PREVALENCE AND RISK FACTORS OF CORONARY ARTERY DISEASE IN PAKISTAN: A MULTICENTER COHORT STUDY

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ABSTRACT

Background

Coronary artery disease (CAD) is a leading cause of morbidity and mortality worldwide, with a disproportionately high burden in South Asian populations, including Pakistan. Lifestyle changes, urbanization, and increasing rates of hypertension, diabetes, obesity, and smoking have contributed to the rising prevalence of CAD. Despite existing research, there is limited multicenter data evaluating the prevalence and risk factors of CAD across different regions of Pakistan.

Objective

This study aimed to determine the prevalence of CAD and identify key demographic, clinical, and lifestyle-related risk factors associated with the disease in a diverse Pakistani population.

Methods

A multicenter, prospective cohort study was conducted at two major cardiology institutions in Pakistan from January 1, 2023, to December 31, 2023. A total of 1,262 adult patients (aged 30–75 years) were enrolled based on clinical suspicion or established CAD diagnosis. Data were collected on demographics, comorbidities, lifestyle habits, and lipid profiles. CAD was defined as ≥50% stenosis in at least one coronary artery, confirmed via angiography. Statistical analyses, including multivariate logistic regression, were performed to identify independent risk factors.

Results

The overall prevalence of CAD was 34.9%, with a higher burden among urban residents (37.2%) compared to rural populations (28.5%) ($p = 0.007$). Men had a higher CAD prevalence (36.7%) than women (32.4%). Hypertension (OR 1.86, $p < 0.001$), diabetes (OR 2.14, $p < 0.001$), smoking (OR 1.52, $p = 0.002$), and obesity (OR 1.42, $p = 0.005$) were independently associated with CAD. Patients with multi-vessel disease exhibited significantly higher LDL cholesterol levels ($p = 0.013$). Nearly 47.3% of patients presented late, with delays more pronounced in rural areas ($p = 0.007$).

Conclusion

This study highlights a high prevalence of CAD in Pakistan, with significant regional and gender disparities. Hypertension, diabetes, smoking, and obesity remain key modifiable risk factors. Early screening programs, public health interventions, and improved rural healthcare access are necessary to reduce CAD morbidity and mortality. Future studies should explore genetic predispositions and long-term intervention outcomes.

Keywords: Coronary artery disease, Pakistan, cardiovascular risk factors, hypertension, diabetes, smoking, obesity, urban-rural disparities, lipid profile, preventive cardiology.

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality worldwide, contributing to a significant burden on healthcare systems, particularly in low- and middle-income countries (1). CAD is characterized by the narrowing or blockage of coronary arteries due to atherosclerosis, leading to ischemic heart disease and increased risks of myocardial infarction and heart failure. Despite advancements in preventive and interventional cardiology, CAD continues to be a major public health challenge (2). Pakistan, like many South Asian countries, faces an increasing prevalence of CAD, driven by lifestyle changes, urbanization, and a high burden of risk factors such as hypertension, diabetes, obesity, and tobacco use (3). Studies have highlighted that South Asians exhibit an earlier onset and greater severity of CAD compared to other populations, suggesting potential genetic, metabolic, and environmental contributions (4).

The growing incidence of CAD in Pakistan necessitates a comprehensive evaluation of its prevalence and associated risk factors. While previous studies have provided insights into CAD burden, there remains a gap in regionally diverse, multicenter investigations assessing population-wide trends (5). Additionally, variations in CAD presentation, risk factor profiles, and treatment accessibility between urban and rural populations warrant further exploration to tailor preventive and therapeutic strategies effectively. Understanding these disparities is crucial in designing targeted interventions and optimizing healthcare resources to mitigate CAD-related morbidity and mortality (6).

This study aims to determine the prevalence of CAD and identify its associated risk factors through a multicenter, retrospective analysis conducted across major cardiology institutions in Pakistan. By incorporating a diverse patient population, this study seeks to provide robust epidemiological data to guide clinical decision-making and public health policies. The findings will contribute to the growing body of evidence necessary to develop region-specific CAD prevention strategies and improve cardiovascular outcomes.

