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Prevalence And Associated Factors of Hypertension Among the Tribal Populations Aged 15–49 Years in India: Evidence from the National Family Health Survey (NFHS–4)

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KEYWORDS

Hypertension, prevalence, tribes, Demographic and Health Survey, India

ABSTRACT:

Introduction: Non-communicable diseases, particularly cardiovascular conditions, are a major global health challenge, with hypertension as a key risk factor. Unlike Western countries with stable rates, India shows rising hypertension, especially among vulnerable tribal populations with limited access to healthcare.

Objectives: Given the scarcity of data, this study aims to estimate the prevalence of hypertension and its associated factors among India's tribal communities.

Methods: This study used secondary data from the National Family Health Survey (NFHS-4, 2015–2016), which employed a two-stage stratified random sampling across all Indian districts. A total of 136,400 scheduled tribe individuals aged 15–49 years (17,412 men and 118,988 women) were included for analysis. The prevalence of hypertension was estimated at national and state levels and factors associated with hypertension were obtained from logistic regression analysis.

Results: The overall sex-adjusted prevalence of hypertension among the Indian tribes was estimated at 13.9% (95% CI; 13.7–14.1). Men and women had a hypertension prevalence of 16.1% (95% CI; 15.6–16.6) and 11.4% (95% CI; 11.2–11.6) respectively. The prevalence of hypertension varied across the states, more among men than women. Among men, the highest and lowest prevalence was seen in Sikkim state (45.8%; 95% CI: 29.1–62.8) and Daman and Diu union territory (4.3%; 95% CI: 1.7–10.2) respectively and among women, in Arunachal Pradesh state (22.9%; 95% CI: 19.4–26.4) and union territory of Chandigarh (8.2%; 95% CI: 4.3–12.2) respectively. Increasing age, male gender, higher wealth index, high body mass index, tobacco use, alcohol consumption, nonvegetarian diet and daily fried food intake were independently associated with hypertension among the study participants.

Conclusions: Hypertension seems to be more prevalent among Indian tribes compared to the general population. Interventions directed towards changing lifestyle behaviour by controlling tobacco use, alcohol consumption and increasing body mass index may play a key role in reducing the burden of hypertension in tribal populations of India.

1. Introduction

Non-communicable diseases (NCDs) are a leading global health challenge, particularly in developing countries, accounting for the majority of current deaths. [1,2] With declining communicable diseases, an epidemic of NCDs has emerged, with cardiovascular diseases as major contributors. [3] Notably, cardiovascular mortality, previously plateaued in developed countries, has shown a recent upward trend. [4]

Hypertension, the silent killer, is a major risk factor for cardiovascular morbidity and mortality. [5] The Global Burden of Disease Study 2019 estimated that high systolic blood pressure accounted for about 10.8 million deaths (19.2% of all global deaths) and was the leading risk factor for disability-adjusted life years (DALYs)

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across all ages and among individuals aged ≥50 years worldwide. [5]

Recent lifestyle changes have driven research on hypertension among young adults; while prevalence has remained stable and prehypertension has declined among those aged 18–39 years in Western countries, [6] India shows a contrasting trend with rising prevalence of both hypertension and prehypertension in young adults. [7,8]

India's National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases & Stroke recommends screening for hypertension and other non-communicable diseases from 30 years of age; however, emerging evidence indicates higher morbidity, mortality, and target end-organ damage in individuals with early-onset compared to late-onset hypertension, supporting the need for earlier screening. [9–11]

Tribal populations in India, constituting 8.6% of the population as per the 2011 Census, often reside in remote and inaccessible areas with limited access to quality healthcare, making them particularly vulnerable. [12] Although hypertension was once considered uncommon among tribal communities, a recent systematic review has shown a rising trend over the past four decades. [13] Despite extensive research in the general population, data on hypertension among tribal groups remain sparse, with many tribes underrepresented in existing meta-analyses. [13]

2. Objectives

The true national burden of hypertension among tribal populations is still unclear. The National Family Health Survey (NFHS-4), the Indian counterpart of the Demographic and Health Survey (DHS), uses nationally representative district-level samples and enables estimation at the national level. In this context, we analyzed NFHS-4 data to estimate the prevalence of hypertension and identify associated factors among India's tribal population.

3. Methods

Study Design

This study is a secondary analysis of data from the fourth round of the National Family Health Survey (NFHS-4), a nationally representative cross-sectional Survey conducted across all districts of India between January 2015 and December 2016. Individual men (IAMR74SV) and women (IAIR74SV) datasets obtained from the DHS website were used for analysis. [14]

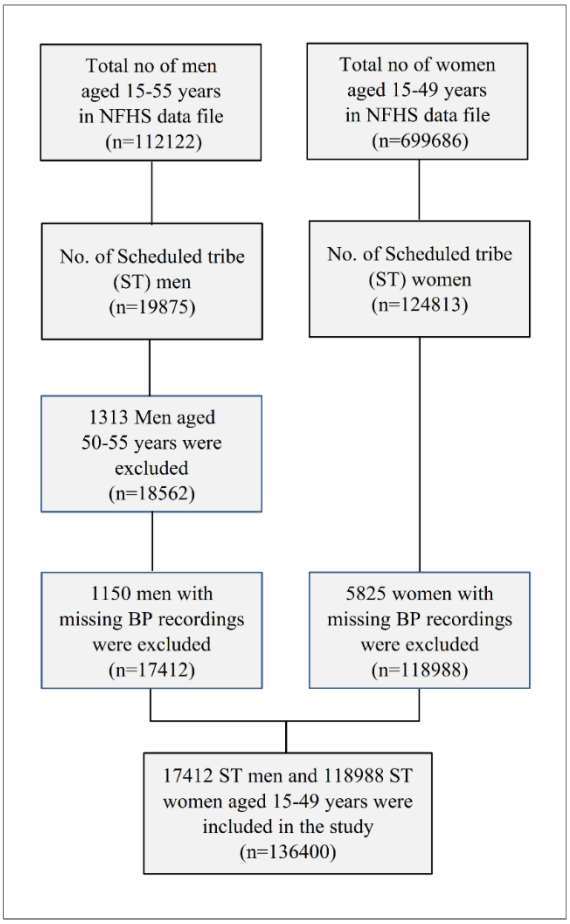

Figure 1: Flow chart depicting the selection of study subjects for the present study

