

Review Article

Regional differences in biochemical markers of coronary artery disease: insights from East, West, Central and North-East India

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Received: 09 September 2025

Revised: 08 November 2025

Accepted: 12 November 2025

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ABSTRACT

Coronary artery disease (CAD) continues to be a major cause of illness and death in India, showing clear regional differences shaped by lifestyle, dietary habits, and genetics. Although dyslipidemia is a key risk factor, few studies have compared biochemical profiles across multiple regions. This review (2014-2024) analyzed data from eighteen peer-reviewed studies covering West, Central, East, and North-East India. These included hospital-based cohorts of CAD, acute coronary syndrome (ACS), and acute myocardial infarction (AMI) patients, along with some community-based studies. The biochemical parameters evaluated were total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), fasting glucose, and HbA1c. Multivariate analysis of variance (MANOVA) assessed regional differences. A general pattern of atherogenic dyslipidemia was consistent nationwide, marked by high TC, LDL-C, and TG with low HDL-C. Central India reported extreme dyslipidemia among diabetic AMI patients, while Western India showed widespread lipid imbalance along with high hs-CRP and Lp(a) levels. Eastern India exhibited strong associations with metabolic syndrome and glycemic irregularities, particularly in urban populations. The North-East highlighted the combined influence of tobacco, alcohol, and high-salt diets on lipid and glucose profiles. MANOVA showed that TC differed significantly by region ($p=0.025$), while LDL-C, HDL-C, and TG patterns were relatively similar. Overall, CAD in India is characterized by low HDL-C, high LDL-C, and raised TG levels, but total cholesterol varies regionally. Targeted preventive measures and region-based lipid monitoring are essential to reduce CAD risk nationwide.

Keywords: Coronary artery disease, Dyslipidemia, Biochemical markers, Regional variation, India

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality in India, accounting for an estimated one-third of adult deaths and imposing a substantial socioeconomic burden.^{1,2} Over the past three decades, India has witnessed a disturbing epidemiological shift, with CAD prevalence rising not only in urban but also rural populations, and occurring at younger ages compared to Western nations. Dyslipidemia, particularly

elevated low-density lipoprotein cholesterol (LDL-C), reduced high-density lipoprotein cholesterol (HDL-C), and hypertriglyceridemia, is a well-established modifiable risk factor that plays a pivotal role in the pathogenesis of atherosclerosis (Expert Panel, 2013). Additional biochemical markers such as total cholesterol (TC), very-low-density lipoprotein cholesterol (VLDL-C), glycated haemoglobin (HbA1c), and fasting plasma glucose (FPG) serve both diagnostic and prognostic purposes in CAD management.²

India's diverse geography, culture, and dietary practices contribute to significant regional variation in the prevalence and biochemical profiles of CAD patients. Dietary habits, lifestyle factors, genetic predisposition, and socioeconomic conditions differ markedly between the eastern, western, central, and north-eastern states, potentially influencing lipid and glycemic patterns. For example, the fish- and rice-based diets of eastern India, the oil-rich cuisine of western states, and the high tobacco and alcohol consumption reported in several north-eastern states may differentially impact atherogenic risk.³⁻⁵ However, despite these variations, systematic region-wise comparative data remain scarce.

Several studies from 2014 to 2024 have investigated lipid and glycemic patterns in CAD and related conditions such as acute myocardial infarction (AMI), acute coronary syndrome (ACS), metabolic syndrome, and high Framingham risk scores across different Indian states. Findings from Gujarat, Maharashtra, Rajasthan, and Madhya Pradesh highlight a consistent pattern of elevated TC, LDL-C, and TG with reduced HDL-C among CAD patients, with diabetics showing more severe derangements.⁶⁻¹³ In the east, data from West Bengal, Jharkhand, and Odisha similarly reveal a high prevalence of dyslipidemia and glucose abnormalities, often clustering with obesity and hypertension.¹⁴⁻¹⁸ North-eastern states such as Assam, Manipur, Mizoram, and Tripura present an alarming scenario, with widespread low HDL-C, high TG, and coexisting high smoking and alcohol rates, leading to some of the highest projected future CVD risks in the country.^{3,4,19-21}

Given these observed differences, a region-wise synthesis of biochemical data could provide valuable insight into the underlying risk factor patterns and inform targeted public health interventions. The present review compiles and compares biochemical parameters — including LDL-C, HDL-C, VLDL-C, TC, TG, HbA1c, and FPG — reported in CAD-related studies from four broad Indian regions (East, West, Central, North-East) over the last decade (2014-2024). By identifying both commonalities and region-specific trends, this analysis aims to enhance understanding of CAD risk profiles and guide both clinical and preventive strategies tailored to India's diverse populations.

