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Effectiveness of an educational intervention on hypertension awareness among college students in Bangladesh: A pre-post interventional study

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Abstract: Hypertension is a major global public health concern, yet awareness among college students remains inadequate. This study evaluated the effectiveness of a structured educational intervention on hypertension knowledge among college students in Bangladesh using a pre-post interventional design. A total of 384 students (236 males, 148 females) aged 18-23 years participated, with 175 assigned to the intervention group and 209 to the non-intervention group. Data were collected using a validated semi-structured, pre-tested questionnaire. The intervention was delivered in three sessions at 15-day intervals. Paired t-test and Fisher's exact test were applied, with $p < 0.05$ considered significant. The intervention group demonstrated significant improvements across all knowledge domains ($t = 44.42$, 48.31, 36.96, 37.39, and 24.66; $p < 0.001$), and knowledge levels increased significantly compared with those in the non-intervention group ($p < 0.001$). No significant change was observed in the non-intervention group ($p = 0.825$). The findings indicate that structured educational intervention programs are highly effective in improving hypertension awareness among college students.

Introduction

Hypertension (HPT) remains a major public health concern and a leading global risk factor for morbidity and mortality, affecting developed and developing countries [1]. According to the World Health Organization (WHO) [2], approximately 1.4 billion adults worldwide are living with HPT, with nearly two-thirds residing in low-and middle-income countries. This highlights a disproportionate burden in resource-limited settings, where prevention, early detection, and effective management remain challenging. Globally, HPT continues to pose a significant threat due to its high prevalence, low awareness, and inadequate control rates. It is estimated that nearly one-third of adults aged 30-79 years are affected by HPT [3]. Despite its widespread occurrence, 44.0% of individuals with HPT remain unaware of their condition, while a similar proportion are diagnosed and receiving treatment. However, 23.0% achieve adequate blood pressure control [2]. These gaps in awareness, diagnosis, and management underscore the persistent challenges in addressing HPT at individual and population

levels. HPT is a leading cause of premature mortality worldwide and a major contributor to cardiovascular diseases (CVDs). One of the major global goals for non-communicable diseases is to achieve a 25.0% reduction in the prevalence of uncontrolled HPT between 2010 and 2025 [2]. It is estimated to cause around 7.6 million deaths annually, 80.0% of which occur in developing countries [4], accounting for 13.0% of total global mortality [5]. Evidence indicates that elevated blood pressure contributes to nearly half of all heart diseases and stroke-related deaths worldwide [5]. HPT promotes arterial stiffness and endothelial dysfunction, thereby predisposing individuals to peripheral vascular disease and chronic kidney disease [2, 6]. Recent estimates indicate that CVDs accounted for about 19.8 million deaths worldwide in 2022, representing 32.0% of all deaths, with the majority due to coronary heart disease and stroke. Over three-quarters of these deaths occur in low-and middle-income countries, underscoring the global health burden of CV risk factors, including elevated blood pressure [7]. In 2023, there were 915,973 deaths attributed to CVDs, including heart disease, stroke, hypertensive disease, and heart failure, accounting for more than one-quarter of all U.S. deaths. On average, a person in the United States died from cardiovascular disease every 34 seconds in 2023 [8].

