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# Prevalence And Risk Factors Of Hypertension Among Medical Students At Al-Aleem Medical College, Lahore

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## ABSTRACT

***Background:*** *Hypertension is a major modifiable risk factor for cardiovascular morbidity and mortality and is increasingly detected in young adults, including medical students exposed to academic stress and adverse lifestyle patterns. Early identification of elevated blood pressure in this population is critical to prevent long-term cardiovascular complications.* ***Objective:*** *To determine the prevalence of elevated blood pressure and hypertension and to evaluate associated risk factors among senior MBBS students at Al-Aleem Medical College, Lahore.* ***Methods:*** *A cross-sectional observational study was conducted among 162 fourth- and fifth-year MBBS students using a census approach. Blood pressure was measured using standardized techniques across two separate visits and classified according to American Heart Association criteria. Anthropometric measurements were recorded, and a structured questionnaire assessed smoking status, physical activity, and family history. Associations were analyzed using chi-square or Fisher's exact tests and multivariable logistic regression; odds ratios (OR) with 95% confidence intervals (CI) were reported.* ***Results:*** *Overall, 69.8% were normotensive, 19.8% had elevated blood pressure, and 10.5% had hypertension. Abnormal blood pressure (elevated or hypertensive) was present in 30.2% of students. Hypertension was significantly associated with male sex (adjusted OR 4.98; 95% CI: 1.61–15.37), overweight status (adjusted OR 4.21; 95% CI: 1.21–14.62), obesity (adjusted OR 10.88; 95% CI: 2.05–57.73), and smoking (adjusted OR 6.42; 95% CI: 1.27–32.44). Family history and physical activity were not statistically significant predictors.* ***Conclusion:*** *Elevated blood pressure and hypertension are common among senior medical students, with male sex, excess body weight, and smoking emerging as key independent risk factors, underscoring the need for early screening and targeted preventive interventions within medical institutions.*

***Keywords:*** *Hypertension; Medical students; Body mass index; Smoking; Cardiovascular risk; Cross-sectional study.*

## INTRODUCTION

Hypertension is a leading modifiable risk factor for cardiovascular disease and premature mortality worldwide, contributing substantially to myocardial infarction, stroke, heart failure, and chronic kidney disease, often progressing silently until complications occur (1)(2)(3). Contemporary epidemiologic patterns show that elevated blood pressure is no longer confined to older adults; it is increasingly detected in younger populations, reflecting shifts in diet, adiposity, physical inactivity, tobacco exposure, and psychosocial stressors that accompany urbanization and changing lifestyles (1)(3). This epidemiologic transition is particularly consequential in low- and middle-income countries, where screening coverage, continuity of care, and long-term blood pressure control remain uneven, amplifying downstream cardiovascular burden (3). In Pakistan, hypertension has emerged as a growing public health challenge alongside broader non-communicable disease trends, with evidence indicating a rising prevalence and substantial unmet need for detection and effective management (4).

Among the established determinants of hypertension, excess adiposity and tobacco use are consistently associated with higher blood pressure through mechanisms that include

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sympathetic activation, vascular dysfunction, metabolic dysregulation, and arterial stiffness (1)(5)(6). Longitudinal evidence from young-adult cohorts demonstrates that greater physical activity is associated with lower incident hypertension over time, supporting the preventive role of exercise and weight control during early adulthood (7). However, medical training environments may paradoxically amplify risk: heavy academic workload, irregular sleep, prolonged sedentary study time, and stress related to examinations and clinical rotations can reduce physical activity and promote maladaptive coping behaviors, including smoking and unhealthy dietary patterns (8)(9). Studies across university and medical student populations in several settings have reported non-trivial proportions of elevated blood pressure and hypertension, often clustering with higher body mass index and tobacco exposure, suggesting that students in health professions are not insulated from early cardiovascular risk (10)(11)(12).

