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Original Research Article

The burden of hypertension in future doctors: a phase-wise cross-sectional study

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ABSTRACT

Background: Hypertension is a growing concern in young adults, yet most studies focus on the elderly. Investigating its prevalence and risk factors in younger populations can enable timely interventions to prevent long-term complications. Medical students, facing academic stress and lifestyle changes, are particularly vulnerable. This study assessed hypertension prevalence and blood pressure variations across four academic phases.

Methods: A cross-sectional analytic study was conducted among 499 medical students aged 18–27 from four academic phases. Participants were selected through multi-stage sampling, and demographic, anthropometric, and clinical data were collected. Blood pressure was measured using an Omron HBP-1320 device, validated per ANSI/AAMI/ISO and ESH IP2 protocols, with classification based on AHA guidelines. Statistical analyses included ANOVA, chi-squared tests, and Spearman's correlation.

Results: Median age increased from 20 years in phase 1 to 23 in phase 4. Mean BMI rose from 22.07±4.01 kg/m² to 23.51±4.67 kg/m². Systolic blood pressure increased across phases but was not statistically significant (p=0.223). Diastolic pressure rose significantly (p=0.011), with hypertension prevalence escalating from 19.5% to 41.2%. Males exhibited higher SBP, DBP, and pulse pressure (p<0.001). Positive correlations were observed between age, BMI, and blood pressure.

Conclusion: The study highlights a rising trend in stage 1 hypertension and diastolic pressure with academic progression, likely due to stress and lifestyle changes. Males had higher blood pressure levels. Early interventions targeting modifiable risk factors are essential to prevent long-term complications.

Keywords: Hypertension, Systolic BP, Diastolic BP, Medical students

INTRODUCTION

Hypertension, a leading health concern and prominent risk factor for death globally, affecting more than 1 billion people. Hypertension is asymptomatic in initial period, and often remains hidden until caught during screening or becomes symptomatic due to heart and brain disease which is why it is often called "the silent killer".[1] About 33% of urban and 25% of rural Indians are hypertensive. Out of these, 25% of rural and about 42% of urban Indians are aware of their hypertensive status.[2] Many studies on Hypertension are from older population, but some studies suggested that hypertension was seen commonly among the younger population also due to 'Globesity' (global epidemic of overweight and obesity), smoking, mental stress.[3]

Over the past three decades, the global prevalence of obesity has nearly tripled.[4] In India, an ICMR study reported obesity prevalence ranging from 11% to 31.3% in one group and 16.9% to 36.3% in another.[5] The rise in obesity and hypertension prevalence in young adults is a result of industrial globalization and urbanization, more specifically eating food which rich in fat, sugar, and salt and is poor in nutrients with decreased physical activity, and the stressful and hectic education and jobs increase the problems.[6-8] Elevated arterial stiffness, driven by RAAS activation, and heightened sympathetic activity associated with stress have been identified as key contributors to this condition.[9] Medical students are also vulnerable to hypertension because of their stressful academic journey, social isolation, and discrepancies between expectations and reality could all together contribute to psychological stress and cardiovascular diseases.[8] Studies suggest that, among medical students, the prevalence of overweight and obesity ranges from 10.0% to 20.0%.[10-12] While that of hypertension ranges from 4.0% to 15.0% .[13,14]

To the best of our literature search, no study was carried out to understand how blood pressure might change as students move through their MBBS academic curriculum, especially from rural India. So, to fill knowledge gap, the present study was carried out to assess prevalence of hypertension, associated risk factors and trend of blood pressure across four academic phases.

METHODS

This cross-sectional study was conducted in rural tertiary care hospital of Maharashtra state with aim of investigate demographic, anthropometric, and clinical parameters, with a focus on blood pressure variations and hypertension prevalence. The study was structured into four distinct phases as per there university curriculum to record variations in blood pressure. Ethical approval was obtained from the institutional ethical committee, and written informed consent was taken from all participants. Confidentiality and anonymity were strictly maintained throughout the study.

A total of 499 medical students aged 18 to 27 years from the phase I to phase IV academic curriculum from a tertiary hospital named Noor Hospital, Jalna Maharashtra were included. Participants were selected based on predefined inclusion criteria and consent to participate. Individuals on antihypertensive medications, any acute or chronic illness that interferes with the accuracy of blood pressure, and pregnant participants were excluded to minimize potential confounding effects.

