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Hypertension Prevalence, Awareness, Treatment, Control and Risk Factors in Tribal Population of India: a Multi-Centric Cross-Sectional Study

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Abstract

The prevalence of hypertension is increasing in the tribal population of India. Lifestyle modifications, including dietary changes and acculturation, are the main reasons for the high prevalence of hypertension among the Indian indigenous (tribal) population. This paper reports hypertension prevalence, awareness, treatment, control and risk factors among tribes in five districts of different geographical zones of India. A cross-sectional study was conducted among the adult tribal population of 7590 from these states. Data related to blood pressure, anthropometry, demographic and behavioural variables were collected with prior consent from the participants. The prevalence of hypertension is 34.0% and 28.3% among men and women, respectively. Of the total hypertensives, 27.5% were aware of their hypertension status; of them, 83.9% were receiving treatment, and blood pressure was in control among 33.5% of patients who were receiving treatment. Age, alcohol intake, sedentary lifestyle, Particularly Vulnerable Tribal Groups status and body mass index are found to be significantly associated with the prevalence of hypertension. The prevalence of hypertension is high among these tribal populations, which could be due to modernization and acculturation. Awareness and treatment-seeking behaviour are poor. Hence, early screening, awareness campaigns for seeking treatment, and health promotion are immediately required. Comprehensive health promotion programs need to promote lifestyle modification and re-orientation of the primary health care system to improve availability and accessibility to hypertension screening and treatment.

Keywords Hypertension · Prevalence · Indigenous · Tribal · Risk factors · India

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Introduction

Hypertension represents a significant health concern and places a substantial burden on both India's cardiovascular health and its healthcare system [1]. The World Health Organization (WHO) estimates that 1.28 billion adults aged 30–79 years worldwide have hypertension. Amongst these, 46% of adults with hypertension are unaware of their condition, 42% are diagnosed and treated, and 21% are under control [1]. Most hypertensives are unaware of their condition because it may not have warning signs or symptoms. For this reason, blood pressure must be measured regularly [2]. Different factors, like social detriments, are responsible for increasing the prevalence of hypertension in the background of rapid transition of lifestyle practices, rapid urbanization and social development in developing countries like India [3]. Among the key determinants, age and gender are important non-modifiable risk factors and are

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also responsible for increasing hypertension prevalence [4]. Besides, educational attainment, economic changes, place of residence, and healthcare for hypertension are the potential predictors of diagnosis [5]. Further, a higher body mass index (BMI), alcohol consumption, changed dietary practices, and reduced physical activity are important contributing factors to the higher prevalence of hypertension in India [5]. A recent large nationwide study reported the prevalence of hypertension as 26.3% [6]. The prevalence of hypertension has increased drastically in India and its states in a few decades [7]. Further, there is a dearth of research in India on hypertension using data to identify high-risk and vulnerable groups.

Globally, there are approximately 476 million indigenous peoples residing in over 90 countries. Despite constituting a mere 5% of the world's population, they account for roughly 15% of those living in extreme poverty [8]. While these indigenous communities encompass distinct cultural groups, they are inevitably exposed to modernization and undergo processes of acculturation. In India, a significant population of 104.3 million indigenous individuals comprises 8.6% of the total Indian populace. These communities exhibit extraordinary diversity in terms of culture, ethnicity, geography, language, developmental levels, and acculturation experiences. Although the Indian government does not officially recognize them as 'indigenous' people, the Constitution of India bestows upon them special privileges and rights. Officially termed 'scheduled tribes,' they will be referred to as tribes in this paper. The Indian government has identified and enlisted 705 tribes, with 75 of them classified as Particularly Vulnerable Tribal Groups (PVTGs). The criteria for designating a tribe as a PVTG include (i) maintaining a pre-agricultural level of technology, (ii) possessing a low literacy rate, (iii) enduring economic backwardness, and (iv) experiencing a declining or stagnant population. PVTGs are among the most vulnerable segments of the tribal population. Often, the tribal population resides in remote forested areas and hilly terrains. However, a substantial proportion of tribal communities have been displaced, and some have migrated to urban and non-tribal rural areas for various reasons. More than 40% of the tribal population in India lives below the poverty line, placing them at the lowest rung of the socio-economic development and political empowerment ladder. Given their disadvantaged socio-economic and political status, it is expected that tribal communities would exhibit poorer health outcomes compared to the rest of the Indian population. Indeed, health data reveal that the health status and health-seeking behaviour of India's tribal population are subpar [9, 10].

There are no large-scale studies or estimates on the prevalence of hypertension among the tribal population in India, except for a few micro-studies [11, 12]. A recently estimated prevalence of hypertension among the tribal population in India, through a meta-analysis, is 16.7% [12]. Though studies are not available from all geographies and tribes of India, regional variations are reported in this review. The most striking observation reported by these reviews is that the prevalence of hypertension among the tribal population has been increasing in recent years [11, 12]. As the prevalence of hypertension is increasing among the tribal population, the Indian Council of Medical Research undertook implementation research among the tribal population of six districts of India. The present paper reports the prevalence of hypertension in five districts of India among tribes, as the data from one district is incomplete. This survey is a part of the formative phase, undertaken before implementation research to strengthen the selected non-communicable diseases (NCDs) screening and management among the tribal population in India.

