBC	0.96	0.001	(0.94, 0.98)
Education	No education	1		
	Primary	1.00	0.914	(0.97, 1.03)
	Secondary	0.92	0.000	(0.90, 0.94)
	Higher	0.81	0.000	(0.78, 0.84)
Place of residence	Urban			
	Rural	0.96	0.001	(0.94, 0.98)
Wealth Status	Poorest	1		
	Poorer	1.08	0.000	(1.04, 1.11)
	Middle	1.13	0.000	(1.09, 1.16)
	Richer	1.22	0.000	(1.18, 1.26)
	Richest	1.21	0.000	(1.17, 1.26)
BMI	Normal	1		
	Overweight (25.0-29.9)	2.02	0.000	(1.98, 2.06)
	Obese (>=30)	3.22	0.000	(3.13, 3.32)
Tobacco use	No			
	Yes	1.01	0.395	(0.99, 1.04)
Alcohol consumption	Never drinks	1	1	
	almost every day	1.45	0.000	(1.34, 1.56)
	About once a week	1.25	0.000	(1.19, 1.31)
	Less than once a week	1.17	0.000	(1.11, 1.22)
Random Effect Part				
Variance (SE)#	State	0.066	0.000	(0.04, 0.11)
	District	0.084	0.000	(0.07, 0.09)
Median Odds Ratio (MOR)	State	1.28		
	District	1.32		

Note. # variance expressed in standard error

Discussion

This article provides estimates on the prevalence of hypertension across different geographical areas in India and examines socioeconomic and life-style factors associated with this condition, by exploiting the latest data from the 4th round (2015-16) of NFHS. Although some previous research have attempted to understand the burden of hypertension in India [9, 12, 13], to the best of our knowledge, this study is the first comprehensive assessment of hypertension prevalence using high quality survey data of each state and district of India.

One of our key findings is that more than 11% of the population age 15-49 in India are hypertensive. However, our estimate on the age-adjusted hypertension prevalence differ considerably from the reported crude prevalence (25%) in Geldsetzer et al's (2018) study on hypertension. This discrepancy is arising mainly because of the reason that our estimates of prevalence pertain to those aged 15-49 years while the said study provided estimates for adults aged 18 and above. Besides the differences in age composition between two samples, the point to be noted is that several states and UTs were not covered in Annual Health Survey (AHS) and District Level Household Survey (DLHS) surveys, which were used for assessing hypertension prevalence in Geldsetzer et al's study. Furthermore, it should be noted while the clinical and anthropometric data for AHS were collected in 2014[2], DLHS was carried out between 2012 and 2013. Hence, the pooled data may not provide true estimates of hypertension at the national level owing to inconsistencies between two surveys in terms of survey design, period of data collection (time gap) and non-inclusion of many states and UTs.

Hypertension was found to be more prevalent among males than among females. Although the prevalence of hypertension was relatively higher in urban than in rural areas at the national level, the rural-urban differences were not large, implying that hypertension epidemic is spreading very fast even in the rural population. This has serious implications for the rural people. The public health system through PHCs in rural areas is still focusing on infectious diseases, reproductive and child health and thus, has become too limited. So, people would have to rely on the private sector

[2] Although AHS was conducted during 2013-2014, the biomarker component i.e., CAB data were collected only from a sub-sample of AHS in the year 2014. For details, see http://www.censusindia.gov.in/2011census/hh-series/HH-2/CAB-Introduction.pdf. In contrast, in DLHS, CAB tests were carried out in all selected households.

for the management of hypertension and its associated diseases, which would substantially add to their financial strain.

Considerable inter-state and inter-district differences were found in the prevalence of hypertension. It was more common in north-eastern states, Jammu & Kashmir, Himachal Pradesh, Punjab, and Telengana than in Kerala and EAG states. The inter-state differentials might have been caused by the differences in risk exposure such as rising affluence, urbanization, sedentary life style, changing dietary habits, obesity prevalence, social stress and possibly, genetic factors. The finding of relatively lower hypertension prevalence in EAG states is consistent with evidence from the latest burden of disease study that classified these states as having low epidemiological transition level [14]. But surprisingly, Kerala, where epidemiologic transition is most advanced among all states, had recorded the lowest prevalence of hypertension. This may be due to the non-inclusion of older persons in NFHS. It should be noted that Kerala has the highest proportion of elderly population (13%) in India. However, more research is needed to pinpoint the reasons for low prevalence in Kerala. Interestingly, in north-eastern states, despite their low per capita income, the prevalence was way higher than states with much higher level of socioeconomic development. The higher burden of hypertension amongst the population of north-east could be attributed to ethnicity and food habits [15]. It may be noted that North East Indians belong to Mongoloid, whereas North Indians and South Indians are part of Indo-Aryan and Dravidian ethnic groups. Hypertension has emerged as a major epidemic in many districts. Examples being two districts of Arunachal Pradesh (part of North East India), where every third person was hypertensive and more than a fifth of the population had the condition in as many as 28 districts.

In majority of the states, hypertension prevalence was higher in urban than in rural areas, though the difference was small and at times, insignificant. However, in Goa, Punjab, Kerala and Nagaland, higher prevalence of hypertension was seen among rural people as compared to their urban counterparts. Such narrowing differentials may be the result of the factors mentioned in a recent study conducted in Punjab. Tripathy and others (2016) reported that there was no rural-urban differential in terms of dietary practices and prevalence of overweight and obesity barring the fact that a markedly higher proportion of individuals from rural areas always/often add salt before/when eating as compared to those from urban areas [16].

Another major finding was the weak link between economic growth (GDP per capita) and hypertension. Our study reveals that hypertension is affecting the people in poorer and not so poor states alike. Furthermore, hypertension is not only affecting the affluent but is also widespread among the poor within states. Another salient finding is the increased proportion of poor suffering from hypertension in many states, particularly in the urban areas. This is in consonance with the findings from studies on non-communicable diseases [17]. These findings paint a disturbing trend, indicating that it is just a matter of time when the less affluent segment of the population in other states would also face a disproportionately higher burden of hypertension. This situation might have arisen due to factors such as the diffusion and adoption of 'modern' lifestyles (the changing dietary behaviour: smoking, drinking, unhealthy diets) across population groups (which is a result of urbanisation, aggressive push of junk food through advertising and marketing and related shifts in sociocultural practice), physical inactivity and high levels of depression and stress (linked to poverty and lack of equal opportunities) [18, 19].

Our study also corroborates the above observations as the evidences point to urban residence, obesity, and alcohol use as some of the key drivers of the hypertension epidemic in India. These were also supported by previous research in India [13, 16, 20]. Surprisingly, use of tobacco was not found to increase the risk of hypertension. While it is difficult to explain why use of tobacco did not display statistically significant association with hypertension, one plausible reason could be the young population of our sample. According to a recent study which examined the life-course impact of smoking on hypertension, found no statistically significant relationship between smoking and the risk of hypertension in the age-group younger than 35; though smoking was found to be significantly associated with hypertension in the later ages [21].

Our study has several notable strengths. This is the first study that used the recently released NFHS data, which is based on a sample of households that is representative at the national, state and district levels, thereby, allowing us to provide estimates of the prevalence of hypertension across various geographical levels. Further, multivariate analysis identified the key drivers of hypertension in India.

Aside from the above mentioned strengths, the study has a few limitations, which merit discussion. The findings of this study are limited to the persons aged between 15 and 49 in India. Further, NFHS provides cross-sectional data. This prevents exploration of causal pathways underlying the reported associations. We could not investigate the role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity in this analysis due to the non-availability of such information in the dataset.

Conclusion

To conclude, hypertension epidemic is spreading alarmingly in India across rural and urban populations. Disturbingly, the hypertension prevalence is now becoming more concentrated among the poor in both urban and rural areas. This phenomenon of rising hypertension prevalence among the least resourceful people has serious social and economic implications for the country and warrants immediate policy interventions to prevent the catastrophe [22, 23]. The district wise estimates on this condition should be used to plan for localised interventions so that the prevalence could be brought down significantly, which would help achieve the national target of 25% relative reduction in the prevalence of hypertension by 2025 [24]. We recommend universal blood pressure screening for high prevalence districts to track the progress of interventions. However, when it comes to interventions, the emphasis should be on primary prevention of hypertension. Policy measures should be taken to improve hazardous working conditions of the poor and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol. On the other hand, a diet rich in fruits and vegetables, regular physical activity and weight control should be promoted.

Contributorship statement

While SG conceptualised the paper, partly analysed the data and wrote the manuscript, MK carried out the analysis of the data. SG edited the paper. The authors discussed the results and approved the revision of the final manuscript.

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Data sharing statement

The data used in this study came from the large scale surveys conducted by government agencies. All data are already in the public domain and can be accessed freely from the Government of

India's data sharing portals. Besides, NFHS data can also be obtained from the following website- www.iipsindia.org.

Conflicts of interest

The authors have none to declare.