METHODS

The aim of this study was to review and compare biochemical markers of coronary artery disease across East, West, Central, and North-East India over the period 2014–2024. An extensive search of literature on biochemical research related to coronary artery disease (CAD) was conducted, focusing on publications on 2014 to 2024. Studies without full-text access were excluded. The collected data were systematically organized into specific categories and subcategories to facilitate analysis and retrieval. The datasets were examined to detect patterns and correlations, and interpretations were drawn accordingly. The review encompassed four regions of India — West, Central, East, and North-East — with appropriate statistical tools applied to derive the results.

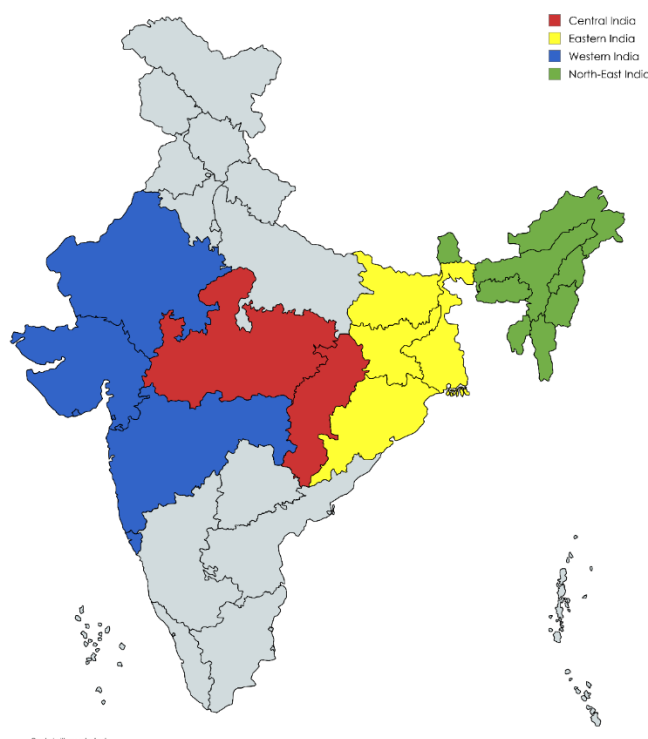


Figure 1: Map of India showing regions included in the study.

CENTRAL INDIA

Studies from Madhya Pradesh and Chhattisgarh consistently show atherogenic dyslipidemia in CAD, ACS, AMI, and high-risk T2DM patients. LDL-C values were persistently elevated, ranging from ~113 mg/dl in asymptomatic T2DM (Kumar et al) to 294 mg/dl in diabetic AMI.^{13,15} HDL-C remained low across cohorts, with the lowest level in diabetic AMI (27.6 mg/dl). TG levels varied from moderate elevations (~136–182 mg/dl) in most CAD groups to severe hypertriglyceridemia (>300 mg/dl) in diabetic AMI, while TC peaked at 274 mg/dl in diabetics with AMI. Glycemic markers (HbA1c 7.1–8.0%) indicated poor control, with higher HbA1c linked to worsened dyslipidemia.^{12,22} Novel insights included bilirubin's inverse association with CAD severity, suggesting an antioxidant role.²⁵ Additional studies demonstrated heightened cardiac injury and oxidative stress in diabetic AMI, confirming severe biochemical derangements compared to non-diabetics.¹³

EASTERN INDIA

Studies from West Bengal, Jharkhand, and Odisha reveal a consistently adverse cardiometabolic profile across AMI patients and high-risk community groups. In West Bengal, AMI cohorts showed elevated TC (>228 mg/dl), LDL-C (>152 mg/dl), and TG (>212 mg/dl) with low HDL-C, especially in diabetics, where poor glycemic control (FBS >160 mg/dl) aggravated dyslipidemia.^{14,15} Jharkhand data highlighted a 43% prevalence of metabolic syndrome among health professionals, with ~50% hypercholesterolemia and >40% low HDL-C despite presumed awareness.¹⁶ Odisha studies reported widespread dyslipidemia (low HDL-C in ~50%, high LDL-C in ~50%), central obesity (>40%), and clustering of obesity (62.6%), diabetes (38.8%), and hypertension (28.3%), even in younger adults.^{17,18} East India is characterized by low HDL-C, high LDL-C, raised TC/TG, and poor glycemic regulation, underscoring the role of lifestyle transitions. Integrated lipid-glucose monitoring and early preventive strategies are urgently needed.

