

Original Research Article

Prevalence and lifestyle correlates of adolescent hypertension in North India: a community and hospital-based cross-sectional study

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ABSTRACT

Background: Adolescent hypertension is an emerging public health concern associated with adult cardiovascular morbidity. Data on adolescent blood pressure and its determinants in rural and semi-urban North India remain limited. This study aimed to determine the prevalence of hypertension and assess its socio-demographic, lifestyle, psychosocial, and anthropometric correlates among adolescents in Sitapur, Uttar Pradesh.

Methods: A cross-sectional observational study was conducted among 387 adolescents aged 10-19 years. Socio-demographic, dietary, physical activity, and psychosocial data were collected using structured questionnaires. Anthropometric indices using WHO BMI-for-age Z-scores were assessed. Blood pressure (BP) was measured using calibrated oscillometric devices and classified per AAP pediatric guidelines. Statistical analysis was performed using IBM SPSS v26.0, employing Chi-square tests for bivariate analysis. A p-value <0.05 was considered significant.

Results: The mean age was 14.48±2.99 years. Overall prevalence of hypertension was 4.9% (19/387), while 9.3% (36/387) exhibited elevated BP. Hypertension occurred exclusively among overweight (9.3%) and obese (24.4%) adolescents ($\chi^2=79.199$, $p<0.001$). Frequent fast-food consumption ($p<0.001$), daily carbonated drink intake ($p<0.001$), inadequate physical activity ($p<0.001$), screen-based sedentary behaviour ($p<0.001$), tobacco chewing ($p<0.001$), smoking ($p<0.001$), positive family history of hypertension ($p=0.008$), and sleep disturbances ($p<0.001$) were significantly associated with blood pressure categories.

Conclusions: Hypertension and elevated BP pose a notable burden among adolescents in Sitapur. Adiposity, physical inactivity, screen time, unhealthy diet, family history, and sleep disruption were key determinants. School health screenings and lifestyle modification programs are urgently needed.

Keywords: Adolescent hypertension, Anthropometry, Blood pressure, Cardiometabolic risk, Dietary habits, Elevated blood pressure, Lifestyle factors, Psychosocial factors

INTRODUCTION

Hypertension, once considered predominantly an adult disorder, is increasingly recognized among children and adolescents and has emerged as an important public health concern worldwide.¹ Rapid urbanization, unhealthy dietary practices, physical inactivity, sedentary behaviour,

obesity, and psychosocial factors have contributed to the increasing burden of elevated blood pressure in younger populations.^{2,3}

Elevated blood pressure during childhood and adolescence may persist into adulthood and increase the risk of cardiovascular morbidity, stroke, chronic kidney disease, and premature mortality later in life.^{3,4} In younger

children, hypertension is more commonly secondary to identifiable conditions, particularly renal disorders, whereas primary hypertension becomes increasingly prevalent during adolescence, especially in the presence of obesity and other cardiovascular risk factors.⁵

The prevalence of hypertension varies considerably across populations because of differences in demographic characteristics, lifestyle, socioeconomic conditions, and diagnostic criteria.⁶ Global trends in blood pressure also demonstrate substantial regional variation, highlighting the growing importance of elevated blood pressure as a public health problem.⁷ A recent systematic review of 81 studies reported a pooled prevalence of childhood hypertension of 4.28%, with prevalence nearly doubling between 2000 and 2020, highlighting the increasing global burden of hypertension among children and adolescents.⁸

In India, the reported prevalence of adolescent hypertension varies considerably across studies, ranging from 2% to 20.5%, with a pooled prevalence of approximately 7.6% in a meta-analysis of cross-sectional studies.⁹ Recent national data from the National Family Health Survey-6 (NFHS-6, 2023-24) demonstrate a substantial burden of elevated blood pressure among individuals aged 15 years and above.¹⁰ Mildly elevated blood pressure (systolic 140-159 mmHg and/or diastolic 90-99 mmHg) was reported in 9.4% of females and 12.4% of males, while moderately or severely elevated blood pressure (systolic ≥ 160 mmHg and/or diastolic ≥ 100 mmHg) was reported in 4.8% of females and 3.3% of males. Overall, elevated blood pressure (systolic ≥ 140 mmHg and/or diastolic ≥ 90 mmHg) or use of antihypertensive medication was reported in 19.4% of females and 22.1% of males.¹⁰

