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EFFECT OF ELEVATED SYSTOLIC BLOOD PRESSURE ON ISCHAEMIC HEART DISEASE: A CROSS SECTIONAL STUDY

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Abstract: : Elevated systolic blood pressure (SBP) is a main adaptable risk factor for controlling ischaemic heart disease (IHD) and contributes significantly to cardiovascular morbidity and mortality globally. In Pakistan, the increasing prevalence of hypertension (HTN) and its associated cardiovascular consequences reflect a serious public health challenge.. An analytical cross-sectional study was conducted on 430 adults aged 30 years and above at tertiary care hospital. Participants were selected using consecutive sampling. Data was collected on socio-demographic characteristics, lifestyle factors, anthropometric measurements, SBP, metabolic comorbidities, and echocardiographic findings. Statistical analysis was performed using SPSS version 29.0. Associations were assessed by chi-square tests and multivariable logistic regression, results reported as adjusted odds ratios (AORs) and 95% confidence intervals (CIs). The majority of study subjects was belonging to age group 50-59 years, and 59.5% were male. Elevated SBP ≥130 mmHg was observed in 58.1% of study subjects. The prevalence of IHD was 39.1%. A significant association was found between elevated SBP categories and the prevalence of IHD ($p < 0.001$). After adjustment for potential confounders, elevated SBP was independently associated with IHD (AOR = 2.48; 95% CI: 1.62-3.79). Adult IHD is strongly and independently correlated with elevated SBP

Key words: Blood Pressure, ischaemic heart disease, acute cardiac events, CVD

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INTRODUCTION

Cardiovascular diseases (CVDs) are the primary cause of deaths and morbidity across the world; accounts for an estimated 17.9 million deaths annually, Ischaemic heart disease (IHD) represent the leading proportion of these deaths (WHO, 2015). Elevated systolic blood pressure (SBP) has been identified as a most modifiable cardio-metabolic risk factor for IHD, substantially contribute to the global burden of cardiovascular events and deaths (Murray *et al*., 2020). Elevated SBP exert deleterious effects on arterial walls, promotes atherosclerosis, and increases coronary vessels stress, all of which predispose patients to Ischaemic pathology (Chobanian *et al*., 2003). Despite significant advances in management and prevention, a large percentage of high SBP-related cardiovascular risk remains un-mitigated, particularly in low- and middle-income countries such as Pakistan, where healthcare systems have unique socioeconomic and demographic challenges (Yusuf *et al*., 2014)

Hypertension (HTN) is clinically defined by elevated SBP and diastolic blood pressure (DBP) values above thresholds established by guidelines. Current guidelines categorize normal blood pressure as less than 120/80 mmHg, with elevated SBP beginning at 120 mmHg and HTN defined at higher thresholds depending on the guideline authority (e.g., ≥130/80 mmHg according to American College of Cardiology/American Heart Association) because increasing SBP levels have been associated with increases cardiovascular risk (Whelton *et al.*, 2018).

SBP represent arterial pressure during ventricular contraction; persistently high SBP accelerates arterial endothelial injury and promote the progression of atherosclerotic plaques. Mechanistically, high levels of SBP increases mechanical stress on the vascular intima, which encourage endothelial dysfunction an early step in athero-genesis (Ross, 1999). Gradually, this detrimental process leads to lipid accumulation, cause inflammation, and plaque formation within the coronary arteries, ultimately result in narrowing and reduced myocardial perfusion. Chronic elevated SBP also associated with ventricular hypertrophy, not only reduced coronary reserve, but also increased myocardial oxygen demand, additionally influence to cause Ischaemic events such as angina and myocardial infarction (MI) (Levy, *et al*., 1990). Elevated SBP often coexists with other metabolic risk factors for instance diabetes mellitus, dyslipidemia, and obesity that synergistically initiate cardiovascular risk, particularly IHD (Kannel, 2000). In South Asian populations, these risk factors tend to noticeable

at young ages with higher severity than Western populations, which generate an urgent need for region-specific research to plan interventional strategies (Joshi *et al.,* 2007). High SBP is one of the leading contributors to global disease burden, accountable to millions of deaths and disability-adjusted life years (DALYs).