Study Population

The data of 136400 individuals, comprising 17412 men, and 118988 women aged 15–49 years belonging to scheduled tribes found to be eligible (Figure 1) for the study was analysed. Tribes refer to the social organization of smaller groups or bands with political integrations bound by common descent, ideology, traditions, culture, and language. [15] The scheduled tribes in India refer to the communities listed in Article 324 under Article 366 (25) of the Constitution of India declared by the Honourable President of India or by Acts amended in the Parliament of India. [16] In the constitution of India, around 705 ethnic groups and subgroups have been notified as scheduled tribes across

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all the states and union territories except Punjab, Haryana, Delhi, Chandigarh, and Puducherry.

Sampling strategy

A two-stage stratified random sampling technique was utilized for data collection in the survey. Census (2011) data was used for selecting Primary sampling units (PSUs) listing blocks and villages, respectively in urban and rural areas, with probability proportional to size in the first stage. In the second stage, 22 houses were carefully chosen from each of the PSUs enlisted in the first stage using systematic random sampling.

Data Collection

Male and female interviewers were recruited for carrying out interviews of respective genders. At least three visits to households were made if the eligible members were not available in the initial visits. A uniform questionnaire translated into 18 Indian languages was used to ensure the quality and comparability of evaluations at district, state, and national levels.

Information on sociodemographic variables—including age, residence, marital status, education, employment status, and wealth index—was collected. Participants were classified as rural or urban; marital status as never married, married, or widowed/divorced/separated; education as no education, primary, secondary, or higher than secondary; and employment as current workers or non-workers (including homemakers).

The wealth index, derived using principal component analysis of housing conditions, household assets, and access to essential services, was used to assess standard of living. Households were categorized into poorest, poorer, middle, richer, and richest wealth quintiles. [17]

The biomarkers analysed in the present study were body mass index and blood pressure levels. For BMI calculation, the weight of the individuals was measured in kilograms (kg) using a Seca 874 digital scale and height was measured in meters (m) using a Seca 213 stadiometer. Blood pressure was measured using an Omron Automatic digital battery operated Blood Pressure Monitor thrice with a break of 5 minutes in between the recordings and the average of the three readings was taken as the final blood pressure for an individual.

Hypertension was defined according to JNC-7 criteria as systolic ≥140 mmHg or diastolic ≥90 mmHg, [18] or if the individual had a prior diagnosis or was on antihypertensive medication. Body mass index (BMI), calculated as weight (kg)/height² (m²), was classified for Asian Indians [19] as underweight (<18.0 kg/m²), normal (18.0–22.9 kg/m²), overweight (23.0–24.9 kg/m²), and obese (≥25.0 kg/m²).

Information on tobacco and alcohol use was collected. Participants were classified as tobacco smokers (cigarettes, bidis, cigars, pipes, hookah), smokeless tobacco users (paan masala, gutkha, paan with tobacco, other chewing tobacco, snuff), or non-tobacco users. Alcohol consumption was categorized as never drinkers or drinkers, with frequency classified as almost every day, about once a week, or less than once a week.

Statistical analysis

Data of eligible Scheduled Tribe men and women were analyzed using SPSS version 20. Missing values were excluded. Associations between hypertension and sociodemographic factors, BMI, tobacco and alcohol use, and dietary factors were assessed using chi-square tests, with unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) estimated. Statistically significant factors ($p < 0.01$) were included in binary logistic regression using the 'Enter' method to obtain adjusted ORs with 95% CIs. Significance was set at $p < 0.05$.

4. Results

Background characteristics

Of the 136,400 Scheduled Tribe participants, 12.8% were men and 87.2% were women. Sociodemographic factors such as age, residence, marital status, and wealth index were similarly distributed, but a higher proportion of women (34.1%) than men (14.5%) had no education. Additionally, three-fourths of men were currently working, compared to only one-fourth of women (Table 1).

Obesity was more common in men than women (20.6% and 15.5%, respectively), whereas more women were underweight than men (19.9% and 15.4%, respectively). Half (50.7%) of men compared to 8.7% of women were tobacco users. Among both the genders, more subjects used only smokeless forms of tobacco (22.1% men and

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Table 1. Background characteristics of respondents