Methods

Study area

This study is conducted in five districts located across the country (Fig. 1). Following is a brief description of the study sites.

1. **Chamba district**: This district of Himachal Pradesh is located in the northernmost part of India. It is predominantly inhabited by the Gaddi tribe. Agriculture is the primary source of livelihood. Tribes constitute 26.1% of the district population.
2. **Chamarajanagar district**: Chamarajanagar district is in Karnataka, a southern state of India. 11.8% are tribal people in this district. Gond and Nayaka are the two dominant tribes of this district.
3. **Kargil District**: Kargil district is in Ladakh, a union territory located in the extreme north of India. It is dominated by Puriga and Balti tribes, which are of Tibetan origin. Tribal constitutes 86.9% of the total population.
4. **East Khasi Hills**: This district is in Meghalaya, one of the Northeastern states of India. It is predominantly inhabited by the Khasi tribe, who are agriculturists. Khasi is a matrilineal society and follows the traditional way of life. Tribal population constitutes 80% of the total population.
5. **Sundargarh district**: Sundargarh district is in Odisha, an eastern state of India. The main tribes in the district are Oraon, Munda, Kisan, Khadia, and Bhuyan. The tribal population constitutes 50.7% of the district population.

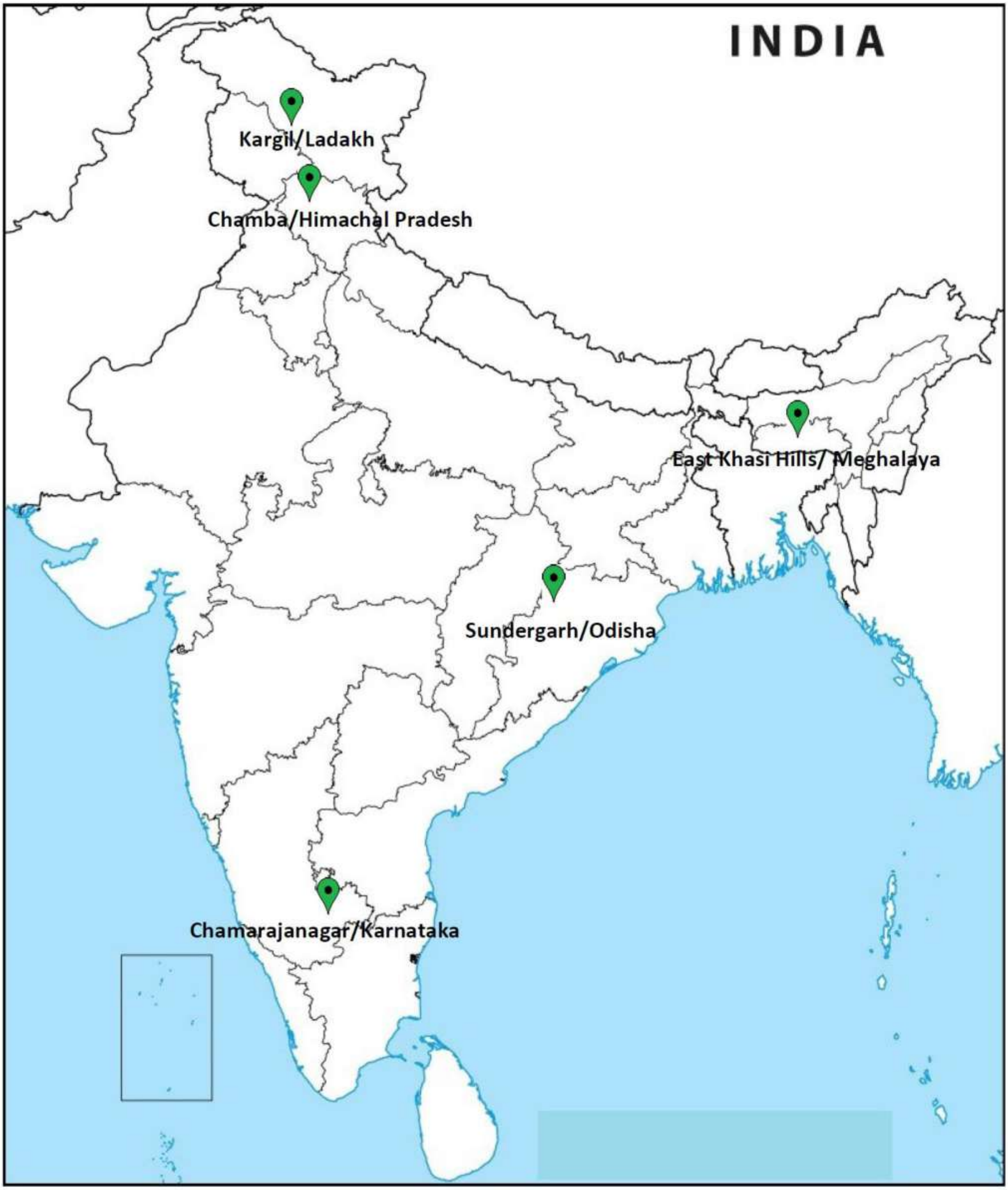

Fig. 1 Map showing the study sites

Study design, characteristics of study participants and information collection

This study is based on primary data collected from June 2020 to July 2021. For this cross-sectional study, a cluster random sampling method was used. The required sample size would be calculated according to the formula $n = \frac{\left\{Z_{1-\alpha/2}2\sqrt{2\overline{p}(1-\overline{p})}+Z_{1-\beta}\sqrt{[p_1(1-p_1)]+[p_2(1-p_2)]}\right\}^2}{(p_1-p_2)^2}$ of Lwanga & Lemeshow, [13] by considering the prevalence of utilization of government healthcare service (p) of 27.5% calculated for the tribal population using all India data of the second India Human Development Survey) [14]. As this study is implementation research to improve the utilization of government healthcare for selected NCDs management, the above indicator was considered for sample size calculation. With 95% confidence and with 80% of power, the sample size would be 343 for each arm. Considering the design effect of 2.0, as cluster sampling is adopted, the sample size would be 686 for each arm. By considering 10% of the non-response rate, the sample size for each arm would be 755 per arm. The sample would be 1510 per site for implementation and control arms. For each district, 4 PHCs were selected, and from each PHC area, 377.5 households were to be sampled. These households were sampled from PHC village, health sub-centre village, and no health facility villages. Thus, a total of 7590 participants were included from the selected five states. The inclusion criteria were healthy adults and those who belonged to tribal communities. Participants who were unwilling to participate and people suffering from acute or chronic illnesses during the time of the survey were not included in the survey, and participants with incomplete data were excluded during the analysis.

