

Original Research Article

Rising hypertension and post-COVID cardiovascular risk among rural women in Punjab: implications for community-based screening and surveillance

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ABSTRACT

Background: Hypertension is the foremost modifiable cardiovascular risk factor globally and constitutes a growing non-communicable disease (NCD) burden in rural India. The COVID-19 pandemic has introduced an additional layer of complexity to hypertension epidemiology.

Methods: A community-based cross-sectional study was conducted among 2,160 adult women aged 18-69 years residing in rural Punjab. Participants were recruited through multistage stratified cluster sampling, with data collection guided by the WHO STEPwise approach to Non-Communicable Disease Risk Factor Surveillance (STEPS). Blood pressure was measured using standardised protocols and JNC VIII guidelines.

Results: Among the 2,160 participants, more than one-third (38.3%, n=827) were found to be hypertensive, comprising 27.9% with Stage 1 and 10.4% with Stage 2 hypertension, while an additional 31.1% were classified as pre-hypertensive. Significant associations were identified between hypertension and older age (45-69 years: 66.1%), married marital status (90.7%), illiteracy (64.6%), labourer occupation (71.0%), lower socioeconomic class (45.9%), and overweight or obese BMI (≥ 23 kg/m²). While a prior history of COVID-19 infection did not independently predict hypertension status ($\chi^2=0.411$, $p=0.524$), the occurrence of blood pressure fluctuations during or following COVID-19 illness and the presence of pre-existing comorbidities before COVID-19 infection were both strongly and significantly associated with hypertension.

Conclusions: Rural women in Punjab carry a substantial and largely underdiagnosed burden of hypertension, with 38.3% prevalence and an additional 31.1% at the pre-hypertensive threshold. These findings underscore the urgent need for systematic community-based blood pressure screening, gender-sensitive preventive interventions, and dedicated post-COVID cardiovascular surveillance to reduce long-term cardiovascular morbidity in this vulnerable population.

Keywords: Hypertension, Rural women, Non-communicable diseases, COVID-19, BMI

INTRODUCTION

Hypertension, defined as persistently elevated systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg, is among the most prevalent and

preventable non-communicable diseases (NCDs) worldwide. The World Health Organization estimates that approximately 1.28 billion adults aged 30-79 years are living with hypertension, with nearly two-thirds residing in low- and middle-income countries.¹ Globally,

hypertension accounts for 10.4 million deaths annually and is the leading risk factor for stroke and ischaemic heart disease.² In India, hypertension prevalence ranges from 25-40% among adults, with significant heterogeneity across rural-urban divides, states, and demographic subgroups.³

Rural women in India represent a particularly vulnerable yet understudied group, exposed to convergent biological and socioeconomic risks including menopausal hormonal transitions, low educational attainment, economic dependence, agricultural labour, biomass fuel exposure, and chronic psychosocial stress.^{4,5} Punjab, despite its relatively higher per-capita income, records one of the highest NCD burdens in India, with WHO STEPS survey data documenting hypertension prevalence of approximately 40.1%, with less than half of affected individuals aware of their condition.⁶ Inter-district and rural-urban disparities compound the epidemiological challenge, with districts such as Ludhiana and Amritsar demonstrating disproportionately high burden.⁷

The COVID-19 pandemic introduced a new and complex dimension to hypertension epidemiology. Hypertension is simultaneously a major risk factor for severe COVID-19 outcomes and a potential haemodynamic consequence of SARS-CoV-2 infection through angiotensin-converting enzyme 2 (ACE2) receptor engagement, cytokine storm, endothelial injury, and autonomic dysregulation.⁸ Blood pressure fluctuations during and after COVID-19 infection have been documented in clinical settings; however, their community-level epidemiological significance particularly among rural women remains poorly characterized. Understanding the COVID-19 hypertension interface in this population is critical for post-pandemic cardiovascular care planning.

The present study was designed to comprehensively assess hypertension prevalence and staging per JNC VIII criteria, identify socio-demographic and anthropometric determinants, and characterize the COVID-19 hypertension association among adult women in rural Punjab, thereby generating an integrated, community-level evidence base to guide targeted public health policy and preventive programming.