Participants were recruited through a multi-stage sampling method during the tenure of six months from June 2024 to November 2024. Initially, regions were purposively selected to reflect geographic and demographic diversity. Within each region, simple random sampling was used to identify participants, reducing selection bias

Data collection

Data collection was standardized and carried out in four phases. Demographic data, including age, gender, and residential address, were recorded through structured interviews. Anthropometric measurements, including height and weight, were taken using calibrated stadiometers and weighing scales with accuracy to the nearest 0.1 cm and 0.1 kg, respectively.[15] Body mass index (BMI) was calculated using the formula (BMI=weight (kg)\height (m)^2). Blood pressure was measured in a seated position as per standard guidelines using an automatic blood pressure measuring device (Omron HBP-1320, Sr no. 202306000263L) validated according to ANSI/AAMI/ISO 81060-2:2013 protocol and European society of hypertension protocol, 2010 revision (ESH IP2).[16,17]

For each participant, three readings were taken at one-minute intervals, and the mean of these readings was used. We took readings at the same time of day for all students, all data was entered in online google case record form. Blood pressure classification followed American heart association (AHA) guidelines, categorizing participants into normal, pre-hypertensive, hypertension stage 1, or hypertension stage 2 groups based on systolic and diastolic readings.[18]

Data analysis was performed using IBM SPSS Statistics (Version 28). Descriptive statistics summarized the demographic and clinical characteristics of the participants. Analytical techniques included analysis of variance (ANOVA) to compare blood pressure metrics across phases, while chi-squared tests evaluated associations between categorical variables such as hypertension classification and gender or phase. Correlation analyses using Spearman’s rho identified relationships between continuous variables like age, BMI, and blood pressure metrics.

Statistical analysis

The statistical package for the social sciences (IBM SPSS Statistics for Windows, IBM Corp., Version 25.0, Armonk, NY) was used to analyse the data collected for our study. Descriptive statistics such as percentage, frequency, and mean±standard deviation (SD) was used to analyse the data. To compare the means of quantitative data, Student’s t-test was used, while categorical data were compared using the chi-square “$\chi 2$” test. All analyses were conducted at a 95% confidence level and a p value of less than 0.05 was deemed statistically significant.

Several quality control measures were implemented to ensure data validity and reliability. All instruments were calibrated before use, and measurements were conducted by trained personnel following standardized protocols. Data were double-checked during entry and cleaned to address outliers or missing values. Despite these efforts, the study has some limitations. As a cross-sectional design, it cannot establish causal relationships between variables. Additionally, self-reported demographic data may have introduced recall bias. Future longitudinal studies are recommended to address these limitations and further explore the relationships between the investigated variables.

RESULTS

The study analyzed demographic, anthropometric, and clinical data across four phases. Total students from phase I are 128 (M:58, F:70), phase II 136 (M:62, F:74), phase III 138 (M:64, F:74), and phase IV 97 (M:49, F:48) are included (Table 1). Lowest age of participants was 18 to highest 27 years.

The median age increased from 20 years in phase 1 to 23 years in phase 4, accompanied by a steady rise in anthropometric measures such as height, weight, and BMI. For instance, the mean BMI increased from 22.07±4.01 kg/m² in phase 1 to 23.51±4.67 kg/m² in phase 4, indicating a progressive change in body composition over time (Table 2).

Blood pressure measurements revealed notable trends. The mean systolic blood pressure (SBP) increased from 112.85±11.71 mmHg in phase 1 to 116.01±13.33 mmHg in phase 4, although the difference was not statistically significant ($F_{(3,495)}=1.466$, $p=0.223$). In contrast, diastolic blood pressure (DBP) showed a significant rise from 74.09 ±8.46 mmHg in phase 1 to 77.63±7.64 mmHg in phase 4 ($F_{(3,495)}=3.744$, $p=0.011$). Post hoc analysis revealed that Phase 4 participants had significantly higher DBP compared to phase 1 ($p<0.01$). Pulse pressure (PP) displayed slight variations across phases but did not exhibit statistically significant differences ($F_{(3,495)}=0.856$, $p=0.464$). The trends in SBP, DBP and PP are visualized in Table 3.

Hypertension classification, based on AHA guidelines, showed a dynamic shift across the phases. While the proportion of normotensive participants decreased from 66.4% in phase 1 to 51.5% in phase 4, the prevalence of hypertension stage 1 nearly doubled from 19.5% to 41.2% during the same period (Table 4).