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Figure 1. Prevalence of hypertension across states, India, 2015-16

Figure 2. Prevalence of hypertension across districts, India, 2015-16

Figure 3. Prevalence of hypertension by sector across selected states, 2015-16

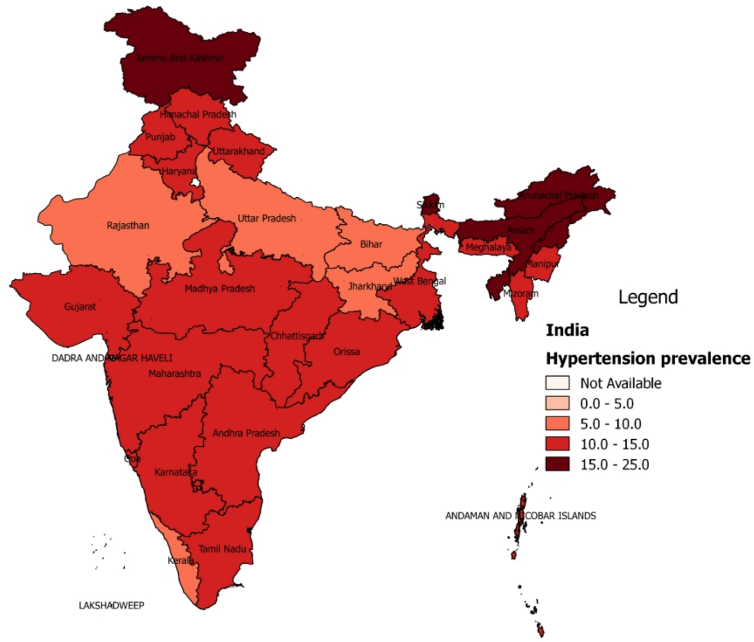

Fig 1. Prevalence of hypertension across states, India, 2015-16

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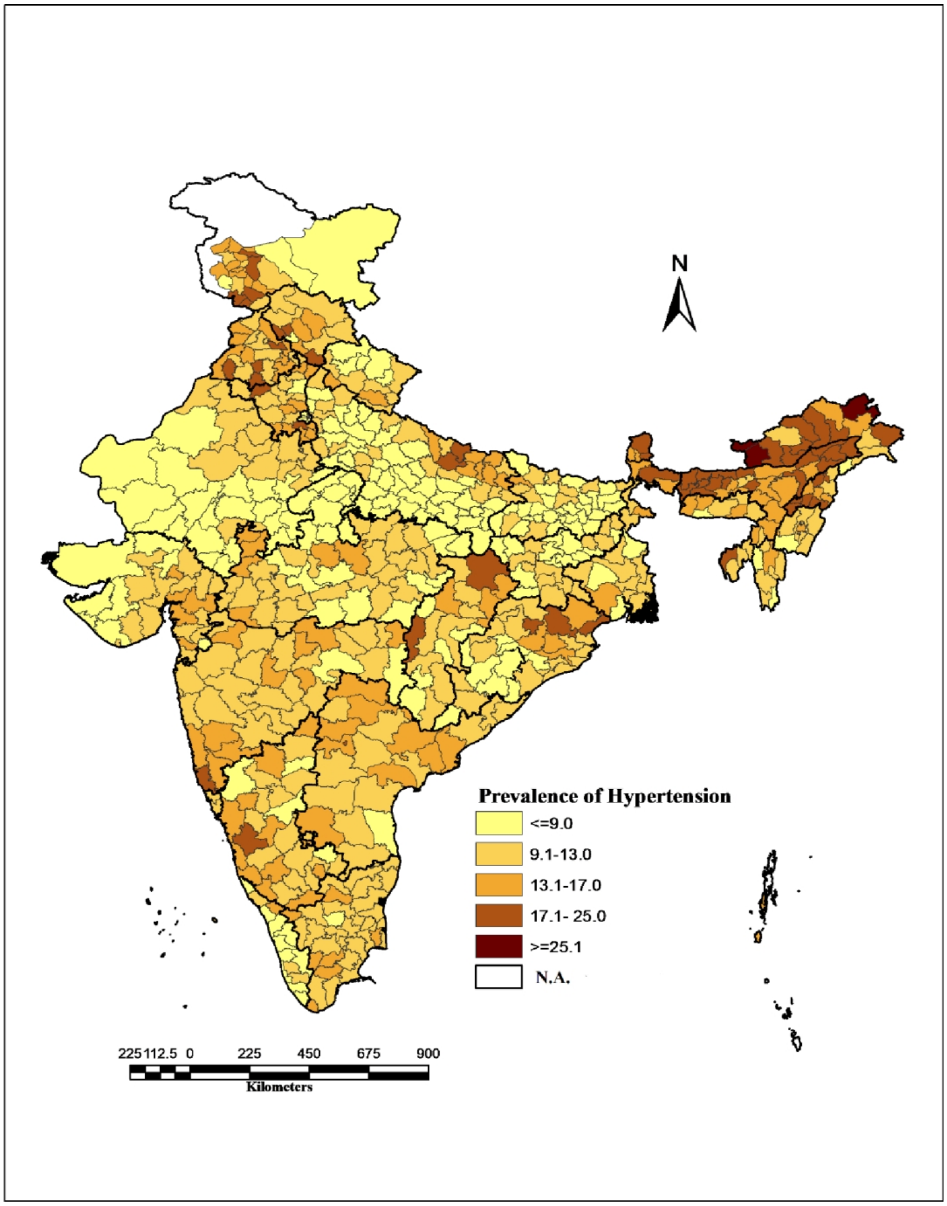

Figure 2. Prevalence of hypertension across districts, India, 2015-16

145x185mm (300 x 300 DPI)

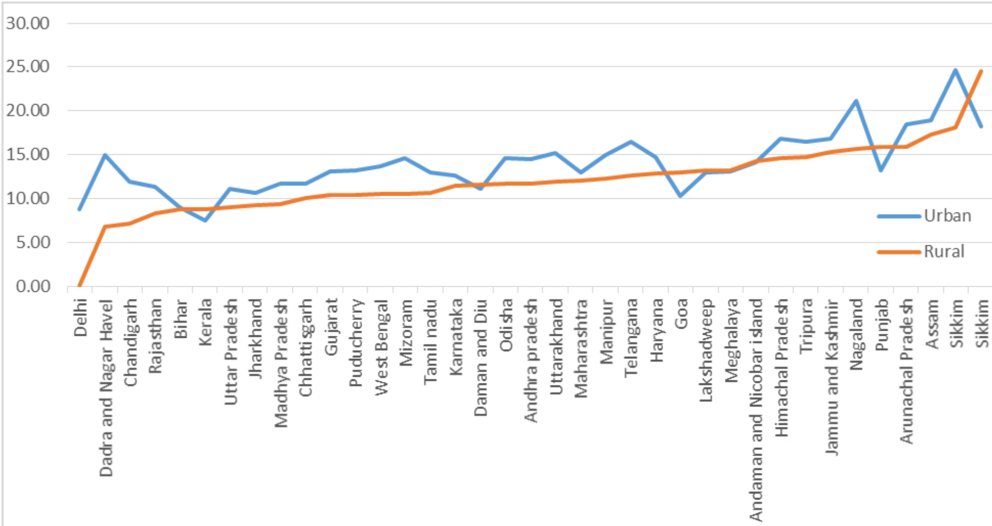

Figure3. Prevalence of hypertension by sector across selected states, 2015-16

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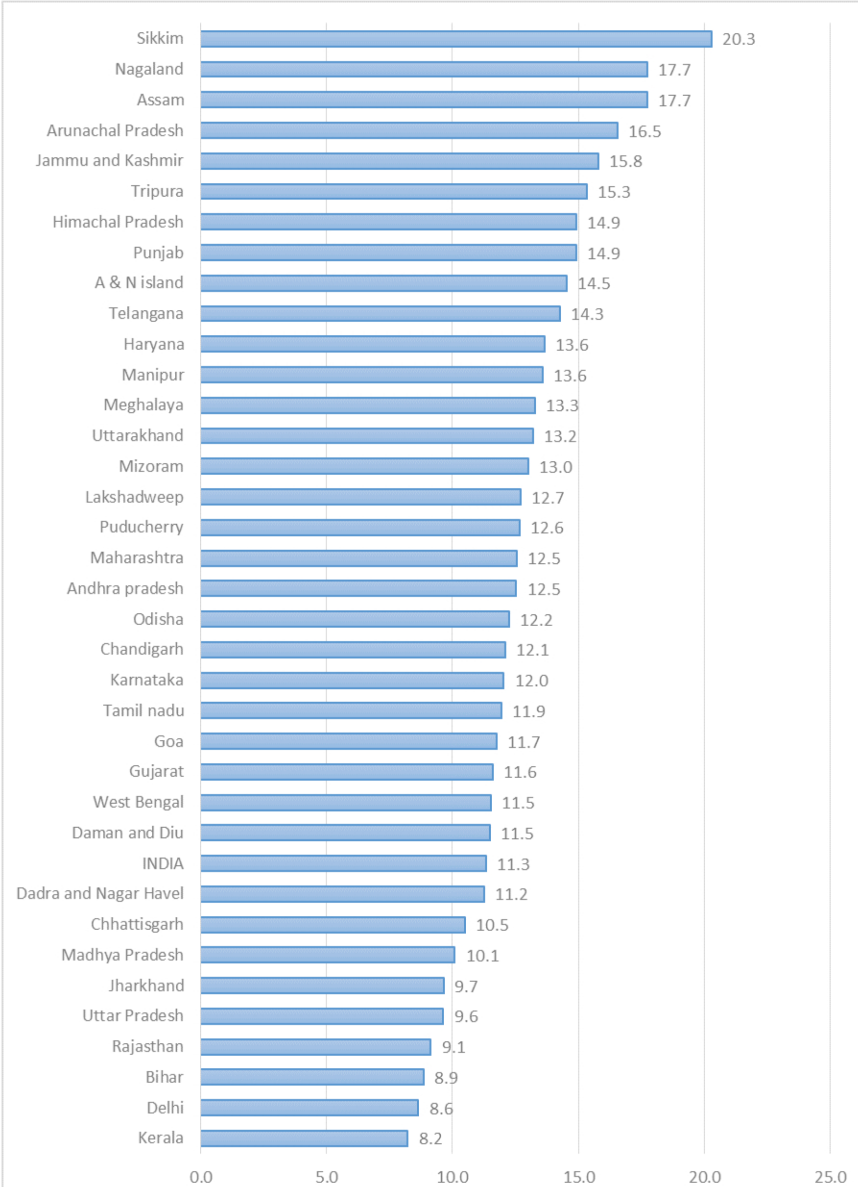