Ethical considerations

Ethical clearance was approved by the institutional ethical committees (IECs) of the respective author's (SKR, YCB, SRM, NT, ASK) institutions, and each of the five IECs approved the study protocol for the corresponding district. Participants were informed about the purpose of the study, and their consent was obtained.

Blood pressure measurement and diagnostic criteria

Blood pressure was taken by trained nurses using an automated sphygmomanometer with an appropriate-sized cuff [15]. Two readings in a sitting position were taken from all the participants with the arm supported at the heart level and with feet on the floor after 15 min of resting. For participants who had eaten, smoked or consumed alcohol, blood pressure (BP) readings were performed after allowing them to rest for 1 h. The average of the two readings was taken during the analysis. In addition to blood pressure, height, weight, waist and hip circumferences were measured by standard procedures [16]. The diagnosis and staging of hypertension were based on the criteria of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-8) [17]. The participants with systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg were classified as having hypertension [17]. The diagnosis of hypertension was made either by blood pressure measurement or by self-reported hypertension. Based on the anthropometric measurements, BMI (underweight, normal, overweight, and obese) and waist-hip circumference were calculated. Information on other variables, namely, smoking (active/passive), alcohol intake (active/passive), extra salt intake (yes/no), vigorous-intensity activity (yes/no), sedentary lifestyle (not involved/involved), and Particularly Vulnerable Tribal Groups (PVTGs) (yes/no) were collected through a structured questionnaire. The PVTGs are characterized by pre-agricultural subsistence systems, including hunting and gathering, no or negative population growth, and very low literacy rates, and were identified through the list available [18].

Data processing and statistical method

After computerising the data, it was cleaned for unqualified data before analysis. We used SPSS V. 26 to analyze the data. The continuous variables were summarised as mean ± standard deviation (SD), while the categorical variables were summarised as count (n) with percentage (%). The prevalence was shown with a 95% confidence interval (CI). Multinomial logistic analysis was conducted to find the association of age, tobacco consumption, alcohol consumption, and extra salt intake with pre-hypertension and hypertension. This was run by a backward stepwise elimination procedure with a *p*-value of > 0.10 to exit. During this process, only the independent variables with a univariate association of $p < 0.25$ with the dependent variables were included [19].

Results

Table 1 presents the socio-demographic and lifestyle variables of the study participants. Of the total, 64.0% are females, 24.2% are in the age group 35–44 years and 12.3% are of 65 + years. About 28% are overweight and obese, and 12.4% are underweight. A high waist-hip ratio is seen among 82.9%. About 12% of participants reported tobacco smoking