Despite this, institution-specific data from Pakistan—particularly among senior MBBS students approaching graduation—remain limited, and existing estimates are not always comparable due to heterogeneity in diagnostic thresholds, measurement protocols, and the number of readings used to classify blood pressure status (4)(10)(11). Guideline selection matters: the American Heart Association/American College of Cardiology approach emphasizes lower thresholds for early detection and recommends confirmation using standardized measurement techniques and repeated readings, which is especially pertinent in young adults where lifestyle intervention can prevent progression to sustained hypertension (2)(13). From a biostatistical and public health perspective, generating locally relevant prevalence estimates using clearly defined classification criteria, along with quantified associations for modifiable exposures, is necessary to inform campus screening policies and targeted prevention programs, while also shaping future clinicians' personal health behaviors and counseling credibility.

Accordingly, this study was designed to quantify the prevalence of elevated blood pressure and hypertension among senior MBBS students at Al-Aleem Medical College, Lahore (Population), and to evaluate associations with key putative risk factors including sex, body mass index category, smoking status, physical activity, and family history (Exposures), comparing blood pressure status across these strata (Comparison), using guideline-based blood pressure categories as the primary outcomes (Outcome) (2)(13). The primary research question was: among senior medical students at Al-Aleem Medical College, what is the prevalence of elevated blood pressure and hypertension, and are male sex, higher body mass index, and smoking associated with higher odds of abnormal blood pressure compared with their respective reference groups?

## MATERIALS AND METHODS

A cross-sectional observational study was conducted to determine the prevalence of elevated blood pressure and hypertension and to examine their association with selected demographic and lifestyle factors among senior medical students. This design was chosen because it allows estimation of point prevalence and evaluation of exposure–outcome relationships within a defined population at a single time point, consistent with recommendations for reporting observational studies (14). The study was carried out at Al-Aleem Medical College, Lahore, in academic collaboration with Gulab Devi Hospital, a tertiary care teaching institution affiliated with the college. Data collection was completed over a six-month period, during which recruitment, measurements, data entry, and verification procedures were performed in a standardized manner.

The source population comprised all students enrolled in the 4th and 5th year MBBS classes during the study period. A census approach was adopted to enhance representativeness and statistical precision by inviting all eligible students rather than selecting a sample. Inclusion criteria were enrollment in the 4th or 5th year of the MBBS program, attendance on scheduled data collection days, and provision of written informed consent. Students were excluded if they declined participation or refused blood pressure or anthropometric measurements. Recruitment was conducted during scheduled academic sessions to maximize participation. Students were informed verbally and in writing about the study objectives, procedures, voluntary nature of participation, and confidentiality safeguards. Written informed consent was obtained prior to any measurement or questionnaire administration.

Blood pressure measurement followed standardized clinical procedures aligned with international recommendations to reduce measurement error and white-coat effect (2)(13). Measurements were performed using a calibrated aneroid sphygmomanometer, with calibration verified against a mercury reference standard at the start of the data collection period. Participants were instructed to avoid caffeine, smoking, and vigorous physical activity for at least 30 minutes prior to assessment. After a seated rest of at least five minutes in a quiet room, blood pressure was measured with the participant seated, back supported, feet flat on the floor, and the arm supported at heart level. An appropriately sized cuff was selected based on mid-arm circumference. Two readings were taken at an interval of five minutes during the initial visit, and the procedure was repeated on a separate day within one week. Blood pressure was measured in both arms at the first encounter, and the arm with the higher systolic reading was used for subsequent measurements. The final blood pressure value for classification was calculated as the mean of all valid readings obtained from the designated arm across both visits.

Blood pressure categories were defined according to the American Heart Association/American College of Cardiology criteria: normal (systolic <120 mmHg and diastolic <80 mmHg), elevated (systolic 120–129 mmHg and diastolic <80 mmHg), Stage 1 hypertension (systolic 130–139 mmHg or diastolic 80–89 mmHg), and Stage 2 hypertension (systolic ≥140 mmHg or diastolic ≥90 mmHg) (13). For analytic purposes, hypertension was defined as Stage 1 or Stage 2, and an additional composite outcome of abnormal blood pressure (elevated or hypertension) was examined in sensitivity analyses.

Anthropometric measurements were obtained using standardized techniques. Body weight was measured to the nearest 0.1 kg using a digital scale placed on a flat surface, with participants wearing light clothing and no footwear. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, with the participant standing erect, heels together, and head in the Frankfurt plane. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²) and categorized according to Centers for Disease Control and Prevention adult criteria: underweight (<18.5 kg/m²), healthy weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥30.0 kg/m²) (15).