These patterns are consistent across diverse regions; emphasize the significance of SBP in cardiovascular epidemiology. Pakistan, is a lower-middle-income South Asian country with over 240 million populations, reflects the larger global shift to higher burden of non-communicable diseases (NCD), particularly CVD. According to national and regional estimates of the global burden of disease, IHD-related death and disability have increased dramatically over the past few decades, with cardiovascular causes accounting for more than half of all NCD-related mortality. According to the Institute for Health Metrics and Evaluation's (IHME) 2023 estimate, over 37% of Pakistani adults have hypertension; therefore, managing SBP should be a top priority for public health (IHME, 2023). Pakistani patients with IHD had a high burden of HTN, even according to hospital-based data. Despite high burden, there are limited studies done on quantitative association between SBP levels and IHD in Pakistan. Moreover, a cross-sectional study design will allow for the simultaneous assessment of SBP, cardio-metabolic risk factors other than HTN, and outcomes of IHD in a Pakistani context and variations across age, gender, lifestyle, and co-morbid conditions. This study aims to support evidence-based public health policies that address not only HTN but also its consequences such as IHD.

The primary objective of present research is to investigate the effect of elevated SBP on the prevalence of IHD in Pakistani adults. Secondary objectives include examining the relationship between SBP and other risk factors e.g., age, DM, and lipid profiles, to identify potential thresholds at which SBP most strongly associated with Ischaemic outcomes. To improve cardiovascular health, it is important to understand these connections, especially since the population is facing two problems at once: an increasing burden of noncommunicable diseases (NCDs) and limited healthcare resources. This shows how important it is to quickly find, prevent, and manage modifiable risk factors. This study aims to inform clinical practice and identify targeted interventions to address the alarming burden of Ischaemic heart disease (IHD) linked to elevated systolic blood pressure (SBP) by generating robust, population-specific evidence.

MATERIALS AND METHODS

Study Design and Setting

Current research was an observational, analytical cross-sectional study, carried out from January 2024 to December 2024 at outpatient clinics from Karachi Institute of Heart Diseases (KIHD) a tertiary care hospital through non probability consecutive sampling technique. A reason to chosen cross-sectional methodology was as it allows concurrent evaluation of exposure that was SBP and outcome was prevalence of IHD within a defined population, and enables estimation of prevalence and examination of associations at a single point in time.

Study Population

Study subjects were eligible when they met all the following criteria, Adults aged ≥30 years, willing to participate by providing written informed consent, had completed all medical records including readings of blood pressure, history of cardiovascular diseases, and relevant laboratory information. Subjects who were already known for secondary hypertension due to renal artery stenosis, endocrine disorder, had any acute health conditions which required immediate medical attention for e.g., acute coronary syndrome at the time of recruitment or pregnancy, post-surgical patients e.g., recent valvular surgery.

Data Collection Procedures

Data was collected by trained clinical research officers, who underwent standardized training on blood pressure measuring techniques, interview procedure, medical record extraction and hoe to fill study questionnaires. Following American Heart Association guidelines was considered for monitoring blood pressure**:** required rest for at least 5 minutes before measuring BP**,** consider monitoring in the seated position, use a calibrated digital sphygmomanometer, take two measurements 5 minutes apart**,** mean of both SBP was used for final analysis, SBP categories were as Normal:<120 mmHg**,** Elevated: 120-129 mmHg**,** Stage 1 Hypertension: 130-139 mmHg, Stage 2 Hypertension**:** ≥140 mmHg. In contrary IHD status was evaluated by a combination of **c**linical history confirmed physician diagnosis, or symptoms of angina, Electrocardiogram (ECG) indication of ischemia, any diagnostic reports done previously e.g. stress test, echocardiography, clinical records which confirmed the diagnosis of myocardial infarction or coronary artery disease, participants were then categorized into: IHD Present**,** IHD Absent.

Structured questionnaire was modified and translated into Urdu taken from previous validated health surveys. Following variables were included in the questionnaire age**,** gender**,** Body Mass Index (BMI)**,** smoking status**,** DM self-reported or fasting glucose ≥126 mg/dL, dyslipidemia**,** family history of cardiovascular disease**,** and levels of physical activity**.**

Ethical Considerations

The KIHD Institutional Review Boards (IRBs) gave their approval to the study, written informed consent following education about the goals, methods, risks, and advantages of the study. Data entries were coded to ensure confidentiality.