Obesity is an important modifiable risk factor for adolescent hypertension.¹¹ Obesity-related hypertension involves multiple mechanisms, including sympathetic nervous system activation, insulin resistance, altered renal sodium handling, endothelial dysfunction, and neurohormonal activation.¹²

Recent studies from Northern India and Uttar Pradesh have highlighted the burden of overweight and obesity among adolescents, emphasizing the importance of nutritional status in the assessment of adolescent cardiometabolic risk.^{13,14} Adolescent nutritional health encompasses both undernutrition and excess weight, and recent Indian studies have examined the relationship between nutritional status, demographic characteristics, and dietary habits.¹⁵

Other potentially modifiable factors, including unhealthy dietary practices, physical inactivity, sedentary behaviour, and family history, have also been associated with hypertension among adolescents.¹⁶ Screen-time behaviour may vary according to sociodemographic characteristics and is relevant to the assessment of sedentary behaviour among adolescents.¹⁷ Family history of cardiovascular disease may also be associated with blood pressure and

anthropometric risk indicators during adolescence.¹⁸ Assessment of lipid profiles may also contribute to the identification of early cardiometabolic risk among schoolchildren.¹⁹

In India, the prevalence of adolescent hypertension shows considerable regional variation.²⁰ A multicentre study involving children from urban and rural areas also demonstrated differences in the prevalence and determinants of primary hypertension.²⁰ Differences in lifestyle, nutritional patterns, and socioeconomic conditions between urban and rural populations may contribute to variation in cardiovascular risk and hypertension.²⁰ Early identification of elevated blood pressure and associated risk factors during adolescence provides an opportunity for timely intervention and prevention of subsequent cardiovascular morbidity.²¹ However, evidence from rural and semi-urban populations, particularly in North India, remains relatively limited.

Therefore, the present study was undertaken to determine the prevalence of hypertension among adolescents in Sitapur, Uttar Pradesh, India, and to assess its association with dietary habits, physical activity, sedentary behaviour, body mass index, family history of hypertension, and psychosocial factors.

METHODS

Study design and setting

This cross-sectional observational study was conducted in the Department of Pediatrics, Hind Institute of Medical Sciences, Sitapur, Uttar Pradesh, India, from August 2024 to January 2026. Adolescents were recruited from outpatient services, schools, and community centres within the study area.

Inclusion criteria

Adolescents aged 10-19 years who presented to or were screened at the study sites were included in the study.

Exclusion criteria

Adolescents with known chronic hepatic, renal, cardiac, or respiratory diseases were excluded following clinical evaluation. Participants or guardians who did not provide written informed consent or assent were also excluded.

Sample size

The sample size was calculated using Cochrane's formula based on an expected prevalence of hypertension of 12.9% from a previous Indian study, with a 95% confidence level, 5% absolute precision, and a design effect of 2.^{22,23} The calculated minimum required sample size was 346. After accounting for a 10% non-response rate, the final target sample size was estimated at 387 participants.

Sampling procedure

Adolescents meeting the inclusion criteria were recruited using convenience sampling from schools, community centres, and outpatient departments of the tertiary care center during the study period. Permission was obtained from school authorities and community center administrators before participant recruitment. Eligible participants were enrolled after obtaining written informed consent from parents or legal guardians and assent from the adolescents.

Data collection

Data collection was conducted by trained healthcare personnel using a structured, pretested questionnaire administered in the local language. Information regarding demographic characteristics, dietary habits, physical activity, sedentary behaviour, tobacco use, family history of hypertension, and psychosocial factors was recorded.