Data on demographic characteristics and potential risk factors were collected using a structured, pretested questionnaire administered in person. Variables included age, sex, family history of hypertension in first-degree relatives, smoking status, and physical activity frequency. Smoking was defined as self-reported current use of cigarettes at least once per week. Physical activity was operationalized as the number of days per week engaged in moderate-to-vigorous exercise of at least 30 minutes' duration and categorized into none, 1–2 days, 3–4 days, and ≥5 days per week. To minimize information bias, questionnaires were

completed anonymously, and participants were assured that responses would not influence academic standing.

Several steps were implemented to reduce measurement and selection bias. All measurements were performed by trained investigators who underwent standardized instruction and inter-observer reliability checks prior to study initiation. The same equipment was used throughout the study period. Repeated blood pressure measurements across two visits were incorporated to reduce random error and regression to the mean. A census-based recruitment strategy minimized sampling bias. Potential confounding by sex, BMI, and smoking was addressed analytically through multivariable modeling.

The sample size was determined by the total number of eligible students enrolled during the study period. Using an anticipated hypertension prevalence of approximately 10% based on prior studies in similar populations (10)(11), a population of this size provided adequate precision to estimate prevalence with a 95% confidence interval width of approximately ±5%, while also permitting exploratory analysis of associations with common exposures.

Data were entered into a password-protected database using double-entry verification to ensure accuracy and minimize transcription errors. Statistical analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics; categorical variables were reported as frequencies and percentages, and continuous variables as means with standard deviations. Prevalence estimates for elevated blood pressure and hypertension were calculated with 95% confidence intervals using binomial exact methods. Associations between categorical risk factors and blood pressure categories were initially assessed using the chi-square test; Fisher's exact test was applied when expected cell counts were less than five. To quantify associations, unadjusted odds ratios with 95% confidence intervals were calculated. Multivariable logistic regression models were constructed to estimate adjusted odds ratios for hypertension and for abnormal blood pressure, controlling for sex, BMI category, smoking status, physical activity, and family history. Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test. Missing data were assessed for randomness; complete-case analysis was performed when missingness was minimal (<5%), with sensitivity analysis comparing key estimates to ensure robustness. A two-sided p-value of $<0.05$ was considered statistically significant.

Ethical approval was obtained from the institutional review authority of Al-Aleem Medical College prior to commencement of the study. Participation was voluntary, and confidentiality was maintained through anonymized data coding. Students identified with elevated blood pressure or hypertension were counseled and referred for further clinical evaluation. All procedures adhered to principles outlined in the Declaration of Helsinki for research involving human participants (16). Measures to ensure reproducibility included standardized protocols for measurement, documentation of calibration procedures, predefined analytic plans, and secure archiving of de-identified datasets and syntax files for audit and secondary verification.

## RESULTS

A total of 162 senior MBBS students were evaluated. As shown in Table 1, 113 students (69.8%; 95% CI: 62.3–76.5) had normal blood pressure. Elevated blood pressure was identified in 32 students (19.8%; 95% CI: 14.0–26.9). Stage 1 hypertension was present in 12 students (7.4%; 95% CI: 3.9–12.6), while 5 students (3.1%; 95% CI: 1.0–7.1) met criteria for Stage 2 hypertension. When combined, 17 students were hypertensive, giving an overall hypertension prevalence of 10.5% (95% CI: 6.3–16.2). The composite prevalence of abnormal

blood pressure (elevated or hypertensive) was 30.2% (49/162; 95% CI: 23.5–37.7), indicating that nearly one in three students had blood pressure above the normal range.

The socio-demographic and lifestyle profile of participants (Table 2) showed that most students were aged 21–23 years (92.0%), with only 8.0% aged 24–25 years. Females constituted two-thirds of the cohort (66.0%), while males accounted for 34.0%. Regarding body mass index, 66.0% were within the healthy weight range, 18.5% were overweight, and 5.6% were obese; 9.9% were underweight. Smoking was reported by 6.2% of students. A positive family history of hypertension was present in 70.4% of participants. In terms of physical activity, 20.4% reported no regular activity, whereas 43.8% exercised at least five days per week.