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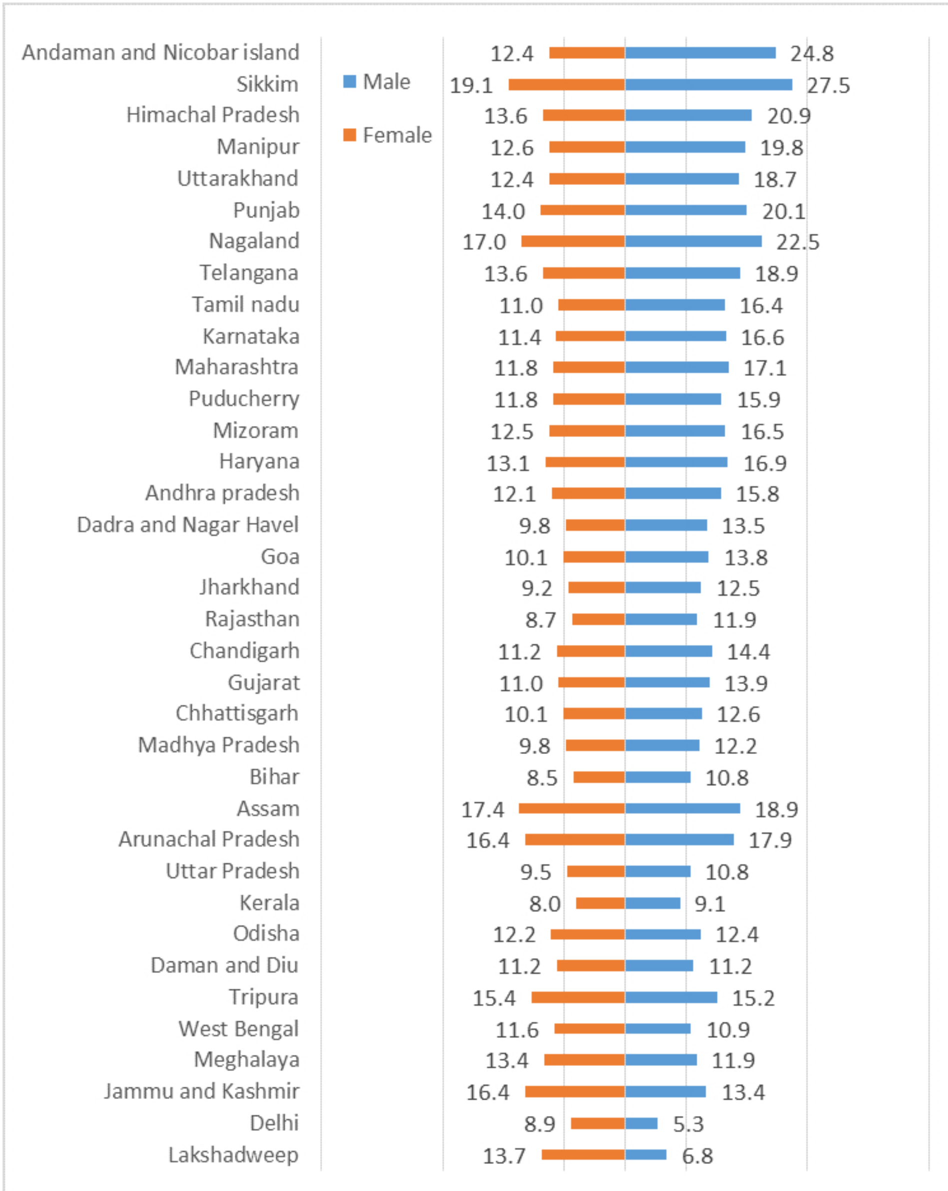
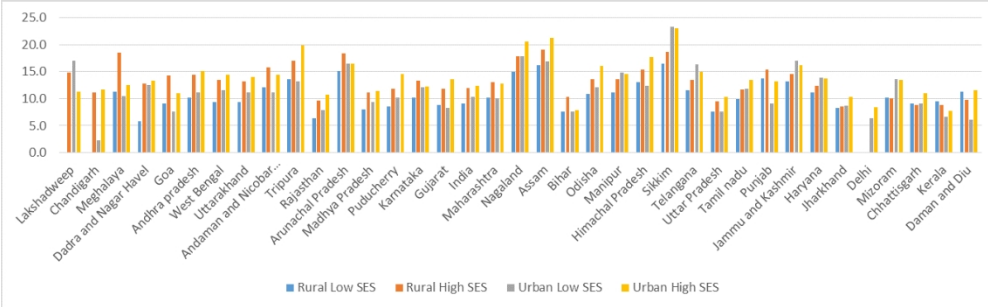
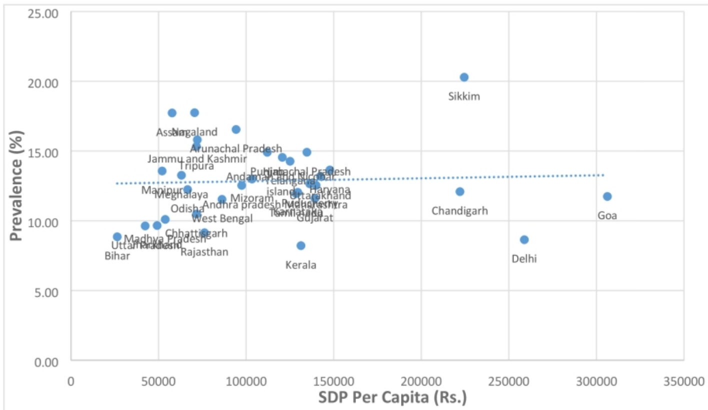


127x159mm (150 x 150 DPI)



228x71mm (150 x 150 DPI)



Note: The source of GDP data is Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India

215x279mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	*6*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross sectional study

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Prevalence and associated risk factors of hypertension among persons aged 15-49 in India: a cross-sectional study

Abstract

Objectives This is the first attempt to provide estimates on the prevalence of hypertension at the national, state and district level, a prerequisite for designing effective interventions. Besides, the study aims to identify the risk factors of hypertension.

Design We analysed cross-sectional survey data from the 4th round (2015-16) of National Family Health Survey (NFHS). NFHS was conducted between January 2015 and December 2016, gathering information on a range of indicators including blood pressure. The age adjusted prevalence of hypertension was calculated for state comparison, while multilevel logistic regression analysis was done to assess the correlates of hypertension.

Setting and participants India (2015-16 n=811,917) aged 15-49 years.

Primary and secondary outcome measures The primary outcome is hypertension, which has been defined as systolic blood pressure (SBP) ≥140 mm Hg and/ or diastolic blood pressure (DBP) ≥90 mm Hg.

Results The age-adjusted prevalence of hypertension in India was 11.3% (95% CI 11.16 to 11.43) among persons aged between 15 and 49 years and was 4 percentage points higher amongst males-13.8% (95% CI 13.46 to 14.19) than among females-10.9% (95% CI 10.79 to 11.06). Persons in the urban location (12.5%, 95% CI 12.25 to 12.80) had a marginally higher prevalence than persons in rural location-(10.6%, 95% CI 10.50 to 10.78). The proportion of population suffering from hypertension varied greatly between states, with a prevalence of 8.2% (95% CI 7.58, 8.85) in Kerala to 20.3% (95% CI 18.81, 21.77) in Sikkim. Advancing age, obesity/overweight, male sex, socioeconomic status and consumption of alcohol were found to be the major predictors of hypertension.

Conclusions Hypertension prevalence is now becoming more concentrated amongst the poor. Policy measures should be taken to improve the hazardous working conditions and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol.