Over the past decade, an increasing prevalence of health-risk behaviors has been documented among college and university students worldwide. Recent evidence indicates that a high proportion of students engage in multiple lifestyle behaviors that predispose them to non-communicable diseases, including HPT and CVD [9]. These unhealthy behaviors-including physical inactivity, poor diet, excessive alcohol use, and overweight- are well-established contributors to elevated blood pressure and the development of CV risk profiles in young adults. Together, such patterns emphasize the need for targeted health education and prevention interventions among college students to mitigate the growing burden of HPT and associated CVD [10]. Previous research has explored awareness of HTN and related cardiovascular risk factors among young adults. For example, a study of university students in Egypt found that a high proportion of participants correctly identified major CV risk factors, although knowledge gaps remained for some risk factors [11]. This suggests that while many college students are aware of key determinants of CV, a comprehensive understanding is still suboptimal and warrants educational interventions [12]. Untreated HPT is often associated with a progressive and sustained increase in blood pressure over time. Blood pressure is continuously distributed across populations, without a distinct natural threshold to demarcate ‘HPT; rather, the risk of CV events increases progressively with rising blood pressure levels. Historically, estimates indicate that the number of individuals with HPT increased from approximately 30 million in 1960 to 59 million in 1980 and 94 million in 1990 [13]. More data show that over 1.28 billion adults aged 30-79 years are now affected worldwide, reflecting a substantial increase in prevalence, particularly in low-and middle-income countries [1]. HPT is one of the most prevalent chronic diseases in China and represents a leading risk factor for CVDs mortality among urban and rural populations [14]. Recent national estimates indicate that 23.2% of Chinese adults aged ≥18 years, equivalent to about 244.5 million individuals, are affected by HPT. These findings underscore the significant and growing public health challenge posed by HPT in rapidly developing settings [14, 15]. In India, HPT remains a major contributor to CV morbidity and mortality. It has been estimated that elevated blood pressure is responsible for 57.0% of stroke-related deaths and 24.0% of deaths due to coronary heart disease, highlighting its substantial role in the national burden of non-communicable diseases. More evidence continues to confirm that HPT is one of the leading modifiable risk factors for CV mortality in India, underscoring the urgent need for improved prevention, early detection, and effective management strategies [16]. Studies from India and Bangladesh have demonstrated a marked upward trend in the prevalence of HPT over time, with substantial increases observed in urban and rural populations. Rapid urbanization, population growth, and technological advancement have contributed to lifestyle changes, reduced physical activity, and increased psychological stress, particularly among younger individuals. These factors are associated with a rising risk of HPT among young adults, including college students [2, 17]. Despite

the growing global burden of HPT and its well-established role as a major risk factor for CVDs, awareness and knowledge regarding HPT remain inadequate, particularly among young adults. Most existing studies have primarily focused on older populations or clinical groups, while relatively limited attention has been given to college students, who represent a critical group for early prevention and long-term risk reduction. Although some studies have assessed HPT awareness among university students in different settings, there is a lack of interventional evidence, especially in low-and middle-income countries. In Bangladesh, where rapid urbanization and lifestyle transitions are increasing the risk of non-communicable diseases, data on the effectiveness of educational interventions targeting young populations remain scarce. Further, existing studies are often descriptive in nature and do not evaluate pre-post changes in knowledge following a structured health education program. Given that many behavioral risk factors for HPT, improving awareness at the college level is essential for effective prevention. This study was undertaken to address this gap by evaluating the effectiveness of a structured educational intervention in improving HPT-related knowledge among college students in Bangladesh. This study aimed to assess baseline knowledge of HPT among college students and to evaluate the effectiveness of a structured educational intervention in improving their awareness and understanding of HPT and its associated risk factors using a pre-post interventional approach.

Materials and methods

Study design and sample: The study employed a pre-post interventional (quasi-experimental) design to assess the effectiveness of an educational intervention on HPT awareness among college students. A non-probability sampling approach, incorporating convenience and purposive sampling techniques, was used to recruit participants. Data were collected using a validated semi-structured, pre-tested questionnaire, administered through face-to-face interviews. The study was conducted over 12 months, from July 2024 to June 2025. Participants were recruited from two selected university colleges in Bangladesh, namely Sonargaon University College, Sonargaon, Narayanganj, and Dania University College, Jatrabari, Dhaka. A total of 384 students (236 males and 148 females), aged 18-23 years, were enrolled in the study. Of these, 175 students were allocated to the intervention group, while 209 students were assigned to the non-intervention (control) group.

Ethical approval: Before data collection, the purpose and procedures of the study were clearly explained to each participant, and students were invited to participate following their class sessions. Written informed consent was obtained from all participants. Ethical approval for the study was obtained from the BIHS (Bangladesh Institute of Health Sciences) Institutional Review Board (IRB).

