Section: Pathology

Original Research Article

THE EMERGING BURDEN OF CARDIOMETABOLIC RISK: A LAB-BASED CROSS-SECTIONAL ANALYSIS OF DYSLIPIDEMIA AND GLYCEMIC DYSREGULATION IN THE WORKING- POPULATION (18–60 YEARS) OF UTTAR PRADESH

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ABSTRACT

Background: India is witnessing an alarming rise in sudden myocardial infarction (MI) among individuals in the productive age group. This paradox of early cardiovascular events is largely driven by occult glycaemic and dyslipidemic abnormalities that may remain undetected when assessment relies primarily on LDL cholesterol. Evidence exploring apolipoprotein based risk stratification in North Indian populations, particularly from Uttar Pradesh, is limited.

Materials and Methods: A retrospective, cross-sectional evaluation of laboratory records was performed for 583 adults aged 18-60 years who underwent fasting biochemical testing at multiple LPL diagnostic facilities across Uttar Pradesh. Glycaemic categorization used ADA HbA1c thresholds and WHO fasting plasma glucose criteria. Lipid assessment, based on LAI and CSI recommendations, included total cholesterol, triglycerides, directly measured LDL-C, HDL-C, non-HDL cholesterol, apolipoprotein B, apolipoprotein A1, and the ApoB/ApoA1 ratio. Cardiometabolic risk was defined as abnormal glycaemic status in combination with at least one atherogenic lipid abnormality. Statistical evaluation comprised trend analysis, group comparisons, and multivariable logistic regression.

Results: Dyslipidaemia increased across worsening glycaemic states and was present in 120 (62.2%) individuals with prediabetes and 103 (78.6%) with diabetes. HbA1c identified a broader spectrum of dysglycaemia than fasting glucose across all age groups; in the 51-60-year age group, HbA1c identified diabetes in 72 (40.4%) individuals compared with 48 (27.0%) by fasting glucose, and prediabetes was detected as early as 18-30 years in 18 (22.0%) individuals. Apolipoprotein profiling showed substantial LDL-C/ApoB discordance, with 129 (22.1%) participants having normal LDL-C but elevated ApoB, while 157 (26.9%) had concordant elevation of both markers. Cardiometabolic risk increased with age, reaching 112 (62.9%) in the 51-60-year age group, and was higher in males than in females, affecting 159 (52.0%) and 101 (36.5%) participants, respectively.

Conclusion: The findings indicate a considerable reservoir of concealed cardiometabolic risk among working age adults, providing a mechanistic substrate for premature and sudden MI. Apolipoprotein B demonstrates superior ability to capture atherogenic burden in dysglycaemic states compared with traditional lipid markers. Incorporation of HbA1c and ApoB into routine laboratory screening may facilitate earlier identification of high risk individuals and support effective primary prevention strategies.
Keywords: Cardiometabolic risk; dyslipidaemia; glycaemic dysregulation; HbA1c; fasting glucose; apolipoprotein B; ApoB/ApoA1 ratio; LDL-C; non-HDL cholesterol; prediabetes; diabetes mellitus; Uttar Pradesh; working-age population.

INTRODUCTION

In India, the rising burden of myocardial infarction reflects the increasing prevalence of cardiometabolic risk factors.Nationally representative data from the ICMR INDIAB study demonstrate a high prevalence of diabetes and prediabetes among adults, while the overall burden of cardiovascular disease, including coronary artery disease, has increased substantially over recent decades.[1,2] This trend highlights the need to better understand the interplay between metabolic abnormalities and cardiovascular risk in younger populations.

Metabolic syndrome (MetS) is a major contributor to the rising burden of noncommunicable diseases, particularly ASCVD and type 2 diabetes mellitus. It is characterized by a constellation of central obesity, hypertriglyceridemia, low high-density lipoprotein cholesterol (HDL-C), hyperglycemia, and hypertension, with diagnosis requiring at least three of these abnormalities as per established criteria.The underlying pathophysiology-including insulin resistance, adipose tissue dysfunction, and chronic low-grade inflammation-accelerates atherosclerosis and predisposes individuals to premature cardiovascular events.[3,4]

Traditionally considered diseases of older adults, dyslipidemia and glycemic disorders are increasingly affecting working-age populations. This shift is largely driven by urbanization, sedentary lifestyles, and dietary transitions.[5,6] In the Indian population, glycemic dysregulation often progresses rapidly from insulin resistance to overt diabetes.[1,2] Dyslipidemia in this context includes elevated low-density lipoprotein cholesterol (LDL-C), non-HDL cholesterol, triglycerides, and apolipoprotein B (ApoB), along with reduced HDL-C. While LDL-C remains the primary therapeutic target, ApoB provides an estimate of the total number of atherogenic particles and may offer additional clinical insight.[3,7]

