

Women at the Edge of Hypertension: Early Cardiometabolic Risk in Manipur, Northeast India

ABIGAIL LALNUNENG[‡], V SOUZH PAO[†], THIYAM SEITYAJIT SINGH[†] &
KALLUR NAVA SARASWATHY[†]

*Department of Anthropology, Faculty of Science,
University of Delhi 110007, Delhi*

E-mail: abigaillalnuneng@gmail.com / alalnuneng@anthro.du.ac.in
<https://doi.org/10.47509/SAA.2026.v26i01.08>

KEYWORDS: Women's Health. Cardiometabolic Risk. Prehypertension. Hypertension. Obesity. Central Obesity. Diabetes. Manipur.

ABSTRACT: Elevated blood pressure, including pre-hypertension, is increasingly prevalent among women in India, yet state-level evidence from Manipur, Northeast India is limited. This study examined the prevalence and biosocial determinants of pre-hypertension and hypertension among women aged 15–49 years (n=6831) in Manipur using data from the National Family Health Survey-5 (2019–2021). Blood pressure was classified using JNC-7 guidelines, and survey-weighted logistic regression models assessed socio-demographic, behavioural, and biological correlates. Hypertension prevalence increased with age and varied significantly across districts. In adjusted models, older age, primary education, overweight/obesity, elevated waist circumference, and diabetes were independently associated with both pre-hypertension and hypertension, while underweight status was protective. Social category was associated with hypertension but not pre-hypertension. The high burden of pre-hypertension alongside widespread central adiposity underscores early cardiometabolic risk among women. These findings highlight the need for gender-sensitive, regionally grounded strategies for early detection and prevention of hypertension in Northeast India.

INTRODUCTION

Cardiovascular disease remains the leading cause of death globally, with elevated blood pressure constituting its most prevalent and modifiable risk factor (World Health Organisation [WHO], 2023). An estimated 1.4 billion adults live with hypertension globally, with nearly two-thirds residing in low- and middle-income countries (LMICs), where early detection, treatment, and long-term control remain uneven (WHO, 2023; 2025). Importantly, hypertension rarely manifests abruptly; rather, it develops along a continuum beginning with modest

elevations in blood pressure, commonly classified as pre-hypertension, which signal early vascular and metabolic dysregulation and substantially increase the likelihood of progression to overt hypertension and subsequent cardiovascular morbidity (Vasan *et al.*, 2001; Whelton *et al.*, 2018). These early alterations often remain undetected, particularly among women, despite their significant contribution to future cardiovascular morbidity and mortality.

Over recent decades, the burden of elevated blood pressure has shifted decisively toward LMICs undergoing rapid epidemiological, nutritional, and social transitions (WHO, 2025). Rising levels of overweight, central adiposity, and glycaemic dysregulation increasingly co-occur with elevated

[‡] Assistant Professor, corresponding author

[†] Ph.D. Scholar

[†] Professor

blood pressure, reflecting the clustering of cardiometabolic conditions within populations experiencing changing dietary patterns, reduced physical activity, and expanding urban environments (Popkin, *et al.*, 2020; Lauder *et al.*, 2023). Women's blood pressure trajectories are shaped by sex-specific physiological processes across the life-course, alongside social and structural constraints that influence health behaviours and access to care (Ji *et al.*, 2020; Connelly *et al.*, 2022). Recognising elevated blood pressure as a biosocial continuum rather than a binary clinical condition is therefore critical for understanding early cardiometabolic vulnerability.

India bears a substantial share of the global hypertension burden, with approximately one in four adults (24% men and 21.3% women) exhibiting elevated blood pressure and considerable regional heterogeneity in prevalence (International Institute for Population Sciences [IIPS] and ICF, 2021a; Varghese *et al.*, 2023). National analyses indicate that the northeastern states record the second highest prevalence of hypertension in the country for women (Mittal *et al.*, 2025). Within this region, Manipur exhibits a relatively high prevalence of hypertension among women (23%) (IIPS and ICF, 2021b), however, state-representative population-level analysis examining early-stage blood pressure variation alongside anthropometric and metabolic indicators with socio-demographic factors among women remain limited.

Blood pressure variation reflects the combined influence of social conditions, dietary patterns, and ecological exposures acting through physiological pathways (Hanna and Baker, 1979; Zuckerman, 2018). Northeast India is characterised by marked ethnic diversity, distinct dietary practices, and heterogeneous ecological and socioeconomic contexts, factors that may shape adiposity, glucose regulation, and cardiovascular function among women (Lalnuneng and Khongsdier, 2017; Zimik *et al.*, 2023). However, few population-based studies have simultaneously examined both pre-hypertension and hypertension within an integrated biosocial framework that incorporates metabolic indicators alongside social determinants.

Examining pre-hypertension alongside hypertension allows characterisation of early blood

pressure patterns and their distribution across the female life course. In this context, the present study describes the prevalence and biosocial correlates of pre-hypertension and hypertension among women aged 15–49 years in Manipur using state-representative data from the National Family Health Survey-5.

MATERIALS & METHODS

Study Design and Data Source

This study used data from the fifth round of the NFHS-5, a nationally representative, cross-sectional survey conducted in India between June 2019 and April 2021. NFHS-5 employed a stratified multistage sampling design with probability proportional to size selection of primary sampling units and systematic household sampling. The survey data collected information on socio-demographic, economic, behavioural, and health outcomes. The present analyses focused on women aged 15–49 years residing in Manipur, Northeast India.

Study Sample

Data was extracted from the NFHS-5 women's individual recode file (IAIR7EFL) obtained from the Demographic and Health Surveys (DHS) Program database. Of the 724,115 women interviewed nationally, 8,042 women were from Manipur. Women who were pregnant at the time of the survey ($n = 420$) were excluded due to pregnancy-related alterations in blood pressure and anthropometric measures. Women who self-reported chronic illness ($n = 493$) and those with missing data on anthropometry, blood pressure, or blood glucose ($n = 297$) were also excluded to ensure analytic consistency across biological measures. The final analytical sample comprised 6,831 women. Sampling weights and survey design variables provided by NFHS-5 were applied in all analyses to produce population-representative estimates.

Socio-demographic and Socio-economic Variables

Socio-demographic and socio-economic variables included place of residence (urban or rural), district, sex of household head, household size, age, marital status, duration of cohabitation,

educational attainment, and household wealth index. These variables were selected to characterise social and household contexts commonly examined in population-based studies of cardiometabolic risk.

Behavioural Variables

Dietary behaviour was assessed based on self-reported frequency of consumption of milk or curd, pulses or beans, dark green leafy vegetables, fruits, eggs, fish, chicken or meat, fried foods, and aerated drinks. Response categories (never, occasionally, weekly, daily) were aggregated to generate composite scores for healthy foods (milk or curd, pulses or beans, dark green leafy vegetables, fruits, eggs, fish, chicken or meat) and unhealthy foods (fried foods and aerated drinks). Substance use variables included cigarette smoking, tobacco chewing, and alcohol consumption.

Blood Pressure, Anthropometric, and Blood Glucose Measures

Systolic and diastolic blood pressure were measured three times, and the average of the second and third readings were used for analysis. Blood pressure categories were defined according to the Seventh Report of the Joint National Committee guidelines. Blood pressure categories were defined as normal (<120/80 mmHg), pre-hypertension (120–139/80–89 mmHg), stage 1 hypertension (140–159/90–99 mmHg), and stage 2 hypertension ($\geq 160/\geq 100$ mmHg) (Chobanian et al., 2003). Women reporting antihypertensive medication use were classified as hypertensive.

Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared and categorised using Asia-Pacific cut-offs as underweight (<18.5 kg/m²), normal (18.5–22.9 kg/m²), overweight (23.0–24.9 kg/m²), and obese (≥ 25.0 kg/m²) (WHO, 2000). Overweight and obese categories were combined for regression analyses as the revised obesity guidelines for Asian Indians recommend a BMI cut-off of ≥ 23.0 kg/m² for defining obesity (Misra et al., 2025). Central obesity was assessed using waist circumference (WC) and waist-to-hip ratio (WHR). High WC was defined

as greater than 80 cm for women, and high WHR as greater than 0.80, following WHO and Asian-specific guidelines (WHO, 2000).

Blood glucose was measured using capillary finger-stick samples. Fasting status was derived from self-reported time since last caloric intake, with fasting defined as at least 8 hours. Fasting glucose was classified as normal (<100 mg/dL), pre-diabetic (100–125 mg/dL), or diabetic (≥ 126 mg/dL). Random glucose was classified as normal (<140 mg/dL), pre-diabetic (140–199 mg/dL), or diabetic (≥ 200 mg/dL) (WHO, 2006). Women reporting the use of glucose-lowering medication were classified as diabetic.

Statistical Analyses

Analyses were conducted using IBM SPSS Statistics version 28, accounting for survey weights and complex sampling design. Descriptive statistics were presented as weighted proportions or means with standard errors and 95% confidence intervals. Weighted chi-square tests examined differences across blood pressure categories. Survey-weighted binary logistic regression models were fitted separately for pre-hypertension and hypertension. Unadjusted and adjusted odds ratios with 95% confidence intervals were reported. Statistical significance was defined as $p < 0.05$.

RESULTS

Background Characteristic of Study Participants

Table 1 presents the weighted *socio-demographic, economic and behavioural* characteristics of women in Manipur. The sample was predominantly rural (62.3%), with urban residents comprising 37.7%. District representation varied, with the largest weighted sample drawn from Thoubal (22.5%), followed by Imphal West (21.7%), Imphal East (21.1%), and Bishnupur (10.4%), whereas hill districts including Tamenglong (3.6%), Chandel (3.7%), Senapati (4.6%), Ukhul (4.7%), and Churachandpur (7.8%) each accounted for less than 8% of the weighted sample. The age distribution was relatively even across the 15–44-year groups (29.6% 15–24 years; 30.5% 25–34 years; 28.6% 35–

44 years), with a smaller proportion in the 45-49-year category (11.3%).

Women identifying as Scheduled Tribes constituted 26.7% of the population, followed by Other Backward Classes (21.0%) and Scheduled Castes (8.7%), with 43.6% classified under the "Other" category. Most women were currently married (62.3%) and resided in male-headed households (82.0%). Over half of women lived in households with more than five members (57.7%). Among ever-married women, cohabitation duration was broadly distributed, with notable representation in the 5–14-year categories (15.7% 5-9 years, 14.0% 10-14 years).

Educational attainment was concentrated at the secondary level (63.0%), whereas 19% reporting higher education, 9.5% with primary schooling, and 8.3% with no formal education. The wealth distribution was relatively balanced across quintiles (18.5%-21.3%).

Dietary patterns reflected frequent consumption of plant-based foods, particularly dark green leafy vegetables (74.7%) and pulses (65.1% weekly). Fruit consumption was less regular, and nearly half reported weekly intake of fried foods (49.4%). Substance use was uncommon, with very low prevalence of smoking (0.3%), tobacco chewing (3.4%), and alcohol consumption (1.6%).

