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Original Article

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BEAT-HTN India: Burden, Epidemiology, and Trends of Hypertension - A Nationwide Survey

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Abstract

Background: Hypertension is a growing public health concern in India, increasingly interlinked with metabolic disorders such as diabetes and characterized by significant regional and demographic variation. Despite advancements in diagnosis and treatment, control rates remain unsatisfactory. Elevated resting heart rate (HR), an emerging marker of sympathetic overactivity, may offer additional insight into the underlying pathophysiology of Indian hypertensives. The objective of the study was to assess the prevalence of hypertension across India, explore its association with diabetes, elevated HR, and regional variation, and evaluate the potential role of sympathetic overdrive as a common pathophysiological thread.

Methods: A nationwide, cross-sectional survey was conducted among 41,370 adults across 31 Indian regions. Data on systolic and diastolic blood pressure, resting HR, diabetes history, age, gender, and region were collected and analyzed to identify patterns of comorbidity and demographic distribution.

Results: Overall hypertension prevalence was 29.8% (95% confidence interval (CI): 29.4 - 30.2), higher among males, 33.2% (95% CI: 32.6 - 33.8) than females, 27.2% (95% CI: 26.6 - 27.8). A notable proportion (14.6%, 95% CI: 14.2 - 15.0) of hypertensives also had diabetes, with this comorbidity more prevalent in males (15.8%, 95% CI: 15.2 - 16.4) than females (13.3%, 95% CI: 12.8 - 13.8). The mean resting HR was 83.9 bpm across all participants, exceeding 80 bpm even among normotensives, and was highest in diabetic hypertensives (85.9 vs. 82.2 bpm in non-diabetics; $P < 0.05$). Hypertension was more common in older adults, males, and those residing in urbanized or rapidly transitioning regions. Though obesity data were not captured, the strong associations between hypertension, diabetes, and elevated HR point toward underlying metabolic dysfunction and sympathetic overactivity.

Conclusion: This large-scale survey reinforces the complex cardiometabolic burden in India and highlights elevated resting HR as a potential surrogate marker of sympathetic overactivity in hypertensives, especially those with diabetes. Regional and demographic disparities underscore the need for integrated, population-specific approaches that go beyond blood pressure control to address the broader spectrum of metabolic and autonomic dysfunction.

Keywords: Hypertension; Diabetes; Resting heart rate; Sympathetic overactivity; India; Epidemiology; Comorbidity; Regional variation

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Introduction

Non-communicable diseases (NCDs), especially cardiovascular diseases (CVDs), continue to be the leading cause of premature mortality worldwide [1]. In India, hypertension remains a key and rapidly growing contributor to this burden, affecting nearly one in every four adults. Alarmingly, despite

various awareness campaigns and treatment availability, only about 10% of individuals with hypertension achieve optimal blood pressure (BP) control [2]. The ICMR-INDIAB national cross-sectional study estimated the weighted prevalence of hypertension at 35.5%, reflecting the extensive reach of this condition across the country [3]. Hypertension is a well-established modifiable risk factor for CVDs, including ischemic heart disease, stroke, heart failure (HF), and chronic kidney disease (CKD) [4]. In India, CVDs account for nearly 28.1% of all deaths, with high systolic BP (SBP) alone contributing to 8.5% of disability-adjusted life years (DALYs) [5]. Furthermore, hypertension is responsible for 57% of stroke-related deaths and 24% of coronary heart disease (CHD) mortality [6].

Traditionally viewed in isolation, hypertension is now increasingly recognized as part of a broader metabolic continuum, often coexisting with obesity, insulin resistance, and dyslipidemia, collectively constituting metabolic syndrome. A growing body of literature documents the interrelationship between obesity, diabetes, and CVDs, emphasizing visceral adiposity's significant role in driving systemic inflammation, sympathetic overactivity, and endothelial dysfunction, key precursors to hypertension and atherosclerosis [7-10]. The rising prevalence of obesity in India, especially among urban youth and middle-aged adults, further exacerbates the hypertension burden. A hospital-based study by Chopra et al 2007 found abdominal waist circumference (> 90 cm in males and > 80 cm in females) as the most reliable predictor of metabolic risk, highlighting its significance in early identification of high-risk individuals [11]. Moreover, 3D echocardiographic assessments have shown that metabolic syndrome frequently coexists with subclinical CVD. The left ventricular myocardial performance index (LVMPI) has emerged as a sensitive early marker of diastolic dysfunction [12]. Similarly, left ventricular hypertrophy (LVH), particularly concentric hypertrophy, increases progressively with declining renal function, highlighting the need for early CV risk assessment in patients with CKD [13].