Characteristics	Men		Women	
	No.	(%)	No.	(%)
Age in Years				
15-19	3326	(19.1)	2236	(18.8)
20-29	5712	(32.8)	41344	(34.7)
30-39	4712	(27.1)	30995	(26.0)
40-49	3662	(21.0)	24280	(20.4)
Place of residence				
Urban	4729	(27.2)	30287	(25.5)
Rural	12683	(72.8)	88701	(74.5)
Marital status				
Never married	6637	(38.1)	28090	(23.6)
Married	10502	(60.3)	85912	(72.2)
Widowed/Divorced/Separated	273	(1.6)	4986	(4.2)
Educational level				
No education	2533	(14.5)	40547	(34.1)
Primary	2499	(14.4)	16710	(14.0)
Secondary	10299	(59.1)	52334	(44.0)
Higher	2081	(12.0)	9397	(7.9)
Currently Working				
Yes	13113	(75.3)	5303	(26.1)
No	4299	(24.7)	14987	(73.9)
Wealth index				
Poorest	3470	(19.9)	28249	(23.7)
Poorer	4446	(25.5)	29058	(24.4)
Middle	4120	(23.7)	26535	(22.3)
Richer	3201	(18.4)	20842	(17.5)
Richest	2175	(12.5)	14304	(12.0)
Body mass index				
Underweight	2407	(15.4)	23628	(19.9)
Normal	7953	(50.8)	62729	(52.8)
Overweight	2080	(13.3)	14047	(11.8)
Obese	3223	(20.6)	18435	(15.5)
Tobacco use				
No	8580	(49.3)	108635	(91.3)
Smoking	2934	(16.9)	1732	(1.5)
Smokeless	3849	(22.1)	8352	(7.0)
Smoking and Smokeless	2049	(11.8)	269	(0.2)
Alcohol consumption				
Never drinks	10965	(63.0)	117774	(99.0)
Almost every day	855	(4.9)	170	(0.1)
About once a week	2654	(15.2)	407	(0.3)
Less than once a week	2938	(16.9)	637	(0.5)
Dietary pattern				
Vegetarian	3232	(18.6)	33643	(28.3)
Nonvegetarian	14180	(81.4)	85345	(71.7)
Frequency of fried food intake				
Daily	1632	(9.4)	10727	(9.0)
Less than daily	15780	(90.6)	108261	(91.0)

7% women). Also, 11.8% of men and 0.2% of women were using tobacco in both smoked and smokeless forms. Alcohol intake was also more common in men (37%) compared to women (1%). Majority of the subjects were nonvegetarian (81.4% in men and 71.7% in women) whereas 9.4% men and 9.0% women consumed fried foods daily. (Table 1)

Prevalence

The overall sex-adjusted prevalence of hypertension among tribal populations of India was found to be 13.9% (95% CI; 13.7 – 14.1). Among men and women, 16.1% (95% CI: 15.6 – 16.6) and 11.4% (95% CI: 11.2 – 11.6) had hypertension, respectively. (Table 2)

Table 2. Gender wise prevalence of hypertension among tribal populations of India

	Prevalence (%)	95% Confidence interval
Men	16.1	(15.6 - 16.6)
Women	11.4	(11.2 - 11.6)
Overall	13.9	(13.7 – 14.1)

A substantial variation in the prevalence of hypertension was observed among the states and union territories. Among men, Daman and Diu Union territory had the least prevalence of 4.3% (95% CI: 1.7 – 10.2), whereas Sikkim state had the highest prevalence of 45.8% (95% CI: 29.1 – 62.8). Among women, the Union territory of Chandigarh reported the least prevalence of 8.2% (95% CI: 4.3 – 12.2) and Arunachal Pradesh state had the highest prevalence of 22.9% (95% CI: 19.4 – 26.4). (Table 3) Overall, the prevalence of hypertension in the Northern and North-Eastern regions of the country was high, while Central India showed the lowest prevalence. (Figure 2 and Figure 3)

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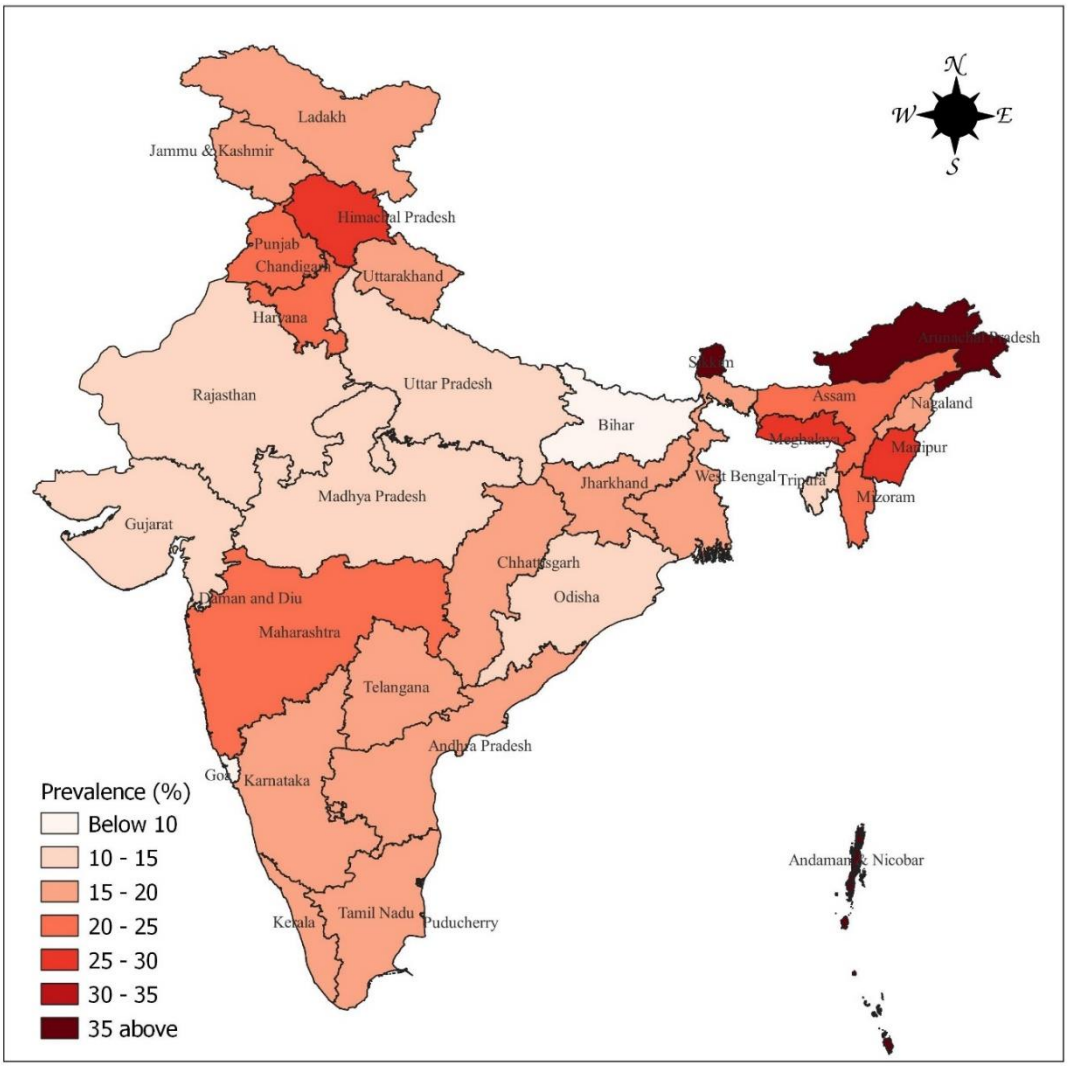