Key words: Hypertension, prevalence, factors, state, district and India

Article summary

Strengths and limitations of the study

- First epidemiological study to provide estimates on prevalence of hypertension at national, state and district level

- Multivariate analysis identified the key drivers of hypertension

- The use of cross-sectional data that does not allow for exploration of causal pathways underlying the reported associations

- The role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity could not be explored in this analysis

- Findings are limited to the persons aged between 15 and 49

Introduction

Hypertension is the single largest contributor to the avoidable deaths and diseases in India. It is a leading risk factor for cardiovascular disease, which accounted for 23% of total deaths and 32% of adult deaths in 2010-2013[1]. India has committed to take an array of actions to meet the Sustainable Development Goals (SDG) target of reducing premature mortality from non-communicable diseases (NCDs) by one-third by 2030. However, much of the success in meeting this target hinges on its ability to check the rise of hypertension. The Global Burden of Hypertension study has highlighted that of the global burden of 212 million DALYs related to hypertension, 18% occurred in India in 2015[2]. The burden of hypertension in India is expected to rise considerably in the coming years due to rapid environmental and 'life-style' changes that emanate from hazardous working conditions and growing social pressures of survival [3, 4].

Monitoring and evaluation for SDG

It is, therefore, imperative that blood pressure trends are monitored to evaluate the progress that the country makes vis-à-vis the SDG goal of reduction in NCD mortality. To do that, data on hypertension is needed so that stakeholders can design appropriate interventions and evaluate national programmes aimed at effectively addressing hypertension and associated NCDs. But there was a paucity of reliable information on the status of hypertension in India. As a result, to assess the magnitude of this problem, policy makers had to rely on community studies or surveys that provided self-reported data on hypertension [5, 6, 7, 8]. Further, data from small studies were extrapolated to obtain national level estimate on hypertension [9]. Although these studies were helpful and used as a key resource in the arsenal of health policy makers, in the absence of active surveillance or data from population based surveys, policy makers are unable to determine the true burden of hypertension in India.

The recent health surveys have measured blood pressure, providing an opportunity to explore the trends in prevalence of hypertension both at the national, sub-national (state) and district level. Given the heterogeneity in the demographic and socioeconomic conditions across states in India, it is very likely that there would be considerable inter-state variations in hypertension prevalence [9]. Moreover, the socioeconomic disparities are widespread even within the state. Hence, estimates at the state and district levels are required for policy formulation, setting intervention priorities and to evaluate national programmes. This study is the first in India to provide estimates on the prevalence of hypertension at the national level and for each state, district, and by rural and urban areas and individual characteristics such as age, sex and economic status using the most recent large-scale survey data. Aside from providing estimates on hypertension prevalence, an attempt was also made to identify the correlates of hypertension.

Methods

Data

The current study is based on the data from the 4th wave of National Family Health Survey (NFHS), which is the Indian version of Demographic and Health Survey (DHS) carried out periodically in over 90 countries across the globe. NFHS 4 was conducted under the stewardship of the Ministry of Health and Family Welfare (MOH&FW) and led by International Institute for Population Sciences. The survey was a collaborative effort of 14 research organisations, including three Population Research Centres (under MOH&FW). ICF International provided technical assistance at all stages of NFHS project. NFHS 4 began on 20th January 2015 and ended on 4th December 2016. The survey was conducted across all 29 states and 7 Union Territories (UTs) in India. The survey is representative not only at the national and state level but also at the district level.

NFHS adopted a 2-stage stratified random sampling approach by selecting primary sampling units (PSUs) [villages in rural areas and census enumeration blocks in urban areas] with probability proportional to population size at the first stage and subsequently, picking the same number of households from each of selected PSUs through systematic random sampling. Both male and female interviewers were recruited by field agencies to interview respondents of the same sex. The data collection team made up to 3 visits in case no body was present in the chosen household or any eligible member was not available at the time of the household visit.

The household level questionnaire of NFHS covered the details on possession of 33 assets and access to certain utilities. The information on assets and utilisation of utilities were used for constructing wealth index, which reflects the standard of living of households. The wealth index categorises households into 5 wealth quintiles: 'poorest', 'poor', 'middle', 'rich' and richest. In NFHS, the Biomarker Questionnaire collected details on height, weight, and haemoglobin for children, and measurements of height, weight, haemoglobin, blood pressure, and random blood glucose for women aged 15-49 years and men aged 15-54 years. The different age ranges for men and women were chosen, considering the average spousal age gap of 5 years in India. The survey used same questionnaires, field procedures and procedures for biomarker measurements across the country to ensure comparability across states and to ensure the highest possible data quality. The response rate for BP measurements was 97% among women and 92% among men. Apart from taking BP measurements, all participants irrespective of their BP were asked, "Were you told on two or more different occasions by a doctor or other health professional that you had hypertension or high blood pressure?" If they responded in the affirmative, they faced a follow-on question, "To lower your blood pressure, are you taking a prescribed medicine?"

The analysis was restricted to women and men aged 15-49, after excluding men aged 49-54 (n=8,618) to ensure an equal age range among women and men. Missing values (n=32,268) were also excluded from the analysis. Data were weighted prior to analysis.

Ethics approval

The study is based on an anonymous publicly available dataset with no identifiable information on the survey participants; therefore, no ethics statement is required for this work.

Statistical analysis

Hypertension was considered as the outcome variable of this study. Three blood pressure readings were taken in NFHS. The first measurement was discarded and then, based on the average of second and third readings of blood pressure, it was decided whether a participant was hypertensive or not. Hypertension was defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg. The definition was based on the criteria given by WHO and American Heart Association [10]. In addition, an individual is classified as having hypertension if she/he is currently taking antihypertensive medication to lower his or her blood pressure. To make the prevalence of hypertension comparable, age adjusted prevalence rates were calculated for all states, UTs and districts using the direct standardization method. The national population, as per 2011 Census, was used as a reference population for carrying out the standardization technique. To understand how hypertension prevalence varies by socioeconomic status (SES), the wealth index was converted into a dichotomous variable; where the bottom 60% i.e., 'poorest', 'poor' and 'middle' were combined into one group (low SES), the remaining two categories were clubbed into the other category (high SES). Besides conducting bivariate analyses, multi-level (first level:

individual; second level: district; third level: state) logistic regression model with random intercepts and fixed slopes were employed to calculate multilevel odds ratios (OR) with corresponding 95% confidence intervals (CI).

Dependent variable

Hypertension for persons aged between 15 and 49 years. The dichotomous variable, hypertension, was defined as 1=hypertensive, else=0.

Explanatory variables

Predictors were selected based on their effects on hypertension.

Sociodemographic variables: Age, sex, marital status, caste[1], education, place of residence, wealth status. Besides sociodemographic variables, we included body mass index, tobacco use and alcohol consumption as proxy for behavioural risk factors. The education categories are defined based on number of years of education completed by an individual: 0 year as "no education"; 1 to 5 years as "primary education"; 6 to 12 years as "secondary education"; and more than 12 years of educational attainment categorised as "higher studies".

All statistical analyses were performed using STATA 14.

Patient and Public Involvement

No patients or public were involved in the conception, design and planning of this study.

Results

Sample characteristics

As seen in table1, of the total 779,649 persons who participated in the survey, a little more than half of them (51.3%) were aged between 15-29 years. It is worth noting that as per India's Census, the median age was 24 years in 2011. Nearly 13% of men and 27% of women never went to school.

[1] Indian society is mainly divided into four castes within the framework of the Hindu caste system. The castes used to be classified according to occupation. Historically, many sub-castes have faced discrimination, deprivation and social exclusion on account of their assigned 'low-status'. Recognising the marginalisation of certain communities and socioeconomic differences among different population groups, the constitution of India categorised the Indian population into four major groups: Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Class (OBC) and General. ST is the most socio-economically disadvantaged group, followed by the SC and OBC and together they comprise 69% of India's population, with SC at 19.7%, ST at 8.5% and OBC at 41.1%.

Further, 13% of both sexes attended school only up to primary level. Almost 64% of men and 73% of women were currently married. A third of the study population were urban residents and a quarter of them were either overweight or obese. Around 48% of men were users of some form of tobacco as compared with 10% of women. The gap between men's and women's tobacco use is not unusual. It is in consonance with results of other nationally representative household surveys. For instance, as per Global Adult Tobacco Survey (2016-17), 19% of men and 2% of women smoke tobacco in India [11]. It may be pointed out that traditionally tobacco usage is significantly higher in males than in females in the Indian sub-continent. This could be attributed to cultural disapproval, prohibiting women from smoking in India. Under-reporting of tobacco use by women is also partly responsible.

Like tobacco use, a significantly greater proportion of men (nearly 31%) reported consuming alcohol either almost every day, about once a week or less than once a week as compared to 2.5% amongst women.

Prevalence of hypertension at national, state and district level

Table 2 shows crude and age-adjusted prevalence of hypertension amongst persons aged 15-49 years for the year 2015-16. The data reveals that the age-adjusted prevalence of hypertension in India was 11.3% and the prevalence was 4 percentage points higher in men (13.8%) than in women (10.9%). Hypertension prevalence was 12.5% in urban, compared with 10.6% in rural location.