TABLE 1

Weighted distribution of socio-demographic, economic, behavioural, and dietary characteristics among women aged 15–49 years in Manipur, Northeast India

Background characteristics	Weighted n (weighted proportion 95% CI)	Unweighted n (%)
Socio-demographic and economic factors		
<i>Type of place of residence</i>		
Urban	404 [37.7 (35.4-40.1)]	1867 (27.3)
Rural	668 [62.3 (59.9-64.6)]	4964 (72.7)
<i>District</i>		
Senapati	49 [4.6 (4.0-5.2)]	711 (10.4)
Tamenglong	39 [3.6 (3.1-4.2)]	718 (10.5)
Churachandpur	83 [7.8 (6.4-9.4)]	746 (10.9)
Bishnupur	112 [10.4 (9.2-11.8)]	863 (12.6)
Thoubal	241 [22.5 (21.1-23.9)]	955 (14)
Imphal west	232 [21.7 (19.3-24.2)]	749 (11)
Imphal east	226 [21.1 (19.1-23.3)]	817 (12)
Ukhrul	50 [4.7 (4.1-5.3)]	606 (8.9)
Chandel	40 [3.7 (3.2-4.2)]	666 (9.7)
<i>Social category</i>		
Scheduled caste	88 [8.7 (6.2-12.0)]	450 (6.8)
Scheduled tribe	269 [26.7 (24.6-29.0)]	3372 (51.2)
OBC	211 [21.0 (18.3-23.9)]	905 (13.7)
Others	440 [43.6 (40.3-47.0)]	1864 (28.3)
<i>Sex of household head</i>		
Male	879 [82.0 (80.5-83.4)]	5629 (82.4)
Female	193 [18.0 (16.6-19.5)]	1202 (17.6)
<i>Age</i>		
15-24	318 [29.6 (28.3-31.1)]	1981 (29)
25-34	327 [30.5 (29.0-32.0)]	2177 (31.9)
35-44	306 [28.6 (27.4-29.7)]	1915 (28)
45-49	121 [11.3 (10.4-12.2)]	758 (11.1)
<i>Marital status</i>		
Never married	342 [31.9 (30.4-33.4)]	2127 (31.1)
Married	667 [62.3 (60.7-63.8)]	4310 (63.1)

Background characteristics	Weighted n (weighted proportion 95% CI)	Unweighted n (%)
Socio-demographic and economic factors		
DSW	63 [5.8 (5.2-6.6)]	394 (5.8)
<i>Family size</i>		
<5	453 [42.3 (40.1-44.5)]	2868 (42)
>5	619 [57.7 (55.5-59.9)]	3963 (58)
<i>Cohabitation duration</i>		
Never married	342 [31.9 (30.4-33.4)]	2127 (31.1)
0-4	126 [11.7 (10.7-12.8)]	815 (11.9)
5-9	168 [15.7 (14.5-16.9)]	1073 (15.7)
10-14	150 [14.0 (13.0-15.0)]	930 (13.6)
15-19	117 [10.9 (10.0-11.9)]	748 (11)
20-24	98 [9.1 (8.3-10.0)]	631 (9.2)
25-29	56 [5.3 (4.7-6.0)]	407 (6)
30+	15 [1.4 (1.1-1.8)]	100 (1.5)
<i>Highest educational level</i>		
No education	89 [8.3 (7.4-9.3)]	676 (9.9)
Primary	101 [9.5 (8.4-10.6)]	827 (12.1)
Secondary	676 [63.0 (61.5-64.6)]	4230 (61.9)
Higher	206 [19.2 (17.6-21.0)]	1098 (16.1)
<i>Wealth index</i>		
Poorest	200 [18.6 (16.8-20.6)]	1827 (26.7)
Poorer	226 [21.1 (19.6-22.7)]	1535 (22.5)
Middle	219 [20.4 (18.8-22.2)]	1294 (18.9)
Richer	228 [21.3 (19.6-23.1)]	1242 (18.2)
Richest	198 [18.5 (16.5-20.7)]	933 (13.7)
Behavioural factors		
<i>Frequency takes milk or curd</i>		
Never	149 [13.9 (12.4-15.6)]	1035 (15.2)
Daily	208 [19.4 (17.3-21.7)]	1098 (16.1)
Weekly	289 [26.9 (24.4-29.6)]	1773 (26)
Occasionally	426 [39.8 (37.4-42.1)]	2925 (42.8)
<i>Frequency eats pulses or beans</i>		
Never	4 [0.4 (0.2-0.7)]	28 (0.4)
Daily	192 [17.9 (15.7-20.4)]	1106 (16.2)
Weekly	698 [65.1 (62.8-67.4)]	4379 (64.1)
Occasionally	178 [16.6 (14.9-18.4)]	1318 (19.3)
<i>Frequency eats dark green leafy vegetable</i>		
Never	1 [0.1 (0.0-0.2)]	6 (0.1)
Daily	800 [74.7 (72.0-77.1)]	5167 (75.6)
Weekly	246 [23.0 (20.8-25.3)]	1522 (22.3)
Occasionally	24 [2.3 (1.7-3.0)]	136 (2)
<i>Frequency eats fruits</i>		
Never	28 [2.6 (2.1-3.2)]	146 (2.1)
Daily	118 [11.0 (9.9-12.3)]	742 (10.9)
Weekly	455 [42.4 (39.8-45.1)]	2915 (42.7)
Occasionally	470 [43.9 (41.4-46.4)]	3028 (44.3)
<i>Frequency eats eggs</i>		
Never	31 [2.8 (2.3-3.5)]	170 (2.5)

Background characteristics	Weighted n (weighted proportion 95% CI)	Unweighted n (%)
Socio-demographic and economic factors		
Daily	70 [6.5 (5.6-7.6)]	361 (5.3)
Weekly	551 [51.4 (48.8-54.1)]	3304 (48.4)
Occasionally	420 [39.2 (36.6-41.8)]	2996 (43.9)
<i>Frequency eats fish</i>		
Never	11 [1.1 (0.8-1.5)]	78 (1.1)
Daily	244 [22.8 (20.3-25.4)]	1248 (18.3)
Weekly	477 [44.5 (42.1-47.0)]	2716 (39.8)
Occasionally	339 [31.6 (29.2-34.2)]	2789 (40.8)
<i>Frequency eats chicken or meat</i>		
Never	45 [4.2 (3.5-5.1)]	185 (2.7)
Daily	23 [2.1 (1.7-2.6)]	188 (2.8)
Weekly	523 [48.8 (46.4-51.3)]	3519 (51.5)
Occasionally	480 [44.8 (42.5-47.2)]	2939 (43)
<i>Frequency eats fried food</i>		
Never	15 [1.4 (1.0-1.9)]	129 (1.9)
Daily	157 [14.6 (12.6-16.9)]	814 (11.9)
Weekly	530 [49.4 (46.3-52.5)]	3184 (46.6)
Occasionally	370 [34.5 (31.6-37.6)]	2704 (39.6)
<i>Frequency takes aerated drinks</i>		
Never	195 [18.2 (16.3-20.2)]	1354 (19.8)
Daily	19 [1.8 (1.3-2.4)]	106 (1.6)
Weekly	193 [18.0 (16.0-20.3)]	1100 (16.1)
Occasionally	665 [62.0 (59.4-64.6)]	4271 (62.5)
<i>Food frequency score [Healthy food]</i>		
High	440 [41.1 (38.3-43.9)]	2514 (36.8)
Medium	324 [30.2 (28.3-32.1)]	2107 (30.8)
Low	308 [28.7 (26.2-31.4)]	2210 (32.4)
<i>Food frequency score [Unhealthy food]</i>		
High	264 [24.6 (22.3-27.1)]	1433 (21)
Medium	368 [34.3 (32.5-36.2)]	2202 (32.2)
Low	440 [41.0 (38.3-43.8)]	3196 (46.8)
<i>Smokes cigarettes</i>		
No	1068 [99.7 (99.5-99.8)]	6795 (99.5)
Yes	3 [0.3 (0.2-0.5)]	36 (0.5)
<i>Chews tobacco</i>		
No	1035 [96.6 (95.9-97.2)]	6507 (95.3)
Yes	36 [3.4 (2.8-4.1)]	324 (4.7)
<i>Alcohol Consumption</i>		
No	1054 [98.4 (97.7-98.8)]	6706 (98.2)
Yes	17 [1.6 (1.2-2.3)]	125 (1.8)

Blood Pressure, Anthropometric, and Blood Glucose Profile

Table 2 presents weighted mean physiological and anthropometric indicators. Mean SBP and DBP were 115.8 mmHg (95% CI: 115.4–116.3) and 79.5 mmHg (95% CI: 79.2–79.8), respectively. The mean

BMI was 23.7 kg/m² (95% CI: 23.6–23.9). Central adiposity indicators were notable, with mean waist circumference of 80.6 cm (95% CI: 80.1–81.1) and mean waist-to-hip ratio of 0.87 (95% CI: 0.871–0.877). Mean blood glucose concentration was 109.8 mg/dL (95% CI: 108.9–110.8).

TABLE 2

Prevalence of prehypertension, hypertension, malnutrition, central obesity, and glycaemic profiles among women in Manipur

Variable	Mean $\pm$ SE	95% Confidence Interval
SBP mmHg	115.83 $\pm$ 0.22	115.38 - 116.27
DBP mmHg	79.46 $\pm$ 0.16	79.16 - 79.77
Weight (kg)	55.02 $\pm$ 0.20	54.63 - 55.42
Height (m)	1.52 $\pm$ 0.001	1.520 - 1.525
Body Mass Index (kg/m ²)	23.72 $\pm$ 0.07	23.58 - 23.86
Waist circumference (cm)	80.59 $\pm$ 0.23	80.14 - 81.05
Hip circumference (cm)	92.12 $\pm$ 0.24	91.65 - 92.58
Waist-to-Hip Ratio	0.87 $\pm$ 0.002	0.871 - 0.877
Glucose level (mg/dL)	109.84 $\pm$ 0.47	108.92 - 110.76

Note: Mean ($\pm$ SE) and 95% confidence intervals for blood pressure, anthropometric, and glycaemic measures among women aged 15–49 years in Manipur, Northeast India

Figure 1 shows the prevalence of prehypertension, hypertension, malnutrition, central obesity defined by WC, WHR, and glycaemic status in the study population. Overall, 13.9% of women were hypertensive (11.1% stage 1 and 2.8% stage 2 hypertension), while 37.5% women were classified as pre-hypertensive, while 37.5% women were classified as pre-hypertensive. Based on BMI, 7.2% of women were underweight, 19.4% were overweight and 32.7% were obese. Central obesity was more common, with 49.3% of women having high WC, and 86.4% having high WHR. With respect to glycaemic status, 7.7% of participants had pre-diabetes, and 2.4% had diabetes.

