



## HYPERTENSION AND ITS ASSOCIATED FACTORS AMONG UNDERGRADUATE MEDICAL STUDENTS: A CROSS-SECTIONAL STUDY

### Public Health

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### ABSTRACT

**Background:** Hypertension is an emerging public health concern among young adults, including medical students, due to increasing exposure to behavioural and lifestyle-related risk factors. This study aimed to estimate the prevalence of hypertension and its associated factors among undergraduate medical students. **Methods:** A cross-sectional study was conducted among 230 undergraduate medical students at a tertiary care teaching institution in Chandigarh, India. Participants were selected using stratified random sampling. Data on sociodemographic, behavioural, psychosocial, anthropometric, and biochemical variables were collected using standardised tools. Blood pressure was classified according to the JNC-7 criteria. Multivariable logistic regression analysis was performed to identify factors associated with hypertension. **Results:** The mean age of the participants was  $19.9 \pm 1.4$  years, and 51.7% were females. The prevalence of hypertension was 9.1%, while 50.0% of participants were pre-hypertensive. Hypertension was significantly associated with body mass index (BMI) ( $p = 0.017$ ). Overweight/obese students had significantly higher odds of hypertension than those with underweight/normal BMI (adjusted odds ratio = 5.8, 95% CI = 1.8–18.9;  $P = 0.003$ ). **Conclusion:** A high prevalence of JNC 7 pre-hypertension was observed among undergraduate medical students. Overweight and obesity were independently associated with hypertension, highlighting the importance of routine blood pressure screening and lifestyle interventions promoting healthy weight and cardiovascular risk reduction.

### KEYWORDS

#### INTRODUCTION

Hypertension is one of the leading modifiable risk factors for cardiovascular disease and remains a major contributor to global morbidity and mortality. Although traditionally considered a disease of middle-aged and older adults, hypertension is increasingly being reported among adolescents and young adults, resulting in prolonged exposure to elevated blood pressure and an increased lifetime risk of cardiovascular complications.<sup>1-7</sup> Early identification of hypertension and its modifiable risk factors is therefore essential for preventing future cardiovascular disease.

Undergraduate medical students constitute a unique population at increased risk of developing elevated blood pressure because of academic stress, irregular sleep patterns, unhealthy dietary habits, sedentary behaviour, and other lifestyle-related factors. Despite their medical knowledge, these risk factors may predispose them to pre-hypertension and hypertension at a young age. Previous studies from India and other countries have reported a considerable prevalence of elevated blood pressure among medical students, highlighting the need for regular screening and early preventive interventions.<sup>8,9</sup>

Among the recognised determinants of hypertension, obesity remains one of the most important modifiable risk factors, while excessive dietary sodium intake, psychological stress, and inflammatory and neuroendocrine mechanisms have also been implicated in its development.<sup>10-20</sup> However, relatively few studies from India have comprehensively evaluated behavioural, anthropometric, psychosocial, and biochemical determinants of hypertension simultaneously among undergraduate medical students.

Therefore, the present study was undertaken to determine the prevalence of hypertension and identify its associated behavioural, anthropometric, psychosocial, and biochemical determinants among undergraduate medical students at a tertiary care teaching institution in Chandigarh, India. The findings may help inform institution-based screening and lifestyle interventions aimed at reducing future cardiovascular risk in this vulnerable population.

#### METHODS

A cross-sectional study was conducted among undergraduate MBBS students at the Government Medical College and Hospital (GMCH), Chandigarh, India, with approximately 600 students enrolled across