Table 1 Socio-demographic and lifestyle variables of the study sample

	Himachal Pradesh (n = 1521) %	Karnataka (n = 1464) %	Ladakh (n = 1610) %	Meghalaya (n = 1519) %	Odisha (n = 1476) %	Total (n = 7590) %
Gender						
Male	24.1	19.3	60.0	30.0	44.8	36.0
Female	75.9	80.7	40.0	70.0	55.2	64.0
Age (in years)						
18–24	3.41	17.5	0.7	5.9	7.05	6.7
25–34	22.6	27.3	6.3	22.1	21.7	19.8
35–44	27.1	22.3	20.1	24.8	27.2	24.2
45–54	22.8	12.3	27.3	19.7	19.4	20.5
55–64	14.5	11.3	25.3	15.0	15.5	16.5
65 +	9.6	9.43	20.2	12.6	9.01	12.3
Body mass index						
Underweight	7.4	33.1	5.2	6.7	11.0	12.4
Normal	48.5	51.5	57.3	71.8	70.5	59.9
Overweight	36.9	12.8	29.4	18.5	15.1	22.7
Obese	7.23	2.60	8.2	3.0	3.5	5.0
Waist hip ratio						
Low	18.9	23.6	0	5.8	0	9.5
Moderate	15.1	19.1	0	4.3	0	7.6
High	66.1	57.2	100.0	89.9	100.0	82.9
Tobacco smoking						
Smokers	13.1	10.8	8.1	25.9	3.0	12.2
Non-smokers	86.9	89.2	91.9	74.1	97.0	87.8
Alcohol intake						
Alcoholic	12.2	2.4	0	98.7	28.9	28.3
Non-alcoholic	87.8	97.6	100.0	1.3	71.1	71.7
Extra salt intake						
Yes	25.0	0.4	4.8	61.5	47.4	27.6
No	75.0	99.6	95.2	38.5	52.6	72.4
Vigorous physical activity						
Yes	4.14	30.1	20.7	21.7	13.0	17.9
No	95.9	69.9	79.3	78.3	87.0	82.1
Sedentary lifestyle						
Yes	41.9	26.3	66.9	82.2	21.4	48.3
No	58.1	73.7	33.1	17.8	78.6	51.7
Particularly vulnerable tribal group						
Yes	0	6.1	0	0	29.5	6.9
No	100.0	93.9	100.0	100.0	70.5	93.1

and 28.3% reported alcohol intake. However, none of the participants from Ladakh reported alcohol intake. This can be attributed to cultural factors, as the Muslim population of the Ladakh region abstains from alcohol consumption, and all participants from Ladakh are Muslim. Consumption of extra salt was reported by 27.6% of the participants. No vigorous physical activity is found among 82.1% and 48.3% of the participants reported sedentary lifestyle. Of the total study participants, only 6.9% are from PVTGs from Karnataka and Odisha states.

Table 2 presents the prevalence of hypertension at the time of the survey. The total prevalence of hypertension is 30.3% (95% CI: 29.31–31.39). Prevalence among men (34% (95% CI: 32.28–35.87)) is higher than among women (28.3% (95% CI: 26.99–29.55)). Among the five sites, Jammu and Kashmir (38.8% (95% CI: 36.37–41.19)) reported the highest prevalence, while Meghalaya reported (21.3% (95% CI: 19.29–23.48)) the lowest prevalence of hypertension. The total prevalence of self-reported and under-control is 2.3% (95% CI: 2.02–2.71). Of the total participants, 46.5%

Table 2 Prevalence of hypertension, self-reported hypertension and treatment with 95% confidence intervals

