



Review Article

Comparative Analysis of Coronary Artery Disease in Young Adults: Insights from Southern India and Nigeria

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ABSTRACT

Coronary artery disease (CAD) is increasingly becoming common in individuals aged ≤ 40 years, particularly in low- and middle-income countries, due to increasing modifiable risk factors such as diabetes, hypertension, smoking, and dyslipidemia. However, limited data on angiographic patterns exist for this age group from underrepresented regions such as sub-Saharan Africa and southern India. A comparison of two recent studies from Kerala, India, and Nigeria provides perspective. The Indian study retrospectively compared 74 young adults with established CAD and identified 57.14% with Single Vessel Disease (SVD), most frequently of the left anterior descending (LAD) artery; diabetes and male sex were the prevailing risk factors. In Nigeria, 77.7% of patients younger than 40 years had normal coronary arteries, and the most frequent abnormality was single vessel disease (SVD). Vessel involvement was significantly associated with age ($p = 0.049$) which means the statistical finding from the Nigerian study indicating that the severity of coronary artery disease—measured by the number of vessels affected (normal coronaries, SVD, Double Vessel Disease (DVD), Triple Vessel Disease (TVD))—varied significantly across different age groups. These findings underscore the presence of premature CAD in both populations, with the need for region-specific early preventive and screening measures to reduce premature CAD burden.

Keywords: Coronary artery disease; Young adults; Modifiable risk factors; Angiographic pattern; Regional comparison.

Introduction

Coronary artery disease (CAD) is characterized by progressive atherosclerosis of the coronary arteries that, until recently, was clinically silent in most cases until the disease was well advanced. It describes a spectrum of clinical syndromes commonly termed coronary heart disease (CHD) or ischemic heart disease (IHD), including stable angina, silent myocardial ischaemia, and acute coronary syndrome (ACS), the latter consisting of myocardial infarction and unstable angina. [1–3]

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CAD is still the leading cause of death and disability-adjusted life years (DALYs) globally. In 2015, it accounted for 8.9 million deaths and 164 million DALYs, with the bulk of this burden falling on low- and middle-income countries, where survivors of myocardial infarction have much higher risks of recurrence and death.[4] There is impairment of the supply of oxygen to the myocardium from narrowing or occlusion of the coronary arteries due to atheromatous plaque accumulation, causing an imbalance between demand for and supply of oxygen. CAD was a rarity at the beginning of the 20th century, but its incidence increased steadily to a peak in the 1960s and it remains one of the leading causes of death in most parts of the world today.[5] The risk of CAD increases with advancing age because of age-related rises in systolic blood pressure.[6]

The aetiology of CAD encompasses both modifiable and nonmodifiable factors. Age, sex, family history, and genetic predisposition are the

nonmodifiable risks, while hypertension, smoking, dyslipidemia, obesity, and psychosocial stressors are major modifiable contributors.[7] Dietary changes, physical inactivity, and urbanized lifestyles have deteriorated IHD in high-income countries. Improved health care has delayed the onset of the disease in the United States, but smoking is still the number one cardiovascular risk factor, as noted by 15.5% of adults who smoked in 2016.[8] Men are generally more vulnerable to CAD than women. Dyslipidemia is one of the strongest determinants of CAD; elevated LDL levels increase the risk of CAD, whereas HDL has a protective effect on the development of CAD.

Tools for risk assessment, such as the American Heart Association's calculator, were developed to estimate the 10-year atherosclerotic cardiovascular disease risk. [9,10] Inflammatory markers, including high-sensitivity C-reactive protein (hs-CRP), predict CAD; however, the routine clinical use is still debated.[11] Another important factor is obesity, especially central obesity. Studies indicate that waist circumference is a better predictor of CAD risk than body mass index (BMI). Even patients with normal BMI but increased waist circumference showed an increased risk for CAD.[12] Central obesity was related to higher mortality even in patients with normal BMI, as shown in a large study involving more than 7,000 CAD patients.[13]

The global rise in the CAD burden is predominantly attributed to an increase in the rates of modifiable risk factors such as diabetes, hypertension, obesity, and smoking. However, most data come from an older demographic, and current knowledge about early-onset CAD among underrepresented populations in southern India and Africa remains limited. These populations from different parts of the world have differences in their genetics, socioeconomics, and environment-all potential drivers that may shape unique patterns of the disease. Recent angiographic studies in Kerala, India (West African Journal of Medicine, 2024; 41[3]:238–243), and Nigeria (Journal of the American Heart Association, 2022;11: e020244; DOI:10.1161/JAHA.120.020244) brought attention to the rapidly increasing burden of CAD in adults ≤ 40 years and present shared features but also regional variability in vessel involvement and severity, and in risk-factor distribution.