Intervention, baseline, and post-intervention data collection: Data collection was conducted in two phases. During the baseline assessment, anthropometric measurements-including height, weight, and blood pressure-were recorded, and baseline data on HPT-related knowledge were collected using a structured questionnaire. The educational intervention was implemented among the intervention group in three sequential sessions, delivered at 15-day intervals. The intervention consisted of structured health education focusing on HPT awareness, risk factors, prevention, and control strategies. Following completion of the intervention, post-intervention data were collected two weeks after the final session using the same questionnaire to assess changes in knowledge. The questionnaire was pre-tested among a randomly selected group of 25 students before the main study to ensure clarity and reliability. Participants' confidentiality and anonymity were strictly maintained throughout the study, and no incentives were provided for participation. For analytical purposes, students' knowledge levels were categorized as follows: poor knowledge (≤ 50.0% correct responses), moderate knowledge (50.0-80.0% correct responses), and good knowledge (81.0-100% correct responses).

Statistical analysis: The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 25.0. Descriptive statistics, including frequencies, percentages, means, and standard deviations (SD), were computed to summarize the characteristics of the study participants and their responses. Inferential statistical analyses were performed to assess differences between groups. The Student's t-test was used to compare mean knowledge scores between the intervention and non-intervention groups. The Chi-square test or Fisher's exact test was applied to examine associations and differences in categorical variables derived from questionnaire responses. All statistical tests were two-tailed, and a p-value of < 0.05 was considered significant.

Results

A total of 384 students participated in this study, of whom 61.0% were male, and 39.0% were female, with a mean age of 19.76 ± 1.65 years. The mean monthly family income of the participants was 38437.50 ± 19483.17 BDT, and the average family size was 4.73 ± 1.39 members. The mean body weight and height of the participants were 52.40 ± 6.41 kg and 161.10 ± 5.23 cm, respectively. The mean body mass index (BMI) was 20.38 ± 3.49 kg/m^2. The average systolic and diastolic blood pressure levels were 110.54 ± 9.94 mmHg and 71.08 ± 6.98 mmHg, respectively. Regarding family structure, 88.0% of the participants belonged to nuclear families, while 12.0% were from joint families. More than half of the students (53.0%) lived in rented housing, whereas 47.0% resided in their own homes. In terms of lifestyle behaviors, 64.0% of participants were non-smokers, 19.0% were current smokers, and 17.0% were former smokers. Notably, a high proportion of students (72.0%) reported the habit of consuming additional salt with meals, while 28.0% did not report this practice.

Table 1: Demographic and student characteristics of the study participants (Mean ± SD)

Variables	Intervention group (n = 175)	Non-intervention group (n = 209)	Total (n = 384)
Gender Male	107 (61.0%)	129 (62.0%)	236 (61.0%)
Female	68 (39.0%)	80 (38.0%)	148 (39.0%)
Age (years)	19.85 ± 1.72	19.68 ± 1.59	19.76 ± 1.65
Monthly family income	36257.14 ± 17132.25	40263.16 ± 21120.59	38437.50 ±19483.17
Size of family members	4.83 ± 1.27	4.64 ± 1.49	4.73 ± 1.39
Weight (Kg)	52.15 ± 6.88	52.61 ± 6.00	52.40 ± 6.41
Height (cm)	161.35 ± 5.26	160.89 ± 5.20	161.10 ± 5.23
BMI (Kg/m^2)	20.07 ± 2.38	20.64 ± 4.20	20.38 ± 3.49
Systolic BP (mmHg)	110.89 ± 10.28	110.25 ± 9.66	110.54 ± 9.94
Diastolic BP (mmHg)	70.92 ± 6.85	71.22 ± 7.11	71.08 ± 6.98
Major of study (%)			
Types of families			
Nuclear families	89.%	87%	88%
Joint families	11%	13%	12%
Types of houses			
Self house	47%	47%	47%
Rented house	53%	53%	53%
Smoking behavior			
Current smokers	16%	22%	19%
Non-smokers	66%	62%	64%
Former smokers	18%	16%	17%
Extra salt added to meals			
Yes	68%	76%	72%
No	32%	24%	28%