With hypertension and metabolic syndrome on the rise, diastolic heart failure (DHF), which now accounts for over half of all HF cases, has become a major clinical challenge. Early-stage dysfunction is often subclinical and may go undetected without advanced imaging modalities [14]. Although body mass index (BMI) or waist circumference was not directly measured in this survey, the role of obesity cannot be overlooked in any epidemiological study on hypertension. Recent data from NFHS-5 and other national registries indicate a significant rise in overweight and obesity rates across all socioeconomic strata, further linking hypertension with the broader obesity-diabetes-CVD triad [15]. This interconnected cluster of lifestyle-related conditions represents a modern-day syndemic that requires an integrated public health response.

India is undergoing a rapid epidemiological transition, with urbanization and lifestyle changes contributing significantly to the rising prevalence and regional disparities in hypertension. To address these challenges, a comprehensive pan-India evaluation of hypertension is imperative, not just to assess prevalence, but also to understand its demographic trends, regional variations, and association with key comorbidities like diabetes and elevated heart rate (HR). Such efforts are aligned with the 2024 World Hypertension Day theme, "Measure Your Blood Pressure Accurately, Control It, Live Longer," and are vital to formulate national strategies and health policies [16]. The BEAT-HTN India Survey (Burden, Epidemiology, and Trends of Hypertension) was thus conceptualized to fill critical data gaps and provide evidence-based insights into the evolving burden of hypertension and its metabolic determinants in Indian population.

Materials and Methods

Study design and setting

This BEAT-HTN India Survey was designed as a nationwide, cross-sectional community-based screening initiative conducted under the "BP Right Karo" campaign. The survey spanned 1 year, from October 2023 and October 2024, and covered a representative mix of urban, semi-urban, and rural populations across various regions of India. The objective was to estimate the burden, demographic distribution, and associated trends of hypertension in Indian adults.

Ethical considerations

The study followed ethical standards for research involving human participants and complied with the Declaration of Helsinki. Verbal informed consent was obtained prior to data collection. As the survey involved anonymous community-level screening without clinical intervention or sensitive data collection, prior ethics approval was not required for data collection. However, ethics approval for publication was obtained from the Kusum Independent Ethics Committee (approval no. ECR/1802/Inst/MH/2023), in accordance with ICH-GCP, ICMR guidelines, and the New Drugs and Clinical Trials Rules, 2019.

Participants

Participants were recruited through community-based screening camps and outpatient clinics. Eligible participants included adults aged ≥ 18 years, recruited from 28 Indian states and three Union Territories, representing a total of 31 regions. Participation was voluntary, and verbal informed consent was obtained from each participant. A total of 41,370 individuals were included in the final analysis. Trained personnel collected demographic data (age, sex, and geographic region), self-reported history of hypertension and/or diabetes, and use of antihypertensive medication.

BP measurement protocol

Standardized procedures and validated devices were used uniformly across all sites, to minimize inter-observer variability. Participants were seated in a calm setting, with a rest period of at least 10 min before the first reading. Two measurements were taken, 1 min apart. An average of the two readings was consid-

Table 1. Blood Pressure Classification According to the 2019 Indian Guidelines on Hypertension

Category	Systolic BP (mm Hg)	Diastolic BP (mm Hg)
Optimal	< 120 and	< 80
Normal	< 130 and	< 85
High-normal	130 - 139 or	85 - 89
Stage 1 Hypertension	140 - 159 or	90 - 99
Stage 2 Hypertension	160 - 179 or	100 - 109
Stage 3 Hypertension	≥ 180 or	> 110

BP: blood pressure.

ered final and rounded to the nearest whole number. Participants were advised to avoid caffeine or tea at least 10 min prior to measurement. HR was also recorded using the same device.

Definition and classification of hypertension

The Indian Guidelines on Hypertension (IGH) 2019 were used to define and classify BP levels in adults (Table 1) [17]. This guideline was chosen to ensure relevance and contextual accuracy, as it incorporates regional characteristics such as earlier age of onset, urban-rural variation, and BP variability with seasonal and environmental factors [18].