Table 1: Biochemical findings summary table from Central India.

Reference no.	N	TC (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	TG (mg/dl)	VLDL-C (mg/dl)	HbA1c (%)	Other markers
16	100	206.8±42.7	132.5±39.6	35.8±6.4	168.2±59.1	~33.6	NR	FBS 122.5±28.4 mg/dl
22	150	214.5±45.2	139.2±41.5	34.9±6.2	182.3±66.4	~36.5	NR	FBS 128.6±31.7 mg/dl
21	120	202.4±44.1	129.7±38.4	36.1±6.8	174.2±62.5	~34.8	7.12±1.5 (58% ≥6.5%)	FBS 124.3±30.2 mg/dl; PPBS 181.7±48.5 mg/dl
23	160	NR	NR	NR	NR	NR	NR	Bilirubin: TC 0.92 vs 1.19 mg/dl in controls (p<0.001), Direct 0.25 vs 0.51, Indirect 0.67 vs 0.85; Dyslipidemia 62.25% vs 41.25%
11	90	223.3±67.0	112.9±28.0	46.2±7.2	136.0±54.1	~27.2	7.96±1.02	FBS 158.9±43.7 mg/dl; PPBS 239.0±45.4 mg/dl; Non-HDL-C 175.1±66.6 mg/dl
12	300	274.65±21.2 (D-AMI), 238.34±16.5 (N-AMI)	294.32±24.4 (D-AMI), 249.32±32.1 (N-AMI)	27.65±4.21 (D-AMI), 31.54±5.32 (N-AMI)	306.32±54.4 (D-AMI), 232.21±20.1 (N-AMI)	~61.3 (D-AMI)	7.39±2.54 (D-AMI)	Cardiac markers: Troponin-I 3.35 ng/mL; CK-MB 244 IU/L; LDH 1008 IU/L; CRP 7.94 mg/L; Oxidative stress: ↑MDA, ↓SOD, ↓GSH

Table 2: Biochemical findings summary table from Eastern India.

Reference no.	N	TC (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	TG (mg/dl)	VLDL-C (mg/dl)	HbA1c / FBS	Other markers / notes
13	100	205.2±32.1	136.4±24.7	34.3±6.9	170.5±45.3	~34.1	FBS 128.6±35.4	Males: ↑TG, ↓HDL; Elderly: ↑LDL
14	120	228.2±30.7 (DM), 206.7±26.5 (non-DM)	152.6±27.8 (DM), 138.9±23.4 (non-DM)	32.1±5.7 (DM), 36.8±6.1 (non-DM)	212.5±46.2 (DM), 186.3±38.4 (non-DM)	NR	FBS 169.3±41.8 (DM), 104.5±15.7 (non-DM)	Diabetics had significantly worse lipid profile
15	100	~50% >200	NR	>40% low HDL	NR	NR	NR	Metabolic syndrome: 43%; Obesity: 30%
16	350	M: 54.4% high LDL, 49.7% low HDL; F: 49.3% high LDL, 59.6% central obesity	NR	NR	44.2% TG >150 (M)	NR	High FBS ↑ after age 45	Central obesity: M 43.5%, F 59.6%
17	67	NR	NR	NR	NR	NR	38.8% diabetes, HbA1c NR	TC/HDL ratio ↑ in 38.8%; Obesity 62.6%

Table 3: Biochemical findings summary table from Western India.

Reference no.	N	TC (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	TG (mg/dl)	VLDL-C (mg/dl)	HbA1c (%)	Other markers
6	100	176.24±45.83	113.68±41.24	37.52±7.54	138.77±63.35	~27.75	NR	Lp(a) >30 mg/dl (40%); hs-CRP >3 mg/l (34%)
7	250	190.3±42.6	121.8±36.5	38.2±7.2	145.4±68.3	~29.1	6.92±1.8 (46% >6.5%)	Lp(a) >30 mg/dl (28%); hs-CRP >3 mg/L (37%); Homocysteine >15 µmol/l (25%)
8	120	212.6±47.2	138.3±42.5	36.4±6.5	178.4±71.9	~35.7	NR	NR
9	150	198.2±46.1	124.5±39.8	37.8±7.1	172.6±64.5	~34.5	7.3±1.6 (62% >6.5%)	FBS 126.7±34.8 mg/dl; PPBS 182.3±51.4 mg/dl
10	200+	% Abnormal: TC 36.5% (M), 4.5% (F)	LDL-C 30.5% (M), 2.5% (F)	Low HDL-C 36% (M), 4% (F)	TG 46.5% (M), 6.5% (F)	NR	NR	Family screening data available
1	NR	Dyslipidemia 74%	LDL-C >100 mg/dl common	HDL-C <35 mg/dl common	TG >150 mg/dl frequent	NR	NR	Lp(a) elevated in 3/10 tested

Table 4: Biochemical findings summary table from North-East India.