Study area/Gender	Hypertension prevalence by measurement at the time of survey					Self-reported and under control % (95% CI)	Total prevalence % (95% CI)
	Total sample	Normal % (95% CI)	Pre-hypertension % (95% CI)	Stage-1 Hypertension % (95% CI)	Stage-II Hypertension % (95% CI)		
Chamba district, Himachal Pradesh							
Male	367	16.6% (12.96–20.83)	41.4% (36.33–46.64)	24.5% (20.21–29.26)	17.4% (13.70–21.72)	0.54% (0.07–1.95)	42.5% (37.39–47.74)
Female	1154	31.2% (28.53–33.96)	37.3% (34.46–40.12)	21.0% (18.65–23.44)	10.6% (8.86–12.49)	0.78% (0.36–1.48)	32.3% (29.63–35.11)
Total	1521	27.7% (25.44–30.00)	38.3% (35.81–40.76)	21.8% (19.78–23.99)	12.2% (10.62–13.98)	0.72% (0.36–1.29)	34.8% (32.38–37.23)
Chamarajanagar district, Karnataka							
Male	282	27.6% (22.52–33.27)	39.4% (33.62–45.33)	20.9% (16.33–26.14)	12.0% (8.50–16.44)	0.7% (0.09–2.54)	33.7% (28.19–39.53)
Female	1182	52.0% (49.14–54.91)	29.8% (27.18–32.48)	12.6% (10.77–14.63)	5.6% (4.34–7.05)	0.4% (0.14–0.98)	18.6% (16.43–20.95)
Total	1464	47.3% (44.75–49.93)	31.6% (29.25–34.08)	14.2% (12.46–16.10)	6.8% (5.59–8.25)	0.5% (0.19–0.98)	21.5% (19.44–23.71)
Kargil district, Ladakh							
Male	966	51.0% (47.83–54.23)	19.6% (17.11–22.21)	18.7% (16.32–21.34)	10.7% (8.79–12.78)	3.9% (2.80–5.36)	33.3% (30.36–36.41)
Female	644	52.0% (48.08–55.94)	9.8% (7.60–12.34)	25.3% (21.99–28.85)	12.9% (10.40–15.72)	8.7% (6.64–11.14)	46.9% (42.98–50.83)
Total	1610	51.4% (48.96–53.90)	15.6% (13.91–17.52)	21.4% (19.39–23.45)	11.5% (10.03–13.22)	5.8% (4.74–7.10)	38.8% (36.37–41.19)
East Khasi Hills, Meghalaya							
Male	455	71.0% (66.58–75.12)	9.0% (6. 54–12.03)	15.6% (12.39–19.27)	4.4% (2.71–6.71)	1.8% (0.76–3.44)	21.8% (18.05–25.84)
Female	1064	75.1% (72.38–77.67)	6.4% (5.00–8.03)	14.5% (12.41–16.73)	4.0% (2.94–5.41)	2.6% (1.76–3.78)	21.1% (18.73–23.73)
Total	1519	73.9% (71.58–76.06)	7.2% (5.93–8.59)	14.8% (13.06–16.70)	4.1% (3.20–5.28)	2.4% (1.67–3.27)	21.3% (19.29–23.48)
Sundargarh district, Odisha							
Male	661	24.2% (20.99–27.66)	38.9% (35.15–42.71)	24.7% (21.42–28.13)	12.2% (9.85–15.00)	2.1% (1.16–3.53)	39.0% (35.29–42.87)
Female	815	37.7% (34.33–41.10)	33.2% (30.02–36.60)	19.9% (17.19–22.79)	9.2% (7.31–11.40)	1.9% (1.13–3.17)	31.0% (27.88–34.35)
Total	1476	31.6% (29.27–34.08)	35.8% (33.32–38.28)	22.0% (19.93–24.22)	10.6% (9.05–12.25)	2.0% (1.38–2.89)	34.6% (32.19–37.11)
All sites							
Male	2731	40.8% (38.98–42.70)	27.5% (25.8–29.18)	20.7% (19.15–22.22)	11.1% (9.91–12.29)	2.3% (1.81–2.98)	34.0% (32.28–35.87)
Female	4859	49.7% (48.31–51.14)	24.4% (23.17–25.60)	17.9% (16.84–19.01)	8.0% (7.26–8.80)	2.3% (1.94–2.81)	28.3% (26.99–29.55)
Total	7590	46.5% (45.39–47.65)	25.5% (24.50–26.48)	18.9% (18.02–19.79)	9.1% (8.47–9.77)	2.3% (2.02–2.71)	30.3% (29.31–31.39)

CI Confidence interval

(95% CI: 45.39–47.65) are normal, and 25.5% (95% CI: 24.50–26.48) are pre-hypertensive.

Data on awareness, treatment and control of blood pressure are presented in Table 3. Of the total hypertensives, only 27.5% (95% CI: 25.67–29.36) are aware of their condition. Of the hypertensive who are aware of their condition, 83.9% (95% CI: 80.79–86.67) are under treatment, and of those under treatment, only 33.5% (95% CI: 29.51–37.71) are found to be under control.

Table 4 presents the prevalence of hypertension by related factors, namely, gender ($p < 0.000$), age ($p < 0.000$), waist circumference ($p < 0.000$), BMI ($p < 0.000$), hip circumference

Table 3 Hypertension prevalence, awareness, treatment, and control

Gender	Total sample	Prevalence (including self-reported) % (95% CI)	Awareness % (95% CI) to those who are hypertensive	Treatment % (95% CI) to those aware of their hypertension status	Control % (95% CI) to those hypertensives under treatment
Chamba district, Himachal Pradesh					
Male	367	42.5% (37.39–47.74)	5.8% (2.67–10.67)	100%	22.2% (2.81–60.01)
Female	1154	32.3% (29.63–35.11)	8.0% (5.49–11.28)	30% (14.73–49.40)	100%
Total	1521	34.8% (32.38–37.23)	7.4% (5.29–9.94)	100%	28.2% (15.00–44.87)
Chamarajanagar district, Karnataka					
Male	282	33.7% (28.19–39.53)	9.5% (4.42–17.22)	100%	22.2% (2.81–60.01)
Female	1182	18.6% (16.43–20.95)	9.5% (6.01–14.22)	76.2% (52.83–91.78)	31.2% (11.02–58.66)
Total	1464	21.5% (19.44–23.71)	9.5% (6.52–13.32)	83.3% (65.28–94.36)	28% (12.07–49.39)
Kargil district, Ladakh					
Male	966	33.3% (30.36–36.41)	48.8% (43.18–54.36)	79% (71.77–85.07)	30.6% (22.68–39.56)
Female	644	46.9% (42.98–50.83)	64.2% (58.55–69.65)	82.5% (76.38–87.55)	35% (27.64–42.93)
Total	1610	38.8% (36.37–41.19)	56.2% (52.26–60.19)	80.9% (76.40–84.89)	33.1% (27.65–38.90)
East Khasi Hills, Meghalaya					
Male	455	21.8% (18.05–25.84)	34.3% (25.09–44.56)	97.1% (84.67–99.93)	24.2% (11.09–42.26)
Female	1064	21.1% (18.73–23.73)	42.7% (36.12–49.41)	98.9% (94.33–99.97)	29.5% (20.56–39.71)
Total	1519	21.3% (19.29–23.48)	40.1% (34.74–45.69)	98.5% (94.55–99.81)	28.1% (20.54–36.75)
Sundargarh district, Odisha					
Male	661	39.0% (35.29–42.87)	12.8% (8.97–17.49)	90.9% (75.67–98.08)	46.7% (28.34–65.67)
Female	815	31.0% (27.88–34.35)	19.8% (15.04–25.21)	92% (80.77–97.78)	34.8% (21.35–50.25)
Total	1476	34.6% (32.19–37.11)	16.2% (13.15–19.73)	91.6% (83.39–96.54)	39.5% (28.44–51.35)
All sites					
Male	2731	34.0% (32.28–35.87)	26.0% (23.23–28.97)	84.7% (79.55–89.00)	31.2% (24.95–38.05)
Female	4859	28.3% (26.99–29.55)	28.5% (26.10–30.95)	83.4% (79.31–86.93)	34.9% (29.80–40.42)
Total	7590	30.3% (29.31–31.39)	27.5% (25.67–29.36)	83.9% (80.79–86.67)	33.5% (29.51–37.71)