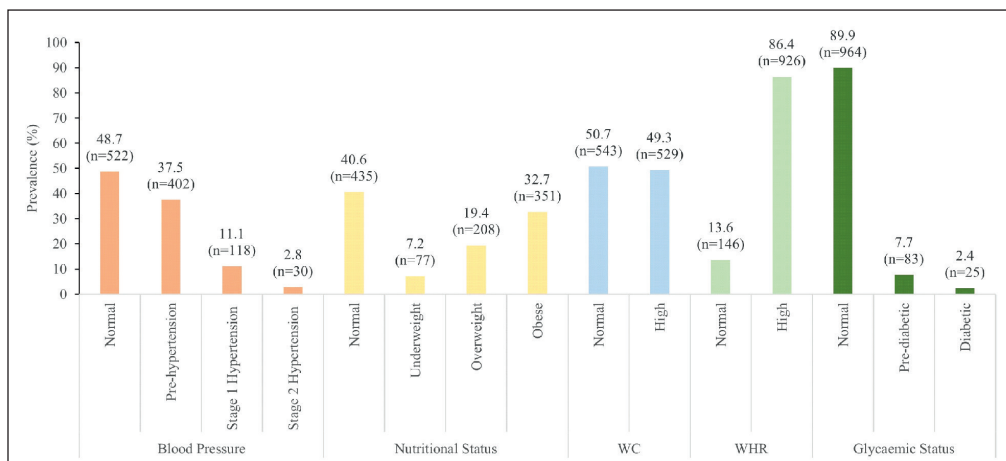


Figure 1: Distribution of blood pressure, nutritional status, central adiposity, and glycaemic status among women aged 15–49 years in Manipur, Northeast India. Note: WC= waist circumference, WHR= waist-to-hip ratio

Variation in Blood Pressure Across Socio-demographic, Economic, Behavioural, and Metabolic Health

Table 3 presents the weighted distribution of normal, pre-hypertension and hypertension across socio-demographic, socioeconomic, behavioural, and health characteristics among women in Manipur. Patterns observed in the weighted analysis were comparable to the unweighted distributions (Supplementary Table 1).

Blood pressure status differed by place of residence, with urban women showing a slightly higher burden of elevated blood pressure (pre-

hypertension: 38.4%, hypertension: 15.3%) compared with rural women (37.0% and 13.0%, respectively; $\chi^2 = 3.41$, $p = 0.034$).

Significant district-level variation was observed ($\chi^2 = 6.96$, $p < 0.001$). Pre-hypertension was most prevalent in Imphal West (43.7%), followed by Thoubal (41.6%), Senapati (39.5%), Chandel (39.2%), Tamenglong (34.5%), Ukhrul (33.7%), Churachandpur (33.2%), Imphal East (31.9%), and Bishnupur (31.4%). A comparable spatial distribution was noted for hypertension, with the highest proportion in Imphal West (16.5%), followed by Chandel (14.8%), Thoubal (14.2%), Bishnupur (14.0%), Imphal East

(13.4%), Tamenglong (13.1%), Ukhrul (12.3%), Senapati (10.1%), and Churachandpur (9.6%).

Variation across social categories was also statistically significant ($\chi^2 = 3.38$, $p = 0.004$). Pre-hypertension was highest among women classified under the “Other” category (39.2%), followed by OBC (36.4%), Scheduled Tribes (35.6%), and Scheduled Castes (34.7%). In contrast, hypertension was most prevalent among Scheduled Castes (15.5%), followed by the “Other” category (14.9%), OBC (13.9%), and Scheduled Tribes (11.2%).

Significant differences were evident across age groups ($\chi^2 = 89.42$, $p < 0.001$). Pre-hypertension and Hypertension was highest among women aged 35–44 years (43.8%), followed by those aged 45–49 years (41.5%) and 25–34 years (40.0%), and lowest among women aged 15–24 years (27.2%). Hypertension was most prevalent among women aged 45–49 years (29.2%), followed by those aged 35–44 years (21.2%) and 25–34 years (10.6%), with the lowest proportion among the youngest age group (4.3%).

Blood pressure distribution also differed by marital status ($\chi^2 = 45.03$, $p < 0.001$). The highest prevalence of pre-hypertension was observed among DSW women (44.8%), followed by married women (40.0%) and never-married women (31.4%). Similarly, hypertension shows 21.8%, 16.6%, and 7.0%, for DSW, married, and never-married women, respectively. Household size showed significant variation ($\chi^2 = 3.907$, $p = 0.021$), with higher prevalence of pre-hypertension (38.4%) and hypertension (15.2%) among women in households with fewer than five members compared with those in larger households (36.8% and 12.9%).

Cohabitation duration was associated with differences in blood pressure distribution ($\chi^2 = 25.27$, $p < 0.001$). Pre-hypertension was most prevalent among women cohabiting for 10–14 years (44.1%), followed by 25–29 years (43.8%) and ≥ 30 years (42.0%), while the lowest proportion occurred among never-married women. Hypertension was highest among women cohabiting for ≥ 30 years (28.7%), followed by 25–29 years (27.6%) and 20–24 years (25.6%), and lowest among never-married women (7.0%).

Educational attainment showed significant variation ($\chi^2 = 9.46$, $p < 0.001$). Pre-hypertension was highest among women with primary education

(43.9%) and those with no formal schooling (43.1%), whereas lower proportions were observed among women with secondary (36.2%) and higher education (36.1%). Hypertension was most prevalent among women without schooling (20.7%), followed by those with primary (16.7%) and higher education (15.8%), and lowest among women with secondary education (11.9%).

Across most dietary and lifestyle behaviours, the distribution of blood pressure categories was broadly similar. Statistically significant differences were observed for fruit intake ($\chi^2 = 6.04$, $p < 0.001$) and meat consumption ($\chi^2 = 4.44$, $p < 0.001$). Pre-hypertension was highest among women who never consumed fruit (41.4%) and lowest among daily consumers (34.1%), while hypertension ranged from 21.5% among non-consumers to 11.0% among daily consumers. Similarly, pre-hypertension was most prevalent among women who never consumed chicken or meat (40.4%) and lowest among occasional consumers (36.1%), with hypertension ranging from 23.7% among non-consumers to 10.7% among daily consumers.

Indicators of nutritional and metabolic health showed pronounced differences in blood pressure distribution (all $p < 0.001$). Pre-hypertension was most prevalent among women classified as overweight or obese (42.6%), followed by those with normal BMI (33.1%) and underweight (25.5%) ($\chi^2 = 73.51$, $p < 0.001$). Hypertension followed the same ordering (19.8%, 8.2%, and 2.8%, respectively), while normal blood pressure was most prevalent among underweight women (71.7%). Elevated waist circumference was associated with higher proportions of pre-hypertension (44.0%) and hypertension (20.2%) compared with normal waist circumference (31.2% and 7.6%) ($\chi^2 = 150.23$, $p < 0.001$), and similar differences were observed for waist-to-hip ratio (39.0% and 15.1% vs. 27.9% and 6.0%; $\chi^2 = 48.19$, $p < 0.001$). Blood pressure distribution also differed by glycaemic status ($\chi^2 = 22.30$, $p < 0.001$), with the highest prevalence of pre-hypertension (43.3%) and hypertension (38.3%) among women with diabetes, followed by pre-diabetic women (38.0% and 21.4%), and the lowest among those with normal glycaemic status (37.3% and 12.6%). In contrast, blood pressure categories did not differ significantly across wealth quintiles ($\chi^2 = 1.867$, $p = 0.068$) or by sex of household head ($\chi^2 = 1.078$, $p = 0.339$).

TABLE 3

Bivariate association between blood pressure categories and socio-demographic, economic, behavioural, and cardiometabolic characteristics (weighted proportions and χ^2 test)

Socio-demographic, economic, behavioural and cardiometabolic Factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
	Frequency (weighted proportion 95% CI)			
<i>Type of place of residence</i>				
Urban	187.247 [46.4 (43.8-49.0)]	155.067 [38.4 (36.0-40.8)]	61.640 [15.3 (13.5-17.2)]	3.409, 0.034*
Rural	334.186 [50.0 (48.1-52.0)]	246.796 [37.0 (35.1-38.8)]	86.844 [13.0 (11.9-14.2)]	
<i>District</i>				
Senapati	24.821 [50.4 (46.2-54.6)]	19.480 [39.5 (35.7-43.4)]	4.985 [10.1 (8.2-12.4)]	6.959, <0.001*
Tamenglong	20.328 [52.4 (47.0-57.6)]	13.407 [34.5 (29.5-39.9)]	5.093 [13.1 (10.5-16.3)]	
Churachandpur	47.573 [57.2 (52.5-61.8)]	27.629 [33.2 (28.5-38.2)]	7.994 [9.6 (7.2-12.7)]	
Bishnupur	60.952 [54.5 (51.4-57.6)]	35.152 [31.4 (28.5-34.5)]	15.684 [14.0 (11.9-16.4)]	
Thoubal	106.514 [44.2 (41.1-47.4)]	100.155 [41.6 (38.7-44.5)]	34.139 [14.2 (12.0-16.6)]	
Imphal West	92.231 [39.7 (36.2-43.3)]	101.505 [43.7 (40.0-47.5)]	38.373 [16.5 (13.9-19.5)]	
Imphal East	123.645 [54.7 (51.0-58.4)]	72.069 [31.9 (28.7-35.3)]	30.178 [13.4 (11.1-16.0)]	
Ukhrul	27.055 [54.0 (48.1-59.9)]	16.872 [33.7 (28.7-39.1)]	6.137 [12.3 (9.3-16.1)]	
Chandel	18.316 [46.0 (40.7-51.4)]	15.593 [39.2 (35.6-42.9)]	5.901 [14.8 (11.8-18.4)]	
<i>Social category</i>				
Scheduled caste	43.626 [49.8 (44.9-54.6)]	30.454 [34.7 (30.4-39.4)]	13.593 [15.5 (11.5-20.6)]	3.375, 0.004*
Scheduled tribe	143.319 [53.2 (50.8-55.6)]	95.762 [35.6 (33.3-37.8)]	30.203 [11.2 (10.0-12.6)]	
OBC	104.940 [49.7 (46.3-53.0)]	76.917 [36.4 (33.4-39.5)]	29.390 [13.9 (11.6-16.6)]	
Others	201.518 [45.9 (43.3-48.5)]	172.484 [39.2 (37.1-41.5)]	65.500 [14.9 (13.3-16.7)]	
<i>Sex of household head</i>				
Male	431.140 [49.1 (47.5-50.7)]	328.553 [37.4 (35.8-39.0)]	118.966 [13.5 (12.5-14.7)]	1.078,
Female	90.294 [46.8 (43.3-50.3)]	73.309 [38.0 (34.7-41.3)]	29.518 [15.3 (12.7-18.3)]	0.339
<i>Age</i>				
15-24	217.677 [68.5 (66.1-70.8)]	86.575 [27.2 (25.0-29.6)]	13.511 [4.3 (3.3-5.5)]	89.422, 0.000*
25-34	161.450 [49.4 (46.7-52.0)]	131.008 [40.0 (37.6-42.6)]	34.673 [10.6 (9.1-12.3)]	
35-44	106.979 [34.9 (32.4-37.6)]	134.182 [43.8 (41.2-46.5)]	65.007 [21.2 (19.1-23.5)]	
45-49	35.328 [29.3 (25.4-33.4)]	50.097 [41.5 (37.4-45.7)]	35.294 [29.2 (25.6-33.2)]	
<i>Marital status</i>				
Never married	210.606 [61.6 (59.0-64.1)]	107.170 [31.4 (29.1-33.7)]	24.057 [7.0 (5.8-8.5)]	45.025, 0.000*
Married	289.973 [43.4 (41.5-45.4)]	266.660 [40.0 (38.0-41.9)]	110.774 [16.6 (15.3-18.0)]	
DSW	20.854 [33.3 (27.8-39.4)]	28.033 [44.8 (38.8-51.0)]	13.653 [21.8 (17.1-27.5)]	
<i>Family size</i>				
< 5	210.458 [46.4 (44.1-48.8)]	173.896 [38.4 (36.3-40.5)]	68.790 [15.2 (13.7-16.8)]	3.907, 0.021*
≥ 5	310.976 [50.3 (48.2-52.3)]	227.966 [36.8 (34.9-38.8)]	79.695 [12.9 (11.5-14.4)]	
<i>Cohabitation duration</i>				
Never married	210.606 [61.6 (59.0-64.1)]	107.170 [31.4 (29.1-33.7)]	24.057 [7.0 (5.8-8.5)]	25.270, 0.000*
0-4	70.351 [56.0 (52.0-59.9)]	43.470 [34.6 (30.7-38.7)]	11.797 [9.4 (7.2-12.2)]	
5-9	83.201 [49.6 (46.0-53.2)]	64.426 [38.4 (35.1-41.8)]	20.177 [12.0 (10.0-14.4)]	
10-14	62.289 [41.5 (37.9-45.3)]	66.146 [44.1 (40.2-48.1)]	21.485 [14.3 (11.5-17.7)]	
15-19	42.353 [36.2 (32.2-40.3)]	48.823 [41.7 (37.6-45.9)]	25.937 [22.1 (18.6-26.1)]	
20-24	31.982 [32.8 (28.7-37.1)]	40.616 [41.6 (37.1-46.2)]	25.019 [25.6 (21.7-30.0)]	
25-29	16.132 [28.6 (23.7-34.0)]	24.750 [43.8 (37.9-49.9)]	15.595 [27.6 (22.7-33.1)]	
≥30	4.520 [29.4 (20.5-40.1)]	6.462 [42.0 (31.5-53.2)]	4.418 [28.7 (19.4-40.3)]	