Anthropometric considerations

While anthropometric measures (weight, height, waist circumference) were not recorded as the primary focus of this survey was blood pressure, HR, and comorbid diabetes, the role of obesity as a parallel epidemic exacerbating hypertension is acknowledged. To address this gap, existing Indian evidence linking central obesity, metabolic syndrome, and cardiovascular risk has been incorporated to interpret our findings within a broader cardiometabolic context.

Statistical analysis

Descriptive statistical analyses were applied to summarize participant characteristics. Categorical variables were expressed as proportions with 95% confidence intervals (CIs), and continuous variables as means with standard deviations and 95% CIs where appropriate. The distribution of BP categories, (normal, high-normal, stage 1, stage 2, and stage 3 hypertension) was analyzed across age groups (18- 30, 31 - 50, 51 - 65, and > 65 years), gender and regions. Associations between hypertension and variables such as age, gender, region, and comorbid diabetes were examined using the Chi-square test. To further account for confounding, multivariable logistic regression was performed adjusting for age, sex, and region, with results reported as odds ratios (ORs) and 95% CIs. All data were compiled and analyzed using Microsoft Excel. A P-value of < 0.05 was considered statistically significant.

Results

A total of 41,370 adult participants were enrolled across 31 regions (28 states and three Union Territories), with a male predominance (62.8%). The mean age of the cohort was 53.4 ± 11.9 years. The average systolic and diastolic BP were 145.7 ± 18.5 and 89.4 ± 11.0 mm Hg respectively, with a mean HR of 83.9 ± 10.9 bpm. Table 2 summarizes the baseline demographic and clinical characteristics of the participants.

Regional prevalence of hypertension

The burden of hypertension varied significantly across India's four major geographical regions (Table 3, Fig. 1). The northern (80.2%) and western (79.6%) regions exhibited the highest hypertension prevalence, while the eastern region had the lowest (70.4%).

Interestingly, the proportion of individuals with prehypertension was relatively consistent across all regions (ranging from 12.7% to 15.3%), highlighting the pervasive risk of future hypertension if early interventions are not implemented.

State-wise prevalence of hypertension in men and women

A state-level analysis revealed notable gender and regional disparities (Table 4). Men consistently had a higher prevalence of hypertension across most states. The highest male-to-female disparity was observed in Chandigarh (76% vs 23%), while Puducherry was the only region where female prevalence

Table 2. Baseline Characteristics of Study Population

Characteristics	Men (n = 25,987)	Women (n = 15,383)	Total (n = 41,370)
History of diabetes	14,942 (57.5%)	8,473 (55.1%)	23,415 (56.6%)
Known history of HT	19,145 (73.7%)	10,854 (70.6%)	29,999 (72.5%)
Mean age (years)	53.6 (SD 12.0)	53.0 (SD 11.9)	53.4 (SD 11.9)
Average of SBP (mm Hg)	146.2 (SD 18.3)	144.8 (SD 18.8)	145.7 (SD 18.5)
Average of DBP (mm Hg)	89.8 (SD 10.9)	88.8 (SD 11.2)	89.4 (SD 11.0)
Average of heart rate (bpm)	84.0 (SD 10.7)	83.9 (SD 11.3)	83.9 (SD 10.9)

BP: blood pressure; SD: standard deviation.

Table 3. Regional Distribution of BP Categories

Region	n	Normal	Prehypertensive	Hypertensive
North	9,634	684 (7.1%)	1,222 (12.7%)	7,728 (80.2%)
South	8,709	1,057 (12.1%)	1,131 (13.0%)	6,521 (74.9%)
East	19,414	2,785 (14.3%)	2,967 (15.3%)	13,662 (70.4%)
West	3,613	268 (7.4%)	468 (13.0%)	2,877 (79.6%)

(60%) surpassed male prevalence (40%). Sikkim reported equal prevalence between genders.

Himachal Pradesh (69%), Jharkhand (63%), and Haryana (58%) reported the highest male hypertension burden. Among women, Puducherry (60%), Tamil Nadu (33%), and Chhattisgarh (33%) had the highest rates. States with large sample sizes such as Maharashtra, Gujarat, and West Bengal showed substantial hypertension burdens in both genders.