The results indicate that the age-adjusted prevalence of hypertension varied greatly between states and UTs, with a prevalence of 8.2% in Kerala to a prevalence of 20.2% in Sikkim (See figures 1 and S1). Quite intriguingly, the prevalence of hypertension was highest in the north-eastern (NE) states, namely Sikkim (20.2%), Nagaland (17.6%), Assam (17.6%), Arunachal Pradesh (16.6%) and Tripura (15.4%). Further, hypertension prevalence was very high in few non-NE states, viz Jammu and Kashmir (15.8%), Punjab (14.8%), Himachal Pradesh (14.8%) and Telangana (14.2%). On the other hand, proportion of population suffering from hypertension was relatively low in states such as Kerala (8.2%), Bihar (8.8%), Delhi (8.6%), Rajasthan (9.1%), Uttar Pradesh (9.6%) and Jharkhand (9.6%).

Table1. Characteristics of sample population by gender, National Family Health Survey, India, 2015-16

Sample Characteristics		Total		Female		Male	
		N	%	N	%	N	%
Hypertension	No	693,875	85.5	602,609	86.1	91,266	81.7
	Yes	85,774	10.6	69,889	10.0	15,885	14.2
	No response	32,268	4.0	27,765	4.0	4,503	4.0
Age group	15-19	144,277	17.8	125,282	17.9	18,995	17.0
	20-29	272,054	33.5	239,307	34.2	32,747	29.3
	30-39	215,796	26.6	187,459	26.8	28,337	25.4
	40-49	171,285	21.1	148,215	21.2	23,070	20.7
Marital Status	Not married	210,107	25.9	170,691	24.4	39,416	35.3
	Married	572,676	70.5	502,074	71.7	70,602	63.2
	Widow/separated/divorced	29,134	3.6	27,498	3.9	1,636	1.5
Caste	Others	165,234	20.4	142,244	20.3	22,990	20.6
	SC	146,969	18.1	126,804	18.1	20,165	18.1
	ST	147,737	18.2	127,661	18.2	20,076	18.0
	OBC	314,661	38.8	271,733	38.8	42,928	38.5
	No response	37,316	4.6	31,821	4.5	5,495	4.9
Education	No education	204,922	25.2	190,537	27.2	14,385	12.9
	Primary	109,102	13.4	94,563	13.5	14,539	13.0
	Secondary	401,720	49.5	336,381	48.0	65,339	58.5
	Higher	96,173	11.8	78,782	11.3	17,391	15.6
Place of residence	Urban	237,105	29.2	202,358	28.9	34,747	31.1
	Rural	574,812	70.8	497,905	71.1	76,907	68.9
Wealth quintile	poorest	152,942	18.8	134,330	19.2	18,612	16.7
	poorer	173,813	21.4	150,489	21.5	23,324	20.9
	middle	171,866	21.2	147,612	21.1	24,254	21.7
	richer	161,338	19.9	138,213	19.7	23,125	20.7
	richest	151,958	18.7	129,619	18.5	22,339	20.0
BMI	Normal (18.5-24.9)	488,801	60.2	418,369	59.7	70,432	63.1
	Overweight (25.0-29.9)	114,970	14.2	98,306	14.0	16,664	14.9
	Obese (>=30)	32,523	4.0	29,516	4.2	3,007	2.7
	No Response	175,623	21.6	154,072	22.0	21,551	19.3
Tobacco use	No	670,194	82.5	615,197	87.9	54,997	49.3
	Yes	126,050	15.5	72,226	10.3	53,824	48.2
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Alcohol consumption	never drinks	744,838	91.7	670,364	95.7	74,474	66.7
	almost every day	6,898	0.8	2,172	0.3	4,726	4.2
	About once a week	20,939	2.6	6,674	1.0	14,265	12.8
	Less than once a week	23,569	2.9	8,213	1.2	15,356	13.8
	No Response	15,673	1.9	12,840	1.8	2,833	2.5
Total		**811,917**	**100**	**700,263**	**100**	**111,654**	**100**

Figure 2 displays the inter-district variations in hypertension prevalence. The proportion of hypertensive population varied tremendously, ranging between 3.5% in district Mahoba, Uttar Pradesh and 34.7% in district Dibang Valley, Arunachal Pradesh. The majority of the districts across the country recorded a high hypertension burden, with more than one-tenth of the persons aged 15-49 hypertensive in 427 districts. Only 10 districts had hypertension levels below 5% and all of them except one were in the relatively less advanced states. Several districts with alarmingly high prevalence of hypertension were clustered across NE states. Five districts in Arunachal Pradesh, two districts in Punjab, one each in Sikkim, Assam and Andaman and Nicobar were among the top ten districts with the highest levels of hypertension. The results revealed that at least one in every five persons aged between 15 and 49 were having hypertension in as many as 28 districts across India.

The findings highlighted that the prevalence of hypertension was higher in men than in women in most states and UTs, except in Delhi, West Bengal, Meghalaya and Jammu and Kashmir (Figure S2). The sex difference in prevalence of hypertension was highest in Andaman and Nicobar Islands (12.4%), followed by Sikkim (8.4%), Himachal Pradesh (7.3%) and Manipur (7.2%). The results also suggest that, in general, the gender differentials were relatively smaller in low prevalence states than in high prevalence states. Figure3 shows the prevalence of hypertension in rural and urban settings of all states. As shown in the above figure, the prevalence rate of hypertension was found to be higher in urban than in rural areas for most of the states. However, there were a few exceptions. The prevalence of hypertension was relatively higher amongst the rural folks than their urban counterparts in Punjab, Goa and Kerala. Another interesting pattern emerges while comparing the prevalence of hypertension between high and low SES categories within rural and urban areas of each of these states (Figure S3). The results suggest hypertension is no longer a disease of the rich. In fact, the distribution of the condition is changing, disproportionately affecting the economically disadvantaged in urban areas of the more developed states such as Punjab, Haryana, Jammu and Kashmir and most of the NE states. Furthermore, the phenomenon of higher prevalence of hypertension among the poor appears to be not limited to only urban setting. In rural areas of Chhattisgarh, Kerala and Mizoram, the burden of hypertension was relatively higher among people from lower socioeconomic groups than those from higher socioeconomic groups. Furthermore, the differences in prevalence of hypertension by low vs high SES categories were generally insignificant in urban areas of most states (<2 percentage points).

Table2. Prevalence of hypertension in India, 2015-2016

Prevalence	**Unadjusted**		**Adjusted**	
	%	**C.I.**	**%**	**C.I.**
Overall	**10.5**	**(10.37, 10.62)**	**11.3**	**(11.16, 11.43)**
Male	14.3	(13.97, 14.70)	13.8	(13.46, 14.19)
Female	10.1	(09.96, 10.22)	10.9	(10.79, 11.06)
Rural	9.8	(9.09, 9.94)	10.6	(10.50, 10.78)
Urban	11.8	(11.12, 12.12)	12.5	(12.25, 12.80)

The weak association between GDP per capita of states and hypertension prevalence (Figure S4) is also the confirmation of the growing convergence of rich-poor difference in the prevalence of hypertension, particularly in the urban areas.

Sociodemographic differentials in prevalence

The bi-variate and multivariate analyses were carried out to understand the relative importance of socioeconomic and behavioural risk factors of hypertension. Since the bi-variate and multivariate analyses yielded very similar results, we are only presenting the findings of multivariate analysis here. Table3 shows results for multilevel logistic regression of hypertension by its different covariates. Expectedly, age was found to be an important predictor of hypertension. The likelihood of being hypertensive increased significantly with age. Odds Ratios suggest that the risk of hypertension was 6.7 times higher in older age group (45-49 years) than in younger age group (15-19 years). The differences in prevalence probabilities between married, widowed and single were statistically significant. Those who were widowed, separated and divorced were more likely to have hypertension than their single counterparts (OR=1.19; $p<0.001$). Interestingly, married persons were also found to be at greater risk of hypertension than those who were never married or single (OR=1.08; $p<0.001$). Educational attainment seems to be inversely related with prevalence, though the effect of education was not significant among those who studied only up to primary level. But persons with secondary (OR=0.92; $p<0.001$) or higher education (OR=0.81; $p<0.001$) were less likely to be hypertensive as compared to those with no formal education.

We tried to understand whether economic status affects hypertension risk in people. The ORs suggest a positive association between economic status and hypertension.