Socio-demographic, economic, behavioural and cardiometaabolic Factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
	Frequency (weighted proportion 95% CI)			
<i>Highest educational level</i>				
No education	32.207 [36.3 (31.6-41.1)]	38.241 [43.1 (38.3-47.9)]	18.372 [20.7 (17.2-24.7)]	9.460, <0.001*
Primary	39.978 [39.4 (34.8-44.2)]	44.555 [43.9 (38.7-49.3)]	16.910 [16.7 (13.5-20.3)]	
Secondary	350.194 [51.8 (49.8-53.9)]	244.743 [36.2 (34.4-38.1)]	80.705 [11.9 (10.8-13.1)]	
Higher	99.054 [48.1 (44.4-51.8)]	74.323 [36.1 (32.8-39.6)]	32.498 [15.8 (13.3-18.7)]	
<i>Wealth Index</i>				
Poorest	103.367 [51.8% (48.9-54.6)]	74.522 [37.3% (34.5-40.3)]	21.832 [10.9% (9.2-12.9)]	1.867, 0.068
Poorer	114.799 [50.8% (47.4-54.1)]	82.284 [36.4% (33.6-39.3)]	29.042 [12.8% (10.8-15.2)]	
Middle	105.655 [48.2% (44.6-51.8)]	81.329 [37.1% (34.0-40.3)]	32.172 [14.7% (12.5-17.2)]	
Richer	106.786 [46.8% (43.6-50.0)]	85.872 [37.6% (34.1-41.3)]	35.703 [15.6% (13.3-18.2)]	
Richest	90.827 [45.8% (42.5-49.1)]	77.856 [39.2% (36.1-42.5)]	29.735 [15.0% (12.5-17.9)]	
Behavioural factors				
<i>Frequency of milk/curd intake</i>				
Never	74.377 [50.0 (45.9-54.0)]	54.823 [36.8 (33.0-40.8)]	19.637 [13.2 (10.5-16.4)]	1.096, 0.362
Daily	94.790 [45.6 (42.2-48.9)]	80.113 [38.5 (35.2-41.9)]	33.169 [15.9 (13.6-18.6)]	
Weekly	139.616 [48.4 (45.4-51.3)]	110.712 [38.4 (35.5-41.3)]	38.313 [13.3 (11.4-15.4)]	
Occasionally	212.651 [49.9 (47.7-52.1)]	156.213 [36.7 (34.6-38.8)]	57.365 [13.5 (12.0-15.0)]	
<i>Frequency of pulses/beans intake</i>				
Never	1.971 [45.3 (25.0-67.3)]	1.849 [42.5 (19.0-69.9)]	0.532 [12.2 (4.8-27.8)]	0.827, 0.528
Daily	88.465 [46.1 (42.2-50.1)]	76.686 [40.0 (36.1-44.0)]	26.634 [13.9 (11.8-16.3)]	
Weekly	341.202 [48.9 (47.0-50.8)]	261.473 [37.5 (35.7-39.3)]	95.182 [13.6 (12.5-14.9)]	
Occasionally	89.795 [50.5 (46.9-54.1)]	61.855 [34.8 (31.4-38.3)]	26.137 [14.7 (12.2-17.6)]	
<i>Frequency of dark green leafy vegetable intake</i>				
Never	0.935 [90.2 (50.9-98.8)]	0.00 [0 (0-0)]	0.101 [9.8 (1.2-49.1)]	1.611, 0.150
Daily	390.869 [48.8 (47.1-50.6)]	301.374 [37.7 (36.1-39.2)]	108.176 [13.5 (12.4-14.7)]	
Weekly	119.611 [48.6 (45.7-51.5)]	91.517 [37.2 (33.9-40.6)]	34.997 [14.2 (12.1-16.6)]	
Occasionally	10.019 [41.4 (31.7-51.8)]	8.972 [37.1 (27.9-47.3)]	5.211 [21.5 (14.0-31.6)]	
Frequency of fruit intake				
Never	10.475 [37.1 (29.4-45.5)]	11.708 [41.4 (32.9-50.5)]	6.067 [21.5 (15.4-29.1)]	6.044, <0.001*
Daily	65.065 [55.0 (50.8-59.0)]	40.322 [34.1 (30.5-37.9)]	12.993 [11.0 (8.6-13.9)]	
Weekly	234.861 [51.6 (49.3-54.0)]	158.885 [34.9 (32.8-37.1)]	61.056 [13.4 (11.9-15.1)]	
Occasionally	211.032 [44.9 (42.3-47.5)]	190.948 [40.6 (38.2-43.1)]	68.369 [14.5 (13.0-16.2)]	
<i>Frequency eats eggs</i>				
Never	14.303 [46.9 (38.6-55.3)]	10.882 [35.7 (28.3-43.7)]	5.330 [17.5 (11.6-25.5)]	0.863, 0.517
Daily	36.653 [52.5 (46.2-58.7)]	23.997 [34.4 (28.6-40.7)]	9.180 [13.1 (9.8-17.3)]	
Weekly	270.796 [49.1 (47.0-51.2)]	208.157 [37.8 (35.8-39.8)]	72.446 [13.1 (11.8-14.6)]	
Occasionally	199.681 [47.5 (45.2-49.9)]	158.826 [37.8 (35.6-40.1)]	61.529 [14.6 (12.9-16.6)]	

Socio-demographic, economic, behavioural and cardiometabolic Factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
Frequency (weighted proportion 95% CI)				
<i>Frequency eats fish</i>				
Never	6.458 [56.2 (43.2-68.4)]	3.905 [34.0 (23.9-45.8)]	1.125 [9.8 (4.1-21.4)]	1.359, 0.232
Daily	113.612 [46.6 (43.5-49.7)]	91.178 [37.4 (34.0-40.8)]	39.201 [16.1 (13.6-18.8)]	
Weekly	235.730 [49.4 (47.2-51.6)]	175.902 [36.9 (34.7-39.1)]	65.591 [13.7 (12.2-15.5)]	
Occasionally	165.634 [48.8 (46.2-51.5)]	130.878 [38.6 (36.0-41.3)]	42.567 [12.6 (11.0-14.3)]	
<i>Frequency eats chicken or meat</i>				
Never	16.238 [36.0 (28.9-43.7)]	18.215 [40.4 (33.4-47.7)]	10.675 [23.7 (16.7-32.5)]	4.444, <0.001*
Daily	11.965 [52.4 (42.7-61.8)]	8.437 [36.9 (28.4-46.3)]	2.451 [10.7 (6.2-18.0)]	
Weekly	256.782 [49.1 (47.1-51.1)]	201.574 [38.5 (36.7-40.4)]	64.980 [12.4 (11.2-13.7)]	
Occasionally	236.448 [49.2 (46.9-51.6)]	173.636 [36.1 (34.0-38.3)]	70.379 [14.6 (13.2-16.2)]	
<i>Frequency eats fried food</i>				
Never	7.017 [46.6 (35.0-58.6)]	5.495 [36.5 (26.2-48.3)]	2.540 [16.9 (10.5-26.0)]	0.590, 0.723
Daily	77.971 [49.7 (45.5-54.0)]	57.200 [36.5 (33.2-39.9)]	21.638 [13.8 (11.1-17.0)]	
Weekly	261.663 [49.4 (46.9-51.9)]	194.026 [36.6 (34.6-38.7)]	74.152 [14.0 (12.6-15.5)]	
Occasionally	174.783 [47.2 (44.7-49.8)]	145.142 [39.2 (36.7-41.8)]	50.154 [13.6 (12.0-15.2)]	
<i>Frequency takes aerated drinks</i>				
Never	91.897 [47.2 (43.9-50.5)]	74.137 [38.1 (35.2-41.1)]	28.695 [14.7 (12.6-17.1)]	1.541, 0.173
Daily	12.153 [64.6 (49.9-76.9)]	5.244 [27.9 (17.2-41.7)]	1.429 [7.6 (3.8-14.5)]	
Weekly	92.062 [47.6 (43.9-51.4)]	74.083 [38.3 (35.0-41.8)]	27.183 [14.1 (11.7-16.8)]	
Occasionally	325.322 [48.9 (47.1-50.7)]	248.399 [37.4 (35.4-39.4)]	91.178 [13.7 (12.5-15.0)]	
<i>Food Frequency Score (Healthy Foods)</i>				
High	216.516 [49.2 (46.9-51.5)]	162.957 [37.0 (34.9-39.2)]	60.678 [13.8 (12.4-15.3)]	0.574, 0.671
Medium	159.082 [49.2 (46.5-51.8)]	122.242 [37.8 (35.2-40.5)]	42.280 [13.1 (11.4-15.0)]	
Low	145.836 [47.3 (44.2-50.5)]	116.663 [37.9 (35.3-40.5)]	45.527 [14.8 (12.9-16.8)]	
<i>Food Frequency Score (Unhealthy Food)</i>				
High	132.652 [50.2 (47.1-53.4)]	97.172 [36.8 (34.3-39.3)]	34.334 [13.0 (11.1-15.2)]	0.865, 0.480
Medium	180.838 [49.2 (46.9-51.5)]	134.643 [36.6 (34.4-38.9)]	52.339 [14.2 (12.5-16.2)]	
Low	207.943 [47.3 (45.0-49.6)]	170.048 [38.7 (36.4-41.0)]	61.812 [14.1 (12.6-15.7)]	
<i>Smokes cigarettes</i>				
No	519.521 [48.6 (47.1-50.2)]	400.521 [37.5 (36.0-39.0)]	148.434 [13.9 (12.9-14.9)]	1.988, 0.150
Yes	1.912 [57.9 (36.5-76.6)]	1.342 [40.6 (21.6-62.9)]	.050 [1.5 (0.2-10.2)]	
<i>Chews tobacco</i>				
No	503.543 [48.6 (47.1-50.2)]	387.655 [37.4 (35.9-39.0)]	144.101 [13.9 (12.9-15.0)]	0.343, 0.710
Yes	17.890 [49.0 (42.4-55.7)]	14.208 [38.9 (32.7-45.5)]	4.384 [12.0 (8.3-17.1)]	
<i>Alcohol Consumption</i>				
No	511.341 [48.5 (46.9-50.1)]	396.313 [37.6 (36.1-39.1)]	146.763 [13.9 (12.9-15.0)]	1.833, 0.166
Yes	10.093 [58.1 (46.4-69.0)]	5.550 [32.0 (23.2-42.2)]	1.721 [9.9 (5.8-16.5)]	
Cardiometabolic				