Chi-squared tests confirmed significant associations between hypertension classification and study phases ($\chi^2(9)=25.385$, $p=0.003$). Gender-wise comparisons highlighted higher SBP, DBP, and p values among males compared to females, with statistically significant differences for all three parameters ($p<0.001$, Table 5). Spearman's Correlation analyses further enriched the findings. Age correlated positively with SBP ($\rho=0.194$, $p<0.001$), DBP ($\rho=0.170$, $p<0.001$), and BMI ($\rho=0.122$, $p=0.006$). Similarly, BMI showed strong positive correlations with both SBP ($\rho=0.300$, $p<0.001$) and DBP ($\rho = 0.261$, $p < 0.001$) (Table 6, Figure 2).

Geographical variations were also evident in the data. Bhandara recorded the highest mean SBP (137 mmHg), albeit based on a limited sample size, whereas Mumbai participants exhibited more stable BP profiles with a mean SBP of 114.17±12.54 mmHg and DBP of 75.03±7.88 mmHg. Parbhani stood out for higher DBP averages compared to other locations (Table 7). A comparison of mean waist circumferences across the four study phases revealed a gradual increase, with mean values, in phase 1-64.31 cm in phase 2-79.59 cm, in phase 3-79.77 cm and in phase 4-80.88 cm. A statistical analysis using ANOVA indicated 0.0032. These findings highlight a trend of increasing waist circumference over the study period (Table 8).

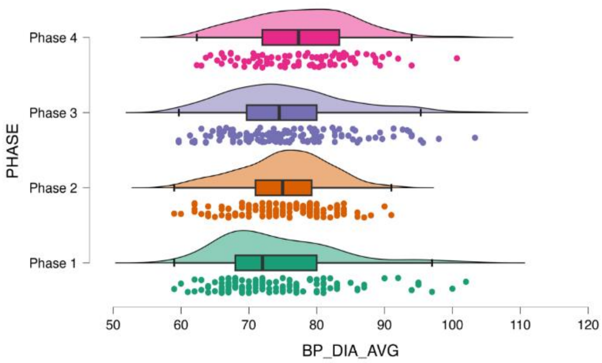

Figure 1: Raincloud plot for average DBP.

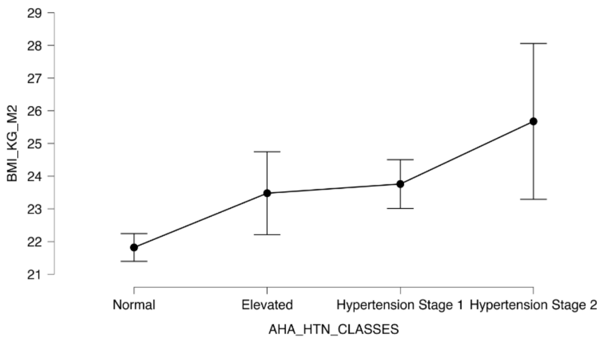

Figure 2: BMI and Blood pressure metrics.

Overall, the results demonstrated significant interplays between age, BMI, gender, and blood pressure, with regional differences adding further context. These findings underscore the complex determinants of hypertension and provide a foundation for targeted interventions and future research.

Table 1: Demographic details.

Particulars	Phase 1	Phase 2	Phase 3	Phase 4
Median Age (in years)	20	21	21	23
Females	70	74	74	48
Males	58	62	64	49
Total	128	136	138	97

Table 2: Descriptive statistics for height, weight, and BMI.

Phases	Means height (m)	Means weight (kg)	Means BMI (kg/m2)
Phase 1	1.639±0.098	59.32±12.32	22.07±4.01
Phase 2	1.637±0.099	61.60±12.20	23.01±3.97
Phase 3	1.652±0.087	61.07±14.30	22.19±3.93
Phase 4	1.664±0.095	65.61±14.95	23.51±4.67

Table 3: Refers to descriptives of ANOVA test done for average SBP, DBP, and PP.

Variables	Phases	Mean	SD	SE (mean)	COV
SBP	Phase 1	112.852	11.7111	1.035	0.104
	Phase 2	115.132	11.947	1.024	0.104
	Phase 3	115.085	11.919	1.015	0.104
	Phase 4	116.014	13.335	1.354	0.115
DBP	Phase 1	74.094	8.455	0.74	0.114
	Phase 2	75.154	6.527	0.560	0.87
	Phase 3	75.616	8.919	0.759	0.118
	Phase 4	77.629	7.641	0.776	0.098
PP	Phase 1	38.836	8.565	0.757	0.221
	Phase 2	40.096	9.558	0.820	0.238
	Phase 3	39.469	8.213	0.699	0.208
	Phase 4	38.385	8.737	0.887	0.228

Total number of students in respective phases: Phase 1: 128, Phase 2: 136, Phase 3: 138, Phase 4: 97

Table 4: Hypertension classification by phase.