METHODS

Study design, setting, and duration

A community-based cross-sectional descriptive and analytical study was conducted among adult women aged 18-69 years in rural Punjab, India, from October 2023 to June 2024 (8 months).

The WHO STEPwise approach to NCD Risk Factor Surveillance (STEPS) provided the overarching methodological framework.⁹

Sample size and sampling strategy

A community-based cross-sectional descriptive and analytical study was conducted among adult women aged 18-69 years in rural Punjab, India, from October 2023 to June 2024 (8 months). The WHO STEPwise approach to NCD Risk Factor Surveillance (STEPS) provided the overarching methodological framework. The sample size was determined following the WHO STEPwise approach to NCD surveillance (STEPS) to estimate hypertension prevalence across three age categories: 18-29, 30-44, and 45-69 years. The required sample size was calculated using the formula:

$$n = \frac{Z^2 P(1 - P)}{e^2}$$

Using a 95% confidence level ($z=1.96$), baseline prevalence of 50% ($p=0.5$), and margin of error of 5%, an initial sample of 384 was obtained. This was subsequently adjusted for a design effect of 1.5 (applied for multistage sampling), three age-group strata, and an anticipated non-response rate of 20%, yielding a final sample size of 2,160. A multistage stratified cluster sampling design was adopted, with districts of Punjab (2011 Census) as strata, villages as primary sampling units (PSUs), and households as final sampling units. Adult women aged 18-69 years permanently residing in selected rural villages and willing to provide written informed consent were included; males, pregnant and lactating women, and those with known psychiatric illness were excluded.

Blood pressure measurement and JNC VIII classification

Blood pressure was measured in the right arm in a seated position using a calibrated digital sphygmomanometer (OMRON HEM-7120) after five minutes of rest. Two readings were taken at five-minute intervals; a third was recorded if the difference exceeded 20 mm Hg systolic or 10 mm Hg diastolic, and the mean of the two closest readings was used. Hypertension was classified per JNC VIII guidelines¹⁰: Normal (<120/<80 mm Hg); Pre-hypertension (120-139/80-89 mm Hg); Stage 1 (140-159/90-99 mm Hg); Stage 2 ($\geq 160/\geq 100$ mm Hg). Participants on antihypertensive medication were classified as hypertensive regardless of measured values.

Anthropometric assessment

Weight and height were measured using standardized protocols. BMI was classified per Asia-Pacific cut-offs: underweight (<18.5 kg/m²); normal (18.5-22.9 kg/m²); overweight (23.0-24.9 kg/m²); Obese Class I (25.0-29.9 kg/m²); Obese Class II (≥ 30.0 kg/m²).¹¹

COVID-19 assessment

COVID-19 history was assessed by a structured interview covering: confirmed COVID-19 infection, symptom

severity (mild/moderate/severe), fever, hospitalization, ICU admission, oxygen therapy, COVID-19 vaccination status (number of doses), blood pressure fluctuations during or after COVID-19 illness, and presence of pre-existing health conditions before COVID-19 infection.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 26.0. Frequencies and percentages described categorical variables; means and standard deviations (SD) described continuous variables. Chi-square (χ^2) tests assessed associations between categorical variables and hypertension status. Statistical significance was set at $p < 0.05$.

Ethical approval

The study was approved by the Institutional Ethics Committee of Sri Guru Granth Sahib World University, Fatehgarh Sahib (Ref: SGGSWU/IEC/2023/14, dated 13 October 2023). Before participation, all enrolled individuals provided their written informed consent, confirming their voluntary agreement to take part in the research. Each participant received clear communication regarding the protected status of their personal information and was explicitly informed of their unconditional right to discontinue participation at any time without facing any form of repercussion.

RESULTS

Hypertension prevalence and blood pressure staging

Among the 2,160 women who participated in the screening, 1,333 (61.7%) were found to be normotensive and 671 (31.1%) were classified as pre-hypertensive. Hypertension was confirmed in 827 women, accounting for 38.3% of the total screened subjects, of whom 602 (27.9%) were categorised as Stage 1 and 225 (10.4%) as Stage 2 hypertensives (Figure 1).