CI Confidence interval

($p<0.05$), tobacco ($p=0.05$) and alcohol intakes ($p<0.000$), extra salt intake ($p<0.000$), and those involved in sedentary lifestyle ($p<0.000$), vigorous-intensity activity ($p<0.05$) and PVTGs ($p<0.000$). These univariate analyses reveal that males are more affected than females. Smoking, sedentary lifestyle, and PVTG status are the factors affecting hypertension. Table 5 presents multinomial logistic regressions to the predictors of pre-hypertension and hypertension. Gender, age, waist and hip circumferences, BMI, alcohol intake, sedentary lifestyle and PVTG status have emerged as significant predictors of both pre-hypertension and hypertension. Lack of intensive physical activity was also found to be a predictor of hypertension.

Table 4 Stages of hypertension in the population according to associated factors

Variable	Normal ($n=3531$)	Pre-hypertension ($n=1934$)	Stage 1 ($n=1434$)	Stage 2 ($n=691$)	Total hypertensives ($n=2125$)	Statistics
Prevalence of hypertension categories by gender (Male/Female)	40.8/49.7	27.5/24.4	20.7/17.9	11.1/8.0	31.7/25.9	$\chi^2=57.30$ $P=0.000$
Mean age (± SD in years) of participants of each stage of hypertension	32.2 ± 1.41	34.7 ± 1.40	41.3 ± 1.36	44.7 ± 1.23	42.4 ± 1.33	F = 256.55 $P=0.000$
Mean waist circumference (± SD in cms) of participants of each stage of hypertension	76.4 ± 11.8	79.6 ± 10.5	82.4 ± 11.3	82.9 ± 11.2	82.6 ± 11.3	F = 135.70 $P=0.000$
Mean BMI (± SD in kg/m^2) of participants of each stage of hypertension	22.4 ± 3.80	22.9 ± 4.18	23.9 ± 4.24	23.7 ± 4.16	23.7 ± 4.51	F = 58.71 $P=0.000$
Mean hip circumference (± SD in cms)	64.1 ± 24.1	66.5 ± 28.2	64.3 ± 28.3	63.5 ± 29.4	64.0 ± 28.6	F = 4.152 $P=0.006$
Prevalence of hypertension categories by tobacco smokers/non-smokers (%)	46.9/46.5	23.0/25.8	19.2/18.9	10.9/8.9	30.1/27.7	$\chi^2=6.409$ $P=0.093$
Prevalence of hypertension categories by alcoholics/non-alcoholics (%)	58.7/41.7	15.3/29.5	18.4/19.1	7.5/9.7	26.0/28.8	$\chi^2=225.42$ $P=0.000$
Prevalence of hypertension categories by people take extra salt in meals/not (%)	52.1/44.4	23.2/26.4	17.1/19.6	7.6/9.7	24.7/29.3	$\chi^2=38.10$ $P=0.000$
Prevalence of hypertension categories by people involved in vigorous intensity activity/not (%)	50.1/45.7	23.9/25.8	17.9/19.1	8.1/9.3	26.0/28.4	$\chi^2=8.92$ $P=0.030$
Prevalence of hypertension categories by people involved in sedentary lifestyle/not (%)	52.7/40.8	18.6/31.9	18.5/19.3	10.2/8.1	28.6/27.4	$\chi^2=197.34$ $P=0.000$
Prevalence of hypertension categories by PVTGs/other tribes (%)	28.8/47.8	35.0/24.8	24.8/18.5	11.4/8.9	36.2/27.4	$\chi^2=72.12$ $P=0.000$

SD Standard deviation; *BMI* Body mass index; *PVTG* Particularly vulnerable tribal groups

Table 5 Multinomial logistic regression results for determinants of pre-hypertension and hypertension