Phases	Normotensive (%)	Pre-hypertensive (%)	Stage 1 (%)	Stage 2 (%)
Phase 1	66.4	7.0	19.5	6.3
Phase 2	58.1	14.0	27.2	0.7
Phase 3	60.1	12.3	24.6	2.9
Phase 4	51.5	4.1	41.2	3.1

Table 5: Gender differences in blood pressure metrics.

Metrics	Male (Mean±SD)	Female (Mean±SD)	P value
SBP	121.08±10.84	109.12±10.43	<0.001
DBP	77.14±7.95	74.04±7.81	<0.001
Pulse pressure	43.99±7.71	35.13±7.49	<0.001

Table 6: BMI and Blood pressure metrics.

AHA_HTN_Classes	N	Mean	SD	SE	Coefficient of variation
Normal	297	21.820	3.720	0.216	0.170
Elevated	50	23.480	4.469	0.632	0.190
Hypertension stage 1	136	23.761	4.397	0.377	0.185
Hypertension stage 2	16	25.677	4.476	1.119	0.174

Table 7: Geographic distribution of blood pressure metrics.

Region	Mean SBP (mmHg)±SD	Mean DBP (mmHg)±SD	Sample size (n)
Bhandara	137.00	82.00	1
Mumbai	114.17±12.54	75.03±7.88	111
Parbhani	118.38±15.52	78.06±8.64	24
Aurangabad	111.98±11.40	75.55±7.76	66
Nanded	117.55±11.64	77.00±6.87	42
Others	Varied	Varied	255

Table 8: Means of waist circumference across four phases.

Phases	Mean waist circumference	SD	P value
Phase 1	64.31 cm	11.68 cm	0.0032
Phase 2	79.59 cm	10.21 cm	
Phase 3	79.77 cm	9.54 cm	
Phase 4	80.88 cm	11.41 cm	

DISCUSSION

Hypertension is no more problem of elderly population as we traditionally believed, as its prevalence is drastically increasing in young adults since last two decades.[19] Same rising trend is observed in India, affecting 1 in 8 young adults between 18 to 40 years of age group.[20] This rise is linked to risk factors such as high-sodium diets, obesity, sedentary lifestyles, modernisation, stress and addictions. Hypertension is the major modifiable risk factor for preventing mortality, resulting in an estimated 10.8 million deaths annually.[21] Timely diagnosis, prevention and control of hypertension will reduce cardiovascular mortality, stroke, renal injury in later life.[22]

A cross-sectional study by Mok et al, revealed significantly higher rates of hypertension (78.8%) and pre-hypertension (75.4%) among medical students compared to non-medical students, whose rates were 21.2% and 24.6%, respectively. Medical students were found to have a fivefold increased risk of hypertension (odds ratio=5.668, p=0.019).[23] These findings are highlighted in some studies and reflect the relevance of our study, which aims to address rising blood pressure concern among medical students.

This cross-sectional analysis study was conducted amongst UG medical students from phase I to phase IV at tertiary rural health care centre from Maharashtra state of India. Aim of this study was to estimate prevalence hypertension and variation in blood pressure values with associated risk factors across academic phases of their curriculum.

There are total of 499 medical students with age group from 18-year-old to 27 years old from the phase I to phase IV academic were included in this study, out of which 233 were Male and 266 were female. The median age of participants increased from 20 years in phase 1 to 23 years in phase 4.

Our study revealed a hypertension prevalence of 6.42% (n = 32), with 5.62% (n = 28) in stage 1 hypertension and 0.8% (n = 4) in stage 2 hypertension. Prehypertension was observed in 25.5% (n=127) of the participants, highlighting a substantial burden of early-stage hypertension within the population and prevalence of Hypertension Stage 1 nearly doubled from 19.5% to 41.2% from phase I to phase IV and while proportion of normotensive participants decreased from 66.4% to 51.5% from phase 1 to phase 4. A cross-sectional study was conducted by AlWabel et al, in 2017 at the College of Medicine, Qassim University, Saudi Arabia, focusing on medical students. Total of 130 participate were there in the study. The prevalence of hypertension among the participants was 14.6% (n=19), with 6.9% (n=9) exhibiting isolated diastolic hypertension, 4.6% (n=6) presenting with isolated systolic hypertension, and 3.1% (n=4) experiencing systolic-diastolic hypertension.[24] AlWabel et al, study findings align closely with the results of our cross-sectional study, which included a total sample size of 499 medical students.