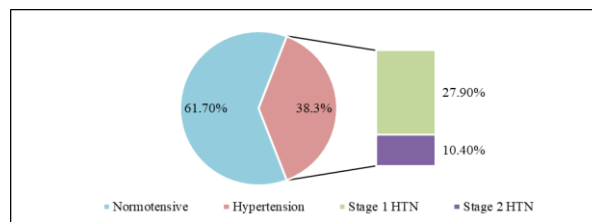


Figure 1: Prevalence and stage-wise distribution of hypertension among adult females.

Socio-demographic correlates of hypertension

All major socio-demographic variables were significantly associated with hypertension status (Table 1). Hypertension prevalence increased sharply with advancing age, recorded at 8.5% among women aged 18-29 years, rising to 25.4% in the 30-44 years group, and reaching 66.1% among those aged 45-69 years ($\chi^2=590.232$, $p=0.001$). Regarding marital status, married women demonstrated the highest hypertension prevalence (90.7%), compared to unmarried women (6.3%), widowed women (2.5%), and divorced women (0.5%) ($\chi^2=203.195$, $p=0.001$), a pattern likely reflecting age confounding and cumulative psychosocial determinants. A clear inverse gradient was observed between educational attainment and hypertension burden, illiterate women recorded the highest prevalence (64.6%), while those who could read only accounted for 9.1% of hypertensives, and the proportion declined progressively with higher education, with graduates representing only 1.7% and those educated above graduate level a mere 0.8% of hypertensive cases ($\chi^2=318.369$, $p=0.001$). Occupationally, labourers demonstrated the highest hypertension burden (71.0%) compared to those engaged in cultivation (19.5%), independent professions (7.7%), business (1.2%), and service (0.6%) ($\chi^2=240.754$, $p=0.001$). Socioeconomic status revealed a striking inverse gradient, with lower-class women exhibiting the highest hypertension prevalence (45.9%), followed by lower-middle-class (27.9%), middle-class (21.3%), and upper-middle-class (4.8%) ($\chi^2=157.398$, $p=0.001$).

Table 1: Association of socio-demographic characteristics with hypertension status.

Variable	Category	Normotensive (%)	Hypertensive (%)	Chi-square value	P value
Age group (years)	18-29	43.0	8.5	590.232	0.001*
	30-44	40.4	25.4		
	45-69	16.6	66.1		
Marital status	Unmarried	32.4	6.3	203.195	0.001*
	Married	66.2	90.7		
	Widowed	1.1	2.5		
	Divorced	0.3	0.5		
Education	Illiterate	38.7	64.6	318.369	0.001*
	Can read only	2.5	9.1		
	Can read and write	2.6	4.6		
	Primary	5.9	7.3		
	Middle	3.3	2.9		
	High school	28.4	9.1		

Continued.

Variable	Category	Normotensive (%)	Hypertensive (%)	Chi-square value	P value		
	Graduate	13.1	1.7	240.754	0.001*		
	And above	5.4	0.8				
Occupation	None	0.2	0.0				
	Labourer	37.7	71.0				
	Business	5.7	1.2				
	Independent profession	13.5	7.7				
	Cultivation	38.0	19.5				
	Service	4.9	0.6				
Socioeconomic status (SES)	Upper middle class	14.3	4.8			157.398	0.001*
	Middle class	25.4	21.3				
	Lower middle class	38.5	27.9				
	Lower class	21.9	45.9				

*Statistically significant (p<0.05)

Table 2: Association of BMI categories with blood pressure status.

BMI category	Normotensive (%)	Hypertensive (%)	Chi-square value	P value
Underweight (<18.5 kg/m ²)	15.3	6.4	122.804	0.001*
Normal (18.5-22.9 kg/m ²)	35.8	23.3		
Overweight (23.0-24.9 kg/m ²)	18.2	21.0		
Obese class I (25.0-29.9 kg/m ²)	25.4	35.1		
Obese class II (≥30.0 kg/m ²)	5.4	14.1		

*Statistically significant (p<0.05)

Table 3: Association of COVID-19-related variables with hypertension status.