METHODS

Study Design and Setting

This multicenter, prospective cohort study was conducted at Shaheed Mohtarma Benazir Bhutto Institute of Trauma and Emergency Response Center, Larkana, and Peshawar Institute of Cardiology, Peshawar. The study aimed to assess the prevalence and associated risk factors of Coronary Artery Disease (CAD) in a diverse Pakistani population. Data collection was carried out from January 1, 2023, to December 31, 2023. The study was approved by the respective institutional ethical review boards of participating hospitals, and written informed consent was obtained from all participants.

Participant Selection

The study included adult patients (**aged 30–75 years**) presenting to cardiology outpatient clinics or admitted for suspected CAD. The inclusion criteria were:

1. Patients diagnosed with CAD through coronary angiography, computed tomography angiography (CTA), or stress testing.
2. Individuals with at least one major cardiovascular risk factor (e.g., hypertension, diabetes, smoking, obesity, dyslipidemia, or a positive family history of CAD).
3. Willingness to participate and provide informed consent.

Exclusion criteria included:

1. Patients with a prior history of coronary revascularization (percutaneous coronary intervention or coronary artery bypass grafting) before the study period.
2. Those with severe systemic illnesses (e.g., end-stage renal disease, terminal malignancies) that could interfere with participation.
3. Patients with incomplete or missing medical records.

Collaboration and Logistics

This study was conducted through a collaborative effort between both participating institutions. A standardized protocol was established to ensure uniform data collection and diagnostic procedures. Regular virtual and in-person meetings were held between researchers at both sites to discuss study progress, troubleshoot data collection issues, and ensure adherence to ethical and methodological standards. Data coordinators were assigned at each hospital to oversee patient recruitment and data entry, ensuring consistency across centers. The logistics of sample transportation, data sharing, and statistical analyses were managed through a centralized data management system to maintain accuracy and integrity.

Sample Size Calculation

The sample size was determined based on the estimated prevalence of coronary artery disease (CAD) in Pakistan. According to a study by Jafary et al. (5), the prevalence of CAD in a Karachi population sample was reported to be 26.9%, with 23.7% in men and 30.0% in women. Using this prevalence rate and employing the WHO sample size calculator, a 95% confidence level and a 5% margin of error were considered. Based on these parameters, the minimum required sample size was approximately 1,136 participants. To account for potential non-responses and missing data, a 10% adjustment was applied, resulting in a final target sample size of approximately 1,262 participants. This ensures sufficient statistical power to assess CAD risk factors and prevalence patterns in the Pakistani population.

Data Collection and Variables

Data collection was performed using structured questionnaires, electronic medical records, and direct patient interviews. The following key variables were recorded:
1. **Demographics:** Age, sex, socioeconomic status, urban/rural residence.
2. **Clinical History:** Hypertension, diabetes mellitus, smoking status, obesity, family history of CAD, dyslipidemia, and lifestyle habits.
3. **Laboratory Investigations:** Lipid profile, fasting blood glucose, HbA1c, and inflammatory markers.
4. **Diagnostic Findings:** Results of coronary angiography, electrocardiography (ECG), echocardiography, and stress tests.

Outcome Measures

The primary outcome was the prevalence of CAD, defined as the presence of at least one coronary artery with ≥50% stenosis confirmed via angiography.
The secondary outcomes included:
- Association of traditional risk factors (hypertension, diabetes, smoking, obesity, and dyslipidemia) with CAD severity.
- Gender-based differences in CAD prevalence.
- Regional variations in CAD burden across Pakistan.

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp, USA). Descriptive statistics (mean, standard deviation, proportions) were used to summarize patient characteristics. The chi-square test was applied for categorical variables, while an independent t-test or Mann-Whitney U test was used for continuous variables. Multivariate logistic regression was performed to identify significant risk factors associated with CAD, adjusting for confounders such as age, gender, and comorbidities. A p-value < 0.05 was considered statistically significant.

The model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test, and odds ratios (OR) with 95% confidence intervals (CI) were reported for risk factor associations. Missing data were handled using multiple imputation techniques to minimize bias. Sensitivity analyses were performed to evaluate the robustness of findings.