Anthropometric measurements, including height and weight were obtained according to World Health Organization (WHO) guidelines.²⁴ Weight was measured using a calibrated electronic weighing scale to the nearest 100 g, while height was measured using a stadiometer to the nearest 0.1 cm.

The body mass index (BMI) was determined by dividing weight in kilograms by the square of height in meters (kg/m^2). Nutritional status was assessed using age- and sex-specific WHO BMI-for-age Z-scores for children and adolescents aged 5–19 years. Participants were classified as severely thin (BMI-for-age <-3 SD), thin (≥-3 SD to <-2 SD), normal weight (≥-2 SD to $\leq+1$ SD), overweight ($>+1$ SD to $\leq+2$ SD), or obese ($>+2$ SD) according to WHO growth reference standards.²⁵

Blood pressure measurement

Blood pressure (BP) was measured using a calibrated oscillometric sphygmomanometer with an appropriately sized cuff according to the recommendations of the American Academy of Pediatrics (AAP).²⁶ Participants were instructed to remain seated quietly for at least five minutes before BP measurement. BP was measured in the right arm at heart level with the participant in the sitting position. Two BP measurements were obtained at an interval of five minutes, and the average of the two readings was recorded. Participants with BP values above the 90th percentile underwent repeat measurements on two additional occasions. Adolescents with persistently elevated BP were reassessed after two weeks using an aneroid sphygmomanometer.

BP categories were defined according to age-specific AAP criteria.²⁶ For participants aged 10–12 years, normal BP was defined as $<90^{\text{th}}$ percentile; elevated BP as $\geq 90^{\text{th}}$ percentile to $<95^{\text{th}}$ percentile or 120/80 mmHg to $<95^{\text{th}}$ percentile, whichever was lower; stage 1 hypertension as

$\geq 95^{\text{th}}$ percentile to $<95^{\text{th}}$ percentile + 12 mmHg or 130/80 to 139/89 mmHg, whichever was lower; and stage 2 hypertension as $\geq 95^{\text{th}}$ percentile + 12 mmHg or $\geq 140/90$ mmHg, whichever was lower. For participants aged ≥ 13 years, normal BP was defined as $<120/<80$ mmHg; elevated BP as 120/ <80 to 129/ <80 mmHg; stage 1 hypertension as 130/80 to 139/89 mmHg; and stage 2 hypertension as $\geq 140/90$ mmHg.²⁶ For the purpose of analysis, hypertension was defined as stage 1 or stage 2 hypertension according to the age-specific AAP criteria.

Assessment of lifestyle and psychosocial factors

Dietary habits, physical activity, sedentary behaviour, and mental health-related variables were assessed using selected components adapted from the Global School-based Student Health Survey (GSHS) questionnaire.²⁷

Dietary habits were evaluated based on weekly consumption frequency. Fruit intake and vegetable intake were recorded separately and categorized as 0 days, 1–3 days, or >3 days per week. Fast food and carbonated drink consumption during the preceding seven days were recorded and similarly categorized by weekly frequency. Inadequate physical activity was defined as failure to perform moderate-to-vigorous physical activity on at least five days per week.²⁷ Sedentary behaviour was defined as screen exposure for two or more hours per day on most days of the week.²⁸

Depressive symptoms were assessed using self-reported responses on a five-point Likert scale adapted from the mental health component of the GSHS questionnaire.²⁷ Participants reporting symptoms “most of the time” or “always” were considered positive for depressive symptoms. A positive family history was defined as history of hypertension in either parent.²⁹

Statistical analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. The chi-square test was used to assess the association between hypertension and categorical variables. All statistical tests were two-sided, and a p value of <0.05 was considered statistically significant.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Hind Institute of Medical Sciences, Sitapur (Approval No.: IHEC-HIMSA/MD/MS-23/RD-35/07-24). Written informed consent was obtained from parents or legal guardians, and assent was obtained from participating adolescents before enrollment.