Taken together, these studies create a rare opportunity to directly compare early-onset CAD in two regional, genetically diverse populations. This review, therefore, synthesizes these findings to identify common and region-specific determinants of premature CAD, with implications for targeted prevention strategies and early detection programs tailored to young adults in low- and middle-income regions.

Methodology

This comparative analysis draws on two published studies related to the presentation of coronary artery disease in young adults from Kerala, India, and Nigeria. While both studies had a retrospective design, they differed in sample size, scope, and depth of analyses. Because of the limited number of eligible studies and their heterogeneity with respect to methodologies, a narrative comparative analysis has been adopted instead of a formal meta-analysis. In this approach, key clinical and epidemiological findings were systematically extracted, described, and juxtaposed for each study to identify meaningful patterns, contrasts, and contextual factors. Although there are essential differences between the two studies, their shared identical focus on age-stratified CAD characteristics, allows for a robust basis for such a structured and informative comparison.

This comparative analysis is based on two studies published using reasonably different methodological frameworks. Because the methodological differences are explicit, misleading interpretations have been avoided. The Indian study, carried out in Kerala, was fully approved by the institutional research and ethics committee, as cited by Ngabea et al. [16]; all data were anonymized to maintain confidentiality. This was a retrospective analytic study restricted to only angiographically confirmed cases of CAD among young adults. The adoption of an exclusive selection criterion of only angiographically positive cases resulted in a highly specific diagnosis. Data collection lasted for twelve months (June 2021–May 2022); in total, 74 patients aged ≤ 40 years with significant coronary lesions were found. Patients with normal or non-obstructive coronaries were excluded to include only clinically significant early-onset CAD. The following variables were measured: the number of vessels involved in the form of single-, double-, or triple-vessel disease; major risk factors comprising diabetes, hypertension, and smoking; sex distribution and the determination of the most frequently involved artery.

The Nigerian study, as presented by Isezuo et al. [17], also received appropriate ethical clearance from institutional ethics review committees and followed principles of informed consent and confidentiality. It had retrospective cross-sectional design. The Nigerian study retrospectively reviewed 1072 coronary artery disease patients, out of which 385(35.9%) patients had coronary angiography and percutaneous coronary intervention (PCI) done. Patients who were diagnosed with acute coronary syndrome according to standard clinical criteria (4) across multiple tertiary health care centres in Nigeria were represented in this dataset. Acute coronary

syndrome cases were identified using a combination of clinical assessment, non-invasive testing, and angiographic findings (4). One hundred and thirty-six (136) out of the total one thousand and seventy-two (1072) patients recruited were less than 40 years of age. Forty-two (42) representing 30.9% of young patients less than 40 years had coronary angiography done out of 77.7% showed normal coronary arteries. These relatively comparable number of young patients (74 VS 136) in the Indian and Nigerian studies respectively allows for direct comparability between the two cohorts.

The Nigerian study stratified the participants into different age groups (<39 years, 40-49 years, and ≥ 50 years) for the analytical purpose of observing age-related patterns of CAD severity. Metrics included the number of vessels involved, the distribution of normal versus abnormal coronary findings, and the relationship between age and disease burden. This wider inclusion strategy allowed the detection of general population-level trends but at the cost of heterogeneity in diagnostic certainty, which needs to be interpreted more cautiously in comparison with the angiographically confirmed Indian cohort.