Table 3 demonstrates a marked sex difference in hypertension prevalence. Among male students, 12 of 55 (21.8%) were hypertensive compared with 5 of 107 females (4.7%). The crude odds of hypertension were 5.63 times higher in males than females (95% CI: 1.92–16.46; $p < 0.001$). In absolute terms, the difference in prevalence between males and females was 17.1 percentage points (21.8% vs 4.7%), highlighting a substantial disparity.

A clear gradient was observed across BMI categories (Table 4). No underweight students were hypertensive (0%). Among students with healthy BMI, 6 of 107 (5.6%) were hypertensive. The prevalence increased to 23.3% (7/30) in the overweight group and 44.4% (4/9) in the obese group. Compared with students of healthy BMI, overweight students had more than five-fold higher odds of hypertension (OR 5.12; 95% CI: 1.60–16.40), while obese students had approximately thirteen-fold higher odds (OR 13.47; 95% CI: 2.90–62.50). The association between BMI category and hypertension was statistically significant ($p < 0.001$), demonstrating a strong dose–response relationship.

Smoking status was also significantly associated with hypertension (Table 5). Among smokers, 4 of 10 (40.0%) were hypertensive, compared with 13 of 152 non-smokers (8.6%). This corresponds to a crude odds ratio of 7.07 (95% CI: 1.62–30.82; $p = 0.004$, Fisher's exact test). The absolute difference in hypertension prevalence between smokers and non-smokers was 31.4 percentage points (40.0% vs 8.6%), indicating a markedly higher burden among smokers.

In contrast, family history of hypertension did not demonstrate a statistically significant association (Table 6). Hypertension was observed in 11.4% (13/114) of students with a positive family history compared with 8.3% (4/48) among those without such history (OR 1.42; 95% CI: 0.45–4.48; $p = 0.804$). The overlapping confidence intervals and small absolute difference (3.1 percentage points) indicate no meaningful association in this cohort.

Similarly, physical activity frequency was not significantly associated with hypertension (Table 7). Hypertension prevalence ranged from 7.1% among those exercising 1–2 days per week to 12.7% among those exercising ≥5 days per week.

Students reporting no physical activity had a hypertension prevalence of 9.1%. Compared with the ≥5 days/week group, the odds ratios for other categories were close to unity and not statistically significant (overall $p = 0.878$), suggesting no detectable protective or harmful effect within this sample.

*Table 1. Distribution of Blood Pressure Categories among Senior MBBS Students (n = 162)*

| Blood Pressure Category | Frequency (n) | Percentage (%) | 95% CI for Prevalence |
|---|---|---|---|
| **Normal** | 113 | 69.8 | 62.3–76.5 |

| | | | |
|---|---|---|---|
| **Elevated** | 32 | 19.8 | 14.0–26.9 |
| **Stage 1 Hypertension** | 12 | 7.4 | 3.9–12.6 |
| **Stage 2 Hypertension** | 5 | 3.1 | 1.0–7.1 |
| **Total Hypertension (Stage 1 + 2)** | 17 | 10.5 | 6.3–16.2 |

Overall, 10.5% (95% CI: 6.3–16.2) of students met the criteria for hypertension, while 30.2% (95% CI: 23.5–37.7) had abnormal blood pressure (elevated or hypertensive).

*Table 2. Socio-Demographic and Lifestyle Characteristics of Participants (n = 162)*

| Variable | Category | n (%) |
|---|---|---|
| **Age (years)** | 21–23 | 149 (92.0) |
| | 24–25 | 13 (8.0) |
| **Gender** | Male | 55 (34.0) |
| | Female | 107 (66.0) |
| **BMI Category** | Underweight | 16 (9.9) |
| | Healthy | 107 (66.0) |
| | Overweight | 30 (18.5) |
| | Obese | 9 (5.6) |
| **Smoking Status** | Smoker | 10 (6.2) |
| | Non-smoker | 152 (93.8) |
| **Family History of Hypertension** | Yes | 114 (70.4) |
| | No | 48 (29.6) |
| **Physical Activity** | None | 33 (20.4) |
| | 1–2 days/week | 14 (8.6) |
| | 3–4 days/week | 44 (27.2) |
| | ≥5 days/week | 71 (43.8) |

Associations between participant characteristics and hypertension (Stage 1 and 2 combined) were examined using chi-square or Fisher's exact tests, as appropriate. Crude odds ratios (OR) with 95% confidence intervals (CI) were calculated using normotensive students as the reference category.