Ethical Considerations

The study was conducted in compliance with the **Declaration of Helsinki** and was approved by ethical review committees of all participating institutions. Written informed consent was obtained from all participants before data collection. Data confidentiality was maintained through anonymization, and patients had the right to withdraw from the study at any stage without consequences.

RESULTS

A total of 1,262 participants were included in the study, with a mean age of 55.4 ± 9.7 years. The cohort comprised 756 (59.9%) males and 506 (40.1%) females. Table 1 provides a detailed breakdown of baseline characteristics. Most participants resided in urban areas (73.2%), while 26.8% lived in rural regions. Hypertension was prevalent in 62.8% (N=792) of the participants, while 41.6% (N=525) had diabetes mellitus, 29.7% (N=375) were current smokers, and 35.2% (N=444) were classified as obese. A positive family history of CAD was reported in 37.3% (N=471).

**Table 1: Baseline Characteristics of Study Participants (N=1,262)**

Variable	N (%)	Mean ± SD
Age (years)	---	55.4 ± 9.7
Male	756 (59.9)	---
Urban residence	923 (73.2)	---
Hypertension	792 (62.8)	---
Diabetes mellitus	525 (41.6)	---
Smoking	375 (29.7)	---
Obesity (BMI ≥ 30)	444 (35.2)	---

The overall prevalence of CAD (≥50% stenosis in at least one coronary artery) was 34.9% (N=441). Table 2 demonstrates the prevalence of CAD by gender. Men had a slightly higher prevalence of CAD (36.7%, N=277) compared to women (32.4%, N=164). Figure 1 illustrates the age-stratified prevalence of CAD, which increases steadily with age.

Table 2: Prevalence of Coronary Artery Disease by Gender

Gender	CAD Present (N, %)
Male	277 (36.7)
Female	164 (32.4)

Figure 1: Age-Stratified Prevalence of CAD

Figure 1: Distribution of CAD Prevalence Across Age Groups
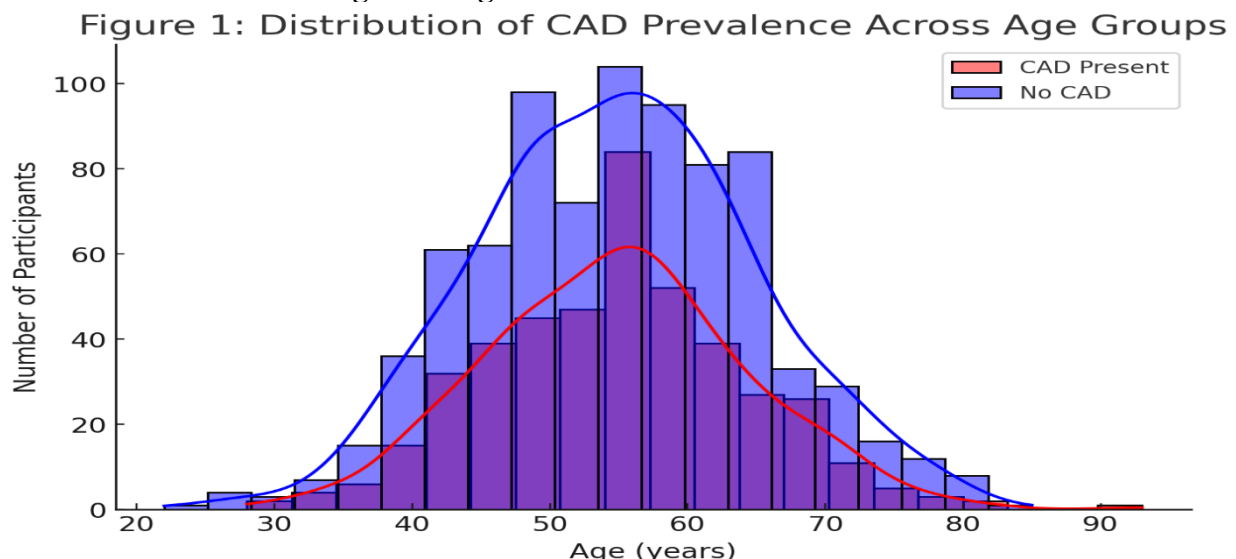
In a multivariate logistic regression analysis (Table 3), diabetes (adjusted OR 2.14, 95% CI: 1.67–2.75, $p < 0.001$), hypertension (adjusted OR 1.86, 95% CI: 1.46–2.38, $p < 0.001$), smoking (adjusted OR 1.52, 95% CI: 1.17–1.98, $p = 0.002$), and obesity (adjusted OR 1.42, 95% CI: 1.11–1.82, $p = 0.005$) were independently associated with a higher likelihood of CAD.