In the light of these methodological differences, especially the fact that one study focused on confirmed angiographic CAD while the other utilized mixed diagnostic criteria, the comparative findings are interpreted descriptively rather than inferentially. These differences do not however invalidate the utility of comparing patterns but relatively limit the strength of conclusions regarding prevalence or true angiographic disease burden. This clarification enhances methodological transparency and ensures that interpretations derived from the comparison remain scientifically valid.

Statistical Analysis

This comparative analysis used data from two retrospective observational studies conducted in Kerala, India, and Nigeria to assess demographic characteristics, risk factors, and angiographic patterns of CAD in adults aged ≤ 40 years. Data from the two studies were summarized using descriptive statistics in the form of frequencies and percentages for categorical variables (sex, diabetes, hypertension, smoking, and pattern of vessel involvement). Age was summarized as mean and standard deviation.

Inferential analysis in the Nigerian study tested the association between age category and extent of coronary involvement with a statistical test of association, using the Chi-square test, and significance set at $p < 0.05$. A significant association was found with $p = 0.049$. Fisher's exact test was used in places where the cell count

was small. Since the Indian study included only cases with angiographically confirmed CAD, comparisons in this study were performed on the basis of proportional differences, rather than pooled statistical testing.

Key Findings

This section undertakes a systematic, theme-based comparison of CAD in young adults (≤ 40 years) in two separate but independent studies: one from Kerala, India, and the other from a Nigerian multi-institutional cohort. Differences in design and diagnosis limit direct equivalence, while the thematic approach highlights demographic, clinical, and angiographic patterns across both populations.

Demographic Characteristics and Gender Distribution

There was a strong male predominance in the Kerala cohort, with 62 males and 12 females (83.8%), thus indicating that male sex is a major determinant of premature CAD. The mean age was 36.38 ± 3.99 years. Nigerian study also had a large proportion of males (62.8%) with coronary artery disease in the under-40 subgroup. There were traditional risk factors as well as non-conventional risk factors for coronary artery identified however hypertension was the predominant risk factor and not diabetes

Distribution of Cardiovascular Risk Factors

India (Kerala): The predominant risk factor was diabetes mellitus. 29.3% of young CAD patients, had diabetes whereas Hypertension and smoking were present in 12.3% and 7.8% of Study participants respectively.

Nigeria: Prevalence of traditional risk factors, quantification of Diabetes, Hypertension, Smoking, and Dyslipidemia were 16.2%, 42.3%, 5.6% and 11.9% respectively for general study participants but these were not calculated specifically for the under-40years subgroup. Lack of this level of granularity reduces the precision of the comparison of risk profiles across regions.

Prevalence of Normal versus Abnormal Coronary Arteries

A major point of divergence between the two studies concerns this inclusion criteria:

- Kerala: All the 74 patients had angiographically confirmed CAD; hence, 0% had normal coronary arteries.

- Nigeria: Conversely, 77.7% of patients <40 years who underwent coronary angiography had normal coronary arteries suggesting a less severity of coronary artery disease and later onset of disease in Nigerian Patients.

Table 2 shows a comparison of angiographic patterns of coronary artery disease in young Adults(<40yrs) between the two studies.

Table 2. Angiographic Vessel Involvement and Disease Patterns

	Southern India (Kerala)	Nigeria (RACE-Nigeria)
Population Studied	74 patients ≤40 years with confirmed CAD	136 patients <40 years from 1,072 patients enrolled with acute coronary syndrome
Prevalence of Single Vessel Disease	57.14%	16.2%
Prevalence of Normal Coronary Arteries	Not reported (all had documented CAD)	77.7% under 40yrs had normal coronary arteries
Most Commonly Involved Artery	Left Anterior Descending (LAD) artery	Left anterior descending Artery
Gender Distribution	Predominantly male	Predominantly Male
Common Risk Factors	Diabetes mellitus, smoking More aggressive	Hypertension, dyslipidemia
Stage of Disease at Diagnosis	(angiographically confirmed, often SVD or higher)	Often mild or preclinical CAD
Association with Age	Not specified	Vessel involvement strongly associated with age (p = 0.049)

Single-, Double-, and Triple-Vessel Disease

Both investigations showed that SVD was the most

common abnormality in young adults, though the magnitudes were different:

Kerala: SVD: 57.14% DVD: 31% TVD: 11.86%
Nigeria: SVD was the most frequent abnormal finding in the under-40 group.