Variable	Pre-hypertension		Hypertension	
	β*	AOR (95% CI)	β*	AOR (95% CI)
Gender (reference: female vs male)	-0.480^{***}	0.619(0.535–0.716)	-0.201^{*}	0.818(0.709–0.944)
Age (years)	0.165^{***}	1.179(1.129–1.231)	0.521^{***}	1.684(1.611–1.760)
Waist circumference (cms)	0.018^{***}	1.018(1.011–1.024)	0.029^{***}	1.030(1.023–1.036)
Hip circumference	0.012^{***}	1.012(1.010–1.015)	0.008^{***}	1.008(1.005–1.010)
BMI (kg/m^2)	0.000^{***}	1.000(0.982–1.018)	0.038^{***}	1.039(1.021–1.057)
Tobacco (reference: non-smokers vs smokers)	0.042^{NS}	1.043(0.844–1.290)	-0.157^{NS}	0.855(0.697–1.048)
Alcohol (reference: non-alcoholics vs alcoholics)	0.937^{***}	2.551(2.169–3.001)	0.353^{***}	1.423(1.223–1.656)
Extra salt (reference: non-takers/takers)	-0.094^{NS}	0.910(0. 787–1.052)	0.070^{NS}	1.073(0.927–1.241)
Vigorous intensity activity (reference: not involved/involved)	0.161^{NS}	1.175(1.007–1.370)	0.208^{*}	1.231(1.054–1.438)
Sedentary lifestyle (reference: not involved/involved)	0.664^{***}	1.943(1.714–2.202)	0.352^{***}	1.422(1.256–1.610)
PVTG (reference: Other tribes vs PVTGs)	-0.986^{***}	0.373(0.293–0.474)	-1.172^{***}	0.310(0.242–0.396)

Significance level: $^{***}p<0.000$, $^{**}p<0.001$, $^{*}p<0.05$; *NS* Not significant, *AOR* Adjusted odds ratio, *CI* Confidence interval, *BMI* Body mass index, *PVTG* Particularly vulnerable tribal groups

Discussion

The present study reports a pooled prevalence of 30.3% among the tribal population of five districts of India. This prevalence is relatively higher. In addition, it reported the prediction of hypertension, including age, alcohol intake, sedentary lifestyle, PVTG status and BMI. High blood pressure is a major public health problem in developing countries and is one of the most important modifiable risk factors for cardiovascular diseases. As reported by the World Health Organization, hypertension is the third 'killer' disease, accounting for one in every eight deaths worldwide. Analysis showed that about 26% of the population globally suffers from hypertension. Prevalence increases with age, and the trend of age versus hypertension was highly significant in combined data (both men and women). To some extent, our findings align with the 'rule of halves,' a concept suggesting that approximately half of individuals with hypertension are aware of their condition, only about half of those who are aware receive treatment, and merely half of those under treatment achieve adequate blood pressure control [20]. Among all the participants diagnosed with hypertension, 27.5% were conscious of their hypertensive status, and a substantial 83.9% of them were currently receiving treatment. Notably, blood pressure was effectively controlled in 33.5% of patients undergoing treatment. However, it's important to note that the applicability of the 'rule of halves' to hypertension management has recently come under scrutiny. This challenge arises from the improvements in healthcare accessibility and heightened community awareness about hypertension, as observed in studies such as those conducted by Marques-Vidal & Tuomilehto [21], Maroof et al. [22], and Lerner et al. [23].

A few micro studies are available from the tribal population of India, and these studies reported a wide range of prevalence from less than 1% to 68%, with a pooled prevalence of 18.4% [12]. The review of these studies reported a higher prevalence of hypertension in the studies conducted after 2005 than before 2005. Over the years, the prevalence of hypertension is progressively increased [12]. It is attributed to the modernization/acculturation and consequent lifestyle and dietary changes among the Indian tribal populations [11, 12]. A study by Kusuma et al. carried out in the hilly tribal area of Andhra Pradesh reported a low hypertension prevalence in a primitive tribal group and a high prevalence in an acculturating tribal population, demonstrating acculturation could be a cause for increased blood pressure levels and increased hypertension prevalence [24]. Another study among the tribal population exposed to the urban environment in Odisha reported a high prevalence of hypertension, also attributed to modernization and acculturation [25]. In the present study, the participants from PVTGs reported lower hypertension prevalence than those from non-PVTGs. PVTGs are less developed and have less contact with urban or non-tribal communities. However, many tribal populations in India are exposed to modernization and, thereby, acculturation. Hence, the pooled prevalence of hypertension among Indian tribes is considerably high [12]. Thus, the current data and data from other studies on tribal populations reveal that these populations are no longer protected against hypertension. In hypertension research, tribal populations provide an interesting epidemiology perspective since studies world over in the twentieth century have shown that they have a lower prevalence [24, 26] and subsequently shown rising hypertension prevalence due to acculturation and modernization [12, 27]. Research conducted on Asian immigrants in Canada found that varying degrees of cultural adaptation are associated with distinct patterns in hypertension prevalence. Disparities in hypertension linked to acculturation status may stem from alterations in lifestyle changes and dietary habits [28, 29]. An investigation involving a diverse sample from the United States similarly indicated that both acculturation and place of birth are correlated with hypertension prevalence [30]. Nonetheless, the observed variations concerning acculturation exhibit distinct patterns across different racial/ethnic groups and genders [31]. In India, research conducted among both PVTGs and non-PVTGs offers insights into the impact of modernization and acculturation on the increasing levels of blood pressure. These associations highlight the societal nature of hypertension. It's worth noting that both acculturation and socioeconomic status are unchanging factors that provide an understanding of how social differences manifest as biological variations. These explanations are crucial for the development of disease aetiology models that encompass social elements [32].