Knowledge on risk factors, consequences, and preventive measures of HPT: Among the 384 participating students, the majority identified smoking as a risk factor for HPT (63.0%). Other commonly reported risk factors included extra added salt with meals (51.6%), obesity (47.4%), increasing age (40.1%), and family history (heredity) (39.6%). Regarding the consequences of HPT, nearly two-thirds of students (62.8%) recognized myocardial infarction (MI) as a complication, followed by heart failure (59.1%), stroke (48.4%), and chronic kidney disease (CKD) (27.9%). Students also demonstrated knowledge of preventive measures for HPT. More than two-thirds (68.8%) reported that avoiding smoking is a preventive strategy. Other commonly recognized measures included reducing dietary salt intake (55.2%), engaging in regular physical exercise (49.5%), controlling heart disease (44.3%), managing obesity (44.0%), and avoiding fatty foods (37.2%).

Table 2: Distribution of hypertension knowledge by gender and study group (intervention vs. non-intervention)

Knowledge on HPT	Intervention group (n=175)		Non-intervention group (n=209)		Total (n = 384)
	Male (n = 107)	Female (n = 68)	Male (n = 129)	Female (n=80)	
Risk factors of HTN					
Increasing age	39 (36.4%)	31 (45.5%)	45 (34.9%)	39 (48.8%)	154 (40.1%)
Family history	42 (39.2%)	30 (44.1%)	50 (38.8%)	30 (37.5%)	152 (39.6%)
Obesity	57 (53.3%)	35 (51.5%)	52 (40.3%)	38 (47.5%)	182 (47.4%)
Extra added salt	68 (63.6%)	26 (38.2%)	70 (54.3%)	34 (42.5%)	198 (51.6%)
Smoking	80 (77.8%)	41 (60.3%)	77 (59.7%)	44 (55.0%)	242 (63.0%)
Consequence of HTN					
Stroke	62 (57.9%)	47 (69.1%)	70 (54.3%)	50 (62.5%)	186 (48.4%)
MI	81 (75.7%)	47 (69.1%)	68 (52.7%)	45 (56.3%)	241 (62.8%)
Heart failure	72 (67.3%)	36 (52.9%)	74 (57.4%)	45 (56.3%)	227 (59.1%)
CKD	22 (20.6%)	38 (55.9%)	29 (22.5%)	18 (22.5%)	107 (27.9%)
Preventive measures of HTN					
Avoid smoking	79 (73.8%)	54 (79.4%)	78 (60.5%)	53 (66.3%)	264 (68.8%)
Reduce extra salt	62 (57.9%)	37 (54.4%)	77 (59.7%)	36 (45.0%)	212 (55.2%)
Limit fatty foods	46 (43.0%)	18 (26.5%)	47 (36.4%)	32 (40.0%)	143 (37.2%)
Control obesity	52 (48.6%)	12 (17.6%)	63 (48.8%)	42 (52.5%)	169 (44.0%)
Control HD & DM	45 (42.1%)	38 (55.9%)	55 (42.6%)	32 (40.0%)	170 (44.3%)
Physical exercise	51 (47.7%)	49 (42.1%)	62 (48.1%)	28 (35.0%)	190 (49.5%)

The result shows the multiple responses of the students. HTN= Hypertension, MI= Myocardial Infarction, CKD= Chronic Kidney Diseases, HD= Heart Disease, DM= Diabetes Mellitus

Effect of educational intervention on HPT knowledge: The mean knowledge level regarding risk factors of HPT among students in the intervention group increased from 0.33 ± 0.21 before the intervention to 0.99 ± 0.24 after the intervention. In comparison, the non-intervention group showed a modest increase from 0.35 ± 0.19 (pre-test) to 0.42 ± 0.23 (post-test). A paired t-test revealed a significant improvement in knowledge in the intervention group ($t = 44.42$, $p < 0.001$). For symptoms of HPT, the mean knowledge score in the intervention group increased from 0.35 ± 0.19 to 0.99 ± 0.24, whereas the non-intervention group showed a smaller increase from 0.38 ± 0.20 to 0.43 ± 0.23. The difference in the intervention group was statistically significant ($t = 48.31$, $p < 0.001$). Regarding the consequences of HPT, the intervention group's mean knowledge improved from 0.39 ± 0.22 to 0.99 ± 0.24, compared with a smaller change in the non-intervention group from 0.41 ± 0.24 to 0.48 ± 0.26. This difference was also significant ($t = 36.96$, $p < 0.001$).