Sample Size Calculation

With the aim of examining the relationship between elevated SBP and IHD in Pakistani adults, the sample size for this study was determined using OpenEpi 3.01 version based on the cross-sectional study design. Expected prevalence of HTN in our population ≈ 37% (based on prior national health surveys & IHME) [13] within large population, assumption

size: ≥1,000,000 at 95% confidence level with 5% margin of error, to improve statistical power, the sample was increased by 20% additionally**,** to compensate for possible non-response, incomplete data, and exclusion due to missing clinical records, produce a final sample of 430 participants. The mean ± standard deviation (SD) is a component of descriptive analysis for continuous variables. Frequencies and percentages were employed for categorical variables. Chi-square tests are used in inferential analysis to evaluate the relationship between SBP categories and the prevalence of IHD. Independent t-tests and ANOVA were used to compare mean of SBP levels in between groups. Logistic Regression analysis include multivariable logistic regression used to assessed the association between SBP and IHD, also adjusting for potential confounders like age, sex, BMI, diabetes and smoking. Results were expressed as Adjusted Odds Ratios (AORs) with 95% Confidence Intervals (CIs)**.** Significance level was set at $p < 0.05$.

RESULTS

Table 1: Socio-Demographic Characteristics of Study Participants (n = 430)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
30–39	78	18.1
40–49	104	24.2
50–59	136	31.6
≥60	112	26.1
Gender		
Male	256	59.5
Female	174	40.5
Marital Status		
Married	346	80.5
Unmarried/Widowed	84	19.5
Education Level		
No formal education	124	28.8
Primary–Secondary	168	39.1
Higher education	138	32.1
Residence		
Urban	302	70.2
Rural	128	29.8

Most participants belong to 50-59 years, were male and married **(Table 1).**. Nearly 29% had no formal education, which highlighting the role of low educational levels as a potential contributor to poor cardiovascular risk awareness and management.

Table 2: Lifestyle and Anthropometric Characteristics

Variable	Frequency (n)	Percentage (%)
Body Mass Index (BMI)		
Normal (<23 kg/m²)	134	31.2
Overweight (23–23.9)	176	40.9
Overweight (24–25.9)	176	40.9
Obese (≥26)	120	27.9
Waist Circumference		
Normal	162	37.7
Center obesity	268	62.3
Smoking Status		
Current smoker	142	33.0
Non-smoker	288	67.0
Physical Activity		
Adequate	158	36.7
Inadequate	272	63.3

Table 2 showed that more than 68% of participants belong to overweight or obese classification along with 62% increased waist circumference, which indicated a higher prevalence of central obesity. Similarly, physical inactivity was also found to be more prevalent, which indicated sedentary lifestyle was common.

Table 3: Clinical characteristics and cardiac Findings

Variable	Frequency (n)	Percentage (%)
Systolic Blood Pressure (SBP)		
Normal (<120 mmHg)	94	21.9
Elevated (120–129 mmHg)	86	20.0
Stage 1 HTN (130–139)	108	25.1
Stage 2 HTN (≥140)	142	33.0
Diabetes Mellitus		
Present	174	40.5
Absent	256	59.5
Dyslipidemia		
Present	123	28.6
Absent	307	71.4
Left Ventricular (LV) Findings		
Normal LV	238	55.3
LV Hypertrophy	142	33.0
LV Dysfunction	50	11.6

Table 3 indicated that majority of participants were categorized in stage 2 HTN, on the other hand abnormal LV findings on echocardiography was approximately 44.6%. LV

hypertrophy was commonly found among hypertensive individuals who are well recognized for chronic pressure overload and impact on cardiac structure.

Table 4: Association between systolic blood pressure and Ischaemic Heart Disease (IHD)

SBP Category	IHD Present n (%)	IHD Absent n (%)	p-value
Normal	14 (14.9)	80 (85.1)	
Elevated	22 (25.6)	64 (74.4)	
Stage 1 HTN	46 (42.6)	62 (57.4)	
Stage 2 HTN	86 (60.6)	56 (39.4)	
Total	**168 (39.1)**	**262 (60.9)**	**<0.001**

The association between SBP categories and the prevalence of IHD was evaluated **(Table 4)**. Elevated SBP levels were found to be strongly and statistically significantly associated with the outcome of IHD. There is a strong dose-response relationship between the prevalence of IHD and higher SBP categories.