Figure 2. State-wise prevalence of hypertension among scheduled tribes Men of India as per NFHS 4 Data. (Map prepared in QGIS version 3.20.0)

Prevalence and associated factors

Hypertension prevalence varied significantly ($p < 0.05$) across age, residence, marital status, education, employment, wealth, BMI, tobacco and alcohol use, and diet for both men and women; fried food intake was significant only among women ($p < 0.001$). Prevalence increased with age, from 4.4% (men) and 3.7% (women) at 15–20 years to 27.9% and 24% at 40–49 years. Urban residents and higher wealth quintiles had higher prevalence. Lowest prevalence occurred in never-married individuals, highest in married men and widowed/divorced/separated women. Women showed an inverse relationship with education, while men showed no clear trend. Hypertension rose with BMI, tobacco use, and alcohol consumption (dose-dependent). Vegetarian diet was protective. Among women, daily fried food intake was associated with higher prevalence, but no such pattern was observed in men (Table 4).

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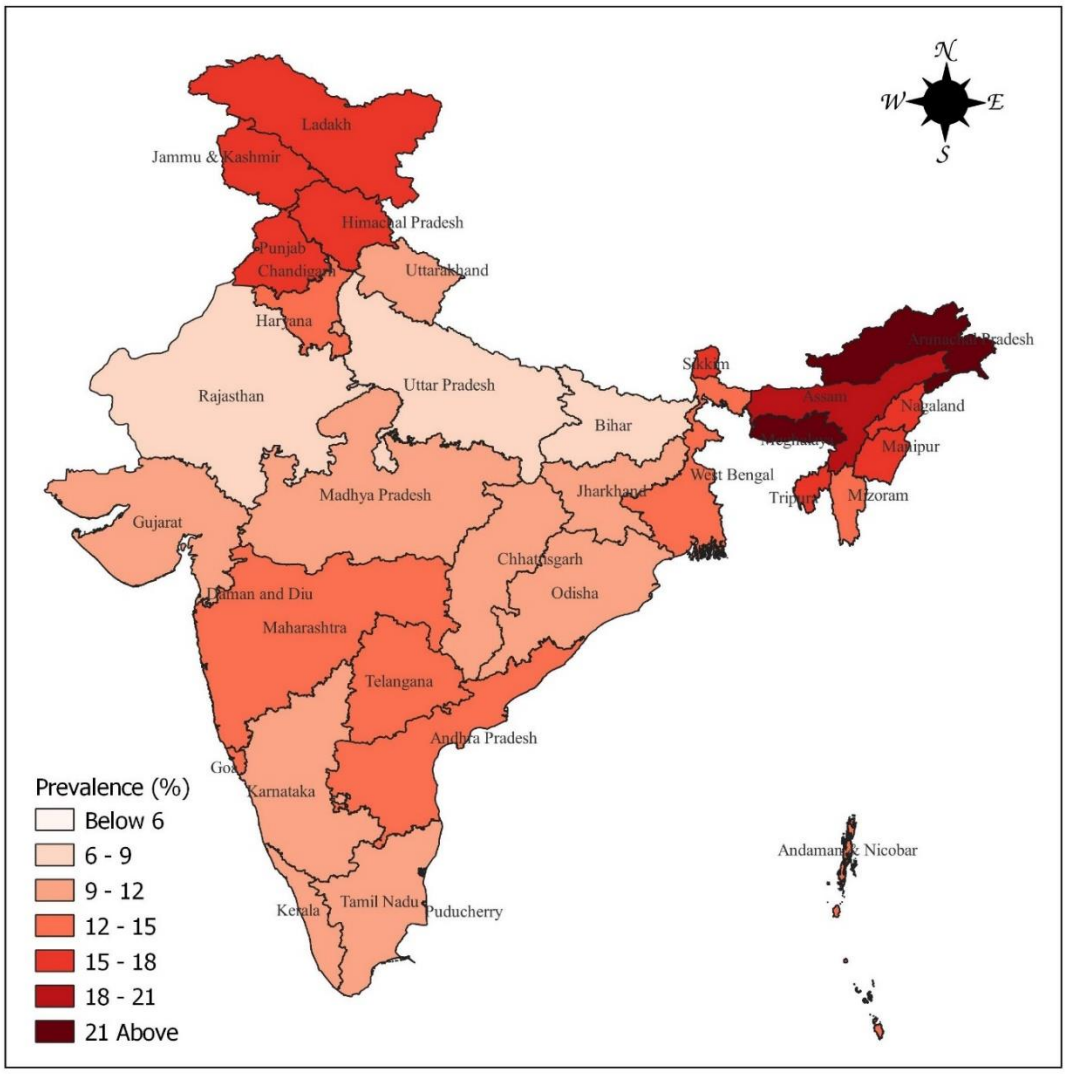