Gender- and age-wise distribution of hypertension

When stratified by stages, stage 1 hypertension was most prevalent across the entire cohort (65.9%), more common in men (66.9%) than women (64.4%). Stage 2 hypertension affected 7.3% of the population (7.7% of men vs. 6.7% of women), while stage 3 hypertension was observed in 1.1% overall, again slightly higher in men (1.2% vs. 1.0%).

Interestingly, a larger proportion of women had normal (13.3%) and high-normal BP (14.6%) than men, suggesting better early BP control or underdiagnosis among women (Fig. 2).

A clear age-related increase in hypertension prevalence was noted in both genders: 1) Among women, prevalence rose sharply from 21.7% in 18 - 30 years old group to 61.6% in the 31 - 50 years, peaking at 84.3% in those above 65. Concurrently, the proportion of normotensive women declined from 64.1% in the youngest group to 6.2% in the oldest (Fig. 3). 2) A similar trend was observed among men, with prevalence increasing from 30.0% (18 - 30 years) to 65.8% (31 - 50 years), and reaching 87.2% in those above 65. Normotension in men dropped from 50.8% to 4.0% over the same span (Fig. 4).

Hypertension and HR

HR patterns were also evaluated across different age groups and genders (Table 5). Analysis of HR across age groups revealed a progressive rise with increasing age.

The mean HR was lowest in the 18 - 30 group (80.0 bpm) and highest among those aged ≥ 65 (84.8 bpm). Gender differences were marginal, with slightly lower HRs in young women (79.5 bpm) compared to men (80.4 bpm). By age 51 and beyond, both genders had similar HRs (approximately 84.8 bpm).

Association between diabetes, hypertension, and HR

Among the 41,370 participants, 48.4% (n = 20,005) were identified as having both diabetes and hypertension. This subgroup exhibited a significantly higher mean HR (85.86 ± 11.12 bpm) compared to participants without diabetes (82.15 ± 10.46 bpm). This difference was statistically significant ($P < 0.05$) (Table 6).

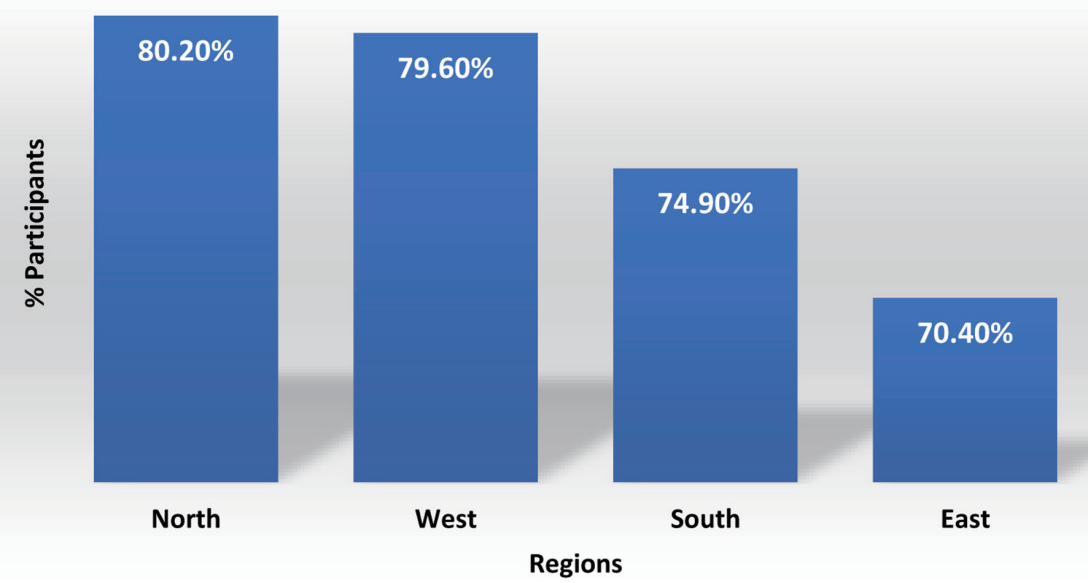

Figure 1. Region-wise prevalence of hypertension.