Recent guidelines recommend a shift beyond traditional LDL-C-centric assessment toward a more comprehensive evaluation of atherogenic burden using non-HDL cholesterol, ApoB, and lipoprotein(a) [Lp(a)]. ApoB, in particular, reflects the total number of atherogenic lipoprotein particles, including verylow-density lipoprotein (VLDL), intermediate-density lipoprotein (IDL), and LDL, and is especially relevant in individuals with diabetes, obesity, or metabolic syndrome where discordance between LDL-C and particle number may occur.[7] Additionally, calculated and directly measured LDL-C values may differ in the presence of elevated triglycerides, further supporting the need for alternative markers.[8] Lipoprotein(a) has also emerged as an important cardiovascular risk modifier that identifies individuals with residual risk despite standard lipid control.[3]

Population-based data from the ICMR-INDIAB study underscore the extent of metabolic risk in India, reporting high prevalence rates of diabetes, prediabetes, obesity, and dyslipidemia.[2] The South Asian phenotype-characterized by increased visceral adiposity and insulin resistance even at lower body mass indices-further amplifies cardiometabolic risk at younger ages.[2] Early onset and accelerated progression of these disorders necessitate timely identification and intervention.

In Uttar Pradesh, socioeconomic disparities and limited access to healthcare services further compound the burden of early-onset metabolic disorders.[9] Despite the high disease burden, there is a relative paucity of region-specific laboratory-based data focusing on working-age adults.

Therefore, the present study aimed to: Determine the prevalence and patterns of dyslipidemia across glycemic categories (normoglycemia, prediabetes, and diabetes); Assess the relationship between ApoB and directly measured LDL-C in dysglycemia; Compare lipid and glycemic abnormalities across age and sex using WHO and ADA criteria and Estimate cardiometabolic risk defined as the coexistence of dyslipidemia and abnormal glycemic status.

MATERIALS AND METHODS

Study design and setting: This laboratory-based, retrospective cross-sectional study evaluated dysglycemia and dyslipidemia among adults aged 18-60 years in Uttar Pradesh, India. Fasting samples received between March 1 and March 20, 2026, at multiple Dr Lal PathLabs centers across Agra, Lucknow, Jhansi, Varanasi, and Saharanpur were included in the analysis.

Study population and sampling: Adults with available fasting glucose, lipid profile, and (where performed) HbA1c results were eligible. Hemolyzed,

lipemic, or pre-analytically compromised samples were excluded. A total of 583 participants met the inclusion criteria.

Data collection and laboratory methods: Age and sex were abstracted from requisition forms. Venous blood was collected after 8-12 hours of fasting and processed under standardized conditions on Roche and Beckman Coulter analyzers with routine internal quality control and external proficiency testing. Fasting glucose was measured using the hexokinase method; HbA1c by HPLC or immunoassay traceable to NGSP/DCCT standards; total cholesterol and triglycerides by enzymatic CHOD-PAP methods; HDL C and LDL C using direct homogeneous assays; non HDL C was calculated; and apolipoproteins A1 and B were measured via immunoturbidimetry.

Operational definitions: Glycaemic status was defined according to standard ADA and WHO guidelines, wherein normal status included fasting blood glucose (FBG) < 100 mg/dL and HbA1c < 5.7%; prediabetes was defined as FBG 100–125 mg/dL and HbA1c 5.7–6.4%; and diabetes was defined as FBG ≥ 126 mg/dL or HbA1c ≥ 6.5%.[10,11] Dyslipidaemia was classified according to NCEP ATP III and LAI criteria, requiring the presence of at least one abnormality: total cholesterol ≥ 200 mg/dL, triglycerides ≥ 150 mg/dL, LDL C ≥ 100 mg/dL, HDL C < 40 mg/dL in men or < 50 mg/dL in women, or non HDL C > 130 mg/dL.[4,6,12] Apolipoprotein-based markers were categorized according to contemporary dyslipidaemia guidance,[13] with high ApoB defined as >90 mg/dL and elevated ApoB/A1 ratio as >0.98 for risk groups. Cardiometabolic risk was defined as the coexistence of dyslipidaemia,[4,12,13] and abnormal glycaemic status.[10,11]