Table3. Results of multilevel logistic regression on hypertension, India, 2015-16

		Odds Ratio	P value	95% CI
Age group	15-19	1		
	20-29	1.86	0.000	(1.77, 1.96)
	30-39	3.80	0.000	(3.60, 4.01)
	40-49	6.71	0.000	(6.36, 7.09)
Marital Status	Unmarried	1		
	Married	1.08	0.000	(1.04, 1.12)
	Widow/separated/divorced	1.19	0.000	(1.13, 1.25)
Caste	Others	1		
	SC	0.98	0.214	(0.96, 1.01)
	ST	1.02	0.312	(0.98, 1.06)
	OBC	0.96	0.001	(0.94, 0.98)
Education	No education	1		
	Primary	1.00	0.914	(0.97, 1.03)
	Secondary	0.92	0.000	(0.90, 0.94)
	Higher	0.81	0.000	(0.78, 0.84)
Place of residence	Urban			
	Rural	0.96	0.001	(0.94, 0.98)
Wealth Status	Poorest	1		
	Poorer	1.08	0.000	(1.04, 1.11)
	Middle	1.13	0.000	(1.09, 1.16)
	Richer	1.22	0.000	(1.18, 1.26)
	Richest	1.21	0.000	(1.17, 1.26)
BMI	Normal	1		
	Overweight (25.0-29.9)	2.02	0.000	(1.98, 2.06)
	Obese (>=30)	3.22	0.000	(3.13, 3.32)
Tobacco use	No			
	Yes	1.01	0.395	(0.99, 1.04)
Alcohol consumption	Never drinks	1	1	
	almost every day	1.45	0.000	(1.34, 1.56)
	About once a week	1.25	0.000	(1.19, 1.31)
	Less than once a week	1.17	0.000	(1.11, 1.22)
Random Effect Part				
Variance (SE)#	State	0.066	0.000	(0.04, 0.11)
	District	0.084	0.000	(0.07, 0.09)
Median Odds Ratio (MOR)	State	1.28		
	District	1.32		

Note. # variance expressed in standard error

Compared with those in poorest quintile, people from richest quintile were having considerably higher likelihood of hypertension (0.21 percentage points). Place of residence was also found to be statistically significantly associated with hypertension. Those from rural areas (OR=0.96; $p<0.01$) were at a lower risk for hypertension. Caste differences in prevalence of hypertension were not much, except that persons belonging to OBC were less likely to have the condition (OR=0.96; $p<0.001$) as compared to those from others.

Overweight or obese persons were significantly more likely to suffer from hypertension (OR=2.02, $p<0.001$ and OR=3.22, $p<0.001$, respectively). Alcohol consumption was found to be positively related with hypertension; however, no statistically significant association was found between tobacco use and hypertension. Those who drank alcohol almost every day (OR=1.45; $p<0.000$), about once a week (OR=1.25; $p<0.001$) and less than once a week (OR=1.17; $p<0.001$) had a higher risk of hypertension than people without alcohol use habit.

We have explored the regional and sub-regional disparities in the prevalence of hypertension in India. Median odds ratio (MOR) indicates geographical heterogeneity in the prevalence of hypertension across India. Overall, the variation in the prevalence of hypertension was of greater magnitude at the district level (MOR= 1.32; $p<0.001$) than at the state level (MOR= 1.28; $p<0.001$). While the MOR was 1.28 and 1.32, ORs for most individual level characteristics were relatively higher, suggesting that unexplained between-district and between-state variations are not as relevant as individual level characteristics for understanding the prevalence of hypertension.

Discussion

This article provides estimates on the prevalence of hypertension across different geographical areas in India and examines socioeconomic and life-style factors associated with this condition, by exploiting the latest data from the 4th round (2015-16) of NFHS. Although some previous research have attempted to understand the burden of hypertension in India [9, 12, 13], to the best of our knowledge, this study is the first comprehensive assessment of hypertension prevalence using high quality survey data of each state and district of India.

One of our key findings is that more than 11% of the population aged 15-49 in India are hypertensive. However, our estimate on the age-adjusted hypertension prevalence differ considerably from the reported crude prevalence (25%) in Geldsetzer et al's (2018) study on hypertension. This discrepancy is arising mainly because our estimates of prevalence pertain to those aged 15-49 years while the said study provided estimates for adults aged 18 years or older. Besides the differences in age composition between two samples, several states and UTs were not covered in Annual Health Survey (AHS) and District Level Household Survey (DLHS) surveys, which were used for assessing hypertension prevalence in Geldsetzer et al's study. Furthermore, while the clinical and anthropometric data for AHS were collected in 2014[2], DLHS was carried out between 2012 and 2013. As a result, the pooled data may not provide true estimates of hypertension at the national level owing to inconsistencies between two surveys in terms of survey design, period of data collection (time gap) and non-inclusion of many states and UTs.

Hypertension was found to be more prevalent in men than in women. Although the prevalence of hypertension was relatively higher in urban than in rural areas at the national level, the rural-urban differences were small, implying that hypertension epidemic is spreading very fast even in the rural population. This has serious implications for the rural people. The public health system through primary health centres in rural areas is still focusing on infectious diseases, reproductive and child health and thus, has become too limited. So, people would have to rely on the private sector for the management of hypertension and its associated diseases, which would substantially add to their financial strain.

Considerable inter-state and inter-district differences were found in the prevalence of hypertension. It was more common in NE states, Jammu & Kashmir, Himachal Pradesh, Punjab, and Telengana than in Kerala and less advanced states. The inter-state differentials might have been caused by the differences in risk exposure such as rising affluence, urbanization, sedentary life style, changing dietary habits, obesity prevalence, social stress and possibly, genetic factors. The finding of relatively lower hypertension prevalence in poorer states is consistent with evidence from the latest burden of disease study that classified these states as having low epidemiological transition level [14]. But surprisingly, Kerala, where epidemiologic transition is most advanced among all states, had recorded the lowest prevalence of hypertension. This may be due to the non-inclusion of older persons in NFHS. It should be noted that Kerala has the highest proportion of elderly population (13%) in India. However, more research is needed to pinpoint the reasons for

[2] Although AHS was conducted during 2013-2014, the biomarker component i.e., CAB data were collected only from a sub-sample of AHS in the year 2014. For details, see http://www.censusindia.gov.in/2011census/hh-series/HH-2/CAB-Introduction.pdf. In contrast, in DLHS, CAB tests were carried out in all selected households.

low prevalence in Kerala. Interestingly, in NE states, despite their low per capita income, the prevalence was way higher than states with much higher level of socioeconomic development. The higher burden of hypertension amongst the population of NE could be attributed to ethnicity and food habits [15]. It may be noted that NE Indians belong to Mongoloid, whereas North Indians and South Indians are part of Indo-Aryan and Dravidian ethnic groups. Hypertension has emerged as a major epidemic in many districts. Examples being two districts of Arunachal Pradesh (part of NE India), where every third person was hypertensive and more than a fifth of the population had the condition in as many as 28 districts.

In majority of the states, hypertension prevalence was higher in urban than in rural areas, though the difference was not large and at times, insignificant. Further, in Goa, Punjab, Kerala and Nagaland, the prevalence of hypertension was observed to be higher in rural than in urban communities. Such narrowing differentials may be the result of the factors mentioned in a recent study conducted in Punjab. Tripathy and others (2016) reported that there was no rural-urban differential in terms of dietary practices and prevalence of overweight and obesity barring the fact that a markedly higher proportion of individuals from rural areas always/often add salt before/when eating as compared to those from urban areas [16].

Another major finding was the weak link between economic growth (GDP per capita) and hypertension. Our study reveals that hypertension is affecting the people in more advanced and less advanced states alike. Furthermore, hypertension is not only affecting the affluent but is also widespread among the poor within states. Another salient finding is the increased proportion of poor suffering from hypertension in many states, particularly in the urban areas. This actually confirms the trend seen in studies on non-communicable diseases [17]. More importantly, these findings paint a disturbing pattern, indicating that it is just a matter of time when the less affluent segment of the population in other states would also face a disproportionately higher burden of hypertension. The situation might have arisen due to factors such as the diffusion and adoption of 'modern' lifestyles (the changing dietary behaviour: smoking, drinking, unhealthy diets) across population groups (which is a result of urbanisation, aggressive push of junk food through advertising and marketing and related shifts in sociocultural practice), physical inactivity and high levels of depression and stress (linked to poverty and lack of equal opportunities) [18, 19]. Our study corroborates the above observations as the evidences point to urban residence, obesity, and alcohol use as some of the key drivers of the hypertension epidemic in India. These were also supported by previous research on hypertension in India [13, 16, 20]. Surprisingly, use of tobacco was not found to increase the risk of hypertension. While it is difficult to explain why use of tobacco did not display statistically significant association with hypertension, one plausible reason could be the young population of our sample. According to a recent study which examined the life-course impact of smoking on hypertension, found no statistically significant relationship between smoking and the risk of hypertension in the age-group younger than 35; though smoking was found to be significantly associated with hypertension in the later ages [21].

Our study has several notable strengths. This is the first study that used the recently released NFHS data, which is based on a sample of households that is representative at the national, state and district levels, thereby, allowing us to provide estimates of the prevalence of hypertension across various geographical levels. Further, multivariate analysis identified the key drivers of hypertension in India.

Aside from the above mentioned strengths, the study has a few limitations, which merit discussion. The findings of this study are limited to the persons aged between 15 and 49 in India. Further, NFHS provides cross-sectional data. This prevents exploration of causal pathways underlying the reported associations. We could not investigate the role of behavioural risk factors such as low fruit and vegetable intake and physical inactivity in this analysis due to the non-availability of such information in the dataset.