Table 4. State-Wise Prevalence of Hypertension in Men and Women

State	n	Men	Women	% Men (> 140/90)	% Women (> 140/90)
Andhra Pradesh	834	517	317	53%	34%
Assam	417	275	142	35%	17%
Bihar	1,652	1,057	595	48%	24%
Chandigarh (UT)	62	47	15	76%	23%
Chhattisgarh	181	112	69	51%	33%
Delhi	2,002	1,240	762	48%	31%
Goa	332	194	138	41%	30%
Gujarat	4,876	3,109	1,767	52%	29%
Haryana	386	278	108	58%	22%
Himachal Pradesh	58	40	18	69%	31%
Jammu and Kashmir	6	6		100%	0%
Jharkhand	673	485	188	63%	22%
Karnataka	2,775	1,793	982	48%	27%
Kerala	1,624	978	646	50%	30%
Madhya Pradesh	1,279	867	412	56%	27%
Maharashtra	6,825	4,142	2,683	42%	27%
Manipur	20	11	9	40%	30%
Meghalaya	15	11	4	33%	13%
Mizoram	8	5	3	25%	0%
Odisha	2,271	1316	955	40%	26%
Puducherry	30	12	18	40%	60%
Punjab	237	148	89	53%	31%
Rajasthan	505	338	167	57%	27%
Sikkim	8	4	4	38%	38%
Tamil Nadu	2,148	1,152	996	42%	33%
Telangana	1,118	730	388	53%	27%
Tripura	69	41	28	32%	20%
Uttar Pradesh	2,173	1,401	772	51%	28%
Uttarakhand	289	203	86	55%	25%
West Bengal	8,497	5,475	3,022	47%	23%

Adjusted predictors of hypertension and diabetes

Beyond descriptive analyses, we performed multivariable logistic regression to adjust for potential confounders (age, sex, and region) and to identify independent predictors of hypertension, diabetes, and their coexistence. Logistic regression adjusting for age, sex, and region showed that advancing age independently increased the odds of hypertension (OR 1.06, 95% CI: 1.05 - 1.06) and diabetes (OR 1.04, 95% CI: 1.04 - 1.04). Male sex was associated with higher odds of hypertension (OR 1.14, 95% CI: 1.08 - 1.20) and combined hypertension with diabetes (OR 1.16, 95% CI: 1.11 - 1.21). Regional variation was evident, with higher odds in the North (hypertension OR 1.29; diabetes OR 1.34) and South (hypertension OR 1.12; diabetes OR 1.37), and lower odds in the West (hypertension OR 0.87; diabetes OR 0.93). Importantly, comorbidity effects were strong, diabetics had nearly fivefold higher odds of hypertension (OR 4.70), while hypertensives had a similar risk of diabetes (OR 4.79). These findings confirm that advancing age and regional variation are dominant drivers of India's hypertension and diabetes burden, with comorbidity substantially amplifying cardiovascular risk.

Discussion

The findings of this large-scale, nationwide survey highlight that nearly one in three Indian adults has hypertension, rein-