Table 5: Multivariable logistic regression analysis of factors associated with IHD

Variable	Adjusted Odds Ratio (AOR)	95% CI	p-value
Elevated SBP (≥130 mmHg)	2.48	1.62–3.	<0.001
Age ≥50 years	1.96	1.28–3.	0.002
Male gender	1.52	1.01–2.	0.041
Obesity (BMI ≥30)	1.74	1.12–2.	0.014
Increased waist circumfere	1.89	1.21–2.	0.005
LV hypertrophy/dysfunction	2.36	1.48–3.	<0.001
Diabetes mellitus	2.11	1.38–3.	<0.001
Dyslipidemia	2.01	1.29-3.	<0.001
Low education level	1.58	1.02–2.	0.039

Multiple regressions were used in **Table 5** to identify the variables linked to IHD. Elevated SBP was still the best independent predictor of IHD out of all the factors. The multifactorial nature of cardiovascular risk in our local population is highlighted by the significant associations found between IHD and cardiac structural abnormalities, central obesity, diabetes mellitus, dyslipidaemia, and low educational attainment.

DISCUSSION

Current cross-sectional study examined the influence of elevated SBP on IHD among our local population. Our study findings highlighted a strong and statistically significant association between increase SBP levels and the prevalence of IHD. It was found that more than half of the study population displayed SBP values higher than normal, and nearly two-fifths were identified with IHD. Elevated SBP remained an independent predictor of IHD even after adjusting for multiple variables including demographic, anthropometric, metabolic, and cardiac structural variables, which emphasize its role in cardiovascular diseases. The most noticeable finding of this study was the strong and clear dose-response relationship between SBP categories and IHD prevalence. Those participants who were with stage 2 HTN had the highest percentage of IHD, in contrary those with normal SBP found to have a lowest prevalence. This observation is consistent with the multiple evidences indicated that SBP is more strongly related to coronary events as compare to diastolic blood pressure (DBP), predominantly among adults (Lewington *et al*., 2002; Franklin *et al*., 2001)). A large meta-analyses and Global Burden of Disease studies have found that the risk of MI and coronary mortality significantly increase on each 10 mmHg elevated SBP (Ettehad *et al*., 2016). Forouzanfar et al. reported that even low SBP levels may contribute markedly to cardiovascular related deaths globally, with IHD account for the major share of SBP related mortality (Forouzanfar *et al*., 2017).The present study strengthens these findings within a context of local population, and showed that even mild elevations in SBP markedly increase the risk of IHD. In this study the prevalence of IHD was higher than reported through community-based surveys but remain consistent with hospital-based studies were also conducted in Pakistan. Jafar *et al*. revealed a high burden of electrocardiographic ischemia, predominantly among those individuals who had uncontrolled HTN (Jafar *et al*., 2008). It was also reported that among patients with IHD admitted in tertiary care hospitals Karachi, HTN was found to be the most common risk factor (Aysha *et al*., 2012).

South Asian populations are well known to experience cardiovascular disease (CVD) from young age and also have lower risk thresholds as compared to Western populations.[10] The present findings add that age ≥50 years was significantly associated with IHD; this was consistent with well-established epidemiological patterns which showed that aging is associated with arterial stiffness, endothelial dysfunction, and aggregate exposure to cardiovascular risk factors, all of them intensify the impact of elevated SBP on coronary arteries (Lakatta, 2003). The interaction between aging and elevated SBP is mostly important, as SBP tends to rise gradually with age due to loss of arterial compliance (Safar and London, 2000).

Another studies finding from global and regional data showed that male gender had higher prevalence of IHD, specifically in middle age males. Similarly, our study concluded that male gender was independently associated with higher risk of IHD as compared to female (Roth, *et al.*, 2020). Inconsistency of gender based result may be due to high smoking rates, low healthcare utilization, and job-related stress. However, emerging evidence suggested that South Asian women is often remain under-diagnosed for cardiovascular risk, which may show an obvious male

prevalence in hospital-based studies (Maas and Appelman, 2010).