four academic years during the study period. The sample size was calculated using an anticipated hypertension prevalence of 17%, a 95% confidence level, and 5% absolute precision, yielding a minimum sample size of 217. After allowing for a 10% non-response rate, the required sample size was estimated to be 240 participants.<sup>21</sup> Participants were selected using stratified random sampling with academic year as the stratification variable. Proportionate allocation ensured representation from each academic year, and simple random sampling was used within each stratum. A total of 240 students were approached, of whom 230 with complete data were included in the final analysis. All undergraduate medical students who provided written informed consent were eligible. Students with known cardiovascular disease, chronic kidney disease, endocrine disorders, or those receiving long-term medications affecting blood pressure were excluded. Data were collected using a pretested semi-structured questionnaire that recorded sociodemographic characteristics, family history of hypertension, tobacco and alcohol use, dietary practices, and blood pressure monitoring behaviour. Knowledge regarding hypertension was assessed by evaluating awareness of diagnostic blood pressure cut-off values and major modifiable risk factors, including obesity, stress, smoking, alcohol consumption, and high salt intake. Perceived stress was assessed using the Perceived Stress Scale-10 (PSS-10), while sleep disturbance was evaluated using the Insomnia Severity Index (ISI). Blood pressure was measured using a calibrated digital sphygmomanometer with an appropriately sized cuff after participants had rested for at least five minutes in the seated position. Two readings were recorded five minutes apart, and their average was used for analysis. Blood pressure was classified according to the Seventh Report of the Seventh Report of the Joint National Committee (JNC-7) into normotension (systolic blood pressure <120 mmHg and diastolic blood pressure <80 mmHg), pre-hypertension (SBP 120–139 mmHg and/or DBP 80–89 mmHg), stage 1 hypertension (SBP 140–159 mmHg and/or DBP 90–99 mmHg), and stage 2 hypertension (SBP  $\geq 160$  mmHg and/or DBP  $\geq 100$  mmHg).<sup>22</sup> Height, weight, waist circumference, and hip circumference were measured using standard procedures. Body mass index (BMI) was calculated as weight (kg)/height ( $m^2$ ), and BMI values were classified according to the WHO Asia-Pacific guidelines.<sup>11</sup> Waist-to-hip ratio was also calculated. Fasting venous blood samples were collected between 8:00 AM and 10:00 AM under aseptic conditions. Serum cortisol was estimated by chemiluminescence assay, high-sensitivity C-reactive

protein (hs-CRP) by immunoturbidimetric assay, fasting blood glucose and total cholesterol using standard laboratory methods, and morning spot urinary sodium by the ion-selective electrode method. Biomarkers were categorised using predefined laboratory cut-offs: serum cortisol  $>23$   $\mu\text{g/dL}$ , total cholesterol  $\geq 200$   $\text{mg/dL}$ , fasting blood glucose  $\geq 126$   $\text{mg/dL}$ , urinary sodium  $\geq 100$   $\text{mmol/L}$ , and hs-CRP  $>3$   $\text{mg/L}$ .<sup>23-25</sup>

Data were analysed using IBM SPSS Statistics for Windows (version 26). Associations between categorical variables were assessed using the Chi-square or Fisher's exact test. Multivariable logistic regression analysis was performed to identify independent determinants of hypertension using age, gender, BMI, family history of hypertension, alcohol consumption, urinary sodium level, perceived stress score, and insomnia severity score as independent variables. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated, and a  $p$ -value  $<0.05$  was considered statistically significant. The study was approved by the Institutional Ethics Committee of Government Medical College and Hospital, Chandigarh, and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment, and confidentiality was maintained throughout the study.

## RESULTS

A total of 230 undergraduate medical students with complete data were included in the analysis. The mean age of the participants was  $19.96 \pm 1.40$  years, and females constituted 51.7% of the study population. The baseline sociodemographic, behavioural, and clinical characteristics are presented in Table 1. Only 24 (10.4%) participants correctly identified the diagnostic blood pressure cut-off values for hypertension, although awareness regarding major modifiable risk factors, including obesity, stress, smoking, alcohol consumption, and high salt intake, was generally high. According to the JNC-7 classification, 94 (40.9%) participants were normotensive, 115 (50.0%) were pre-hypertensive, and 21 (9.1%) were hypertensive, including 17 (7.4%) with stage 1 hypertension and 4 (1.7%) with stage 2 hypertension (Table 2). No significant associations were observed between hypertension and gender, family history of hypertension, alcohol consumption, perceived stress, insomnia severity, or biochemical markers (Table 3 & 4). However, blood pressure status differed significantly across BMI categories, with the prevalence of hypertension increasing progressively from the underweight to the obese category ( $P=0.017$ ) (Table 5).