In our study, significant differences in blood pressure were observed between male and female participants. Males had a higher mean systolic blood pressure (SBP) of 121.08±10.84 compared to females at 109.12±10.43 ($p<0.001$), and similarly, males had higher diastolic blood pressure (DBP), and pulse pressure (PP) compared to females ($p<0.001$ for all). These gender-based variations in blood pressure from our study are consistent with the findings by Nyombi et al, further point up the need to consider gender when assessing cardiovascular risk factors.[25]

The average BMI values for each phase of our study were, phase 1-22.07±4.01, phase 2-23.01±3.97, Phase 3-22.19±3.93, and phase 4-23.51±4.67. These values suggest a gradual increase in BMI across the phases which could contribute to rise diastolic blood pressure across phases and variations in waist circumference and potentially impact hypertension risk. Along with that, in our study, a comparison of mean waist circumferences across the four study phases revealed a gradual increase, with mean values, in phase 1-64.31 cm, in phase 2-79.59 cm, in phase 3-79.77 cm. and in phase 4-80.88 cm. A statistical analysis using ANOVA indicated 0.0032. These findings highlight a trend of increasing waist circumference over the study period.

Siani et al. (reference) found similar rise in waist circumference, which significantly predicts the development of stage 1 and stage 2 hypertension (HTN). Specifically, males with a waist circumference of ≥102 cm have a 3.04 times higher likelihood of being hypertensive compared to those with a waist circumference of <94 cm. Similarly, females with a waist circumference of ≥88 cm have double the risk of become hypertensive compared to those with a waist circumference of <80 cm. In their study, approximately 18.9% (20/106) of males and 18.1% (19/105) of females had waist circumferences that increased their hypertension risk, with a combined total of 39 out of 211 participants showing a waist size that places them at an elevated risk for HTN. Our study findings align with these observations while considering additional factors such as BMI.[26]

We studied region-wide variation of blood pressure among medical students. The results revealed geographical differences in blood pressure levels though statically not significant, this may be due to widely different sample size from different regions. Bhandara et al, recorded the highest mean systolic blood pressure (SBP) at 137 mmHg, although based on a limited sample size. In contrast, participants from Mumbai exhibited more stable blood pressure profiles, with a mean SBP of 114.17±12.54 mmHg and diastolic blood pressure (DBP) of 75.03±7.88 mmHg. Parbhani et al, on the other hand, showed higher DBP averages compared to other locations, spotlights the need for region-specific approaches to manage hypertension effectively in different populations.

Ghosh et al and Kumar et al, studied that, in India, Hypertension prevalence varies significantly across regions, ranging from 3.5% in Mahoba, Uttar Pradesh, to 34.7% in Dibang Valley, Arunachal Pradesh. Over one-tenth of the population in 427 districts is hypertensive, with alarming rates in several Northeast states. In 28 districts, at least one in five people aged 15-49 have hypertension. These findings are comparable to our study findings.[27]

Our study has several notable strengths. It is the earliest study on blood pressure measurement among undergraduate medical students across all academic phases, with sample size of 499 participants. The study employed multivariate statistical analyses, allowing us to identify key factors associated with hypertension, including age, gender, academic curriculum phases and BMI. Additionally, the inclusion of students from Phase I to Phase IV, strengthens the study's relevance, helping to understand potential variations in blood pressure and cardiovascular risk at different stages of medical education.

Standard protocols were followed and blood pressure measured with the help of validated Omron HBP-1320 automated sphygmomanometer by ANSI/AAMI/ISO protocol and ESH IP2 by well-trained doctors to ensure accuracy and authenticity.

The cross-sectional design limits to assess causal relationships between hypertension and its risk factors. We measured blood pressure at one time and one point for each student. We have not included smoking, diet, exercise risk factors in study.

CONCLUSION

Our study highlights significant raising trend in prevalence of diastolic blood pressure and stage I hypertension among medical students from phase I to phase IV, which may be due to increasing academic stress, dietary and lifestyle changes during to their academic journey from phase I to phase IV. Systolic blood pressure also showed same raised trend but not statistically significant. Males exhibited significantly higher blood pressure values compared to females, while significant positive correlations were observed between waist circumference, BMI, and blood pressure metrics. This spotlights the need for early (from Phase I) and targeted strategies to address risk factors of hypertension in medical students like increasing academic stress, obesity, and lifestyle by encouraging them for exercise, yoga, meditation and healthy dietary habits.

Recommendations

Study blood pressure variation in each student from their Phase I to Phase IV education journey at specific decided time interval, as longitudinal study. Also include in depth other risk factors like stress, addiction, diet and sleep in study.

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