Both obesity and center obesity were significantly associated with IHD in multivariable analysis. Central obesity, assessed by waist circumference, showed a particularly robust association with IHD. Same findings were parallel with evidence indicated that abdominal adiposity is a greater predictor of cardiovascular risk than BMI alone, specifically in South Asian populations (Yusuf, *et al*. 2005).Visceral fat contributes to cause many metabolic dysfunction including insulin resistance, systemic inflammation, dyslipidemia, and endothelial dysfunction, all of them exacerbate the athero-genic effects of elevated blood pressure (Després, 2012). Lifestyle alterations characterized by reduced physical activity and increased intake of energy-dense foods reflect through the high prevalence of overweight, obesity, and central adiposity which we observed in this study. These factors may synergistically interact with elevated SBP and accelerate coronary artery disease.

DM was present in majority of the participants and was independently associated with IHD. Similar, study results demonstrated that HTN and DM frequently coexist and have additional effects on cardiovascular risk (Stamler *et al*., 1993).Hyperglycemia stimulates oxidative stress, inflammation, and endothelial damage, which further increase the harmful vascular effects of elevated SBP (Beckman *et al*., 2002). Previous studies done in Pakistan reported that the patients with coronary artery disease had a high prevalence of undiagnosed or poorly controlled DM Shera et al., 2007). The coexistence of DM and HTN is a major challenge for the prevention of cardiovascular risk, it emphasizes the need for integrated risk factor management strategies.

Left ventricular (LV) findings, include LV hypertrophy and dysfunction, were strongly associated with IHD in current study. Chronically elevated SBP leads to pressure overload which result in compensatory myocardial hypertrophy, which eventually impairs coronary perfusion, increases demand of myocardial oxygen, and prompts to ischemia and heart failure (Frohlich *et al*., 1992). The association between LV abnormalities and IHD which observed in this study was strong and significant, consistent with findings from the Framingham Heart Study, established that LV hypertrophy is a powerful predictor of cardiovascular morbidity and mortality (Levy *et al*., 1990). In resource-limited settings such as Pakistan, echocardiographic screening of HTN may aid in identify individuals at high risk for Ischaemic events.

Lower education level was also independently associated with IHD, as education influences health literacy, awareness of risk factors, healthcare-seeking behavior, and adherence to treatment (Cutler and Lleras-Muney, 2006). Individuals with lower literacy may be less likely to understand the importance of blood pressure control or preventive lifestyle modifications. Similar associations between lower education level and cardiovascular disease have been reported from both developed and developing countries (Kaplan and Keil, 1993).

Although marital status was not a predictor in multivariable analysis, the higher ratio of married subjects reflects the demographic structure of our local population. Social support associated with marriage may hypothetically offer protective effect on cardiovascular health (Robles and Kiecolt-Glaser, 2003).

Present study findings have important implications in the prevention of cardiovascular disease. Elevated SBP found to be highly prevalent and strongly associated with IHD, emphasized the urgent need for timely diagnosis, effective management, and interventions at community level to target the reduction of elevated SBP. Lifestyle modifications, including weight management, increased physical activity, reduction in dietary salt intake, and smoking cessation, should be prioritized together with medical therapy. At the policy level, primary healthcare systems should be strengthening for routine blood pressure screening and cardiovascular risk assessment. Strong association between SBP and IHD even at mild to moderately elevated levels, adopting lower SBP level according to international guidelines may produce significant public health benefits (Whelton. *et al*. 2018).

Future longitudinal studies are recommended to establish causal relationships and to assess the effectiveness of interventions to reduce SBP in preventing IHD.

LIMITATION

The hospital setting may restrict generalizability to the community-based population, and the cross-sectional design is unable to produce causal inference. Notwithstanding these drawbacks, the results of this study offer important new information about the connection between SBP and IHD in a high-risk group.

CONCLUSION

The findings concluded that elevated SBP is highly prevalent and significantly associated with the presence of IHD, even after controlling for potential confounder, emphasize the critical role of SBP in cardiovascular risk stratification, these findings support the significance of routine SBP screening and control in adult. Incorporating anthropometric assessment and echocardiographic evaluation into routine care for hypertensive patients may facilitate early identification of high-risk individuals and improve cardiovascular outcomes.

Conflict of interest

Authors declare no conflict of interest.

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