RESULTS

The mean age of participants was 14.48 ± 2.99 years, and the mean BMI was 22.93 ± 4.88 kg/m². The study population (n=387) was nearly equally distributed by sex, with 50.1% males and 49.9% females. Early adolescents constituted the largest age group (163/387, 42.1%). Most participants resided in rural areas (270/387, 69.8%), belonged to nuclear families (248/387, 64.1%), and were

Hindu (287/387, 74.1%). The distribution across socioeconomic classes ranged from 18.4% to 22.5%, with the upper-middle class comprising the largest proportion (87/387, 22.5%). A family history of hypertension was reported by 30.7% (119/387) of adolescents, while parental awareness of hypertension was reported by only 23.8% (92/387) (Table 1).

Table 1: Socio-demographic and familial characteristics of the study participants (n=387).

Parameters	Categories	Number (N)	Percentage (%)
Age groups in years	Early adolescent (10-13)	163	42.1
	Mid adolescent (14-16)	107	27.7
	Late adolescent (17-19)	117	30.2
Gender	Male	194	50.1
	Female	193	49.9
Religion	Hindu	287	74.1
	Muslim	75	19.4
	Christian	17	4.4
	Others	8	2.1
Socioeconomic status	Upper	79	20.4
	Upper middle	87	22.5
	Lower middle	71	18.4
	Upper lower	76	19.6
	Lower	74	19.1
Family type	Joint	139	35.9
	Nuclear	248	64.1
Residence (livelihood)	Rural	270	69.8
	Urban	117	30.2
Family history of hypertension	No	268	69.3
	Yes	119	30.7
Parental awareness of hypertension	No	295	76.2
	Yes	92	23.8

Evaluation of dietary and lifestyle habits demonstrated a high prevalence of unhealthy behaviors among participants. Inadequate fruit consumption (≤ 3 days/week) was reported by 67.2% (260/387) of adolescents, while 68.2% (264/387) consumed vegetables on ≤ 3 days/week. Carbonated drinks and fast food were consumed on at least 1 day per week by 50.6% (196/387) and 48.8% (189/387) of participants, respectively. More than half of the study population engaged in inadequate physical activity (215/387, 55.6%), and 47.8% (185/387) demonstrated sedentary screen time behaviors. According to WHO BMI-for-age Z-scores, 33.8% (131/387) of adolescents were categorized as overweight or obese (22.2% overweight, 11.6% obese), whereas 11.7% (45/387) were thin or severely thin. Substance use and psychosocial stressors were less common: 9.3% (36/387) reported tobacco chewing, 8.3% (32/387) reported smoking, 8.3% (32/387) exhibited depressive symptoms, and 14.2% (55/387) reported sleep disturbances (Table 2).

Based on age-specific AAP criteria, the overall prevalence of hypertension was 4.9% (19/387), while 9.3% (36/387) of adolescents had elevated blood pressure. The majority had normal blood pressure (85.8%; 332/387) (Figure 1).

Bivariate analysis evaluating socio-demographic and familial determinants revealed significant associations between blood pressure categories and age group ($\chi^2=42.846$, $p<0.001$), family history of hypertension ($\chi^2=9.758$, $p=0.008$), and parental awareness regarding hypertension ($\chi^2=12.014$, $p=0.002$). Late adolescents had the highest proportion of elevated blood pressure (28/117, 23.9%), whereas hypertension was most prevalent among early adolescents (9/163, 5.5%). A family history of hypertension was associated with a higher proportion of elevated blood pressure (12.6% vs. 7.8%) and hypertension (9.2% vs. 3.0%) compared with no family history. Similarly, elevated blood pressure and hypertension were more common among adolescents whose parents were aware of hypertension than among those whose parents were not (15.2% vs. 7.5% and 9.8%

vs. 3.4%, respectively). Gender, religion, socioeconomic status, family type, and rural/urban residence showed no

statistically significant associations with blood pressure categories ($p>0.05$) (Table 3).

Table 2: Behavioural, lifestyle, psychosocial, and anthropometric risk profile of study population (n=387).