Socio-demographic, economic, behavioural and cardiometabolic Factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
	Frequency (weighted proportion 95% CI)			
<i>Nutritional status</i>				
Normal	255.594 [58.7 (56.3-61.1)]	144.088 [33.1 (30.9-35.4)]	35.726 [8.2 (7.0-9.6)]	73.513, 0.000*
Underweight	55.403 [71.7 (66.9-76.2)]	19.670 [25.5 (21.0-30.5)]	2.145 [2.8 (1.6-4.9)]	
Overweight and/ Obese	210.437 [37.6 (35.4-39.9)]	238.105 [42.6 (40.5-44.7)]	110.613 [19.8 (18.2-21.5)]	
<i>Central obesity (waist circumference)</i>				
Normal	332.175 [61.2 (59.0-63.3)]	169.249 [31.2 (29.3-33.1)]	41.466 [7.6 (6.5-8.9)]	150.228, 0.000*
High	189.259 [35.8 (33.7-37.9)]	232.614 [44.0 (41.9-46.1)]	107.018 [20.2 (18.6-22.0)]	
<i>Central obesity (waist-to-hip ratio)</i>				
Normal	96.306 [66.1 (62.5-69.5)]	40.717 [27.9 (24.8-31.3)]	8.687 [6.0 (4.3-8.2)]	48.186, 0.000*
High	425.128 [45.9 (44.2-47.6)]	361.146 [39.0 (37.4-40.6)]	139.798 [15.1 (14.0-16.3)]	
<i>Diabetes</i>				
Normal	483.140 [50.1 (48.5-51.8)]	359.385 [37.3 (35.8-38.9)]	121.087 [12.6 (11.6-13.6)]	22.296, 0.000*
Pre-diabetic	33.606 [40.6 (34.9-46.6)]	31.483 [38.0 (33.0-43.4)]	17.678 [21.4 (17.5-25.8)]	
Diabetic	4.688 [18.5 (11.9-27.4)]	10.995 [43.3 (34.8-52.2)]	9.719 [38.3 (29.3-48.1)]	
<i>Note:</i> Associations were tested using Pearson's χ^2 test; p < 0.05 is considered statistically significant (*). χ^2 = Chi-square test.				

Note: Associations were tested using Pearson's χ^2 test; $p < 0.05$ is considered statistically significant (*). χ^2 = Chi-square test.

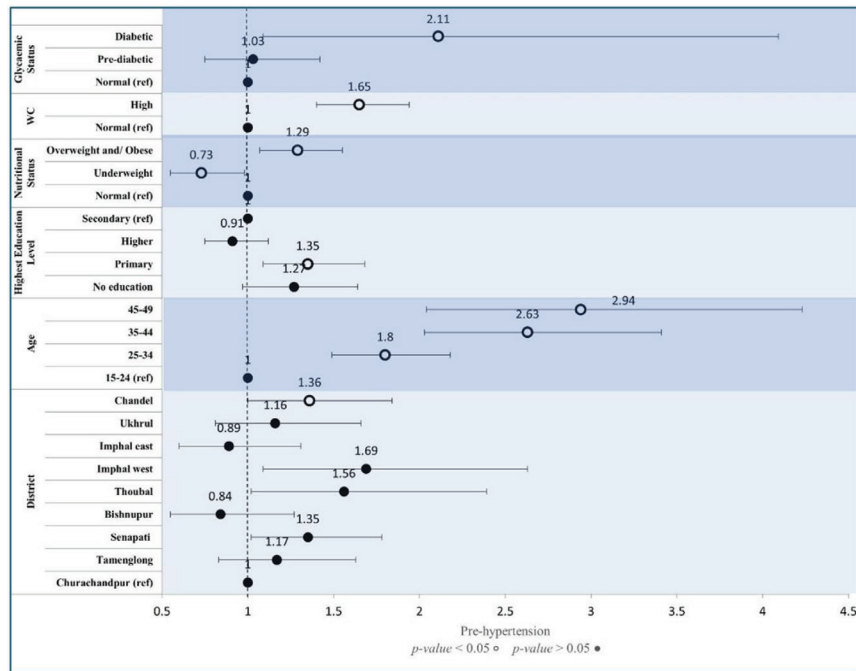
Predictors of pre-hypertension and hypertension

Figure 2 visually summarises the multivariable results presented in *Supplementary Tables 2 and 3*.

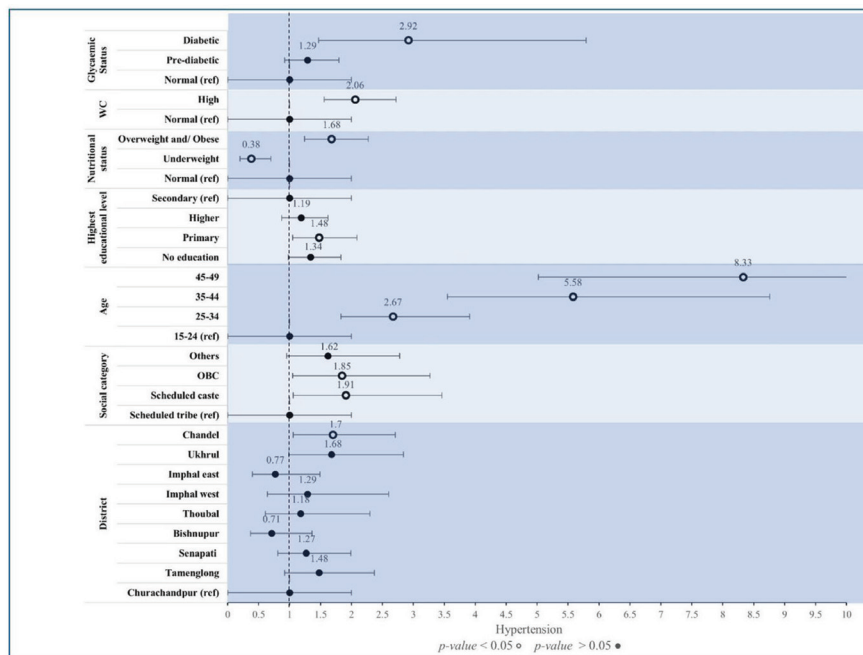
For pre-hypertension (Fig 2A), higher adjusted odds were observed among women aged 25–34 years (AOR = 1.80, 95% CI [1.49, 2.18], $p < 0.001$), 35–44 years (AOR = 2.63, 95% CI [2.03, 3.41], $p < 0.001$), and 45–49 years (AOR = 2.94, 95% CI [2.04, 4.23], $p < 0.001$) relative to those aged 15–24 years. District variation persisted after adjustment, with higher odds in Senapati (AOR = 1.35, 95% CI [1.02, 1.78], $p < 0.05$), Thoubal (AOR = 1.56, 95% CI [1.02, 2.39], $p < 0.05$), Imphal West (AOR = 1.69, 95% CI [1.09, 2.63], $p < 0.05$), and Chandel (AOR = 1.36, 95% CI [1.00, 1.84], $p < 0.05$). Educational differences were modest, although primary education remained associated with higher odds (AOR = 1.35, 95% CI [1.09, 1.68], $p < 0.05$). Indicators of nutritional and metabolic health showed notable gradients: overweight or obesity (AOR = 1.29, 95% CI [1.07, 1.55], $p < 0.001$), elevated waist circumference (AOR = 1.65, 95% CI [1.40, 1.94], $p < 0.001$), and diabetes (AOR = 2.11, 95% CI [1.09, 4.09], $p < 0.05$) corresponded to higher odds, whereas underweight status corresponded to lower

odds (AOR = 0.73, 95% CI [0.55, 0.98], $p < 0.01$). After adjustment, residence, social category, most behavioural indicators, and waist-to-hip ratio were not statistically distinguishable from the reference categories.

For hypertension (Fig 2B), age displayed a strong gradient, with higher odds among women aged 25–34 years (AOR = 2.67, 95% CI [1.83, 3.91], $p < 0.001$), 35–44 years (AOR = 5.58, 95% CI [3.55, 8.76], $p < 0.001$), and 45–49 years (AOR = 8.33, 95% CI [5.02, 13.83], $p < 0.001$). Social category differentials were observed for Scheduled Castes (AOR = 1.91, 95% CI [1.06, 3.46], $p < 0.05$) and OBC groups (AOR = 1.85, 95% CI [1.05, 3.27], $p < 0.05$), whereas estimates for the “Other” category were imprecise (AOR = 1.62, 95% CI [0.95, 2.78]). At the district level, Chandel retained higher adjusted odds (AOR = 1.70, 95% CI [1.06, 2.71], $p < 0.05$), while other districts were not statistically distinct after adjustment. Nutritional and metabolic indicators again showed consistent patterning: overweight or obesity (AOR = 1.68, 95% CI [1.24, 2.27], $p < 0.001$), elevated waist circumference (AOR = 2.06, 95% CI [1.56, 2.72], $p < 0.001$), and diabetes (AOR = 2.92, 95% CI [1.47, 5.79], $p < 0.05$) were associated with higher odds, whereas underweight



(A)



(B)

Figure 2: Forest plot of independent risk factors (AORs) of pre-hypertension (a) and hypertension (b)

status corresponded to lower odds (AOR = 0.38, 95% CI [0.20, 0.70], $p < 0.001$). After multivariable adjustment, residence, marital status, family size, cohabitation duration, most dietary indicators, and waist-to-hip ratio did not demonstrate statistically significant differences.

DISCUSSION

The present study documents the prevalence of pre-hypertension and hypertension and examines their associations with socio-demographic, economic, behavioural, and biological factors among women aged 15–49 years in Manipur, Northeast India. Three principal findings emerge. *First*, a substantial proportion of women were already experiencing elevated blood pressure below diagnostic thresholds, with over one-third classified as pre-hypertensive. *Second*, age and indicators of adiposity, particularly elevated body mass index and waist circumference, demonstrated the most consistent and robust associations with both pre-hypertension and hypertension. *Third*, although geographic and social differentials were evident, many distal socio-economic and behavioural variables attenuated after adjustment, suggesting that metabolic pathways constitute the primary proximate drivers of blood pressure variation in this population.