*Table 3. Association Between Gender and Hypertension (Stage 1 & 2) (n = 162)*

| Gender | Hypertensive n (%) | Non-Hypertensive n (%) | Crude OR (95% CI) | p-value |
|---|---|---|---|---|
| **Male (n=55)** | 12 (21.8) | 43 (78.2) | 5.63 (1.92–16.46) | <0.001 |
| **Female (n=107)** | 5 (4.7) | 102 (95.3) | Reference | |

Male students had significantly higher odds of hypertension compared with females (OR 5.63; 95% CI: 1.92–16.46; $p < 0.001$).

*Table 4. Association Between BMI Category and Hypertension (Stage 1 & 2) (n = 162)*

| BMI Category | Hypertensive n (%) | Non-Hypertensive n (%) | Crude OR (95% CI) | p-value |
|---|---|---|---|---|
| **Underweight (n=16)** | 0 (0.0) | 16 (100) | — | |

| | | | | |
|---|---|---|---|---|
| **Healthy (n=107)** | 6 (5.6) | 101 (94.4) | Reference | |
| **Overweight (n=30)** | 7 (23.3) | 23 (76.7) | 5.12 (1.60–16.40) | <0.001 |
| **Obese (n=9)** | 4 (44.4) | 5 (55.6) | 13.47 (2.90–62.50) | |

There was a statistically significant association between increasing BMI category and hypertension (chi-square test, $p < 0.001$).

*Table 5. Association Between Smoking and Hypertension (Stage 1 & 2) (n = 162)*

| Smoking Status | Hypertensive n (%) | Non-Hypertensive n (%) | Crude OR (95% CI) | p-value* |
|---|---|---|---|---|
| **Smoker (n=10)** | 4 (40.0) | 6 (60.0) | 7.07 (1.62–30.82) | 0.004 |
| **Non-smoker (n=152)** | 13 (8.6) | 139 (91.4) | Reference | |

*Fisher's exact test applied due to small cell counts.

Smoking was significantly associated with hypertension, with smokers demonstrating over seven-fold higher odds compared to non-smokers.

*Table 6. Association Between Family History and Hypertension (Stage 1 & 2)*

| Family History | Hypertensive n (%) | Non-Hypertensive n (%) | Crude OR (95% CI) | p-value |
|---|---|---|---|---|
| **Yes (n=114)** | 13 (11.4) | 101 (88.6) | 1.42 (0.45–4.48) | 0.804 |
| **No (n=48)** | 4 (8.3) | 44 (91.7) | Reference | |

No statistically significant association was observed between family history of hypertension and measured hypertension.

*Table 7. Association Between Physical Activity and Hypertension (Stage 1 & 2)*

| Physical Activity | Hypertensive n (%) | Non-Hypertensive n (%) | Crude OR (95% CI) | p-value |
|---|---|---|---|---|
| **None (n=33)** | 3 (9.1) | 30 (90.9) | 0.68 (0.15–3.04) | 0.878 |
| **1–2 days/week (n=14)** | 1 (7.1) | 13 (92.9) | 0.53 (0.06–4.85) | |
| **3–4 days/week (n=44)** | 4 (9.1) | 40 (90.9) | 0.68 (0.17–2.76) | |
| **≥5 days/week (n=71)** | 9 (12.7) | 62 (87.3) | Reference | |

No statistically significant association was observed between frequency of physical activity and hypertension.