Parameters	Categories	Number (N)	Percentage (%)
Fruit intake (days/week)	0	51	13.2
	1-3	209	54.0
	>3	127	32.8
Vegetable intake (days/week)	0	63	16.3
	1-3	201	51.9
	>3	123	31.8
Carbonated drink intake (days/week)	0	191	49.4
	1-3	171	44.2
	>3	25	6.4
Fast food intake (days/week)	0	198	51.2
	1-3	161	41.6
	>3	28	7.2
Physical activity	Adequate	172	44.4
	Inadequate	215	55.6
Sedentary behaviour	No	202	52.2
	Yes	185	47.8
Substance use	Tobacco chewing (yes)	36	9.3
	Smoking (yes)	32	8.3
Psychosocial profile	Depressive symptoms (yes)	32	8.3
	Sleep disturbance (yes)	55	14.2
	Close friends (0)	24	6.2
	Close friends (1)	175	45.2
	Close friends (≥ 2)	188	48.6
	Severely thin (<-3 SD)	20	5.2
BMI-for-age (WHO Z-score)	Thin (≥ -3 SD to <-2 SD)	25	6.5
	Normal (≥ -2 SD to $\leq +1$ SD)	211	54.5
	Overweight ($>+1$ SD to $\leq +2$ SD)	86	22.2
	Obese ($>+2$ SD)	45	11.6

*BMI=body mass index; SD=Standard deviation

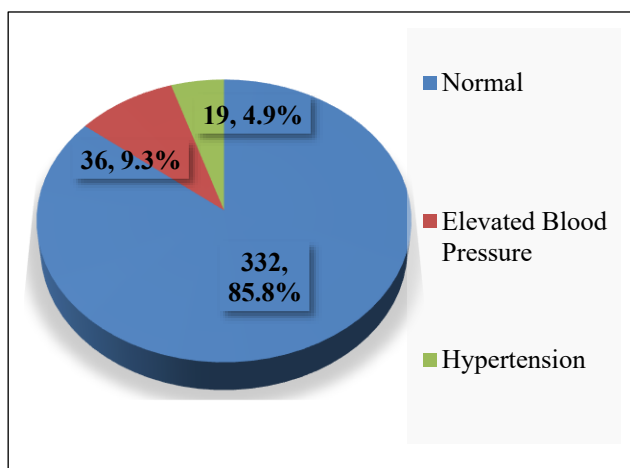


Figure 1: Distribution of blood pressure categories among study participants (n=387).

Bivariate analysis demonstrated that higher BMI-for-age Z-scores were strongly associated with elevated blood pressure and hypertension ($\chi^2=79.199$, $p<0.001$), with hypertension observed only among overweight (8/86, 9.3%) and obese (11/45, 24.4%) participants (Table 4). Significant associations were also observed with frequent fast-food consumption ($\chi^2=82.791$, $p<0.001$), carbonated drink consumption ($\chi^2=91.774$, $p<0.001$), inadequate physical activity ($\chi^2=23.401$, $p<0.001$), sedentary behaviour ($\chi^2=15.972$, $p<0.001$), tobacco chewing, smoking, sleep disturbance, and number of close friends (all $p<0.001$). Fruit intake was also significantly associated with blood pressure categories ($p=0.009$), whereas vegetable intake ($p=0.412$) and depressive symptoms ($p=0.734$) were not.

Table 3: Association between BP categories and socio-demographic and familial characteristics of the study participants (n=387).*