The prevalence of hypertension (13.9%) is comparable to the NFHS-5 state estimate (14.0%) and exceeds the national average reported for women in the same age group (IIPS and ICF, 2021b; Mittal *et al.*, 2025), and reinforces evidence that women in Manipur experience a considerable burden of elevated blood pressure at relatively young ages. More striking is the large proportion of women classified as pre-hypertensive (37.5%), indicating that a substantial segment of the population is already positioned along an adverse cardiovascular trajectory. Conceptualising blood pressure as a continuum highlights the importance of early identification of cardiometabolic risk prior to clinical disease onset (Vasan *et al.*, 2001; Whelton *et al.*, 2018), particularly among reproductive-age women whose long-term health trajectories may influence both individual and intergenerational outcomes.

The coexistence of high pre-hypertension and hypertension prevalence with widespread overweight, obesity, and central adiposity underscores an emerging cardiometabolic risk profile consistent with ongoing nutrition and epidemiological transitions (Popkin *et al.*, 2020; Thanglen and Maheo, 2022; Zimik *et al.*, 2023; Lalnuneng, 2024). Nearly half of the women exhibited elevated waist circumference, while multivariable models confirmed that both overall and central adiposity were independently associated with higher odds of pre-hypertension and hypertension. These findings support extensive evidence identifying excess adiposity, particularly central fat accumulation, as a major driver of elevated blood pressure through mechanisms including insulin resistance, vascular inflammation, and neurohormonal dysregulation (Landi *et al.*, 2018; Pazin *et al.*, 2020; Cheng *et al.*, 2022; Mfuru *et al.*, 2024). The lack of independent association for waist-to-hip ratio after adjustment suggests differential performance of central adiposity indicators across populations. Although diabetes prevalence was comparatively low, its co-occurrence with elevated blood pressure and adiposity indicators reinforces the importance of examining cardiometabolic risk as an interconnected cluster rather than as isolated conditions.

Age emerged as the strongest and most consistent predictor across both pre-hypertension and hypertension. The graded increase across successive age groups aligns with established epidemiological patterns and reflects cumulative physiological and behavioural processes across the life course (Franklin and Wong, 2013; Lalnuneng, 2021). Age-related arterial stiffening, declining vascular elasticity, and endothelial dysfunction are recognised contributors to rising blood pressure (Laurent and Boutouyrie, 2020), while reduced physical activity, dietary changes, comorbidity accumulation, and psychosocial stress may further amplify risk (Singh *et al.*, 2023). Although these mechanisms cannot be directly evaluated in cross-sectional data, the presence of elevated blood pressure even among younger women highlights the importance of early- and mid-life stages in shaping cardiometabolic trajectories.

Marked variation in blood pressure status was observed across districts, with higher levels of both pre-hypertension and hypertension concentrated in more urbanised and densely populated districts such as Thoubal, Imphal West, and Imphal East. These findings are consistent with earlier research documenting substantial intra-state heterogeneity in hypertension prevalence across India (Marbaniang *et al.*, 2022; Gupta *et al.*, 2025). District-level contexts may capture differences in urbanisation, occupational structures, service access, and lifestyle environments. Notably, Chandel district retained higher adjusted odds even after controlling for individual-level characteristics, suggesting the influence of place-based factors that extend beyond simple rural–urban classification. The lack of independent association with urban residence after adjustment further indicates that geographic disparities likely reflect multiple overlapping social and environmental exposures.

Social stratification demonstrated measurable differences. Women belonging to Scheduled Castes and Other Backward Classes exhibited higher adjusted odds of hypertension relative to Scheduled Tribes, while primary education was associated with elevated odds of pre-hypertension. Previous studies have linked lower education and structural disadvantage with differential exposure to behavioural risk factors, reduced health literacy, and barriers to preventive care (Zacher, 2023; Mohammad and Bansod, 2024). However, attenuation of several socio-economic indicators following multivariable adjustment suggests that their influence may operate indirectly through proximal metabolic pathways.

Diabetes status was independently associated with elevated blood pressure, reinforcing the well-documented clustering of elevated blood pressure and diabetes among women in India (Mohammad and Bansod, 2024; Singh *et al.*, 2025). Shared pathophysiological mechanisms, including endothelial dysfunction, chronic inflammation, and insulin resistance, likely underpin this co-occurrence. Although the prevalence of diabetes was comparatively low, its association with both pre-hypertension and hypertension highlights the

importance of integrated cardiometabolic risk assessment.

Several variables that demonstrated significant bivariate associations, including residence, household size, cohabitation duration, and most dietary indicators, did not retain independent significance after adjustment. This attenuation underscores the importance of multivariable modelling in distinguishing confounded associations from independent predictors and suggests that behavioural exposures measured through self-reported dietary frequency may operate through metabolic intermediates.

CONCLUSION

This study demonstrates a substantial burden of both early and established elevated blood pressure among women aged 15–49 years in Manipur, characterised by a high prevalence of pre-hypertension and strong, independent associations with age, general and central adiposity, and glycaemic status. The findings indicate that early-stage cardiometabolic risk is already widespread among women in Manipur, with metabolic factors functioning as the primary proximal drivers of blood pressure variation, while many socio-economic and behavioural influences operate indirectly through these pathways. Marked district-level heterogeneity further suggests that contextual environmental and service-related factors contribute to spatial inequalities beyond conventional rural–urban classifications.

Recognising elevated blood pressure as part of a clustered cardiometabolic risk profile highlights the need for integrated screening approaches that simultaneously assess adiposity, glycaemic status, and blood pressure within primary health systems. Early identification and prevention strategies targeting women in mid- and early adulthood may yield long-term cardiovascular benefits, particularly in rapidly transitioning populations of Northeast India. Strengthening life-course-oriented, population-based prevention initiatives is therefore critical to reducing the future burden of cardiovascular disease in the region.

LIMITATIONS

The cross-sectional design limits causal inference and prevents assessment of temporal relationships between risk factors and blood pressure. Dietary behaviours and substance use were self-reported, introducing potential recall bias, and glycaemic status was based on a single capillary measurement that may result in misclassification. Exclusion of participants with missing biological data may have introduced selection bias, and the analysis was restricted to women aged 15–49 years, limiting generalisability to older populations. Residual confounding from unmeasured factors such as physical activity, salt intake, and psychosocial stress cannot be excluded.

Conflict of Interest: The authors declare that there is no conflict of interest.

ACKNOWLEDGEMENT

The authors acknowledge the Demographic and Health Surveys (DHS) Program for providing access to the NFHS-5 data, and the International Institute for Population Sciences (IIPS), Mumbai, for coordinating the survey. We are grateful to the women who participated in the NFHS-5, whose responses form the foundation of this analysis.

REFERENCES CITED

- Cheng, C., J. Sun, Y. Zhou *et al.* 2022. High waist circumference is a risk factor for hypertension in normal-weight or overweight individuals with normal metabolic profiles. *Journal of Clinical Hypertension*, 24(7): 908-917.
- Chobanian, A.V., G.L. Bakris, H.R. Black *et al.* 2003. The seventh report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure: The JNC 7 report. *Journal of the American Medical Association*, 289(19): 2560-2572.
- Connelly, P.J., G. Currie and C. Delles 2022. Sex differences in the prevalence, outcomes and management of hypertension. *Current Hypertension Reports*, 24: 185-192.
- Franklin, S.S. and N.D. Wong 2013. Hypertension and cardiovascular disease: Contributions of the Framingham Heart Study. *Global Heart*, 8(1): 49-57.
- Gupta, R., K. Gaur, S.C. Sharma, R.S. Khedar and R.K. Dhamija 2025. District level variation in hypertension epidemiology in India and influence of social determinants: National Family Health Survey-5. *RUHS Journal of Health Sciences*, 10(3): 142-150.
- Hanna, J.M. and P.T. Baker 1979. Biocultural correlates to the blood pressure of Samoan migrants in Hawaii. *Human Biology*, 51(4): 481-497.
- International Institute for Population Sciences and ICF 2021a. *National Family Health Survey (NFHS-5), 2019-21: India Volume II*. International Institute for Population Sciences: Mumbai.
- 2021b. *National Family Health Survey (NFHS-5), 2019-21: Manipur*. International Institute for Population Sciences: Mumbai.
- Ji, H., A. Kim, J.E. Ebinger *et al.* 2020. Sex differences in blood pressure trajectories over the life course. *JAMA Cardiology*, 5(3): 19-26.
- Lalnuneng, A. 2021. Age variation in blood pressure: Rural-urban and sex differences among the Hmar adults of Manipur, Northeast India. *American Journal of Human Biology*, 34(3).
- 2024. Correlates of body fat mass index (FMI) and fat free mass index (FFMI) with hypertension in the Hmar tribes of Northeast India. *Journal of Hypertension*.
- Lalnuneng, A. and R. Khongsdier 2017. Rural-urban differences in hypertension among the Hmars of Manipur in Northeast India. *Anthropologist*, 28(3): 173-183.
- Landi, F., R. Calvani, A. Picca *et al.* 2018. Body mass index is strongly associated with hypertension. *Nutrients*, 10(12): 1976.
- Lauder, L., F. Mahfoud, M. Azizi *et al.* 2023. Hypertension management in patients with cardiovascular comorbidities. *European Heart Journal*, 44(23): 2066-2077.
- Laurent, S. and P. Boutouyrie 2020. Arterial stiffness and hypertension in the elderly. *Frontiers in Cardiovascular Medicine*, 7.
- Marbaniang, S.P., H.S. Chungkham and H. Lhungdim 2022. A structured additive modeling of diabetes and hypertension in Northeast India. *PLOS ONE*, 17(1): e0262560.
- Mfuru, G.H., J.N. Allan, A. Njau, O. Ubuguyu and K.Y. Malima 2024. Using waist circumference as a predictor of hypertension in Manzese, Dar es Salaam. *BMC Public Health*, 24(1).
- Misra, A., N.K. Vikram, A. Ghosh *et al.* 2025. Revised definition of obesity in Asian Indians living in India. *Diabetes and Metabolic Syndrome*, 19(1): 102989.
- Mittal, A., S. Gupta, H.K. Natt *et al.* 2025. Spatial variations in the risk factors of hypertension across different age groups in Indian adults. *Indian Journal of Community Medicine*, 50(4): 654-662.
- Mohammad, R. and D.W. Bansod 2024. Hypertension in India: A gender-based study of prevalence and associated risk factors. *BMC Public Health*, 24(1).
- Pazin, D.C., T.L. Da Luz Kaestner, M. Olandoski *et al.* 2020. Association between abdominal waist circumference and blood pressure in Brazilian adolescents. *Global Heart*, 15(1): 1-9.
- Popkin, B.M., C. Corvalan and L.M. Grummer-Strawn 2020. Dynamics of the double burden of malnutrition and the changing nutrition reality. *The Lancet*, 395(10217): 65-74.
- Singh, A., R. Gupta, V. Gupta and D. Prabhakaran 2023. Ageing, lifestyle transitions and psychosocial stress as determinants

- of blood pressure in India. *Journal of Hypertension*, 41(6): 1123-1132.
- Singh, A., D. Prabhakaran, P. Jeemon and V. Mohan 2025. Sex-specific association between diabetes and hypertension in India. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 19(1): 102781.
- Thanglen, H. and L.M. Maheo 2022. Prevalence of obesity and hypertension and its associated risk factors among Chiru females of Manipur. *Indian Journal of Public Health*, 66(1): 3-8.
- Varghese, J.S., N.S. Venkateshmurthy, N. Sudharsanan *et al.* 2023. Hypertension diagnosis, treatment, and control in India. *JAMA Network Open*, 6(10): e2339098.
- Vasan, R.S., M.G. Larson, E.P. Leip *et al.* 2001. Impact of high-normal blood pressure on the risk of cardiovascular disease. *New England Journal of Medicine*, 345(18): 1291-1297.
- Whelton, P.K. *et al.* 2018. 2017 ACC/AHA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults. *Hypertension*, 71(6): 1269-1324.
- World Health Organization 2000. *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment*. World Health Organization: Manila.
- World Health Organization 2006. *Definition and Diagnosis of Diabetes Mellitus and Intermediate Hyperglycaemia*. World Health Organization: Geneva.
- Zacher, M. 2023. Educational disparities in hypertension prevalence. *The Journals of Gerontology Series B*, 78(9): 1535-1544.
- Zimik, U., H. Thanglen, H.S. Devi, M.S. Meitei, Y.S. Devi and K.K. Singh 2023. Obesity and behavioural conditions as a risk factor of hypertension among the Maram tribes of Manipur. *Antrocom Journal of Anthropology*, 19(2): 383-390.
- Zuckerman, M.K. 2018. Biocultural models. *The International Encyclopedia of Biological Anthropology*: 1-8.