Multivariable logistic regression analysis adjusting for gender, BMI category, smoking status, physical activity, and family history demonstrated that male gender (adjusted OR 4.98; 95% CI: 1.61–15.37; $p = 0.005$)

overweight status (adjusted OR 4.21; 95% CI: 1.21–14.62; $p = 0.024$), obesity (adjusted OR 10.88; 95% CI: 2.05–57.73; $p = 0.005$), and smoking (adjusted OR 6.42; 95% CI: 1.27–32.44; $p = 0.024$) remained independently associated with hypertension. Family history and physical activity were not statistically significant predictors in the adjusted model.

The figure demonstrates a pronounced, graded increase in the prevalence of abnormal blood pressure (elevated + Stage 1 + Stage 2) across ascending BMI categories, with 95% confidence intervals. Underweight students exhibited a prevalence of 6.3% (1/16), while those with healthy BMI had 23.4% (25/107).

The prevalence rose sharply to 56.7% (17/30) among overweight students and further to 66.7% (6/9) among obese students. The non-overlapping confidence intervals between healthy-weight and overweight groups indicate a clinically meaningful escalation in risk beginning at the overweight threshold.

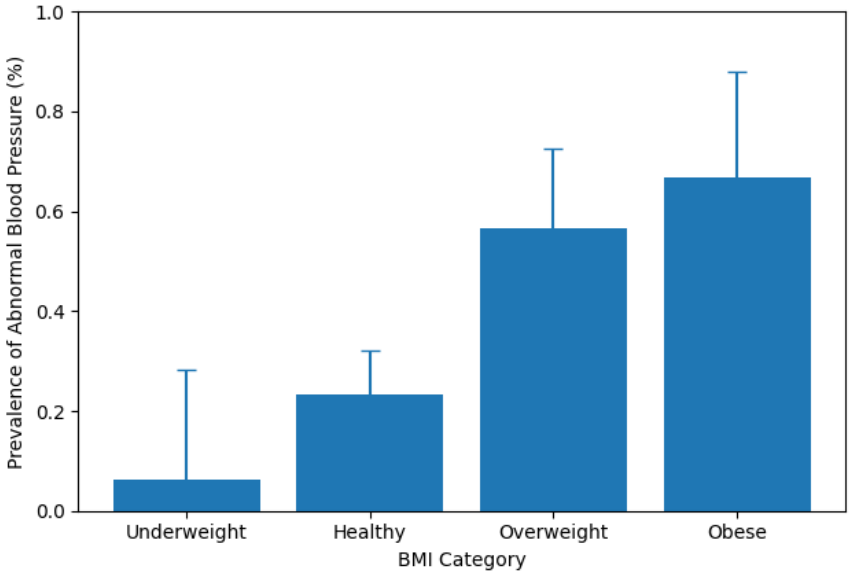


*Figure 1 Prevalence of Abnormal Blood Pressure Across BMI Categories with 95% Confidence Intervals*

The magnitude of increase from healthy to overweight status represents a 33.3 percentage-point absolute rise and more than a two-fold relative increase. Although the obese category shows wider confidence intervals due to smaller sample size, the upward trajectory remains consistent, suggesting a strong dose–response relationship between adiposity and abnormal blood pressure. Clinically, this pattern underscores that excess body weight is associated not merely with overt hypertension but with early-stage blood pressure elevation, reinforcing the importance of weight management interventions at the overweight stage to prevent progression to sustained hypertension.

## DISCUSSION

This study demonstrates that elevated blood pressure and hypertension are prevalent among senior MBBS students, with 30.2% exhibiting abnormal blood pressure and 10.5% meeting criteria for hypertension. These findings are clinically significant because they indicate that nearly one in three future physicians already display early cardiovascular risk markers during young adulthood. The observed prevalence aligns with reports from university-based cohorts in comparable settings, where hypertension or prehypertension rates among medical students have ranged from 8% to over 20%, depending on diagnostic thresholds and measurement protocols (10)(11)(12). The use of guideline-based classification and repeated measurements in this study strengthens the internal validity of prevalence estimates and reduces misclassification bias (13)(14).

A marked sex disparity was identified, with males demonstrating a hypertension prevalence of 21.8% compared with 4.7% in females, corresponding to an adjusted odds ratio of approximately five-fold. Similar sex-based gradients have been described in young adult populations, potentially attributable to hormonal protection in premenopausal women, differences in sympathetic tone, and behavioral risk exposures (5)(7). The magnitude of association observed in this cohort suggests that male medical students represent a high-risk subgroup warranting targeted screening and early intervention. From a pathophysiological standpoint, sex-related differences in vascular reactivity and neurohormonal regulation may

partially explain these findings, although behavioral covariates such as smoking and body weight likely contribute synergistically.