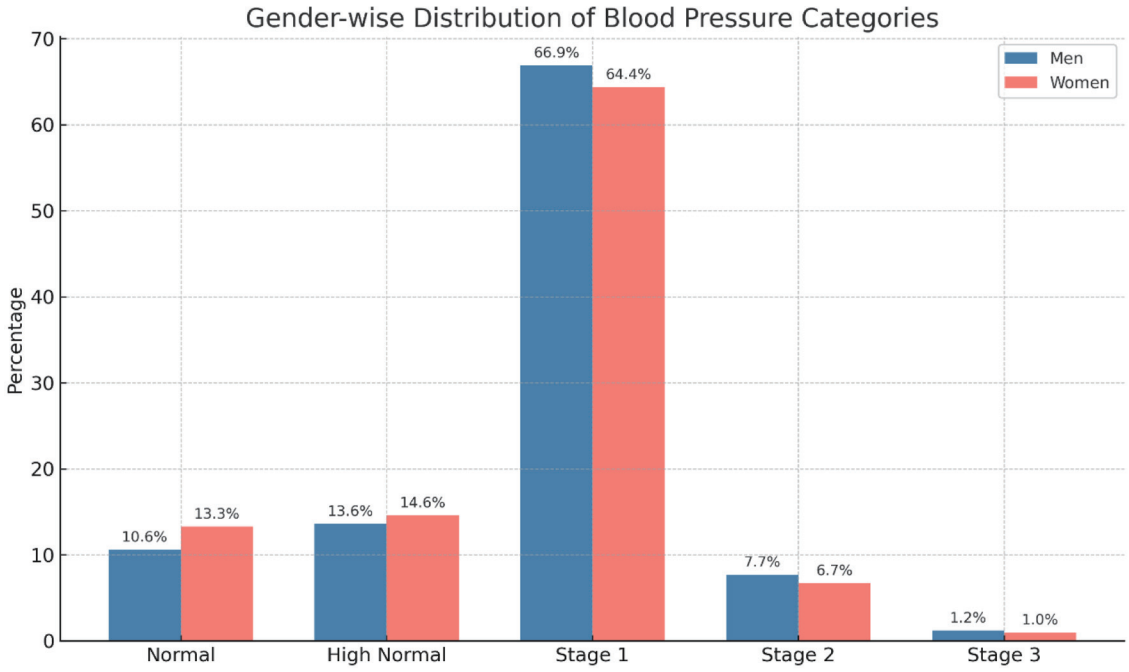

Figure 2. Gender-wise distribution across hypertension stages.

forcing the urgent need for clinicians to actively screen beyond traditional high-risk groups, especially in urbanizing regions. These findings provide critical insights into India's escalating burden of hypertension and highlight the complex interplay of metabolic risk factors driving the NCD epidemic.

Although direct anthropometric measurements were not captured, the strong coexistence of diabetes, elevated resting HR, and age-related trends strongly suggests obesity as a unifying driver of cardiometabolic risk [19]. Obesity is increasingly recognized as a chronic, low-grade inflammatory condition [20], which promotes endothelial dysfunction, insulin resistance, and sympathetic overactivity, three mechanisms central to hypertension and CVD [21]. Large epidemiological studies confirm obesity as a catalyst for hypertension, type

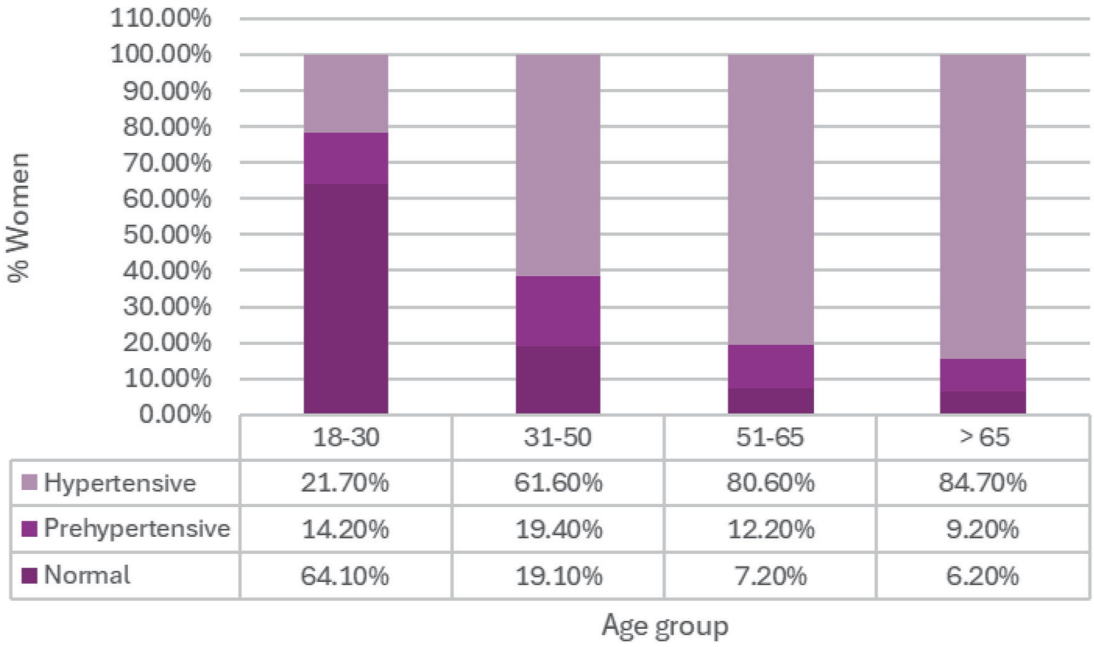

Figure 3. Prevalence of hypertension by age amongst women.