Figure 3. State-wise prevalence of hypertension among scheduled tribes Women of India as per NFHS 4 Data. (Map prepared in QGIS version 3.20.0)

Factors independently associated with hypertension

Age, gender, marital status, and wealth index were independently associated with hypertension ($p<0.05$). Participants aged ≥40 years had the highest odds (OR: 6.659; 95% CI: 5.531–8.017) compared to those <20 years, and men were more likely than women to be hypertensive (OR: 1.476; 95% CI: 1.343–1.623; $p<0.001$). Individuals in the middle to richest wealth quintiles also had significantly higher odds than those in the poorest category ($p<0.001$).

BMI, tobacco, and alcohol use were strong predictors. Obese (OR: 2.089; 95% CI: 1.862–2.345) and overweight (OR: 1.503; 95% CI: 1.326–1.705) individuals had higher odds compared to the underweight. Tobacco smokers (OR: 1.175; 95% CI: 1.012–1.365) and combined users of smoking and smokeless forms (OR: 1.270; 95% CI: 1.093–1.476) had greater odds than non-users. Alcohol intake showed a dose-dependent association, with risk increasing significantly with frequency of consumption ($p<0.001$).

Dietary factors also played a role. Vegetarians had lower odds of hypertension (OR: 0.912; 95% CI: 0.841–0.990; $p=0.027$), while daily fried food consumption increased the odds (OR: 1.166; 95% CI: 1.046–1.301; $p=0.006$). (Table 5)

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Table 3. State/Union Territory-wise prevalence of hypertension among tribal men and women in India

STATE/Union Territory	MEN				WOMEN			
	N (Total)		% (95% CI)		N (Total)		% (95% CI)	
Andaman and Nicobar Islands	17	(47)	36.2	(21.9 - 50.4)	16	(110)	14.5	(7.9 - 21.2)
Andhra Pradesh	32	(210)	15.2	(10.3 - 20.1)	253	(1866)	13.6	(12 - 15.1)
Arunachal Pradesh	27	(71)	38.0	(26.5 - 49.6)	131	(572)	22.9	(19.4 - 26.4)
Assam	90	(366)	24.6	(20.2 - 29.0)	511	(2745)	18.6	(17.2 - 20.1)
Bihar	95	(1008)	9.4	(7.6 - 11.2)	750	(8756)	8.6	(8.0 - 9.2)
Chandigarh	3	(29)	10.3	(-1.4 - 22.1)	16	(194)	8.2	(4.3 - 12.2)
Chhattisgarh	63	(372)	16.9	(13.1 - 20.8)	274	(2743)	10.0	(8.9 - 11.1)
Dadra and Nagar Haveli	2	(15)	13.3	(-6.2 - 32.8)	6	(39)	15.4	(3.5 - 27.2)
Daman and Diu	2	(47)	4.3	(-1.7 - 10.2)	11	(114)	9.6	(4.1 - 15.2)
Goa	3	(41)	7.3	(-1.0 - 15.6)	16	(129)	12.4	(6.6 - 18.2)
Gujarat	75	(537)	14.0	(11.0 - 16.9)	237	(2447)	9.7	(8.5 - 10.9)
Haryana	177	(844)	21.0	(18.2 - 23.7)	746	(5747)	13.0	(12.1 - 13.8)
Himachal Pradesh	118	(470)	25.1	(21.2 - 29.0)	327	(2142)	15.3	(13.7 - 16.8)
Jammu and Kashmir	78	(402)	19.4	(15.5 - 23.3)	296	(1709)	17.3	(15.5 - 19.1)
Jharkhand	78	(429)	18.2	(14.5 - 21.8)	421	(3784)	11.1	(10.1 - 12.1)
Karnataka	120	(662)	18.1	(15.2 - 21.1)	627	(5272)	11.9	(11.0 - 12.8)
Kerala	29	(154)	18.8	(12.6 - 25.1)	102	(1061)	9.6	(7.8 - 11.4)
Madhya Pradesh	224	(1688)	13.3	(11.7 - 14.9)	970	(9868)	9.8	(9.2 - 10.4)
Maharashtra	156	(737)	21.2	(18.2 - 24.1)	587	(4822)	12.2	(11.3 - 13.1)
Manipur	37	(127)	29.1	(21.1 - 37.1)	154	(994)	15.5	(13.2 - 17.7)
Meghalaya	5	(19)	26.3	(4.5 - 48.1)	49	(224)	21.9	(16.4 - 27.3)
Mizoram	3	(12)	25.0	(-3.7 - 53.7)	15	(112)	13.4	(7.0 - 19.8)
Nagaland	11	(56)	19.6	(8.9 - 30.4)	65	(378)	17.2	(13.4 - 21.0)
Delhi	13	(105)	12.4	(6.0 - 18.8)	107	(1056)	10.1	(8.3 - 12.0)
Odisha	74	(649)	11.4	(9.0 - 13.9)	643	(5504)	11.7	(10.8 - 12.5)
Puducherry	18	(108)	16.7	(9.5 - 23.8)	75	(713)	10.5	(8.3 - 12.8)
Punjab	243	(1129)	21.5	(19.1 - 23.9)	1248	(7695)	16.2	(15.4 - 17)
Rajasthan	161	(1233)	13.1	(11.2 - 14.9)	644	(7699)	8.4	(7.7 - 9.0)
Sikkim	17	(37)	45.9	(29.1 - 62.8)	43	(251)	17.1	(12.4 - 21.8)
Tamil Nadu	244	(1280)	19.1	(16.9 - 21.2)	918	(7982)	11.5	(10.8 - 12.2)
Telangana	28	(156)	17.9	(11.9 - 24.0)	206	(1403)	14.7	(12.8 - 16.5)
Tripura	22	(189)	11.6	(7.0 - 16.3)	177	(999)	17.7	(15.3 - 20.1)
Uttar Pradesh	345	(3093)	11.2	(10.0 - 12.3)	1845	(21239)	8.7	(8.3 - 9.1)
Uttarakhand	88	(454)	19.4	(15.7 - 23.0)	445	(3700)	12.0	(11.0 - 13.1)
West Bengal	104	(634)	16.4	(13.5 - 19.3)	646	(4917)	13.1	(12.2 - 14.1)