Body mass index demonstrated the strongest graded association with abnormal blood pressure, revealing a clear dose–response pattern. While only 23.4% of students with healthy BMI exhibited abnormal blood pressure, the prevalence increased to 56.7% among overweight students and 66.7% among obese students. Adjusted analyses confirmed that overweight and obese students had approximately four- and eleven-fold higher odds of hypertension, respectively. This gradient is consistent with extensive epidemiologic and mechanistic evidence linking excess adiposity to elevated blood pressure through insulin resistance, activation of the renin–angiotensin–aldosterone system, increased sympathetic nervous system activity, and vascular remodeling (1)(5)(7). Importantly, the substantial rise in abnormal blood pressure beginning at the overweight category emphasizes that cardiovascular risk acceleration may occur prior to overt obesity, reinforcing the preventive importance of early weight management within university populations.

Smoking was independently associated with hypertension, with smokers exhibiting a 40.0% prevalence compared with 8.6% among non-smokers. Although the number of smokers was relatively small, the magnitude of effect remained statistically and clinically significant after adjustment. Tobacco exposure is known to acutely elevate blood pressure via catecholamine release and chronically impair endothelial function, contributing to arterial stiffness and long-term hypertensive risk (5). The high relative risk observed in this young cohort underscores the additive cardiovascular burden of smoking even before midlife and supports targeted cessation programs within medical institutions.

In contrast, no statistically significant associations were observed between hypertension and family history or physical activity frequency. While genetic predisposition is a recognized determinant of blood pressure regulation, its effect may not yet be fully expressed in early adulthood or may require longitudinal follow-up to detect cumulative impact (3)(7). Similarly, the absence of association with self-reported physical activity may reflect measurement limitations, residual confounding, or insufficient variability in exercise intensity. Objective measures of physical activity and dietary intake may yield more precise estimates in future research.

The findings have important educational and public health implications. Medical students are future healthcare providers whose personal health behaviors may influence their credibility and effectiveness in counseling patients. The presence of modifiable cardiovascular risk factors within this population suggests a need for institutional screening programs, structured lifestyle interventions, and integration of preventive cardiology into medical curricula. Regular blood pressure monitoring within academic institutions could facilitate early detection and reinforce preventive health behaviors.

This study has several strengths, including standardized measurement procedures, repeated blood pressure assessments across separate visits, and multivariable adjustment to reduce confounding. However, limitations inherent to the cross-sectional design preclude causal inference, and the single-institution setting may limit generalizability. Additionally, small subgroup sizes, particularly among smokers and obese students, resulted in wider confidence intervals, indicating reduced precision of effect estimates. Nonetheless, the consistent dose–response pattern between BMI and blood pressure, combined with statistically robust associations for sex and smoking, supports the internal validity of the primary findings. Future multi-center longitudinal studies incorporating objective behavioral metrics and ambulatory blood pressure monitoring would enhance causal understanding and external applicability.

## CONCLUSION

Elevated blood pressure and hypertension are common among senior medical students, affecting nearly one-third of the cohort, with male sex, excess body weight, and smoking emerging as independent and clinically meaningful predictors. The clear dose–response relationship between BMI and abnormal blood pressure highlights adiposity as the dominant modifiable risk factor in this population. These findings underscore the necessity for routine institutional screening, targeted lifestyle interventions, and early preventive strategies within medical colleges to mitigate long-term cardiovascular risk among future healthcare professionals..

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## DECLARATIONS

**Ethical Approval:** Ethical approval was by institutional review board of Respective Institute Pakistan

**Informed Consent**: Informed Consent was taken from participants.

**Authors' Contributions:**

Concept: MMC; Design: UK; Data Collection: RM; Analysis: MU; Drafting: SI

**Conflict of Interest**: The authors declare no conflict of interest.

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**Data Availability**: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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**Study Registration:** Not applicable.