Parameters	Categories	Blood pressure categories			χ^2 value	P value
		Normal, N (%)	Elevated BP, N (%)	Hypertension, N (%)		
Age groups (years)	Early adolescent	150 (92.0)	4 (2.5)	9 (5.5)	42.846	<0.001
	Mid adolescent	97 (90.7)	4 (3.7)	6 (5.6)		
	Late adolescent	85 (72.6)	28 (23.9)	4 (3.4)		
Gender	Male	172 (88.7)	13 (6.7)	9 (4.6)	3.262	0.196
	Female	160 (82.9)	23 (11.9)	10 (5.2)		
Religion	Hindu	246 (85.7)	25 (8.7)	16 (5.6)	1.943	0.925
	Muslim	65 (86.7)	8 (10.7)	2 (2.7)		
	Christian	14 (82.4)	2 (11.8)	1 (5.9)		
	Others	7 (87.5)	1 (12.5)	0 (0.0)		
Socioeconomic status	Upper	71 (89.9)	7 (8.9)	1 (1.3)	9.934	0.270
	Upper middle	79 (90.8)	4 (4.6)	4 (4.6)		
	Lower middle	56 (78.9)	8 (11.3)	7 (9.9)		
	Upper lower	65 (85.5)	8 (10.5)	3 (3.9)		
	Lower	61 (82.4)	9 (12.2)	4 (5.4)		
Family type	Joint	120 (86.3)	11 (7.9)	8 (5.8)	0.773	0.679
	Nuclear	212 (85.5)	25 (10.1)	11 (4.4)		
Residence (livelihood)	Rural	233 (86.3)	25 (9.3)	12 (4.4)	0.422	0.810
	Urban	99 (84.6)	11 (9.4)	7 (6.0)		
Family history of hypertension	No	239 (89.2)	21 (7.8)	8 (3.0)	9.758	0.008
	Yes	93 (78.2)	15 (12.6)	11 (9.2)		
Parents awareness about hypertension	No	263 (89.2)	22 (7.5)	10 (3.4)	12.014	0.002
	Yes	69 (75.0)	14 (15.2)	9 (9.8)		

*BP=Blood Pressure, χ^2 =Chi-square test; Data presented as N (%); Significant p value <0.05**Table 4: Association between blood pressure categories and behavioural, lifestyle, psychosocial, and anthropometric risk profile of study population (n=387).***

Parameters	Categories	Blood pressure categories			χ^2 value	P value
		Normal, N (%)	Elevated BP, N (%)	Hypertension, N (%)		
Fruit intake in days per week	0	47 (92.2)	4 (7.8)	0 (0.0)	13.510	0.009
	1-3	183 (87.6)	12 (5.7)	14 (6.7)		
	>3	102 (80.3)	20 (15.7)	5 (3.9)		
Vegetable intake in days per week	0	102 (82.9)	16 (13.0)	5 (4.1)	3.958	0.412
	1-3	57 (90.5)	3 (4.8)	3 (4.8)		
	>3	173 (86.1)	17 (8.5)	11 (5.5)		
Carbonated drink intake in days per week	0	11 (44.0)	3 (12.0)	11 (44.0)	91.774	<0.001
	1-3	175 (91.6)	14 (7.3)	2 (1.0)		
	>3	146 (85.4)	19 (11.1)	6 (3.5)		
Fast food intake in days per week	0	183 (92.4)	14 (7.1)	1 (0.5)	82.791	<0.001
	1-3	135 (83.9)	19 (11.8)	7 (4.3)		
	>3	14 (50.0)	3 (10.7)	11 (39.3)		
Physical activity	Adequate	164 (95.3)	6 (3.5)	2 (1.2)	23.401	<0.001
	Inadequate	168 (78.1)	30 (14.0)	17 (7.9)		
Sedentary behavior	No	187 (92.6)	10 (5.0)	5 (2.5)	15.972	<0.001
	Yes	145 (78.4)	26 (14.1)	14 (7.6)		
Tobacco chewing	No	318 (90.6)	25 (7.1)	8 (2.3)	82.625	<0.001
	Yes	14 (38.9)	11 (30.6)	11 (30.6)		
Smoking	No	320 (90.1)	27 (7.6)	8 (2.3)	84.458	<0.001
	Yes	12 (37.5)	9 (28.1)	11 (34.4)		

Continued.