INTERNET LINKS

- World Health Organization 2025. Hypertension. Available at: <https://www.who.int/news-room/fact-sheets/detail/hypertension>

SUPPLEMENTARY TABLE 1

Unweighted distribution of blood pressure status by socio-demographic, economic, behavioural, and cardiometabolic characteristics among women aged 15–49 years in Manipur

Socio-demographic and economic factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
	Frequency (%)			
<i>Type of place of residence</i>				
Urban	879 (47.1)	702 (37.6)	286 (15.3)	13.745, 0.001*
Rural	2550 (51.4)	1792 (36.1)	622 (12.5)	
<i>District</i>				
Senapati	358 (50.4)	280 (39.4)	73 (10.3)	93.430, <0.001*
Tamenglong	372 (51.8)	255 (35.5)	91 (12.7)	
Churachandpur	427 (57.2)	250 (33.5)	69 (9.2)	
Bishnupur	466 (54)	274 (31.7)	123 (14.3)	
Thoubal	418 (43.8)	399 (41.8)	138 (14.5)	
Imphal West	303 (40.5)	315 (42.1)	131 (17.5)	
Imphal East	444 (54.3)	259 (31.7)	114 (14)	
Ukhrul	324 (53.5)	209 (34.5)	73 (12)	
Chandel	317 (47.6)	253 (38)	96 (14.4)	
<i>Social category</i>				
Scheduled caste	224 (49.8)	153 (34)	73 (16.2)	26.888, <0.001*
Scheduled tribe	1774 (52.6)	1213 (36)	385 (11.4)	
OBC	448 (49.5)	322 (35.6)	135 (14.9)	
Others	880 (47.2)	705 (37.8)	279 (15)	
<i>Sex of household head</i>				
Male	2842 (50.5)	2049 (36.4)	738 (13.1)	1.438, 0.487
Female	587 (48.8)	445 (37)	170 (14.1)	
<i>Age</i>				
15-24	1388 (70.1)	518 (26.1)	75 (3.8)	710.407, 0.000*
25-34	1109 (50.9)	837 (38.4)	231 (10.6)	
35-44	696 (36.3)	826 (43.1)	393 (20.5)	
45-49	236 (31.1)	313 (41.3)	209 (27.6)	
<i>Marital status</i>				
Never married	1335 (62.8)	651 (30.6)	141 (6.6)	247.025, 0.000*
Married	1957 (45.4)	1666 (38.7)	687 (15.9)	
DSW	137 (34.8)	177 (44.9)	80 (20.3)	
<i>Family size</i>				
< 5	1369 (47.7)	1075 (37.5)	424 (14.8)	15.533, <0.001*
≥ 5	2060 (52)	1419 (35.8)	484 (12.2)	
<i>Cohabitation duration</i>				
Never married	1335 (62.8)	651 (30.6)	141 (6.6)	485.166, 0.000*
0-4	476 (58.4)	272 (33.4)	67 (8.2)	
5-9	552 (51.4)	398 (37.1)	123 (11.5)	
10-14	414 (44.5)	390 (41.9)	126 (13.5)	
15-19	277 (37)	320 (42.8)	151 (20.2)	
20-24	216 (34.2)	253 (40.1)	162 (25.7)	
25-29	127 (31.2)	171 (42)	109 (26.8)	
≥30	32 (32)	39 (39)	29 (29)	

Socio-demographic and economic factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
	Frequency (%)			
<i>Highest educational level</i>				
No education	257 (38)	283 (41.9)	136 (20.1)	102.468, 0.000*
Primary	344 (41.6)	346 (41.8)	137 (16.6)	
Secondary	2280 (53.9)	1471 (34.8)	479 (11.3)	
Higher	548 (49.9)	394 (35.9)	156 (14.2)	
<i>Wealth Index</i>				
Poorest	936 (51.2)	682 (37.3)	209 (11.4)	16.499, 0.036*
Poorer	799 (52.1)	548 (35.7)	188 (12.2)	
Middle	632 (48.8)	481 (37.2)	181 (14)	
Richer	615 (49.5)	439 (35.3)	188 (15.1)	
Richest	447 (47.9)	344 (36.9)	142 (15.2)	
Behavioural factors				
<i>Frequency of milk/curd intake</i>				
Never	538 (52)	364 (35.2)	133 (12.9)	10.468, 0.106
Daily	514 (46.8)	411 (37.4)	173 (15.8)	
Weekly	887 (50)	654 (36.9)	232 (13.1)	
Occasionally	1490 (50.9)	1065 (36.4)	370 (12.6)	
<i>Frequency of pulses/beans intake</i>				
Never	12 (42.9)	11 (39.3)	5 (17.9)	6.666, 0.353
Daily	526 (47.6)	416 (37.6)	164 (14.8)	
Weekly	2224 (50.8)	1598 (36.5)	557 (12.7)	
Occasionally	667 (50.6)	469 (35.6)	182 (13.8)	
<i>Frequency of dark green leafy vegetable intake</i>				
Never	5 (83.3)	0 (0)	1 (16.7)	6.169, 0.404
Daily	2598 (50.3)	1893 (36.6)	676 (13.1)	
Weekly	760 (49.9)	555 (36.5)	207 (13.6)	
Occasionally	66 (48.5)	46 (33.8)	24 (17.6)	
<i>Frequency of fruit intake</i>				
Never	54 (37)	59 (40.4)	33 (22.6)	42.915, <0.001*
Daily	407 (54.9)	251 (33.8)	84 (11.3)	
Weekly	1539 (52.8)	993 (34.1)	383 (13.1)	
Occasionally	1429 (47.2)	1191 (39.3)	408 (13.5)	
<i>Frequency eats eggs</i>				
Never	82 (48.2)	61 (35.9)	27 (15.9)	4.015, 0.675
Daily	187 (51.8)	120 (33.2)	54 (15)	
Weekly	1675 (50.7)	1199 (36.3)	430 (13)	
Occasionally	1485 (49.6)	1114 (37.2)	397 (13.3)	
<i>Frequency eats fish</i>				
Never	44 (56.4)	27 (34.6)	7 (9)	19.444, 0.003*
Daily	594 (47.6)	452 (36.2)	202 (16.2)	
Weekly	1393 (51.3)	955 (35.2)	368 (13.5)	
Occasionally	1398 (50.1)	1060 (38)	331 (11.9)	
<i>Frequency eats chicken or meat</i>				
Never	72 (38.9)	74 (40)	39 (21.1)	20.741, 0.002*
Daily	91 (48.4)	74 (39.4)	23 (12.2)	
Weekly	1763 (50.1)	1319 (37.5)	437 (12.4)	
Occasionally	1503 (51.1)	1027 (34.9)	409 (13.9)	

Socio-demographic and economic factors	Blood pressure			χ^2 , p-value
	Normal	Pre-hypertension	Hypertension	
<i>Frequency eats fried food</i>	Frequency (%)			
Never	66 (51.2)	45 (34.9)	18 (14)	9.815, 0.133
Daily	420 (51.6)	278 (34.2)	116 (14.3)	
Weekly	1634 (51.3)	1125 (35.3)	425 (13.3)	
Occasionally	1309 (48.4)	1046 (38.7)	349 (12.9)	
<i>Frequency takes aerated drinks</i>				
Never	667 (49.3)	496 (36.6)	191 (14.1)	3.308, 0.769
Daily	59 (55.7)	35 (33)	12 (11.3)	
Weekly	545 (49.5)	401 (36.5)	154 (14)	
Occasionally	2158 (50.5)	1562 (36.6)	551 (12.9)	
<i>Food Frequency Score (Healthy Foods)</i>				
High	1263 (50.2)	901 (35.8)	350 (13.9)	5.463, 0.243
Medium	1084 (51.4)	747 (35.5)	276 (13.1)	
Low	1082 (49)	846 (38.3)	282 (12.8)	
<i>Food Frequency Score (Unhealthy Food)</i>				
High	736 (51.4)	504 (35.2)	193 (13.5)	4.262, 0.372
Medium	1125 (51.1)	783 (35.6)	294 (13.4)	
Low	1568 (49.1)	1207 (37.8)	421 (13.2)	
<i>Smokes cigarettes</i>				
No	3408 (50.2)	2480 (36.5)	907 (13.3)	3.543, 0.170
Yes	21 (58.3)	14 (38.9)	1 (2.8)	
<i>Chews tobacco</i>				
No	3267 (50.2)	2369 (36.4)	871 (13.4)	1.299, 0.522
Yes	162 (50)	125 (38.6)	37 (11.4)	
<i>Alcohol Consumption</i>				
No	3360 (50.1)	2452 (36.6)	894 (13.3)	1.349, 0.509
Yes	69 (55.2)	42 (33.6)	14 (11.2)	
<i>Cardiometabolic</i>				
<i>Nutritional status</i>				
Normal	1797 (60.2)	955 (32)	231 (7.7)	455.687, 0.000*
Underweight	333 (71.3)	116 (24.8)	18 (3.9)	
Overweight and/ Obese	1299 (38.4)	1423 (42.1)	659 (19.5)	
<i>Central obesity (waist circumference)</i>				
Normal	2275 (61)	1170 (31.4)	284 (7.6)	449.533, 0.000*
High	1154 (37.2)	1324 (42.7)	624 (20.1)	
<i>Central obesity (waist-to-hip ratio)</i>				
Normal	647 (67.4)	252 (26.3)	61 (6.4)	138.472, 0.000*
High	2782 (47.4)	2242 (38.2)	847 (14.4)	
<i>Diabetes</i>				
Normal	3176 (51.4)	2254 (36.5)	752 (12.2)	116.797, 0.000*
Pre-diabetic	226 (43.6)	186 (35.9)	106 (20.5)	
Diabetic	27 (20.6)	54 (41.2)	50 (38.2)	

Note: Associations were tested using Pearson's χ^2 test; p < 0.05 is considered statistically significant (*). χ^2 = Chi-square test.