The TVD was rare in young adults and increased significantly with age, peaking in the 60–79 years subgroup. Normal Artery Findings As noted, Kerala reported 0% normal coronaries due to inclusion criteria, whereas Nigeria reported 77.7% normal coronaries in individuals <40 years (p = 0.198, not statistically significant across age groups).

Arteries Most Commonly Affected: The Kerala study showed the most frequently involved vessel to be the (Left Anterior Descending artery) LAD artery, followed by the (Right Coronary Artery) RCA and (Left Circumflex artery) LCX. The least affected was the posterolateral artery (PLB). In Nigeria Study, left anterior descending artery was most frequently affected followed by Left circumflex artery whereas the posterior descending artery was the least affected. The Nigerian study found that age and number of diseased vessels were significantly related (p = 0.049). The Kerala study did not present age-related correlations for the group ≤40 years.

Discussion

Comparative Views on Coronary Artery Disease in Young Adults: Cross-Regional Comparison

CAD is no longer exclusive to the elderly but is now a rising problem among young adults.^[18] Two recent articles from Indian and Nigerian research provide comparative pictures of CAD presentation in young patients, with shared and differing features. [16,17] This new pattern of premature CAD in young adults is both clinically important and of public health importance, as it affects individuals in their most productive years, thereby contributing to the high socioeconomic cost of the disease. Differences in angiographic profiles and risk factor distributions among regions, as observed in Indian and Nigerian studies, are indicative of the role played by genetic predispositions, lifestyle changes, and access to health care in shaping disease patterns. In South India, for example, premature and more severe CAD has been attributed to the presence of a cluster of genetic risk factors, such as high lipoprotein(a), along with a high prevalence of diabetes, smoking, and dietary habits with high consumption of refined carbohydrates. [16,17] Conversely, in Nigeria, although CAD appears to be less severe at presentation, increasing urbanization, sedentary lifestyles, and clustering of

modifiable risk factors presage a future epidemic of disease severity in the coming decades. [19] These findings underscore the urgency of region-specific preventive interventions aimed at both nonmodifiable and modifiable determinants of premature CAD.

Disease Severity and Diagnostic Inclusion Criteria CAD is no longer only common among elderly individuals but is now increasingly common in young adults. [18] Two current Indian and Nigerian studies are helpful in providing comparative pictures of CAD presentation among young patients, with concomitant and contrasting characteristics. [16,17]

a high incidence of diabetes, and carbohydrate-rich diets. Conversely, while CAD is less severe at presentation in Nigeria, urbanization, physical inactivity, and co-clustering of modifiable risk factors project an anticipatable future increase in disease severity within the next few decades. These findings underscore the need for region-specific preventive measures that target nonmodifiable and modifiable determinants of premature CAD.

The two articles agreed that young adults typically present with less severe CAD. [16,17] However, the Indian population had higher rates of severe angiographically confirmed CAD, which may have been partly because the inclusion criteria

Table 1: Comparison of clinical and angiographic characteristics of young people(<40years) in the two studies

Parameter	India (Kerala Study)	Nigeria (RACE Nigeria Study)
Study Population	74 patients ≤40 years with angiographically confirmed CAD	136 patients in Subgroup <40 years from a larger cohort (1,072 patients)
Single Vessel Disease (SVD)	57.14%	16.2%
Double Vessel Disease (DVD)	31%	6.1%
Triple Vessel Disease (TVD)	11.86%	Rare in <40 group; highest in 60–79 age group
Normal Coronary Arteries	0% (only patients with documented CAD were included)	77.7% of <40 group had normal coronaries (not statistically significant, p=0.198)
Most Commonly Affected Artery	Left Anterior Descending (LAD)	Left anterior descending artery
Next Most Affected Arteries	Right Coronary Artery (RCA), then Left Circumflex (LCX)	Left Circumflex Artery
Least Affected Artery	Right Posterior Left Branch (PLB)	Posterior descending Artery
Age and Vessel Involvement Correlation	Not reported	Significant correlation between age and vessel involvement (p = 0.049)
Pattern of Disease	Focal, early-stage atherosclerosis in young adults	Milder disease, often normal findings in young adults