Multivariable logistic regression analysis was performed to identify factors independently associated with hypertension (Table 6). After adjustment for family history of hypertension, alcohol consumption, urinary sodium category, age group, gender, perceived stress score (PSS-10), and insomnia severity score (ISI), BMI remained the only independent predictor of hypertension. Students who were overweight or obese had significantly higher odds of hypertension than those who were underweight or had normal BMI (adjusted odds ratio [AOR] = 5.8, 95% confidence interval [CI]: 1.8–18.9;  $P=0.003$ ). No significant independent associations were observed for family history of hypertension, alcohol consumption, urinary sodium category, age group, gender, perceived stress score, or insomnia severity score ( $P > 0.05$  for all).

## DISCUSSION

The present study evaluated the prevalence of hypertension and its associated factors among undergraduate medical students at a tertiary care teaching institution. Although the prevalence of hypertension was 9.1%, half of the participants were classified as pre-hypertensive, indicating that a substantial proportion of apparently healthy young adults are already at increased risk of developing hypertension. Among the variables evaluated, BMI was the only factor independently associated with hypertension after adjustment for potential confounders.

The prevalence of hypertension observed in this study is comparable with findings reported among medical students from different regions of India, where prevalence has ranged from 7% to 17%.<sup>8,21,26</sup> Similar estimates have also been reported among university students from other low- and middle-income countries.<sup>27</sup> Differences between studies may be explained by variations in study populations, lifestyle characteristics, sampling methods, and blood pressure classification criteria.

An important observation was the high prevalence of JNC 7 pre-

hypertension (50%). Similar findings have been reported previously,<sup>27,28</sup> suggesting that elevated blood pressure is common even among apparently healthy young adults. Since JNC 7 pre-hypertension is an established associated factor for future hypertension and cardiovascular disease, regular blood pressure screening and early lifestyle interventions should be encouraged in medical colleges.

BMI demonstrated a significant association with hypertension in both univariate and multivariable analyses. This finding is consistent with previous studies among medical students and young adults that have identified excess body weight as one of the strongest modifiable risk factors for elevated blood pressure.<sup>8,26,29</sup> Obesity contributes to hypertension through several mechanisms, including increased sympathetic nervous system activity, insulin resistance, endothelial dysfunction, and activation of the renin–angiotensin–aldosterone system.<sup>11,12</sup> These findings emphasise the importance of maintaining a healthy body weight during early adulthood and support the inclusion of weight management strategies in campus-based health promotion programmes.

In contrast, no independent associations were observed between hypertension and age, gender, family history of hypertension, alcohol consumption, urinary sodium level, perceived stress score, or insomnia severity score. Similarly, serum cortisol, hs-CRP, fasting blood glucose, total cholesterol, and urinary sodium levels were not significantly associated with hypertension. The absence of significant associations may reflect the relatively homogeneous study population, the low prevalence of behavioural risk factors such as smoking and alcohol consumption, and the limited number of hypertensive participants. It is also possible that biochemical alterations associated with hypertension become more apparent after prolonged exposure to cardiovascular risk factors than is typically observed in this young population.<sup>14-20</sup>

The findings have important public health implications. Medical students represent the future of healthcare, and early identification of elevated blood pressure provides an opportunity to promote healthy lifestyle practices before the onset of established cardiovascular disease. Institution-based programmes promoting regular blood pressure screening, healthy dietary habits, physical activity, and weight management may help reduce future cardiovascular risk.