Reference No.	N	TC (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	TG (mg/dl)	VLDL-C (mg/dl)	HbA1c/ FBS	Other markers/notes
3	100	~206	~135	<40 in 62% (mean ~38)	~172	Elevated in 48%	NR	↑ prevalence in men; low HDL in both sexes
4	80	205 ± 34	133 ± 28	36 ± 7; <40 in 68%	178 ± 42	NR	~32% DM, ~45% HTN	STEMI had ↑TG, ↓HDL
5	50 cases / 50 controls	↑ vs control	↑ vs control	↓ vs control	↑ vs control	NR	NR	LDL/HDL, TC/HDL ratios markedly higher in AMI
18	50	NR	NR	Low in both sexes	NR	NR	FPG: 117.9 (M), 100.5 (F)	High smoking (60%), alcohol (50%)
19	1812	NR	NR	Low HDL common in Mizoram males	High TG common	NR	NR	Framingham risk: overweight + low HDL + high BP highest risk
20	290	NR	NR	NR	NR	NR	FBS: 55.9% diabetes	19.7% high CVD risk; 96% smoking/alcohol

Table 5: Statistical analysis of regional biochemical data.

Tests of between-subjects effects						
Source	Dependent variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	LDL_C	7973.748 ^a	3	2657.916	1.836	.194
	HDL_C	11.013 ^b	3	3.671	.222	.879
	TG	4595.735 ^c	3	1531.912	1.104	.385
	TC	3332.366 ^d	3	1110.789	4.475	.025
Intercept	LDL_C	313321.354	1	313321.354	216.440	.000
	HDL_C	17105.642	1	17105.642	1034.411	.000
	TG	462429.782	1	462429.782	333.310	.000
	TC	631216.503	1	631216.503	2542.739	.000
Region	LDL_C	7973.748	3	2657.916	1.836	.194
	HDL_C	11.013	3	3.671	.222	.879
	TG	4595.735	3	1531.912	1.104	.385
	TC	3332.366	3	1110.789	4.475	.025
Error	LDL_C	17371.362	12	1447.613		
	HDL_C	198.439	12	16.537		
	TG	16648.651	12	1387.388		
	TC	2978.913	12	248.243		
Total	LDL_C	360939.392	16			
	HDL_C	20604.863	16			
	TG	536165.442	16			
	TC	725987.793	16			
Corrected total	LDL_C	25345.109	15			
	HDL_C	209.452	15			
	TG	21244.386	15			
	TC	6311.279	15			

a. R Squared=.315 (Adjusted R Squared=0.143); b. R Squared=0.053 (Adjusted R Squared=-0.184); c. R Squared=0.216 (Adjusted R Squared=0.020); d. R Squared=0.528 (Adjusted R Squared=0.410).

WESTERN INDIA

Six studies from Gujarat, Maharashtra, and Rajasthan consistently report a high burden of dyslipidemia in CAD and ACS patients. LDL-C levels were universally elevated (~113 mg/dl in young ACS to ~138 mg/dl in CAD cohorts), with most values above therapeutic cut-offs. HDL-C remained low (36–38 mg/dl), while TC ranged from ~176 mg/dl in younger patients to >212 mg/dl in older CAD groups. TG levels were frequently raised (>150 mg/dl), peaking around 172–178 mg/dl in Maharashtra and Rajasthan, with VLDL-C (~28–36 mg/dl) reflecting similar trends. Recent studies highlighted poor glycemic control, with 46–62% of patients having diabetic-range HbA1c, which correlated with adverse lipid profiles.^{6,9} Gujarat cohorts also documented elevated Lp(a) and hs-CRP, underscoring genetic and inflammatory risk. Rajasthan studies, particularly in younger CAD patients, revealed high prevalence of abnormal LDL-C, hypertriglyceridemia, and low HDL-C, with strong male predominance. Overall, West India demonstrates a consistent pattern of atherogenic dyslipidemia, compounded by poor glycemic control and emerging inflammatory and genetic markers, calling for integrated lipid–glucose risk management.