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Table 4. Prevalence of hypertension according to background characteristics among men and women respondents

Characteristics	MEN				WOMEN			
	N	%	(95% CI)	p	N	%	(95% CI)	p
Age in Years								
15-19	148	4.4	(3.7 - 5.2)	<0.001	824	3.7	(3.4 - 3.9)	<0.001
20-29	641	11.2	(10.4 - 12.0)		2679	6.5	(6.2 - 6.7)	
30-39	993	21.1	(19.9 - 22.2)		4249	13.7	(13.3 - 14.1)	
40-49	1021	27.9	(26.4 - 29.3)		5825	24.0	(23.5 - 24.5)	
Place of residence								
Urban	885	18.7	(17.6 - 19.8)	<0.001	3719	12.3	(11.9 - 12.6)	<0.001
Rural	1918	15.1	(14.5 - 15.7)		9858	11.1	(10.9 - 11.3)	
Marital status								
Never married	558	8.4	(7.7 - 9.1)	<0.001	1247	4.4	(4.2 - 4.7)	<0.001
Married	2194	20.9	(20.1 - 21.7)		11408	13.3	(13.1 - 13.5)	
Widowed/Divorced/Separated	51	18.7	(14 - 23.3)		922	18.5	(17.4 - 19.6)	
Educational level								
No education	454	17.9	(16.4 - 19.4)	<0.001	6074	15.0	(14.6 - 15.3)	<0.001
Primary	428	17.1	(15.6 - 18.6)		2112	12.6	(12.1 - 13.1)	
Secondary	1537	14.9	(14.2 - 15.6)		4695	9.0	(8.7 - 9.2)	
Higher	384	18.5	(16.8 - 20.1)		696	7.4	(6.9 - 7.9)	
Currently Working								
Yes	2395	18.3	(8.6 - 10.4)	<0.001	637	12.0	(11.1 - 12.9)	<0.001
No	408	9.5	(17.6 - 18.9)		1557	10.4	(9.9 - 10.9)	
Wealth index								
Poorest	424	12.2	(11.1 - 13.3)	<0.001	2745	9.7	(9.4 - 10.1)	<0.001
Poorer	573	12.9	(11.9 - 13.9)		3130	10.8	(10.4 - 11.1)	
Middle	704	17.1	(15.9 - 18.2)		2973	11.2	(10.8 - 11.6)	
Richer	633	19.8	(18.4 - 21.2)		2747	13.2	(12.7 - 13.6)	
Richest	469	21.6	(19.8 - 23.3)		1982	13.9	(13.3 - 14.4)	
Body mass index								
Underweight	302	12.5	(11.2 - 13.9)	<0.001	1505	6.4	(6.1 - 6.7)	<0.001
Normal	1234	15.5	(14.7 - 16.3)		5386	8.6	(8.4 - 8.8)	
Overweight	356	17.1	(15.5 - 18.7)		2114	15.0	(14.5 - 15.6)	
Obese	650	20.2	(18.8 - 21.6)		4548	24.7	(24.0 - 25.3)	
Tobacco use								
No	1229	14.3	(13.6 - 15.1)	<0.001	11930	11.0	(10.8 - 11.2)	<0.001
Smoking	567	19.3	(17.9 - 20.8)		262	15.1	(13.4 - 16.8)	
Smokeless	658	17.1	(15.9 - 18.3)		1340	16.0	(15.3 - 16.8)	
Both forms	349	17.0	(15.4 - 18.7)		45	16.7	(12.2 - 21.2)	
Alcohol consumption								
Never drinks	1474	13.4	(12.8 - 14.1)	<0.001	13305	11.3	(11.1 - 11.5)	<0.001
Almost every day	267	31.2	(28.1 - 34.3)		39	22.9	(16.6 - 29.3)	
About once a week	564	21.3	(19.7 - 22.8)		98	24.1	(19.9 - 28.3)	
Less than once a week	498	17.0	(15.6 - 18.3)		135	21.2	(18.0 - 24.4)	
Dietary pattern								
Vegetarian	465	14.4	(13.2 - 15.6)	0.003	3657	10.9	(10.5 - 11.2)	<0.001
Nonvegetarian	2338	16.5	(15.9 - 17.1)		9920	11.6	(11.4 - 11.8)	
Frequency of fried food intake								
Daily	268	16.4	(14.6 - 18.2)	0.709	1460	13.6	(13.0 - 14.3)	<0.001
Less than daily	2535	16.1	(15.5 - 16.6)		12117	11.2	(11.0 - 11.4)	