Conclusion

To conclude, hypertension epidemic is spreading alarmingly in India across rural and urban populations. Disturbingly, the hypertension prevalence is now becoming more concentrated among the poor in both urban and rural areas. This phenomenon of rising hypertension prevalence among the least resourceful people has serious social and economic implications for the country and warrants immediate policy interventions to prevent the catastrophe [22, 23]. The district wise estimates on this condition should be used to plan for localised interventions so that the prevalence could be brought down significantly, which would help achieve the national target of 25% relative reduction in the prevalence of hypertension by 2025 [24]. We recommend universal blood pressure screening for high prevalence districts to track the progress of interventions. However, when it comes to interventions, the emphasis should be on primary prevention of hypertension. Policy measures should be taken to improve hazardous working conditions of the poor and growing social pressures of survival responsible for 'life-style' changes such as consumption of high calorie food and alcohol. On the other hand, a diet rich in fruits and vegetables, regular physical activity and weight control should be promoted.

Contributorship statement

While SG conceptualised the paper, partly analysed the data and wrote the manuscript, MK carried out the analysis of the data. SG edited the paper. The authors discussed the results and approved the revision of the final manuscript.

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Data sharing statement

The data used in this study came from the large scale surveys conducted by government agencies. All data are already in the public domain and can be accessed freely from the Government of India's data sharing portals. Besides, NFHS data can also be obtained from the following website- www.iipsindia.org.

Conflicts of interest

The authors have none to declare.

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Figure 1. Prevalence of hypertension across states, India, 2015-16

Figure 2. Prevalence of hypertension across districts, India, 2015-16

Figure 3. Prevalence of hypertension by sector across selected states, 2015-16

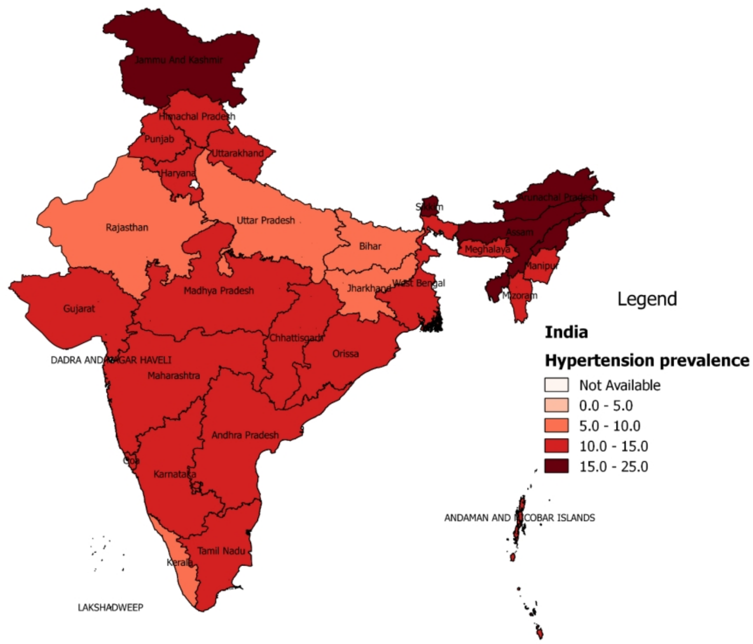


Fig 1. Prevalence of hypertension across states, India, 2015-16

228x161mm (220 x 220 DPI)

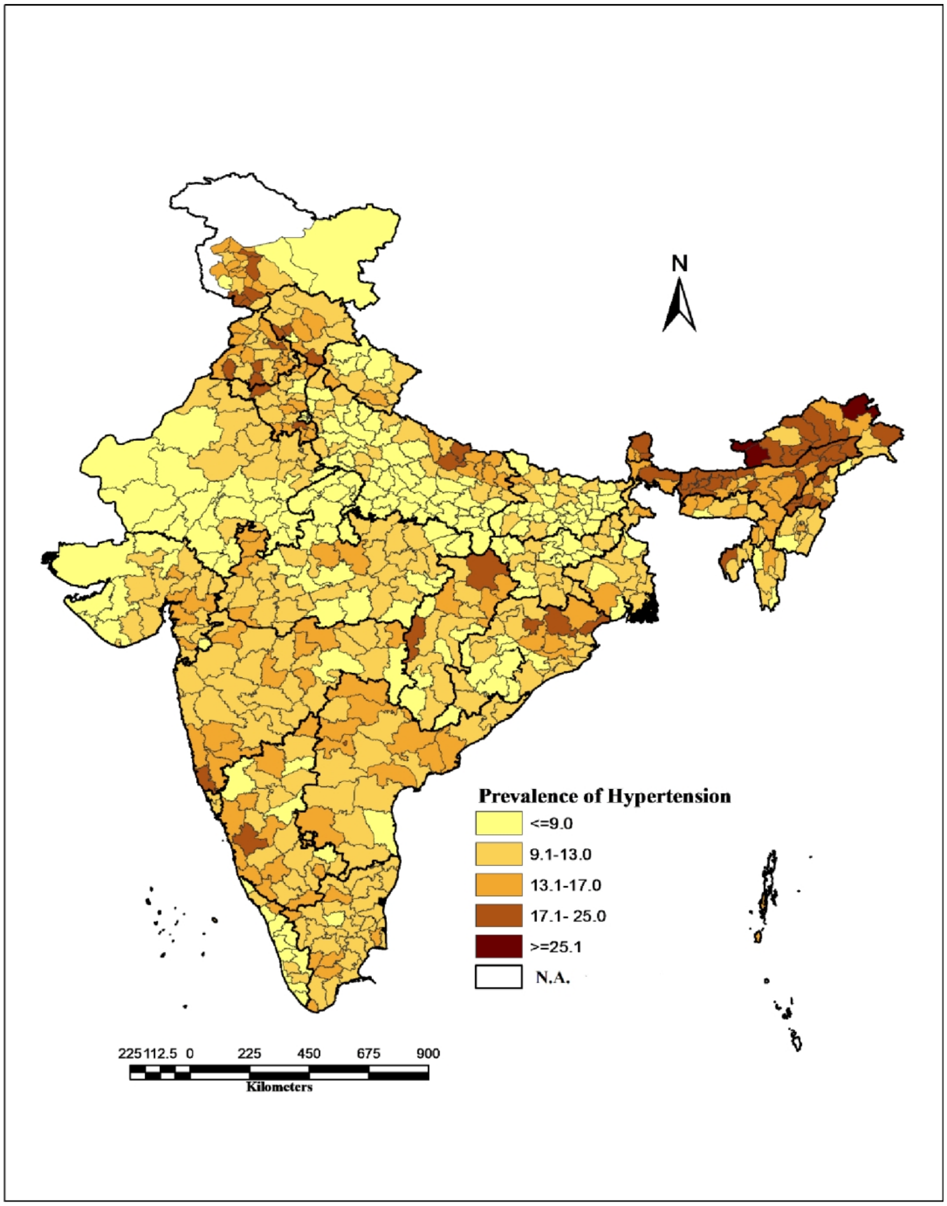


Figure 2. Prevalence of hypertension across districts, India, 2015-16

145x185mm (300 x 300 DPI)