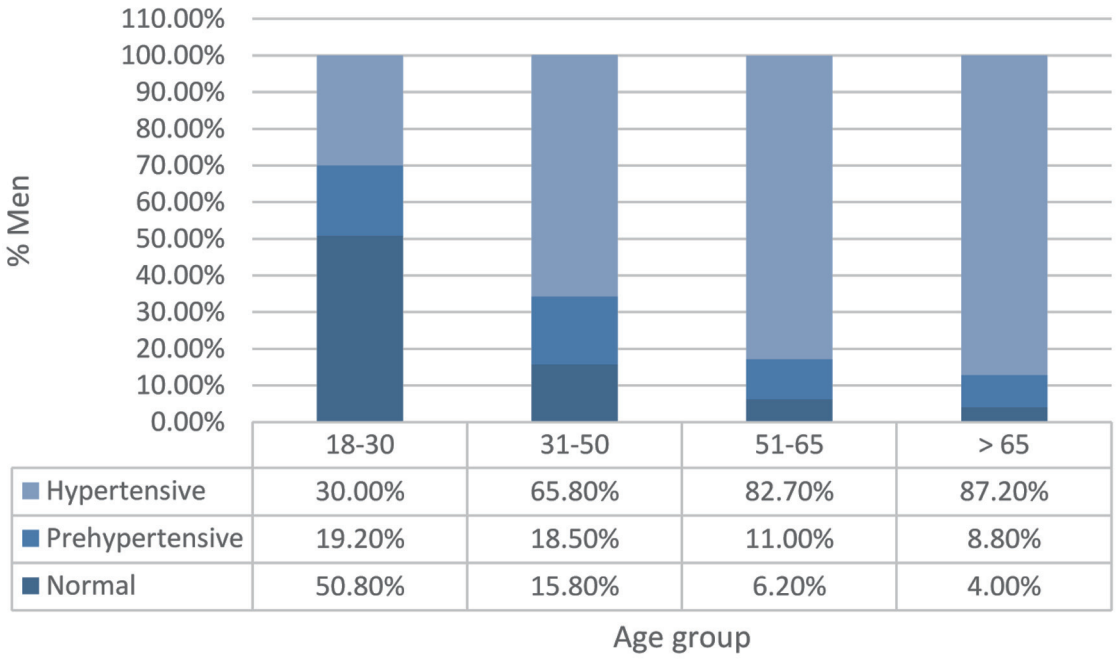

Figure 4. Prevalence of hypertension by age amongst men.

Table 5. Mean Heart Rate (bpm (95% CI)) by Age and Gender

	Overall	18 - 30 years	31 - 50 years	51 - 65 years	> 65 years
Overall	83.9 (83.8 - 84.1)	80.0 (79.4 - 80.7)	83.1 (83.0 - 83.3)	84.6 (84.4 - 84.7)	84.8 (84.5 - 85.1)
Men	84.0 (83.8 - 84.1)	80.4 (79.6 - 81.2)	83.3 (83.1 - 83.5)	84.4 (84.2 - 84.6)	84.8 (84.5 - 85.2)
Women	83.9 (83.7 - 84.1)	79.5 (78.5 - 80.5)	82.8 (82.6 - 83.1)	84.8 (84.6 - 85.1)	84.8 (84.3 - 85.3)

CI: confidence interval.

2 diabetes, coronary artery disease, arrhythmias, and HF [22, 23]. With abdominal obesity rates rising sharply in India, clinicians should consider obesity a cardiovascular risk equivalent and proactively screen and intervene at earlier stages.

Our findings reaffirm known demographic patterns: hypertension prevalence was higher among older adults, men, and urban dwellers. Even without direct obesity data, the clustering of diabetes and elevated HR signals to metabolic syndrome and autonomic dysfunction as underlying mechanisms. The mean resting HR of 83.9 bpm in this cohort, above the ESC/ESH threshold of 80 bpm for elevated CV risk [24], particularly in those with diabetes, should be regarded by clinicians as a practical red flag for heightened sympathetic overdrive and increased CV risk [25, 26]. Indian and global evidence, consistently link elevated HR to poor outcomes [27-30], and our findings reinforce the value of incorporating HR assessment into routine hypertension care to refine risk stratification and management.