There is a wide variation in socio-cultural, lifestyle, dietary patterns and substance use among tribes inhabiting different parts of India [33–35]. In the present tribal populations, we found that higher levels of BMI (25 kg/m^2 and above) are also significant predictors of hypertension, and this association is well-known [11, 36, 37]. Other modifiable lifestyle factors, such as consumption of tobacco and alcohol, habit of smoking, and sedentary lifestyle, also play an important role in increasing the risk of hypertension [20, 24–27, 33–43]. The current study populations have sedentary lifestyles and extra salt intake, which are risk factors for hypertension. Also, the prevalence of tobacco use and alcohol consumption are also higher among the study population, which may be the risk factor for the high prevalence of hypertension.

The Government of India is massively addressing NCDs, including hypertension, through Ayushman Bharat (AB), a national health protection scheme to attain Universal Health Coverage (UHC). Developing Comprehensive Primary Health Care (CPHC) through Health and Wellness Centres (HWCs) is a key component of AB [44]. One HWC is meant for about 3,000 population in tribal areas, against 4,000 population in non-tribal areas. Health promotion and information provision at the community level are integral to the expanded range of services under the CPHC of HWCs. The approach of providing a continuum of care for hypertension and other non-communicable diseases (NCDs) through Health and Wellness Centers (HWCs) encompasses several key steps. These steps include population enumeration, identification of populations at risk, screening, diagnostics, initiating treatment, and conducting follow-up care. The CPHC services include community-level health promotion and the provision of health-related information. Furthermore, the CPHC involves identifying individuals with chronic illnesses and organising regular patient group meetings at the HWCs. Additionally, the personnel at HWCs conduct outreach services and home visits as part of their commitment to the follow-up care of chronic illness patients [45]. Wellness interventions are also part of CPHC, and they include a few operational components, namely, healthy diet, physical activity, stress management, behavioural change, and management of substance use disorders. Health is affected by various social and environmental determinants, and actions to address these issues often do not fall in the purview of health systems alone and, therefore, require inter-sectoral convergence and people's participation. Other barriers to tribal healthcare access are poor quality of care, lack of medicines, diagnostics and medical equipment, dependency on unqualified practitioners, low level of awareness, distance and inaccessibility of the health facility, etc.

Further, the lack of awareness of the disease and poor healthcare-seeking practices complicate hypertension-related problems. The Indian government's National Programme for Prevention & Control of Non-Communicable Diseases (NP-NCD) aimed to promote health through behaviour change, early diagnosis through screening, case management, referral and strengthening of infrastructure and capacity building [46]. These issues are being addressed through CPHC. In this context, this study on the prevalence of hypertension among Indian tribal communities was conducted to understand the extent of the problem of hypertension and the risk factors of hypertension. However, their associations may be caused by the cross-sectional design of the study. In addition, we could not collect data on lifestyle changes to link the increased blood pressure levels to lifestyle changes. Despite these limitations, the study has been conducted with methodological strengths like a scientifically drawn sample from different zones of the country with a common methodology, high response rate, etc.

Conclusions

In the current study, the overall prevalence of hypertension is 30%, which is considered to be high among tribes in India. It concludes that the prevalence of hypertension is increasing among the tribal population, and the awareness level and treatment-seeking behaviour are low. Of the numerous risk factors, age, alcohol intake, sedentary lifestyle, PVTG status and BMI are found to be significant. Hypertension is an emerging public health challenge in tribal India. If appropriate interventions are not initiated, low awareness and poor control will translate into high cardiovascular disease morbidity and mortality in this population. There is a need for comprehensive health promotion programmes to encourage lifestyle modification and re-orientation of the primary health care system to improve availability and accessibility to hypertension screening and treatment.

Authors' Contributions All authors contributed to the study conception and design. Material preparation and data collection were performed by Sunil K. Raina, Shariq R Masoodi, Yogish C. Basappa, Nihal Thomas, Anna S Kerketta and Felix K. Jebasingh. Data analysis was performed by Bontha V. Babu, Chaya R. Hazarika. The first draft of the manuscript was written by Chaya R. Hazarika and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability Data will be available on request to corresponding author with a reasonable request.

Code Availability Not applicable.

Declarations

Ethics Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committees of the respective author's (SKR, YCB, SRM, NT, ASK) institutions, and each of the five IECs approved the study protocol for the corresponding district.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent for Publication Not applicable.

Competing Interests The authors have no relevant financial or non-financial interests to disclose.

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