This emerging trend of premature CAD in young adults has significant public health and clinical consequences because it affects people in their productive years, thereby increasing the socioeconomic burden of disease. Regional heterogeneity in angiographic patterns and risk factor distributions, as observed in Indian and Nigerian studies, implies that genetic predispositions, lifestyle modifications, and access to health care all play complex roles in determining disease patterns. In South India, for example, increased severity and premature development of CAD have been linked to a synergistic combination of genetic risk factors, such as elevated levels of lipoprotein(a), as well as extensive use of tobacco,

were restricted to only those patients with proven disease. [18] Conversely, the Nigerian study included a more extensive range of diagnoses, ranging from normal to abnormal coronary findings. This contrast in methodology revealed that most Nigerian young adults under the age of 40 years possessed normal coronary anatomy, an indication of a previous stage of disease evolution among this population relative to Indians. Comparisons such as these demonstrate how study design and the local environment can influence reported CAD severity, strengthening the need for standard techniques in cross-regional studies and for interventions targeted to local risk patterns.

Vessel Involvement Patterns

Findings from both studies lean towards single-vessel disease (SVD) as the most frequent coronary artery disease (CAD) presentation among young patients, in line with the global intuition that premature CAD presents with single vessel rather than diffuse multivessel involvement (Osadnik et al., 2018; Jariwala et al., 2022). This epidemiological observation is also pathophysiologic in the sense that it suggests staged atherosclerosis progression in younger patients. Initial endothelial dysfunction, driven by lifestyle-related clustering of risk factors such as dyslipidemia, smoking, and insulin resistance, may initially render individual vascular beds vulnerable to plaque deposition. SVD dominance highlights segments' vulnerability to inflammation and lipid infiltration, rendering plaques unstable even without systemic arterial disease. This finding adds clinical importance to the use of sensitive diagnostic tests for the detection of vessel-specific ischemic changes at a time when standard risk-prediction strategies may underestimate overall cardiovascular risk in such patients.

Indian analysis provides vital vessel-specific data, with evidence that the left anterior descending (LAD) artery is the most commonly involved vessel, which is consistent with global experience. [20,21] The predominance of the LAD to supply the anterior wall and interventricular septum makes early LAD involvement disproportionately vital, typically making it present clinically severely despite moderate angiographic disease. Mechanically, hemodynamic stress and shear forces within the LAD accelerate atherogenesis, increasing susceptibility to early plaque formation and rupture in young patients. This overlap of anatomical importance and pathophysiological vulnerability explains the increased morbidity of LAD-dominant SVD. These vessel-specific epidemiological and mechanistic observations in tandem augment global insight into premature CAD, with clinical and public health practice implications. More specifically, they advocate early intervention protocols and targeted diagnostic vigilance in high-risk young populations to prevent the onset of multivessel disease and reduce the long-term cardiovascular burden.

Risk Factor Profiling and Preventive Implications

Risk factor analysis remains central to understanding the trajectory and heterogeneity of CAD presentation in populations. [22] Both analyses support diabetes mellitus as a primary determinant of premature CAD, a finding in accordance with mechanistic data that have linked hyperglycemia, endothelial dysfunction, oxidative stress, and

augmented inflammatory signalling, each of which fosters atherogenesis. The Indian study provides a finer division of the risk profile, thereby highlighting not only the predominance of diabetes but also the synergistic impact of metabolic comorbidities and lifestyle determinants in enhancing cardiovascular vulnerability at a young age. In contrast, the Nigerian study identifies the independent prognostic value of age as a disease outcome predictor, a testament to its broader age range and to the likelihood that biological aging itself, with its cumulative effect on vascular stiffness, arterial remodelling, and subclinical inflammation, plays a role as a catalyst in disease progression.