Parameters	Categories	Blood pressure categories			χ^2 value	P value
		Normal, N (%)	Elevated BP, N (%)	Hypertension, N (%)		
Depressive symptoms	No	305 (85.9)	32 (9.0)	18 (5.1)	0.618	0.734
	Yes	27 (84.4)	4 (12.5)	1 (3.1)		
Close friend	0	22 (91.7)	1 (4.2)	1 (4.2)	43.21 3	<0.00 1
	1	156 (89.1)	2 (1.1)	17 (9.7)		
	≥ 2	154 (81.9)	33 (17.6)	1 (0.5)		
Sleep disturbance	No	296 (89.2)	25 (7.5)	11 (3.3)	23.10 2	<0.00 1
	Yes	36 (65.5)	11 (20.0)	8 (14.5)		
Body mass Index for age (WHO Z-score)	Severely thin (<-3 SD)	19 (95.0)	1 (5.0)	0 (0.0)	79.19 9	<0.00 1
	Thin (≥ -3 SD to < -2 SD)	25 (100.0)	0 (0.0)	0 (0.0)		
	Normal (≥ -2 SD to $\leq +1$ SD)	199 (94.3)	12 (5.7)	0 (0.0)		
	Overweight ($> +1$ SD to $\leq +2$ SD)	59 (68.6)	19 (22.1)	8 (9.3)		
	Obese ($> +2$ SD)	30 (66.7)	4 (8.9)	11 (24.4)		

*BP=Blood Pressure, χ^2 =Chi-square test; SD=standard deviation; Data presented as n(%); Significant p-value <0.05

DISCUSSION

The present study evaluated the prevalence of hypertension and its socio-demographic, familial, lifestyle, psychosocial, and anthropometric determinants among adolescents aged 10-19 years in Sitapur, Uttar Pradesh, India. The overall prevalence of hypertension was 4.9% (19/387), while an additional 9.3% (36/387) of adolescents had elevated blood pressure. These findings align closely with global estimates reported by Zhou et al (2026), who observed a pooled global childhood hypertension prevalence of 4.28% in an updated systematic review and meta-analysis.⁸

Furthermore, our observed prevalence falls within the reported Indian range of 2% to 20.5% identified across regional studies, as well as the pooled national prevalence of approximately 7.6% reported by Sumna et al (2023) in rural North India.⁹ Our results are also consistent with recent NFHS-6 national survey data demonstrating a significant burden of elevated blood pressure among adolescents and young adults across India.¹⁰ Identifying 9.3% of participants with elevated blood pressure highlights a critical target population for early preventive strategies to halt the progression of elevated blood pressure into adulthood and mitigate long-term cardiovascular morbidity.^{3,21}

Age was significantly associated with BP category ($p < 0.001$), with late adolescents having the highest proportion of elevated BP (23.9%). Increasing age may be accompanied by greater exposure to sedentary behaviour, unhealthy dietary practices, and other adverse lifestyle factors.^{2,16} However, gender, religion, socioeconomic status, family type, and rural/urban residence were not significantly associated with BP status in our study,

suggesting that these socio-demographic characteristics did not clearly differentiate BP categories within this population.

Excess adiposity emerged as the primary anthropometric correlate of elevated blood pressure in our study cohort ($p < 0.001$). Hypertension was observed exclusively among overweight (9.3%) and obese (24.4%) adolescents, whereas no cases were identified among normal-weight or thin participants. This finding is consistent with established evidence identifying obesity as an important modifiable risk factor for pediatric hypertension.¹¹ Studies from Northern India and Uttar Pradesh have also demonstrated the burden of overweight and obesity among adolescents, underscoring the importance of early nutritional assessment and weight-management strategies.^{13,14} Pathophysiologically, obesity-induced hypertension involves complex interconnected mechanisms, including sympathetic nervous system hyperactivation, insulin resistance, altered renal sodium handling, endothelial dysfunction, and neurohormonal dysregulation.¹² As pediatric obesity rates rise globally and across transitioning rural and semi-urban Indian populations,^{2,20} these findings support the value of assessing BMI-for-age Z-scores alongside blood pressure during adolescent health evaluations.²⁴⁻²⁶

Behavioural and dietary risk profiles were significantly associated with blood pressure status in our population. Frequent consumption of fast food (> 3 days/week; $p < 0.001$) and carbonated drinks ($p < 0.001$) were associated with elevated blood pressure categories, consistent with global evidence linking sodium-dense, sugar-sweetened, and processed diets to pediatric vascular dysfunction.^{2,16} Low fruit intake was also significantly associated with blood pressure categories ($p = 0.009$). The absence of a

clear dose-response pattern for fruit intake warrants cautious interpretation.