The strengths of this study include validated instruments for assessing perceived stress and insomnia, as well as objective biochemical measurements. However, the cross-sectional design limits causal inference. Behavioural information was self-reported and may be subject to recall bias. In addition, the study was conducted at a single institution, which may limit the generalisability of the findings.

## CONCLUSION

Around one tenth (9.1%) of the study participants were hypertensive, and half of them (50%) were pre-hypertensive. Overweight and obesity were independently associated with hypertension. These findings highlight the importance of routine blood pressure screening and lifestyle interventions focusing on healthy diet, regular physical activity, and weight management among medical students. Early identification and modification of cardiovascular risk factors in this population may help reduce the future burden of hypertension and cardiovascular disease.

**Table 1. Baseline Characteristics of the Study Participants (N = 230)**

| Characteristic                    | Category  | n (%)      |
|-----------------------------------|-----------|------------|
| Age (years)                       | <20       | 88 (38.3)  |
|                                   | $\geq 20$ | 142 (61.7) |
| Gender                            | Male      | 111 (48.3) |
|                                   | Female    | 119 (51.7) |
| Family history of hypertension    | Yes       | 79 (34.3)  |
|                                   | No        | 151 (65.7) |
| Smoking                           | Yes       | 4 (1.7)    |
|                                   | No        | 226 (98.3) |
| Alcohol consumption               | Yes       | 23 (10.0)  |
|                                   | No        | 207 (90.0) |
| Regular blood pressure monitoring | Yes       | 56 (24.3)  |
|                                   | No        | 174 (75.7) |

|                           |                                    |            |
|---------------------------|------------------------------------|------------|
| Perceived stress (PSS-10) | Low                                | 11 (4.8)   |
|                           | Moderate                           | 202 (87.8) |
|                           | High                               | 17 (7.4)   |
|                           |                                    |            |
| Insomnia severity (ISI)   | No clinically significant insomnia | 149 (64.8) |
|                           | Subthreshold insomnia              | 56 (24.3)  |
|                           | Moderate clinical insomnia         | 23 (10.0)  |
|                           | Severe clinical insomnia           | 2 (0.9)    |

Values are presented as number (percentage). PSS-10 = Perceived Stress Scale-10; ISI = Insomnia Severity Index.

Table 2. Distribution of Participants According to Blood Pressure Categories (JNC-7)

|                         |             |
|-------------------------|-------------|
| Blood pressure category | n (%)       |
| Normotensive            | 94 (40.9)   |
| Pre-hypertensive        | 115 (50.0)  |
| Stage 1 hypertension    | 17 (7.4)    |
| Stage 2 hypertension    | 4 (1.7)     |
| Total                   | 230 (100.0) |

Blood pressure was classified according to the Seventh Report of the Joint National Committee (JNC-7).

Table 3. Association of Hypertension with Sociodemographic and Behavioural Characteristics

|                     |                           |                    |         |
|---------------------|---------------------------|--------------------|---------|
| Variable            | Category                  | Hypertension n (%) | P value |
| Age                 | <20 years                 | 6 (6.8)            | 0.163   |
|                     | ≥20 years                 | 15 (10.6)          |         |
| Gender              | Male                      | 12 (10.8)          | 0.393   |
|                     | Female                    | 9 (7.6)            |         |
| Academic year       | First–Second              | 9 (6.9)            | 0.053   |
|                     | Third–Fourth              | 12 (11.8)          |         |
| Family history      | Yes                       | 8 (10.1)           | 0.704   |
|                     | No                        | 13 (8.6)           |         |
| Alcohol consumption | Yes                       | 2 (8.7)            | 1.000   |
|                     | No                        | 19 (9.2)           |         |
| Smoking             | Yes                       | 0 (0.0)            | >0.05*  |
|                     | No                        | 21 (9.3)           |         |
| High salt intake    | Yes                       | 14 (8.4)           | 0.299   |
|                     | No                        | 7 (14.3)           |         |
| Perceived stress    | Low                       | 1 (9.1)            | 0.990   |
|                     | Moderate                  | 19 (9.4)           |         |
|                     | High                      | 1 (5.9)            |         |
| Insomnia severity   | No clinically significant | 13 (8.7)           | 0.652   |
|                     | Subthreshold              | 6 (12.5)           |         |
|                     | Moderate clinical         | 2 (8.0)            |         |
|                     | Severe clinical           | 0 (0.0)            |         |

Values are presented as number (percentage) of participants with hypertension within each category. Chi-square test or Fisher's exact test was used as appropriate.