SUPPLEMENTARY TABLE 2

Unadjusted odds ratio (OR) and adjusted odds ratios (AOR) for pre-hypertension according to socio-demographic, behavioural, and cardiometabolic factors among women aged 15–49 years in Manipur, Northeast India

Socio-demographic and economic factors	Pre-hypertension			
	OR (95% CI)	p-value	AOR (95% CI)	p-value
<i>Type of place of residence</i>				
Urban	1.12 (0.98-1.29)	0.107	1.02 (0.86-1.20)	0.855
Rural	Ref		Ref	
<i>District</i>				
Churachandpur	Ref		Ref	
Tamenglong	1.14 (0.82-1.58)		1.17 (0.83-1.63)	
Senapati	1.35 (1.02-1.79) *		1.35 (1.02-1.78) *	
Bishnupur	0.99 (0.77-1.29)		0.84 (0.55-1.27)	
Thoubal	1.62 (1.25-2.09) *	<0.001*	1.56 (1.02-2.39) *	<0.001*
Imphal west	1.90 (1.44-2.49) *		1.69 (1.09-2.63) *	
Imphal east	1.00 (0.77-1.32)		0.89 (0.60-1.31)	
Ukhrul	1.07 (0.77-1.50)		1.16 (0.81-1.66)	
Chandel	1.47 (1.09-1.97) *		1.36 (1.00-1.84) *	
<i>Social category</i>				
Scheduled tribe	Ref		Ref	
Scheduled caste	1.05 (0.83-1.32)		1.07 (0.72-1.60)	
OBC	1.10 (0.92-1.31)	0.008*	1.03 (0.71-1.50)	0.936
Others	1.28 (1.10-1.49) *		1.08 (0.77-1.53)	
<i>Age</i>				
15-24	Ref		Ref	
25-34	2.04 (1.76-2.37) *	0.000*	1.80 (1.49-2.18) *	<0.001*
35-44	3.15 (2.67-3.73) *		2.63 (2.03-3.41) *	
45-49	3.57 (2.84-4.47) *		2.94 (2.04-4.23) *	
<i>Marital Status</i>				
Never married	Ref		Ref	
Married	1.81 (1.58-2.07) *	0.000*	0.54 (0.28-1.05)	0.018
DSW	2.64 (1.93-3.61) *		0.76 (0.38-1.55)	
<i>Family size</i>				
<5	1.13 (0.99-1.28)	0.066	0.95 (0.82-1.09)	0.436
>5	Ref		Ref	
<i>Cohabitation duration</i>				
Never married	Ref		Ref	
0-4	1.21 (0.98-1.50)		1.59 (0.80-3.15)	
5-9	1.52 (1.26-1.83) *		1.42 (0.74-2.72)	
10-14	2.09 (1.73-2.52) *		1.50 (0.79-2.84)	
15-19	2.27 (1.81-2.83) *	0.000*	1.31 (0.68-2.56)	0.806
20-24	2.50 (1.97-3.17) *		1.31 (0.69-2.48)	
25-29	3.02 (2.25-4.05) *		1.36 (0.70-2.66)	
30+	2.81 (1.65-4.77) *		1.00 (1.00-1.00)	

Socio-demographic and economic factors	Pre-hypertension			
	OR (95% CI)	p-value	AOR (95% CI)	p-value
<i>Highest educational level</i>				
No education	1.70 (1.32-2.19) *		1.27 (0.97-1.64)	
Primary	1.60 (1.28-1.99) *	<0.001*	1.35 (1.09-1.68) *	0.023*
Higher	1.07 (0.89-1.30)		0.91 (0.75-1.12)	
Secondary	Ref		Ref	
<i>Behavioural factors</i>				
<i>Frequency eats fruits</i>				
Daily	Ref		Ref	
Weekly	1.09 (0.89-1.35)		0.88 (0.72-1.09)	
Occasionally	1.46 (1.18-1.81) *	<0.001*	0.99 (0.80-1.22)	0.446
Never	1.80 (1.20-2.71) *		1.02 (0.63-1.65)	
<i>Frequency eats chicken or meat</i>				
Daily	Ref		Ref	
Weekly	1.11 (0.74-1.68)		1.01 (0.66-1.55)	
Occasionally	1.04 (0.68-1.59)	0.075	0.96 (0.62-1.49)	0.814
Never	1.59 (0.97-2.61)		1.10 (0.64-1.92)	
<i>Cardiometabolic</i>				
<i>Nutritional status</i>				
Normal	Ref		Ref	
Underweight	0.63 (0.48-0.82) *	0.000*	0.73 (0.55-0.98) *	0.001*
Overweight and/ Obese	2.01 (1.73-2.33) *		1.29 (1.07-1.55) *	
<i>Central obesity [waist circumference]</i>				
Normal	Ref		Ref	
High	2.41 (2.11-2.76) *	0.000*	1.65 (1.40-1.94) *	<0.001*
<i>Central obesity [waist-to-hip ratio]</i>				
Normal	Ref		Ref	
High	2.01 (1.68-2.41) *	<0.001*	0.93 (0.77-1.13)	0.468
<i>Diabetes</i>				
Normal	Ref		Ref	
Pre-diabetic	1.26 (0.96-1.66)	<0.001*	1.03 (0.75-1.42)	0.102
Diabetic	3.15 (1.86-5.35) *		2.11 (1.09-4.09) *	

Note: The logistic regression model was adjusted for Type of place of residence, District, Social category, family size, Age, Marital status, Cohabitation duration, Highest educational level, Frequency eats fruits, chicken or meat, Nutritional status, Waist circumference, waist-to-hip ratio, and Diabetes. $p < 0.05$ is considered statistically significant (*). Odd ratio is considered statistically significant at the 5% level when 95% CI does not include 1.0. 95% CI = 95% Confidence Interval.

SUPPLEMENTARY TABLE 3

Unadjusted odds ratio (OR) and adjusted odds ratios (AOR) for hypertension according to socio-demographic, behavioural, and cardiometabolic factors among women aged 15–49 years in Manipur, Northeast India

Socio-demographic and economic factors	Hypertension			
	OR (95% CI)	p-value	AOR (95% CI)	p-value
<i>Type of place of residence</i>				
Urban	1.27 (1.05-1.53) *	0.015*	1.01 (0.78-1.31)	0.925
Rural	Ref		Ref	
<i>District</i>				
Churachandpur	Ref		Ref	
Tamenglong	1.49 (0.99-2.26)		1.48 (0.92-2.37)	
Senapati	1.20 (0.80-1.79)		1.27 (0.81-1.99)	
Bishnupur	1.53 (1.06-2.21) *		0.71 (0.37-1.36)	
Thoubal	1.91 (1.31-2.78) *	<0.001*	1.18 (0.61-2.30)	0.001*
Imphal west	2.48 (1.69-3.62) *		1.29 (0.64-2.60)	
Imphal east	1.45 (0.99-2.14)		0.77 (0.40-1.49)	
Ukhrul	1.35 (0.85-2.15)		1.68 (0.99-2.84)	
Chandel	1.92 (1.22-3.00) *		1.70 (1.06-2.71) *	
<i>Social category</i>				
Scheduled tribe	Ref		Ref	
Scheduled caste	1.48 (1.02-2.15) *		1.91 (1.06-3.46) *	
OBC	1.33 (1.03-1.72) *	0.008*	1.85 (1.05-3.27) *	0.228
Others	1.54 (1.25-1.90) *		1.62 (0.95-2.78)	
<i>Age</i>				
15-24	Ref		Ref	
25-34	3.46 (2.52-4.75) *		2.67 (1.83-3.91) *	
35-44	9.79 (7.21-13.30) *	0.000*	5.58 (3.55-8.76) *	<0.001*
45-49	16.10 (11.44-22.64) *		8.33 (5.02-13.83) *	
<i>Marital Status</i>				
Never married	Ref		Ref	
Married	3.34 (2.68-4.17) *	0.000*	0.63 (0.28-1.40)	0.213
DSW	5.73 (3.86-8.52) *		0.80 (0.34-1.91)	
<i>Family size</i>				
<5	1.28 (1.05-1.55) *	0.014*	0.90 (0.74-1.10)	0.315
>5	Ref		Ref	
<i>Cohabitation duration</i>				
Never married	Ref		Ref	
0-4	1.47 (1.04-2.07) *		1.27 (0.55-2.93)	
5-9	2.12 (1.59-2.84) *		1.00 (0.46-2.15)	
10-14	3.02 (2.20-4.16) *		1.05 (0.47-2.34)	
15-19	5.36 (3.89-7.40) *	0.000*	1.21 (0.58-2.52)	0.405
20-24	6.85 (5.06-9.27) *		1.50 (0.72-3.15)	
25-29	8.46 (5.92-12.10) *		1.53 (0.74-3.14)	
30+	8.56 (4.60-15.92) *		1.00 (1.00-1.00)	
<i>Highest educational level</i>				
No education	2.48 (1.84-3.32) *		1.34 (0.98-1.83)	
Primary	1.84 (1.39-2.42) *	<0.001*	1.48 (1.05-2.09) *	0.084
Higher	1.42 (1.11-1.83) *		1.19 (0.87-1.62)	
Secondary	Ref		Ref	

Socio-demographic and economic factors	Hypertension			
	OR (95% CI)	p-value	AOR (95% CI)	p-value
Behavioural factors				
<i>Frequency eats fruits</i>				
Daily	Ref		Ref	
Weekly	1.30 (0.95-1.78)		1.17 (0.81-1.67)	
Occasionally	1.62 (1.18-2.23) *	<0.001*	1.07 (0.76-1.51)	0.476
Never	2.90 (1.71-4.93) *		1.58 (0.81-3.05)	
<i>Frequency eats chicken or meat</i>				
Daily	Ref		Ref	
Weekly	1.24 (0.65-2.37)		1.22 (0.59-2.51)	
Occasionally	1.45 (0.76-2.77)	<0.001*	1.32 (0.63-2.76)	0.703
Never	3.21 (1.47-7.01) *		1.54 (0.61-3.89)	
Cardiometabolic				
<i>Nutritional status</i>				
Normal	Ref		Ref	
Underweight	0.28 (0.15-0.51) *	0.000*	0.38 (0.20-0.70) *	<0.001*
Overweight and/ Obese	3.76 (3.00-4.72) *		1.68 (1.24-2.27) *	
<i>Central obesity [waist circumference]</i>				
Normal	Ref		Ref	
High	4.53 (3.66-5.61) *	0.000*	2.06 (1.56-2.72) *	<0.001*
<i>Central obesity [waist-to-hip ratio]</i>				
Normal	Ref		Ref	
High	3.65 (2.54-5.23) *	<0.001*	0.99 (0.65-1.52)	0.977
<i>Diabetes</i>				
Normal	Ref		Ref	
Pre-diabetic	2.10 (1.54-2.87) *	<0.001*	1.29 (0.92-1.80)	0.003*
Diabetic	8.27 (4.60-14.88) *		2.92 (1.47-5.79) *	
<i>Note:</i> The logistic regression model was adjusted for Type of place of residence, District, Social category, family size, Age, Marital status, Cohabitation duration, Highest educational level, Frequency eats fruits, chicken or meat, Nutritional status, Waist circumference, waist-to-hip ratio, and Diabetes. $p < 0.05$ is considered statistically significant (*). Odd ratio is considered statistically significant at the 5% level when 95% CI does not include 1.0. 95% CI = 95% Confidence Interval.				