Variables		Normotensives (%)	Hypertensives (%)	Chi-square value	P value
Infected with COVID-19	Yes	28.0	29.3	0.411	0.524
	No	72.0	70.7		
Symptoms	No symptoms	72.0	70.7	1.104	0.776
	Mild	10.7	11.7		
	Moderate	14.6	15.2		
	Severe	2.7	2.3		
Range of fever	No fever	72.0	70.7	0.688	0.709
	99-100 F	11.9	11.9		
	100 F	16.1	17.4		
Admitted in hospital	Yes	2.9	2.2	0.919	0.404
	No	97.1	97.8		
Admitted to ICU	No	100	100	—	—
Received oxygen therapy	No	100	100	—	—
BP fluctuation after the COVID period	Yes	11.4	45.0	313.192	0.001*
	No	88.6	55.0		
Pre-COVID health problem	Yes	8.3	39.2	302.023	0.001*
	No	91.7	60.8		
No. of COVID doses	0 dose	1.1	1.2	0.882	0.830
	1 dose	1.4	1.3		
	2 doses	96.9	96.6		
	3 doses	0.5	0.8		

*Statistically significant (p<0.05)

BMI and hypertension

A statistically significant association was observed between BMI category and hypertension status

($\chi^2=122.804, p=0.001$), with a clear and progressive dose-response relationship evident across all BMI categories. Hypertension prevalence was lowest among underweight women (6.4%, BMI<18.5 kg/m²) and rose steadily

through the normal weight (23.3%) and overweight (21.0%) categories, reaching its peak among women classified as Obese Class I (35.1%, BMI 25.0-29.9 kg/m²). Women in the Obese Class II category (BMI \geq 30.0 kg/m²) also recorded a substantially elevated prevalence of 14.1%. In contrast, underweight women were considerably more represented in the normotensive group (15.3%) than among hypertensives (6.4%), reflecting an inverse association between low body weight and blood pressure elevation (Table 2).

COVID-19 variables and hypertension

COVID-19 infection history was reported by 28.0% of normotensive and 29.3% of hypertensive women, with no statistically significant difference between groups ($\chi^2=0.411$, $p=0.524$) (Table 3). Symptom severity was similarly comparable across both groups, with mild symptoms reported by 10.7% of normotensives and 11.7% of hypertensives, moderate symptoms by 14.6% and 15.2% respectively, and severe symptoms by 2.7% and 2.3% respectively ($\chi^2=1.104$, $p=0.776$). Fever patterns, hospitalisation rates, and vaccination status likewise showed no significant inter-group differences. Notably, neither ICU admission nor oxygen therapy was required by any participant in either group, and two-dose COVID-19 vaccination coverage was comparable at 96.9% among normotensives and 96.6% among hypertensives ($\chi^2=0.882$, $p=0.830$).

In sharp contrast, blood pressure fluctuations occurring during or after the COVID-19 period demonstrated a highly significant association with hypertension status ($\chi^2=313.192$, $p=0.001$), with 45.0% of hypertensive women reporting such fluctuations compared to only 11.4% of normotensives.

Pre-existing health conditions prior to COVID-19 infection were equally strongly associated with hypertension ($\chi^2=302.023$, $p=0.001$), documented in 39.2% of hypertensive women versus only 8.3% of normotensives. Collectively, these findings indicate that COVID-19 itself does not independently predict hypertension status, but rather functions as a haemodynamic stressor that unmasks or exacerbates latent hypertensive tendencies in susceptible individuals.

DISCUSSION

The findings of this community-based cross-sectional investigation underscore a significant and largely underdiagnosed burden of hypertension among adult women in rural Punjab, with an overall prevalence of 38.3%. This estimate aligns closely with state-level data derived from the WHO STEPwise surveillance programme for Punjab and Haryana, which recorded a prevalence of approximately 40.1%,⁶ and is further corroborated by Singh et al, who documented comparable hypertension rates across rural and urban districts of Punjab.⁷ The substantial proportion of women classified

as pre-hypertensive (31.1%) warrants equal concern, as this group constitutes a significant at-risk reservoir with demonstrated susceptibility to progression towards established hypertension and early arterial wall changes.¹² A large proportion of women with Stage 1 hypertension had no prior diagnosis before this community screening, reinforcing the well-recognised ‘silent killer’ nature of hypertension that continues to drive underdiagnosed cardiovascular risk across low- and middle-income country (LMIC) populations.