\*Fisher's exact test.

P<0.05 was considered statistically significant.

Table 4: Comparison of Biochemical Parameters Between Normotensive and Hypertensive Participants

|                               |                          |                          |         |
|-------------------------------|--------------------------|--------------------------|---------|
| Parameter                     | Normotensive (Mean ± SD) | Hypertensive (Mean ± SD) | p-value |
| Serum cortisol (µg/dL)        | 18.9 ± 9.3               | 19.4 ± 9.8               | 0.904   |
| hs-CRP (mg/L)                 | 1.79 ± 3.60              | 2.01 ± 3.90              | 0.637   |
| Fasting blood glucose (mg/dL) | 88.18 ± 9.23             | 85.43 ± 7.53             | 0.213   |
| Total cholesterol (mg/dL)     | 154.10 ± 27.19           | 156.52 ± 26.24           | 0.756   |
| Urinary sodium (mmol/L)       | 115.62 ± 82.91           | 98.22 ± 55.01            | 0.546   |

Values are expressed as mean ± standard deviation (SD). Independent t-test or Mann–Whitney U test was applied as appropriate.

p<0.05 was considered statistically significant.

Table 5. Distribution of Blood Pressure Categories According to BMI Classification

|              |                    |                              |                    |       |
|--------------|--------------------|------------------------------|--------------------|-------|
| BMI category | Normotensive n (%) | Pre-hypertensive n (%) JNC 7 | Hypertensive n (%) | Total |
| Underweight  | 10 (55.6)          | 7 (38.9)                     | 1 (5.6)            | 18    |

|            |           |           |          |     |
|------------|-----------|-----------|----------|-----|
| Normal     | 50 (48.5) | 49 (47.6) | 4 (3.9)  | 103 |
| Overweight | 20 (36.4) | 28 (50.9) | 7 (12.7) | 55  |
| Obese      | 14 (25.9) | 31 (57.4) | 9 (16.7) | 54  |
| Total      | 94        | 115       | 21       | 230 |

BMI classified according to WHO Asia-Pacific guidelines. Chi-square test for trend/association: P=0.017. The proportion of both JNC 7 pre-hypertension and hypertension increased progressively with increasing BMI.

Table 6. Multivariable Logistic Regression Analysis of Factors Associated with Hypertension (N = 230)

|                                |                      |                      |         |
|--------------------------------|----------------------|----------------------|---------|
| Variable                       | Category             | Adjusted OR (95% CI) | P value |
| Age                            | <20 years            | Ref                  | 0.086   |
|                                | ≥20 years            | 0.41 (0.15–1.13)     |         |
| Gender                         | Female               | Ref                  | 0.508   |
|                                | Male                 | 1.44 (0.49–4.21)     |         |
| Family history of hypertension | Absent               | Ref                  | 0.840   |
|                                | Present              | 0.90 (0.31–2.61)     |         |
| Alcohol consumption            | No                   | Ref                  | 0.857   |
|                                | Yes                  | 0.86 (0.18–4.26)     |         |
| BMI category                   | Underweight / Normal | Ref                  | 0.003*  |
|                                | Overweight/ Obese    | 5.84 (1.80–18.88)    |         |
| PSS-10 score†                  |                      | 1.03 (0.95–1.12)     | 0.485   |
| ISI score†                     |                      | 0.97 (0.87–1.08)     | 0.586   |

Ref = Reference category. † PSS-10 and ISI were entered as continuous variables in the regression model; therefore, no reference category applies.

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