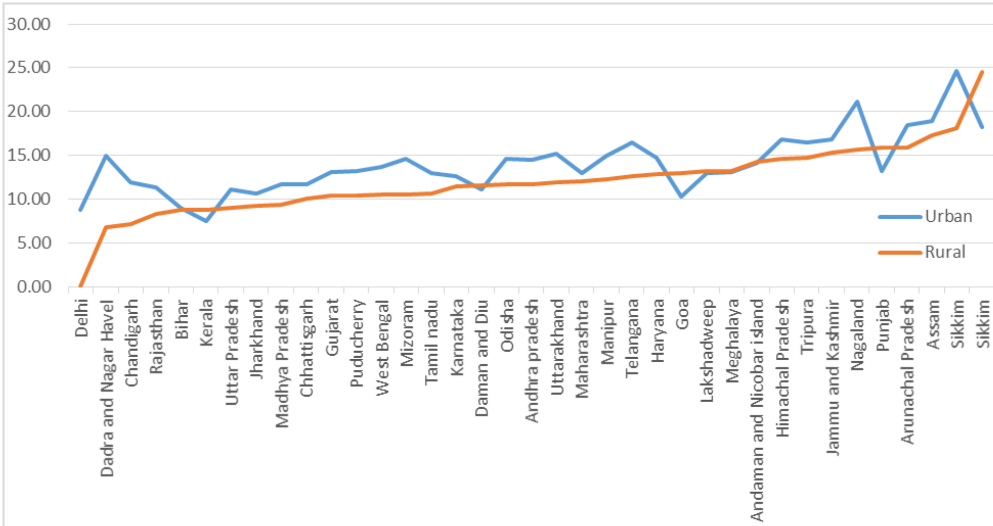
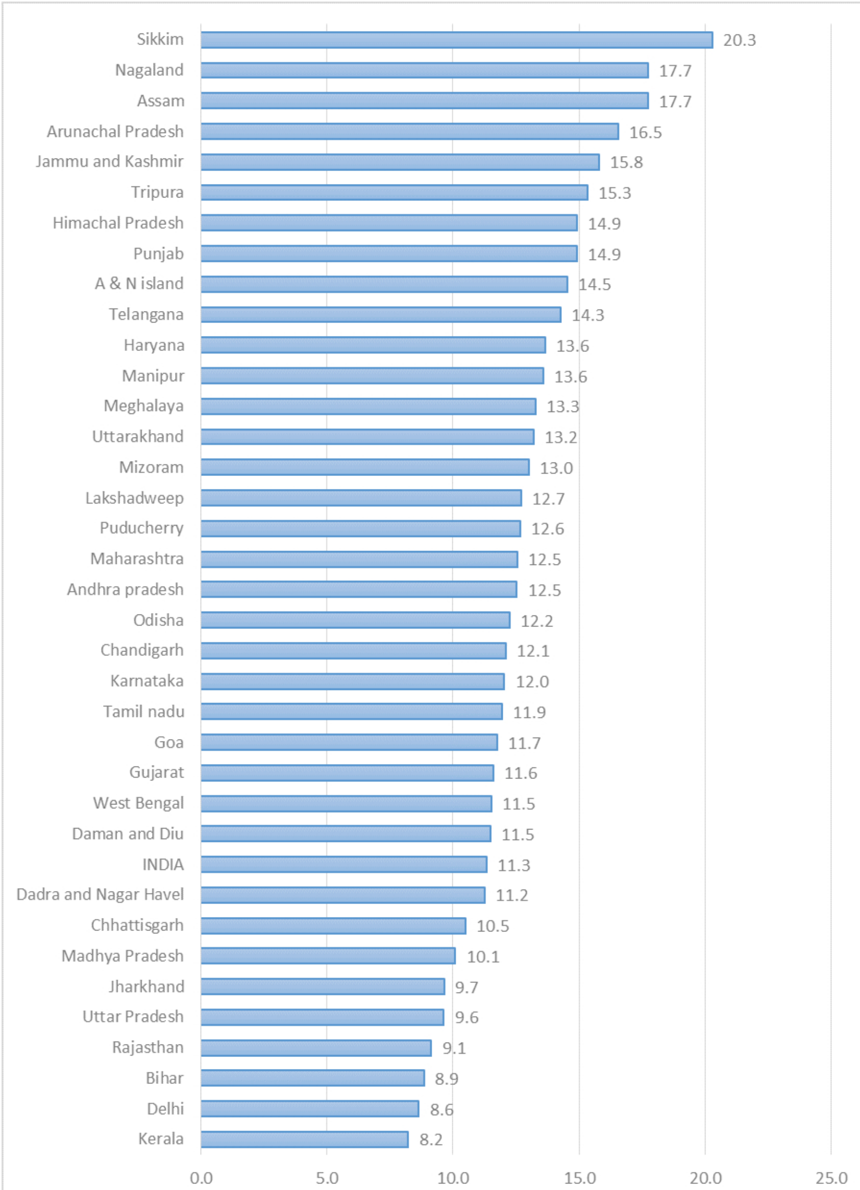
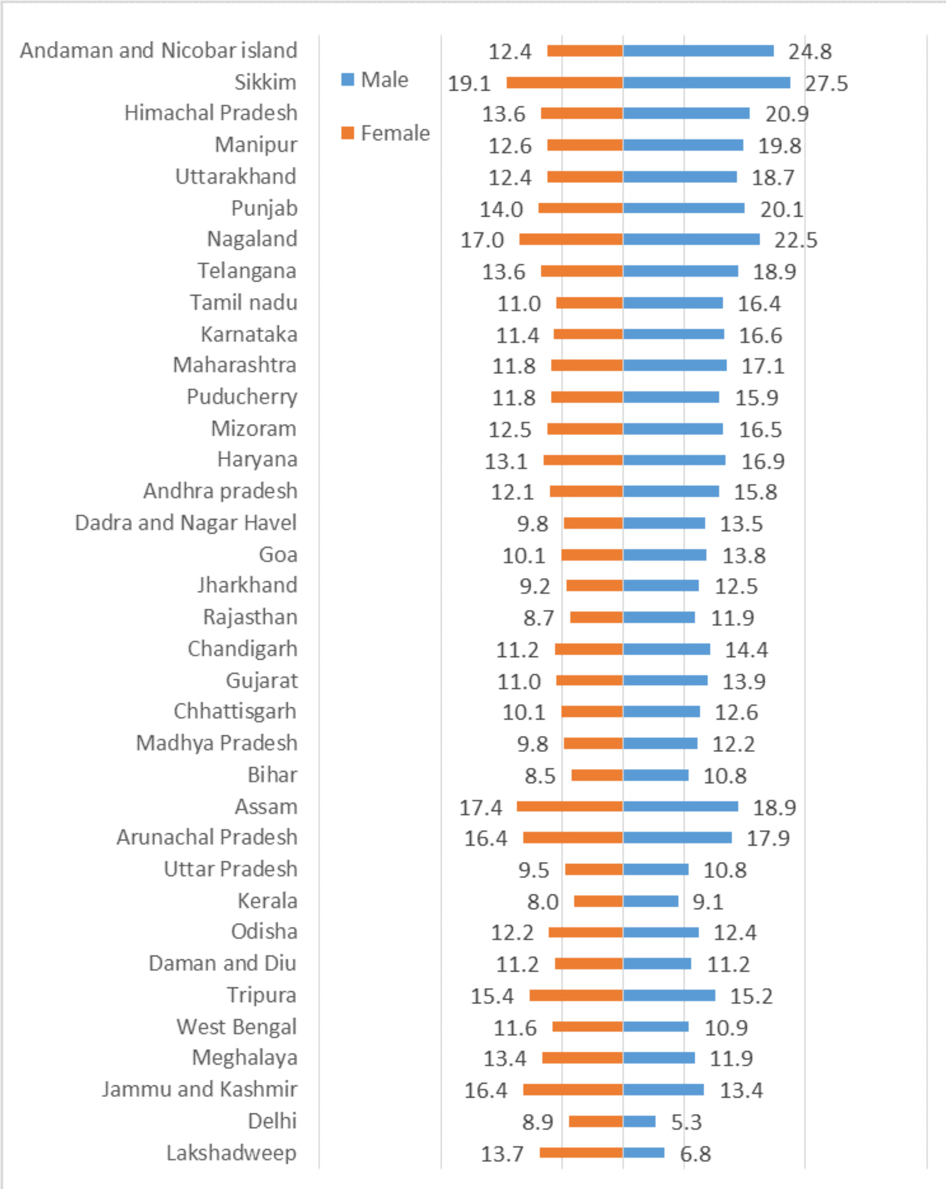


Figure3. Prevalence of hypertension by sector across selected states, 2015-16

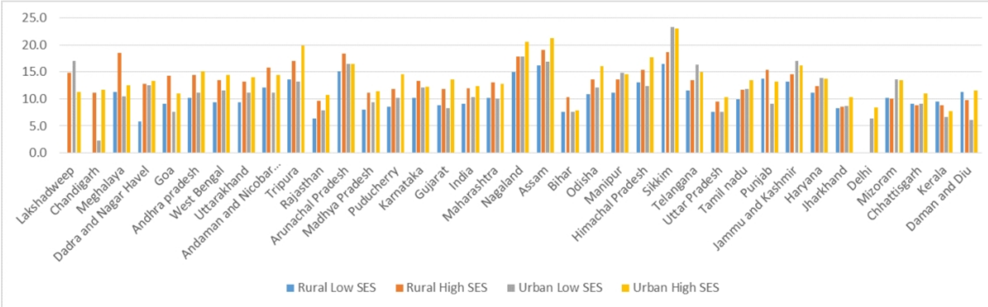
165x87mm (150 x 150 DPI)



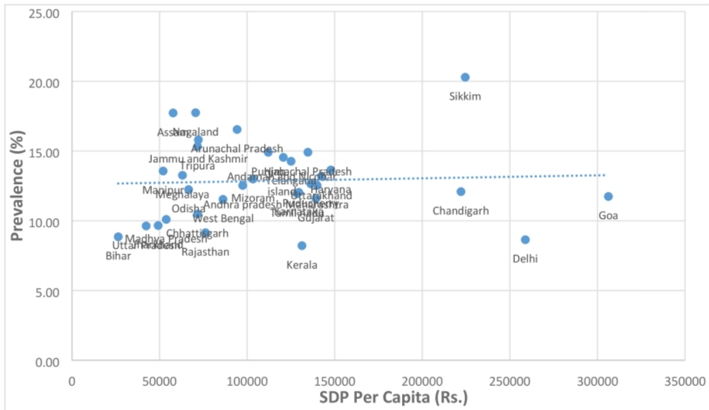
153x211mm (150 x 150 DPI)



127x159mm (150 x 150 DPI)



228x71mm (150 x 150 DPI)



Note: The source of GDP data is Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India

215x279mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	*6*
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.