For preventive measures, the intervention group showed an increase from 0.36 ± 0.24 to 0.98 ± 0.03, while the non-intervention group increased from 0.39 ± 0.23 to 0.45 ± 0.25. The improvement in the intervention group was significant ($t = 37.39$, $p < 0.001$). Finally, for control measures of HPT, the intervention group's mean knowledge increased from 0.45 ± 0.28 to 0.98 ± 0.04, whereas the non-intervention group showed minimal change from 0.53 ± 0.26 to 0.56 ± 0.26. The paired t-test confirmed a significant improvement in the intervention group ($t = 24.66$, $p < 0.001$). In the non-intervention group, a small but statistically significant change was observed over the same period ($t = 2.17$, $p < 0.031$). Overall, these results indicate that the structured educational intervention was highly effective in improving knowledge of risk factors, symptoms, consequences, preventive measures, and control strategies for HPT among college students.

Table 3: Comparison of hypertension knowledge levels between intervention and non- intervention groups, n = 384

Knowledge on HPT	Intervention group (n = 175)			Non-intervention group (n = 209)		
	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	t-value/ p-value	Pre-Test Mean ± SD	Post-Test Mean ± SD	t-value/ p-value
Risk factors of HTN	0.33 ± 0.21	0.99 ± 0.24	44.42/0.001	0.35 ± 0.19	0.42 ± 0.23	5.29/0.261
Symptoms of HTN	0.35 ± 0.19	0.99 ± 0.24	48.31/0.001	0.38 ± 0.20	0.43 ± 0.23	3.44/0.532
Consequences of HTN	0.39 ± 0.22	0.99 ± 0.24	36.96/0.001	0.41 ± 0.24	0.48 ± 0.26	4.96/0.158
Preventive measures of HTN	0.36 ± 0.24	0.98 ± 0.03	37.39/0.001	0.39 ± 0.23	0.45 ± 0.25	3.84/0.347
Control measures of HTN	0.45 ± 0.28	0.98 ± 0.04	24.66/0.001	0.53 ± 0.26	0.56 ± 0.26	2.17/0.031

Where, $p<0.001$

Change knowledge levels on HPT: Among the students in the intervention group, 74.3% had poor knowledge, 20.6% had moderate knowledge, and 5.1% demonstrated good knowledge before the intervention. Following the educational intervention, knowledge levels increased significantly ($p < 0.001$), with poor knowledge decreasing to 0.0%, moderate knowledge decreasing to 0.0%, and good knowledge rising to 94.9%. In contrast, the non-intervention group showed no significant improvement over the two months ($p = 0.825$). Specifically, poor knowledge decreased by 18.2%, moderate knowledge decreased by 11.0%, and good knowledge increased by 29.2%. Comparison between the two groups after the intervention demonstrated that the intervention group had a significantly greater increase in knowledge than the non-intervention group ($p < 0.001$). These findings indicate that the structured educational intervention was highly effective in improving HPT knowledge among college students.

Table 4: Comparison of hypertension knowledge levels between intervention and non-intervention group, n = 384

Level of knowledge	Intervention group (n = 175)				Non-intervene group (n = 209)			
	Before Intervention	After Intervention	% Change	p	Pre-Test	Post-Test	% Change	p
Poor (≤ 50)	130 (74.3%)	(00%)	100%	0.001	141 (67.5%)	103 (49.3%)	18.2%	0.825
Moderate (51-80)	36 (20.6%)	(00%)	100%		46 (22.0%)	23 (11.0%)	11.0%	
Good (81-100)	9 (5.1%)	175 (100%)	94.9%		22 (10.5%)	83 (39.7%)	29.2%	