Furthermore, inadequate physical activity (55.6% of the cohort; $p < 0.001$) and screen-based sedentary behaviour (47.8% of the cohort; $p < 0.001$) demonstrated strong associations with elevated blood pressure. Screen-based sedentary behaviour and physical inactivity promote metabolic dysregulation, excessive weight gain, and diminished arterial compliance among school-aged youth.^{16,28} Promotion of regular physical activity and reduction of sedentary behaviour should therefore form important components of adolescent cardiovascular-risk prevention.^{16,26}

Additionally, tobacco chewing ($p < 0.001$) and smoking ($p < 0.001$) showed significant associations with elevated blood pressure, supporting evidence regarding the vascular risks of nicotine and substance exposure in young populations.² These findings support inclusion of tobacco-use assessment and prevention within adolescent health programmes.

Familial characteristics were also strongly associated with adolescent blood pressure categories. A positive family history of hypertension was present in 30.7% of participants and was significantly linked to elevated blood pressure and hypertension ($p = 0.008$). This finding corroborates evidence from Horvat et al (2024), who identified parental history of hypertension as a major determinant of arterial hypertension in younger populations.²⁹ The association may reflect both genetic susceptibility and shared environmental and behavioural factors.

Parental awareness of hypertension was also significantly associated with elevated blood pressure categories ($p = 0.002$). However, this should not be interpreted as a causal risk factor. Greater awareness may reflect a family history of hypertension, previous healthcare exposure, or increased likelihood of BP assessment in families already considered at risk.^{6,29}

Psychosocially, self-reported sleep disturbance was strongly associated with blood pressure status ($p < 0.001$), supporting literature that links sleep disruption with autonomic imbalances, elevated sympathetic tone, and nocturnal blood pressure elevations.² However, the cross-sectional design prevents determination of temporal or causal relationships.

Self-reported depressive symptoms were not significantly associated with blood pressure status in our cohort ($p = 0.734$), aligning with findings by Mahanta et al, who similarly observed no significant link between psychological distress and adolescent hypertension in Assam.² Although the number of close friends showed a statistically significant association ($p < 0.001$), the distribution was irregular and lacked a clear gradient; thus, as Mahanta et al. suggested for peer dynamics, this finding

should be interpreted cautiously and requires confirmation using validated psychosocial instruments.

This study provides valuable epidemiological evidence on adolescent hypertension from Sitapur, a semi-urban and rural district in Uttar Pradesh where data have previously been limited. Strengths of the study include the application of standardized AAP pediatric diagnostic criteria, calibrated physical measurements, WHO growth reference standards, and validated GSHS survey instruments.

This study has few limitations. The cross-sectional design prevents the establishment of temporal or causal relationships between identified risk factors and hypertension. Dietary intake, physical activity, and substance use relied on self-reported survey responses, introducing potential recall or response bias. Finally, while bivariate Chi-square analysis demonstrated clear associations, multivariable logistic regression modelling could not be stably performed due to quasi-complete separation resulting from the small total number of hypertension cases ($n = 19$).

CONCLUSION

The prevalence of hypertension (4.9%) and elevated blood pressure (9.3%) among adolescents in Sitapur highlights a distinct cardiovascular risk burden in this population. Body mass index (overweight and obesity), physical inactivity, screen-based sedentary behaviour, frequent fast-food and carbonated drink consumption, family history of hypertension, and sleep disturbances were identified as key correlates. Implementing school-based screening programs alongside community interventions focused on physical activity, healthy nutrition, and weight management is necessary to reduce long-term cardiovascular risk in adolescents.

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