This difference in emphasis between the two datasets underscores the multifactorial and context-dependent nature of CAD risk in young adults. Importantly, the Nigerian findings illustrate a potentially actionable window of opportunity for early intervention, wherein age-related susceptibility overlaps with modifiable risk factors, allowing preventive interventions to substantially delay disease onset or decrease severity. In combination with risk stratification of the Indian cohort, these findings highlight the necessity for regionally specific prevention strategies involving metabolic screening, lifestyle modification, and vascular health monitoring at earlier ages. These strategies can not only decrease the burden of premature CAD but also alter long-term cardiovascular trajectories in diverse populations.

Regional and Ethnic Impacts on CAD Representations

An interesting bifurcation at both the ethnic and regional levels is apparent in the epidemiology of coronary artery disease. The high prevalence of angiographically normal coronaries observed among young Nigerians may reflect inherent genetic susceptibility, population-specific clustering of cardiovascular risk factors, or unique protective influences related to dietary, lifestyle, or behavioral patterns.²² Alternatively, this finding need not be purely biological; it can also be caused by differences in access to medical care, diagnostic thresholds, and the timing of coronary angiography, which influence the probability of detecting subclinical disease. This heterogeneity highlights the complex interplay of biological, environmental, and health-system determinants of cardiovascular outcomes. Cumulatively, these findings underscore the importance of precision medicine and the need for population-specific preventive and therapeutic strategies rather than extrapolating a homogeneous "one-size-fits-all" model to heterogeneous demographic and ethnic populations. [23]

Challenges

One of the greatest challenges in having a comparative overview of CAD in young adults in southern India and Nigeria is the disparity in healthcare facilities and diagnostic machinery between the two nations. While the Indian study was performed on angiographically diagnosed cases of CAD, most of Nigeria's health centres may not have routine access to advanced diagnostic modalities such as coronary angiography by virtue of which underdiagnosis or delayed presentation would ensue. Differences in study design, sample, and inclusion criteria between the two studies also restrict comparisons in direct findings. These discrepancies in methods could weaken the potential to recognize subtle but important epidemiological and clinical trends in disease patterns and risk factor distributions in young adults in both regions.

Future Directions

Future research must emphasize standardizing the methods of data collection and offering larger, more representative samples of young adults across different socioeconomic and geographic regions. Multicentre, prospective cohorts with standardized reporting and diagnostic criteria would enable better cross-regional comparisons and further elucidate the natural history of early-onset CAD in low- and middle-income countries. Furthermore, the integration of genomic, behavioural, and environmental data could provide more comprehensive insight into region-specific risk factors for premature CAD. Research could also assess the potential of prevention interventions and education programs aimed at modifiable risk factors such as smoking, diabetes, and dyslipidaemia at a young age.

Conclusion

CAD in young adults is an emerging public health concern in Nigeria and India. The Kerala study showed a higher incidence of angiographically confirmed CAD in individuals ≤ 40 years, with male sex and diabetes as the major risk factors. The Nigerian study found that a large proportion of young adults had either single-vessel disease or normal coronary arteries, though age significantly influenced the extent of vessel involvement ($p = 0.049$). These studies emphasise the imperative need for early detection and region-specific preventive strategies. Targeted screening and aggressive management of diabetes among young adults can lead to a reduction in premature CAD in southern India. In Nigeria, public health education and early lifestyle modifications will help prevent the accrual of cardiovascular risk factors before the development of structural

coronary damage. Collectively, both studies enrich the global understanding of premature CAD and emphasize the need for multicentric, large-scale investigations to clarify regional patterns and optimise preventive and therapeutic interventions.

Author Contribution Statement

Ngabea Murtala A, Kumar N.Prathap and Munir Hussein Y: Designed and conceptualized the research; conducted the investigations; analysed and interpreted the data; contributed kits, equipment, and data analysis tools; and wrote the text.

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List of Abbreviations: ACS- Acute coronary syndrome, BMI= Body mass index, CAD= Coronary artery disease, CHD= Coronary heart disease, DALY= Disability adjusted years, DVD= Dual vessel disease, HDL= High density lipoprotein, HS-CRP= High sensitive C-reactive protein, IHD= Ischemic heart disease, LAD= Left anterior descending artery, LCX= Left circumflex artery, PDA= Posterior descending artery, PLB= Posterolateral artery, RCA= Right coronary artery, TVD= Tripple vessel disease.

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