χ^2 test, where, $p<0.001$ and $p<0.825$

Discussion

The findings of this study indicate that college students demonstrated relatively higher levels of knowledge regarding the risk factors, consequences, and preventive measures of HPT, although important gaps remain. Students were most aware of modifiable behavioral risk factors, particularly smoking (63.0%) and excess dietary salt intake (51.6%), while comparatively fewer recognized obesity as a key risk factor. This pattern is consistent with previous studies, which have reported that young adults tend to have greater awareness of visible or commonly discussed risk factors, such as smoking, but comparatively lower awareness of metabolic risk factors like obesity and sedentary lifestyle [18, 19, 20]. Regarding knowledge of complications, a substantial proportion of participants correctly identified major CV outcomes of HPT, including myocardial infarction (62.8%), heart failure (59.1%), and stroke (48.4%). These findings align with earlier research conducted among university students in developing countries, where awareness of severe cardiovascular consequences was moderate but not comprehensive [21]. However, knowledge of chronic kidney disease (CKD) as a complication remained relatively low, reflecting a gap also observed in other low-and middle-income settings. In terms of preventive measures, the majority of students recognized smoking cessation (68.8%) and reduction of added salt intake (55.2%) as effective strategies. Around half of the participants identified regular physical activity as a preventive measure. These findings are comparable to reduce from the WHO, which emphasizes lifestyle modification, including tobacco avoidance, reducing sodium intake, and increasing physical activity as key components of HPT prevention [22]. Similar trends have been documented in studies from South Asia, where awareness of dietary and behavioral modifications is moderate but often insufficient for effective prevention [23]. Despite this moderate baseline knowledge, this study demonstrated that the educational intervention significantly improved students' knowledge across all domains, highlighting the effectiveness of structural health education programs. This is supported by previous interventional studies showing that targeted educational strategies can substantially enhance awareness and promote positive health behaviors among young adults [24].

The present study demonstrated a significant improvement in HPT-related knowledge following the educational intervention. A clear difference in knowledge levels was observed between the intervention and non-intervention groups. The results showed highly significant improvements in the intervention group across all knowledge domains, including risk factors, symptoms, consequences, preventive measures, and control strategies. In contrast, the non-intervention group did not exhibit a meaningful change in knowledge over the study period, with pre-and post-test differences remaining statistically non-significant. These findings strongly suggest that the educational intervention was effective in enhancing students' knowledge of HPT. These results are consistent with previous interventional studies, which have demonstrated that structured health education programs significantly improve HPT awareness among young adults. For example, a study by Al Shatari et al. [21] reported a marked increase in knowledge scores following a Primary Health Care Center-based educational intervention. Similarly, Kayima and others [25] found that targeted awareness programs significantly improved understanding of HPT risk factors and complications among university students in low-and middle-income settings. Reports from the WHO also emphasize that health education and community-based interventions are essential strategies for improving awareness and control of HPT globally. Furthermore, categorical analysis in the present study revealed substantial improvements in the intervention group, where poor and moderate knowledge levels were eliminated, and good knowledge increased markedly to 95.0% following the intervention. Comparable findings have been reported in other quasi-experimental studies, where educational interventions led to a significant shift from low to high knowledge categories among participants [26, 27]. Conversely, although slight improvements were observed in the non-intervention group after two months, these

changes were not significant, indicating that passive exposure or external influences alone are insufficient to produce meaningful knowledge gains. This finding aligns with earlier studies suggesting that active, structured interventions are necessary, as awareness does not improve substantially in the absence of targeted educational efforts. Overall, the findings of this study reinforce existing evidence that educational interventions are highly effective tools for improving HPT awareness among college students. Incorporating such programs into academic curricula and extending them to families and communities could play a crucial role in promoting early prevention and long-term control of HPT [28, 29].

Conclusion: This study highlights the level of knowledge regarding hypertension among college students and demonstrates the effectiveness of a structured educational intervention. While baseline awareness of risk factors, symptoms, consequences, and preventive measures was moderate, the intervention significantly improved knowledge across all domains. These findings underscore the importance of implementing targeted health education programs within academic institutions. Colleges and universities provide an ideal platform to promote awareness of modifiable risk factors, including smoking, excessive salt intake, physical inactivity, and stress, thereby encouraging healthier lifestyle choices. Enhancing students' understanding and personal risk perception is essential for translating knowledge into practice.

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