Table 3: Multivariate Logistic Regression Analysis of Risk Factors for CAD

Risk Factor	Adjusted OR (95% CI)	p-value
Diabetes	**2.14 (1.67–2.75)**	**<0.001**
Hypertension	**1.86 (1.46–2.38)**	**<0.001**
Smoking	**1.52 (1.17–1.98)**	**0.002**
Obesity	**1.42 (1.11–1.82)**	**0.005**

Regional differences in CAD prevalence were observed (Table 4), with urban centers reporting a prevalence of 37.2% (N=344) compared to 28.5% (N=97) in rural areas ($p = 0.007$).

Table 4: Regional Prevalence of CAD

Residence Type	CAD Present (N, %)	p-value
Urban	**344 (37.2)**	**0.007**
Rural	**97 (28.5)**	**0.007**

Gender differences in the severity of CAD were also evident. Men exhibited a higher prevalence of multi-vessel disease (15.3%, N=116) compared to women (10.7%, N=54). This gender-based distribution of single-vessel versus multi-vessel disease is shown in Table 5.

Table 5: Single-Vessel and Multi-Vessel Disease by Gender

Gender	Single-Vessel Disease (%)	Multi-Vessel Disease (%)	p-value
Male	21.2	15.3	0.024
Female	21.7	10.7	0.024

Dyslipidemia was significantly associated with CAD severity. The mean LDL cholesterol level was 139.2 ± 33.5 mg/dL in multi-vessel disease patients, compared to 128.7 ± 31.2 mg/dL in those with single-vessel involvement ($p = 0.013$). These findings are detailed in Table 6.

Table 6: LDL Cholesterol Levels in Single-Vessel vs. Multi-Vessel CAD

Severity	Mean LDL Cholesterol (mg/dL)	p-value
Single-Vessel	128.7 ± 31.2	0.013
Multi-Vessel	139.2 ± 33.5	0.013