Table 6. Comparison of Heart Rate Between Diabetic and Non-Diabetic Hypertensive Participants

Group	n	Mean heart rate, bpm (95% CI)	Standard deviation
Diabetic hypertensives	20,005	85.86 (85.70 - 86.02)	11.2
Others	21,365	82.15 (82.01 - 82.29)	10.5

CI: confidence interval.

Regional disparities in hypertension prevalence, from higher rates in Himachal Pradesh and Jharkhand to lower prevalence in select Union Territories, reflect India's diversity in lifestyle, dietary patterns, and stages of urbanization. These observations have direct public health implications; targeted, region-specific strategies may yield greater impact than uniform national approaches.

The coexistence of hypertension and diabetes across all demographic groups further signals India's epidemiological shift toward multimorbidity. For clinicians, this underscores the importance of moving from siloed, disease-specific care models to integrated cardiometabolic management. Interventions must simultaneously address obesity, insulin resistance, and autonomic dysregulation to curb the broader cardiometabolic continuum [31]. Importantly, hypertensive individuals with controlled BP remain at higher risk if HR is elevated, with studies showing a 53% increased incidence of CV events in such cases [32]. This highlights HR as a clinically actionable marker for guiding therapy beyond BP targets [33].

Our results also resonate with earlier Indian studies, such as The BEAT survey [34], which reported a mean HR of 82.79 bpm in hypertensives, and global data identifying elevated HR as a predictor of cardiovascular morbidity and mortality, particularly in younger men. The distinct cardiovascular profile of individuals with both diabetes and hypertension, marked by consistently higher HRs, further strengthens the case for aggressive, integrated management of these high-risk patients [35, 36].

In context, this present survey complements prior national efforts such as the Great India Blood Pressure Survey [37], and extends them by adding the dimension of resting HR as a surrogate of autonomic imbalance. Together, these datasets form a robust evidence base for clinicians and policymakers to design more nuanced, high-impact interventions for hypertension and related NCDs in India.

This study has certain limitations. The absence of anthropometric and lifestyle data (e.g., diet, activity, smoking, stress, family history) limits mechanistic interpretation. Participants < 18 years were not included. As participation was voluntary, selection bias cannot be excluded. Finally, the cross-sectional design limits causal inference. Future longitudinal studies are needed to validate these associations and guide targeted intervention.

Conclusion

With data from over 41,000 participants across both urban and rural regions, this nationwide survey represents one of the most comprehensive cross-sectional assessments of hypertension, resting HR, and comorbidities such as diabetes conducted in India to date. Despite the absence of direct anthropometric measurements, the findings strongly point toward underlying metabolic dysfunction likely driven by obesity as a unifying pathway linking elevated BP, diabetes, and increased HR.

Regression analyses further emphasized that age, male sex, and regional disparities are independent determinants of hypertension and diabetes, underscoring the need for integrated, region-specific strategies in India.

Resting HR emerged as a clinically relevant surrogate for autonomic imbalance, with its elevation observed in both diabetic and non-diabetic hypertensives. This pattern underscores a broader, systemic concern: the rising prevalence of sympathetic overactivity in the Indian population. As corroborated by emerging global and Indian evidence, the dynamic interplay between obesity, insulin resistance, and autonomic dysregulation lies at the heart of the current cardiometabolic epidemic.

Taken together, these insights call for a paradigm shift in region-specific hypertension management from a BP-centric model to a more holistic, integrated approach. Also, these findings highlight the urgent need for early screening, lifestyle interventions, and community awareness, supported by longitudinal research to guide tailored public health strategies.

Supplementary Material

Suppl 1. A complete list of participating physicians.

Acknowledgments

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Financial Disclosure

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Conflict of Interest

The authors declare no conflict of interest related to this study.

Informed Consent

Verbal informed consent was obtained from all participants prior to data collection.

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Author Contributions

Dr HK Chopra contributed to the conception and design of the study. Dr. Anu Grover supported in the analysis of data and writing of the manuscript. All other authors critically reviewed the manuscript. All authors have read and approved the final version of the manuscript.

Data Availability

The authors declare that data supporting the findings of this study are available within the article and its supplementary information file.

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