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Table 5. Factors associated with hypertension among respondents obtained from Binary Logistic Regression

Characteristics	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age in Years				
15-19	1 (ref)		1 (ref)	
20-29	1.931 (1.795 - 2.077)	<0.001	2.042 (1.731 - 2.408)	<0.001
30-39	4.377 (4.079 - 4.696)	<0.001	4.229 (3.525 - 5.074)	<0.001
40-49	8.254 (7.699 - 8.850)	<0.001	6.659 (5.531 - 8.017)	<0.001
Gender				
Men	1.490 (1.425 -1.558)	<0.001	1.476 (1.343 - 1.623)	<0.001
Women	1 (ref)		1 (ref)	
Place of residence				
Urban	1.152 (1.111- 1.195)	<0.001	0.986 (0.911 - 1.066)	0.721
Rural	1 (ref)		1 (ref)	
Marital status				
Never married	1 (ref)		1 (ref)	
Married	2.996 (2.848 - 3.152)	<0.001	1.153 (1.017 - 1.306)	0.026
Widowed/Divorced/Separated	4.141 (3.806 - 4.504)	<0.001	1.227 (0.992 - 1.517)	0.060
Educational level				
No education	1 (ref)		1 (ref)	
Primary	0.853 (0.812 - 0.896)	<0.001	0.950 (0.856 - 1.054)	0.330
Secondary	0.619 (0.596 - 0.642)	<0.001	0.951 (0.871 - 1.038)	0.260
Higher	0.582 (0.543 - 0.623)	<0.001	0.933 (0.813 - 1.071)	0.325
Currently Working				
Yes	1.737 (1.635 - 1.846)	<0.001	1.056 (0.974 - 1.146)	0.188
No	1 (ref)		1 (ref)	
Wealth index				
Poorest	1 (ref)		1 (ref)	
Poorer	1.120 (1.065 - 1.180)	<0.001	1.101 (0.991 - 1.222)	0.072
Middle	1.228 (1.168 - 1.291)	<0.001	1.335 (1.200 - 1.485)	<0.001
Richer	1.474 (1.400 - 1.552)	<0.001	1.541 (1.372 - 1.732)	<0.001
Richest	1.574 (1.488 - 1.666)	<0.001	1.519 (1.325 - 1.742)	<0.001
Body mass index				
Underweight	1 (ref)		1 (ref)	
Normal	1.386 (1.313 - 1.463)	<0.001	1.203 (1.085 - 1.333)	<0.001
Overweight	2.425 (2.274 - 2.586)	<0.001	1.503 (1.326 - 1.705)	<0.001
Obese	4.234 (3.999 - 4.483)	<0.001	2.089 (1.862 - 2.345)	<0.001
Tobacco use				
No	1 (ref)		1 (ref)	
Smoking	1.709 (1.582 - 1.846)	<0.001	1.175 (1.012 - 1.365)	0.034
Smokeless	1.549 (1.471 - 1.630)	<0.001	1.086 (0.927 - 1.271)	0.309
Smoking and Smokeless	1.616 (1.448 - 1.804)	<0.001	1.270 (1.093 - 1.476)	0.002
Alcohol consumption				
Never drinks	1 (ref)		1 (ref)	
Almost every day	3.282 (2.868 - 3.756)	<0.001	2.030 (1.709 - 2.412)	<0.001
About once a week	2.128 (1.949 - 2.323)	<0.001	1.318 (1.167 - 1.489)	<0.001
Less than once a week	1.659 (1.520 - 1.811)	<0.001	1.204 (1.067 - 1.358)	0.003
Dietary pattern				
Vegetarian	0.896 (0.863 - 0.930)	<0.001	0.912 (0.841 - 0.990)	0.027
Nonvegetarian	1 (ref)		1 (ref)	
Frequency of fried food intake				
Daily	1.214 (1.150 - 1.280)	<0.001	1.166 (1.046 - 1.301)	0.006
Less than daily	1 (ref)		1 (ref)	

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5. Discussion

The overall sex-adjusted prevalence of hypertension among the tribal populations aged 15 to 49 years of India in the current study was estimated at 13.9%. This seems to be higher compared to 11.3% of individuals with hypertension in the general population of the same age group reported by Ghosh S and Kumar M [20] in their study on similar NFHS 4 data. They also depicted a lower prevalence of 14.2% in men and 10.0% in women in the general population in contrast to our study in which 16.1% of tribal men and 11.4% of tribal women had hypertension. A systematic review by Rizwan SA et al stated a prevalence of 16.1% in a pooled estimate of 64674 subjects from 53 tribal subpopulations of India. [13]

The higher prevalence of hypertension among tribal populations compared to the general population may be attributed to ethnic differences between the two, as reported in a study on the 2014 Demographic and Health Survey of Ghana, in which the prevalence of hypertension varied between 4.3% and 12.6% across various ethnic groups. [21] Another factor that may be responsible for this difference may be the higher substance abuse among tribal populations compared to the general population. [22] In addition, changes in the lifestyle, including dietary factors and modernization, have also been adopted by tribal populations that may further add to the increased prevalence of hypertension and other lifestyle diseases among them as reported in a study by Sathiyanarayanan S et al. [23]