Figure 2: LDL Cholesterol Levels by CAD Severity

LDL Cholesterol Levels by CAD Severity
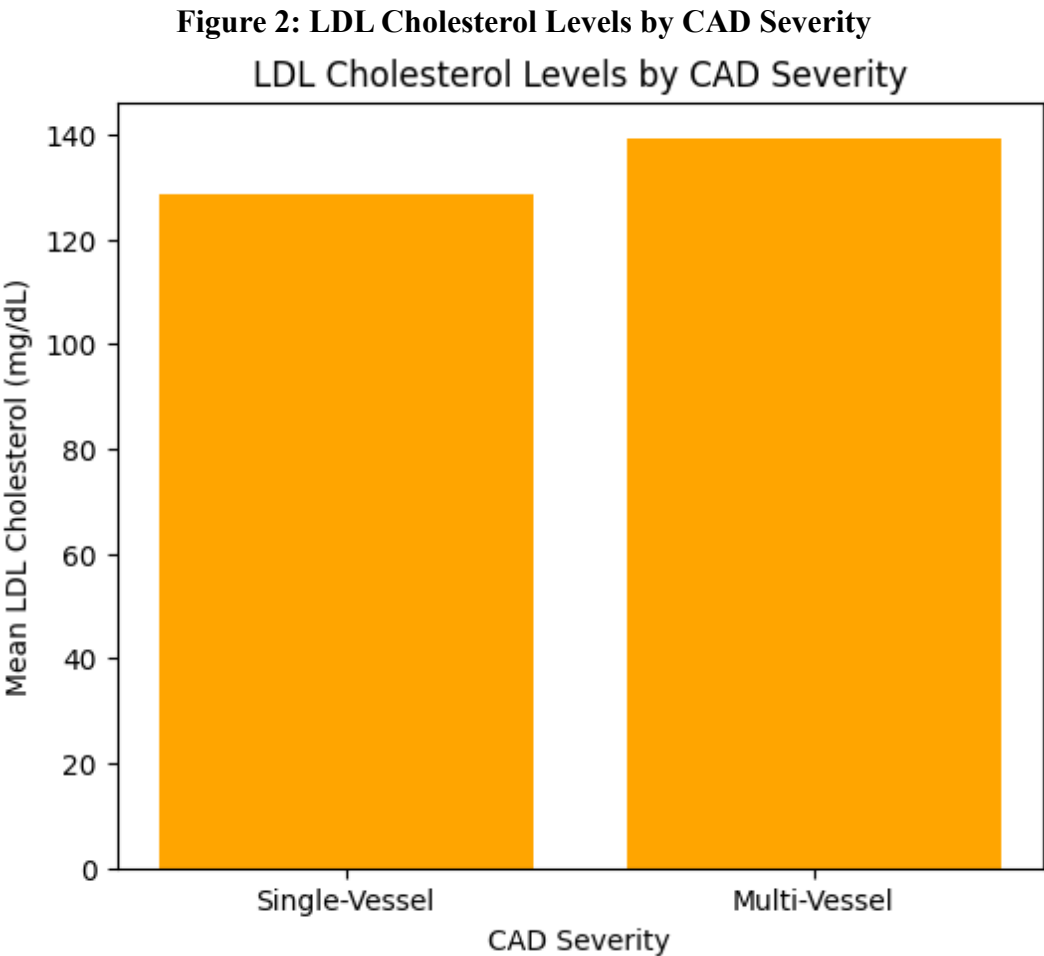
Late presentation for diagnostic evaluation was a prominent issue. Nearly half of the participants (47.3%, N=596) were evaluated only after experiencing symptoms for over six months. Delays were more pronounced in rural residents (53.9%, N=418) compared to urban residents (41.6%, N=178), as shown in Table 7.

Table 7: Diagnostic Delays by Residence Type

Residence Type	Delayed Evaluation (%)	p-value
Urban	41.6	0.007
Rural	53.9	0.007

DISCUSSION

The present study provides a comprehensive assessment of the prevalence and risk factors associated with coronary artery disease (CAD) in Pakistan through a multicenter cohort analysis. The findings indicate a significant burden of CAD, with an overall prevalence of 34.9%, highlighting the growing cardiovascular disease crisis in the region. Hypertension, diabetes, smoking, and obesity emerged as key independent risk factors, consistent with global and regional epidemiological patterns (4,7). The study further revealed substantial gender-based and regional disparities, with men and urban dwellers exhibiting higher CAD prevalence rates, underscoring the influence of lifestyle and environmental factors (5). Comparison with prior literature underscores the consistency of these findings with established global and regional studies. A similar prevalence rate was reported in a study conducted in Karachi, which found a CAD prevalence of 26.9%, though this was limited to a single-center urban cohort (8). The higher prevalence observed in the present study may be attributed to the inclusion of multiple centers across diverse geographical regions, allowing for a more representative sample. Previous investigations have also emphasized the role of hypertension and diabetes as predominant