NORTH-EASTERN INDIA

Studies from Assam, Manipur, Mizoram, and Tripura consistently highlight widespread atherogenic dyslipidemia and modifiable cardiovascular risks. ACS and AMI cohorts reported mean TC ~205 mg/dl, LDL-C ~133–135 mg/dl, TG ~172–178 mg/dl, and persistently low HDL-C (~36 mg/dl), with >60% of patients below optimal HDL thresholds.^{3,4} In Manipur, AMI patients showed significantly higher TC, LDL-C, and TG with lower HDL-C compared to controls, while the Ukhrul district survey revealed central obesity, raised glucose, low HDL, and high prevalence of smoking and alcohol use.¹⁹ Community-based studies in Mizoram and Tripura applied the Framingham risk score. Mizoram males with overweight, low HDL, and hypertension were at highest risk, whereas in Tripura nearly 20% of adults had >20% 10-year CVD risk, strongly driven by tobacco use (96%), obesity (65%), hypertension (56%), and diabetes (56%). The North-East exhibits a dual burden of dyslipidemia and lifestyle-related risks, with tobacco and alcohol use amplifying cardiovascular vulnerability.^{20,21}

STATISTICAL ANALYSIS OF REGIONAL BIOCHEMICAL DATA

The multivariate analysis revealed that among the lipid parameters assessed, only total cholesterol (TC) demonstrated significant regional variation across East, West, Central, and North-East India. In contrast, LDL-C, HDL-C, and triglycerides showed no statistically significant differences, indicating relatively uniform patterns nationwide. The distinct variability in TC suggests its greater sensitivity to region-specific

determinants such as dietary practices, lifestyle habits, and cultural factors. For instance, populations with higher intake of saturated fats, processed foods, or reduced physical activity may exhibit elevated TC, even when other lipid fractions remain comparable. These findings imply that while dyslipidemia is a shared feature of CAD across India, regional distinctions are most strongly reflected in total cholesterol levels, underscoring the influence of localized environmental and lifestyle factors on cardiovascular risk.

DISCUSSION

The present review and comparative analysis of studies from East, West, Central, and North-East India demonstrates a consistent biochemical profile of atherogenic dyslipidemia among patients with coronary artery disease (CAD), acute coronary syndrome (ACS), acute myocardial infarction (AMI), and high-risk diabetic populations. Elevated LDL-C, triglycerides, total cholesterol, and reduced HDL-C were observed uniformly across regions, with poor glycemic control further exacerbating these abnormalities, particularly in diabetic cohorts.^{13–16} Regional variations were evident. Western India reported classical lipid abnormalities along with novel risk markers such as Lp(a), hs-CRP, and homocysteine.^{6,7,9} Central India showed pronounced biochemical derangements in diabetic AMI patients, including markers of oxidative stress and myocardial injury.^{11,21,22} Eastern India highlighted the clustering of dyslipidemia, obesity, and hypertension in both clinical and community settings, reflecting lifestyle transitions.^{13,14,17} North-Eastern India exhibited a high prevalence of low HDL-C, compounded by high tobacco and alcohol use, with community-based projections confirming substantial 10-year cardiovascular risk.^{3,4,5,19} The multivariate analysis (MANOVA) indicated that while LDL-C, HDL-C, and triglycerides showed no significant regional variation, total cholesterol differed significantly, likely reflecting dietary, cultural, and lifestyle influences.

CONCLUSION

In conclusion, while dyslipidemia remains a common biochemical determinant of CAD nationwide, the severity, associated risk markers, and modifying factors vary across regions. These findings highlight the importance of region-specific preventive strategies, integrated lipid–glucose monitoring, and targeted public health interventions to effectively reduce the burden of CAD in India.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the Department of Zoology, University of Lucknow, for providing academic guidance and support throughout this work. Authors acknowledge the collaboration and technical inputs from King George Medical University,

Lucknow, which greatly enriched the study. Special thanks are due to colleagues and research fellows for their assistance in data collection and analysis. Authors also thank the libraries and digital repositories that facilitated access to essential literature. Finally, authors extend appreciation to all those who directly or indirectly contributed to the completion of this research.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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Cite this article as: Singh S, Sharma AK, Swaroop S. Regional differences in biochemical markers of coronary artery disease: insights from East, West, Central and North-East India. Int J Community Med Public Health 2025;12:5858-65.