Increasing age is an established risk factor for hypertension. [24] We also observed age to be independently associated with hypertension, and with increasing age, we observed a progressive rise in the hypertension prevalence. In a study by the National Nutrition Monitoring Bureau among 47401 individuals of tribes from nine Indian states, increasing age exhibited a significant upsurge in the prevalence of hypertension. [25] Similar findings have been reported in other studies carried out among tribals from Kerala, [26] Maharashtra, [27] Madhya Pradesh, [28,29] Himachal Pradesh, [30] and Uttarakhand. [31]

We observed a significantly higher prevalence of hypertension among men in contrast to women. Many studies carried out among tribal populations have also reported gender to be independently associated with hypertension and also found increased hypertension prevalence rates among males compared to females. [28,30,31] The prevalence of hypertension has been consistently found to be elevated in men as opposed to women in literature, [32,33,34] which may be related to hormonal differences among them. [34]

The burden of hypertension was found to be higher in urban areas compared to rural areas. Similar findings were reported by Ghosh S and Kumar M in a study on NFHS 4 data among the general population aged 15 – 49 years across India. [20] A good deal of evidence suggests that people showing extensive urbanization are at a higher risk of developing hypertension and cardiovascular diseases. [35,36,37]

The prevalence of hypertension was more among individuals with no education than those with primary and secondary level education. Comparable findings were reported in a study on tribals from Madhya Pradesh, [28] and another study on NFHS data carried out among the general population across India. [20] This may be attributed to low awareness of hypertension among individuals with lower educational status as reported by Gupta R et al in their study and subsequently not taking preventive measures for hypertension. [38]

In the present study, hypertension and the economic status of the individuals were found to have a significant association. The hypertension prevalence was lowest in people with the poorest wealth index and increased with the hike in their wealth index. Laxmaiah A et al. also reported a positive association between household wealth index and hypertension among tribals from nine Indian states. [25] Similar findings were reported by Ghosh S and Kumar M in their study. [20]

In the present study, hypertension was independently associated with tobacco use and the same observation was reported in a multi-state study on tribal populations by Laxmaiah A et al. [25] However, we did not observe any association between smokeless tobacco use and hypertension. Similarly, Chakma T et al, [28] in a study on tribal populations, also reported tobacco smoking to be associated with hypertension, but could not find any association between smokeless tobacco use and hypertension. Alcohol consumption was also found to be independently associated with hypertension in the current study which has also been reported in many

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studies carried out among different tribal populations. [25,26,29]

In our study, the body mass index was independently associated with hypertension, and with the increase in the body mass index of individuals, the prevalence of hypertension depicted a significant rise. Obese individuals had the highest prevalence of hypertension whereas, those who were underweight had the least prevalence. The association of high BMI with an increased risk of hypertension among tribals has been consistently reported in the literature. [25,27,28,30]

We observed a substantial proportion of tribals to be overweight and obese in our study which may result in a surge of non-communicable diseases burden among them. [39] The rising prevalence of lifestyle diseases among tribal populations of India has been reported by Sathiyanarayanan S et al in a recent study. [23] This is a point of concern as the majority of the tribal populations in India are marginalized, and healthcare infrastructure and services are not optimal to address the increasing burden of non–communicable diseases among them.

Dietary pattern and frequency of fried food intake were also independently associated with hypertension. The prevalence of hypertension was significantly lower in individuals who were vegetarian compared to those who were nonvegetarian which has also been reported in a recent meta-analysis. [40] Also, daily intake of fried foods was significantly associated with higher prevalence of hypertension compared to less frequent intake. Many studies have observed a significant association between high fried food intake and high prevalence of hypertension. [41,42,43]

As per the Census 2011 of India and the Ministry of Tribal Affairs of India, no scheduled tribes reside in some States and Union Territories of India including Punjab, Haryana, Delhi, Chandigarh, and Puducherry. [12,16] However, as evident from NFHS 4 data a considerable number of tribals have been included in the survey from all these 5 States and Union Territories. It is not clear whether these tribes have migrated to these areas or they have not been listed either in the census 2011 or the Gazette of India.

This study has several noteworthy strengths. Most importantly, it estimates the burden of hypertension at the state level, thereby accounting for ethnic, cultural, dietary, and other variations across Indian states. The large sample size strengthens the reliability of the estimates, and the use of logistic regression analysis offers valuable insights into the factors associated with hypertension and the magnitude of these associations among tribal populations.

However, certain limitations must be acknowledged. The sample is skewed toward women, who constituted nearly 87% of the study population, and the findings are restricted to individuals aged 15–49 years, limiting their applicability to the overall tribal population, particularly older adults who carry a higher risk of hypertension. Furthermore, the dataset lacked information on salt intake and physical activity—two important determinants of hypertension—which could not be assessed.

6. Conclusion

Hypertension is a major health problem among the tribal populations. The current burden of hypertension seems to be higher among tribals in comparison to the general population, which may be the reflection of ethnic differences, lack of access to healthcare and higher prevalence of certain risk factors like substance abuse among them. Increasing age seems to be the most significant and consistently reported factor associated with hypertension. Interventions directed towards modifiable risk factors like tobacco use, alcohol consumption, increasing body mass index and high fat intake may be the key to the prevention and control of hypertension among tribal populations of India besides making healthcare more accessible to them.

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