risk factors for CAD in South Asian populations, with estimates suggesting nearly a twofold increase in CAD risk among individuals with these conditions (9,10). This aligns with the present study's multivariate regression analysis, which demonstrated an adjusted odds ratio (OR) of 2.14 for diabetes and 1.86 for hypertension, reinforcing their contribution to CAD pathogenesis. The impact of smoking on CAD risk remains well-documented, with meta-analyses confirming a strong dose-response relationship between tobacco use and atherosclerotic cardiovascular diseases (11,12). The current study's findings align with this, demonstrating a significant association between smoking and increased CAD prevalence (adjusted OR 1.52, p = 0.002). This is consistent with reports from the INTERHEART study, which identified smoking as a major modifiable risk factor for myocardial infarction across diverse populations (4). The present study further stratifies smoking-related risk across urban and rural settings, revealing higher smoking prevalence among urban males, likely due to greater accessibility and sociocultural acceptance of tobacco products in city environments (13). Obesity and dyslipidemia have long been established as contributors to cardiovascular risk. The findings in this study suggest that obesity (adjusted OR 1.42, p = 0.005) plays a critical role in CAD development, which is in line with studies indicating a direct correlation between increased body mass index (BMI) and atherogenesis (14). Notably, LDL cholesterol levels were significantly higher in patients with multi-vessel CAD (139.2 ± 33.5 mg/dL) compared to those with single-vessel involvement (128.7 ± 31.2 mg/dL), suggesting that dyslipidemia exacerbates disease severity (15). This is consistent with findings from a large-scale cohort study that linked elevated LDL cholesterol levels with a higher likelihood of multivessel coronary artery involvement (16). The gender disparities observed in the present study add to the growing body of evidence suggesting differential cardiovascular risk profiles between men and women. Prior research indicates that South Asian men have an inherently higher CAD burden than women, potentially due to metabolic and hormonal differences (17). However, emerging data suggest that postmenopausal women experience an accelerated rise in cardiovascular risk, driven by declining estrogen levels and increased visceral adiposity (18). The current study corroborates this, demonstrating that although men had a higher overall CAD prevalence (36.7%), women exhibited a comparable burden of single-vessel disease, necessitating gender-specific preventive strategies (19). From a clinical perspective, the findings of this study hold significant implications for CAD management and prevention strategies in Pakistan. The high prevalence of modifiable risk factors underscores the urgent need for targeted interventions, including community-based hypertension and diabetes screening programs, smoking cessation initiatives, and public health campaigns promoting lifestyle modifications (20). Additionally, the delayed diagnostic evaluation observed in nearly half of the study participants highlights the necessity of improving healthcare access, particularly in rural regions where late-stage presentations often result in poorer outcomes (21). Strengthening primary healthcare infrastructure and implementing systematic risk assessment tools can facilitate early detection and intervention, ultimately reducing CAD-related morbidity and mortality (22). Future research should focus on elucidating the genetic and epigenetic underpinnings of CAD in the Pakistani population, considering the strong familial clustering observed in this and previous studies (23). Furthermore, prospective cohort studies with longitudinal follow-up can provide deeper insights into disease progression and the efficacy of preventive interventions. Addressing disparities in CAD treatment modalities across socioeconomic strata is also warranted, as financial constraints may influence access to optimal pharmacological and interventional therapies (24).

Limitations

Limitations of this study include its observational design, which precludes causal inferences. Additionally, the reliance on hospital-based recruitment may introduce selection bias, potentially overestimating CAD prevalence compared to community-based studies. Although efforts were made to standardize data collection across centers, variations in diagnostic modalities and reporting criteria may have introduced measurement bias. Future studies employing population-based sampling and standardized diagnostic protocols will be instrumental in refining these findings and guiding public health initiatives (25).

CONCLUSION

This study highlights the significant burden of Coronary Artery Disease (CAD) in Pakistan, with a prevalence of 34.9%, and identifies hypertension, diabetes, smoking, and obesity as key risk factors. Urban residents and men exhibit higher CAD prevalence, while diagnostic delays, particularly in rural areas, contribute to poorer outcomes. Elevated LDL cholesterol levels were associated with increased disease severity. These findings emphasize the need for targeted public health initiatives, including hypertension and diabetes screening, smoking cessation programs, obesity management, and improved healthcare access, especially in underserved regions. Gender-specific prevention strategies should also be considered, as men had a higher burden of multi-vessel disease, while women exhibited comparable rates of single-vessel CAD. Strengthening primary healthcare infrastructure, raising awareness, and implementing early intervention programs can significantly reduce CAD-related morbidity and mortality. Future research should explore genetic predispositions and socio-environmental influences on CAD, while prospective cohort studies can help assess the long-term effectiveness of prevention and treatment strategies.

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