The marked age-related gradient in hypertension prevalence escalating from 8.5% among women aged 18-29 years to 66.1% in the 45-69 years age group is consistent with nationally representative evidence and reflects the combined influence of progressive vascular ageing, declining post-menopausal oestrogen levels, and cumulative exposure to cardiovascular risk factors over time.³ The menopausal transition exerts its hypertensive effect through multiple interconnected pathways, including impaired endothelial vasodilation, reduced arterial compliance, upregulation of the renin-angiotensin-aldosterone system (RAAS), and heightened sympathetic nervous system activity. The inverse relationship between hypertension burden and both educational attainment and socioeconomic status observed in this study is consistent with established epidemiological evidence, wherein limited literacy constrains health knowledge, reduces utilisation of preventive services, and undermines adherence to lifestyle modification strategies. The disproportionately high burden documented among labouring women (71.0%) further reflects the compounding effects of occupational physical strain, nutritional vulnerability, and restricted access to primary healthcare services.

The dose-response relationship between increasing BMI and hypertension prevalence observed in the present study is consistent with findings from large-scale South Asian epidemiological investigations.¹³ In South Asian populations, adiposity-mediated blood pressure elevation operates primarily through insulin resistance, RAAS overactivation, and augmented sympathetic drive, with cardiometabolic risk manifesting at considerably lower BMI thresholds compared to Western populations, thereby validating the application of Asia-Pacific BMI classification criteria in the present study.¹¹

The COVID-19-related observations from this study provide clinically meaningful insights into the hypertension–pandemic interface. The lack of a statistically significant association between a history of COVID-19 infection and hypertension status ($p=0.524$) may be attributable to the predominantly mild clinical course of infection within this community sample, the inherent temporal limitations of the cross-sectional study design, and the relatively younger age profile of COVID-19 positive participants. In contrast, the highly significant association between blood pressure fluctuations occurring during or after COVID-19 illness and hypertension status

($\chi^2=313.192$, $p=0.001$) carries important clinical implications. SARS-CoV-2 is known to inflict endothelial damage through binding to ACE2 receptors on vascular endothelial cells, initiating systemic inflammatory cascades, cytokine-mediated vascular injury, and autonomic cardiovascular dysregulation, mechanisms capable of inducing sustained blood pressure elevation, particularly in women with underlying subclinical hypertensive predisposition.⁸

The significant association between pre-existing comorbidities before COVID-19 and hypertension status ($\chi^2=302.023$, $p=0.001$) additionally highlights the complex bidirectional interplay between hypertension and chronic disease multimorbidity.

Collectively, these findings support the interpretation that COVID-19 operates principally as a haemodynamic trigger that unmasks or accelerates pre-existing hypertensive tendencies, rather than serving as an independent cause of de novo hypertension at the community level.

Limitations

The cross-sectional design precludes the establishment of causal relationships between the identified risk factors and hypertension, and limits the ability to assess temporal associations, particularly regarding post-COVID-19 blood pressure trajectories. The study was restricted to adult women in rural Punjab, which may limit the generalisability of findings to urban populations, men, or other Indian states.

CONCLUSION

This study establishes a substantial, multifactorial, and largely underdiagnosed burden of hypertension among adult women in rural Punjab, with 38.3% prevalence and an additional 31.1% at the pre-hypertensive threshold. Advancing age, lower educational attainment, labourer occupation, lower socioeconomic status, and overweight/obesity are the most significant determinants. COVID-19-related blood pressure fluctuations and pre-existing comorbidities represent clinically important risk dimensions requiring targeted post-COVID surveillance. These findings make an evidence-based case for: universal blood pressure screening integrated into ASHA and ANM community outreach, gender-sensitive NCD awareness campaigns for rural women, targeted obesity and lifestyle interventions; and enhanced post-COVID cardiovascular monitoring in primary health centres across Punjab. Implementation within the Ayushman Bharat and NPCDCS frameworks could substantially reduce the long-term cardiovascular disease burden among this vulnerable population.

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