Statistical analysis: Statistical analyses were performed using IBM SPSS Statistics (version 28). Descriptive statistics were used to summarize continuous variables as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Categorical variables were compared using the chi-square test (or Fisher's exact test when expected cell counts were small). For ordered categories (e.g., age groups and glycemic categories), trend across categories was assessed using the Cochran-Armitage chi-square test for trend. Continuous variables were compared using independent t-tests or one-way ANOVA for normally distributed data; normality and homogeneity of variances were assessed, and non-parametric alternatives (MannWhitney U/Kruskal-Wallis) were used where appropriate. Correlations between lipid parameters and glycemic measures were evaluated using Pearson or Spearman correlation coefficients, depending on distribution. Agreement in dysglycemia classification between HbA1c and fasting glucose (paired data) was assessed using McNemar's test. Multivariable logistic regression models were constructed to identify independent predictors of dyslipidemia and cardiometabolic risk, adjusting for age, sex, and glycemic status, and are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Participant characteristics: A total of 583 participants were included in the study, comprising 306 (52.5%) males and 277 (47.5%) females. The largest proportion of participants belonged to the 51-60-year age group, contributing 178 (30.5%) of the total study population, followed by the 41-50-year age group with 170 (29.2%). Age distribution did not differ significantly between males and females (χ^2 = 3.74, p = 0.29; chi-square test) [Figure 1]

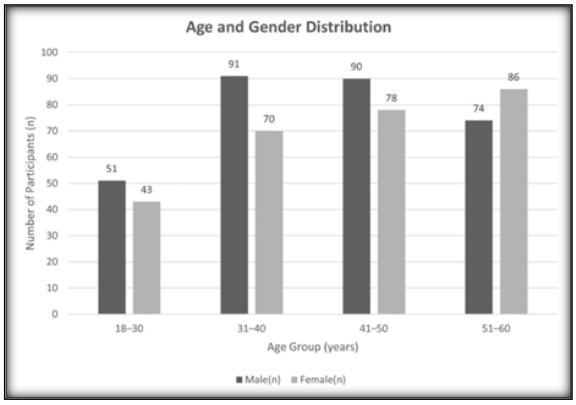

Figure 1: Age- and sex-wise distribution of the study population (chisquare test: χ^2 = 3.74, df = 3, p = 0.29).

Glycemic categories: Glycemic status was assessed using both ADA HbA1c and WHO fasting glucose criteria. In the 18-30-year group, most individuals had normal HbA1c, with minimal diabetes 1 (1.2%). Diabetes increased with age, particularly in males, peaking at 38 (47.5%) in males and 34 (34.7%) in females aged 51-60 years. [Figure 2]

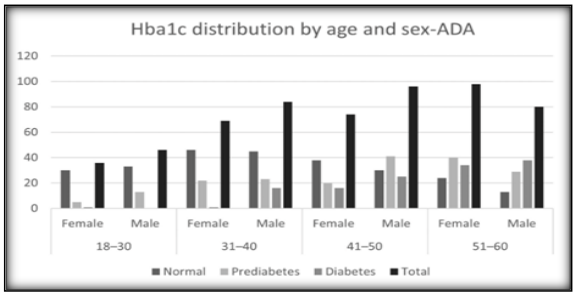

Figure 2: HbA1c distribution by age group and sex (ADA).

Mean HbA1c rose steadily and was higher in males, reaching 6.88 ± 1.59% vs 6.58 ± 1.53% in females. [Table 1]

Table 1: Mean HbA1c distribution by age group and sex (ADA).

Age group	Sex	Mean HbA1c (%)	Median (%)	SD
18–30	Female	5.37	5.30	0.64
	Male	5.46	5.40	0.35
31–40	Female	5.55	5.50	0.62
	Male	6.02	5.60	1.48
41–50	Female	6.14	5.60	1.40
	Male	6.56	5.90	1.79
51–60	Female	6.58	6.10	1.53
	Male	6.88	6.35	1.59

HbA1c detected greater dysglycemia than fasting glucose, identifying prediabetes in 18 (22.0%) individuals aged 18-30 years and diabetes in 72 (40.4%) individuals aged 51-60 years. WHO fasting glucose classification by age group is shown separately in Table 2, where diabetes reached 48 (27.0%) in the 51-60-year age group.

Table 2: Diabetes prevalence by age group (WHO fasting glucose criteria).

Age group (years)	Normal	Prediabetes	Diabetes	Total
18–30	79 (97.5%)	1 (1.2%)	1 (1.2%)	82
31–40	128 (83.7%)	11 (7.2%)	14 (9.2%)	153
41–50	119 (70.0%)	17 (10.0%)	34 (20.0%)	170
51–60	111 (62.4%)	19 (10.7%)	48 (27.0%)	178

The chi-square test showed that HbA1c identified significantly more dysglycemia than fasting glucose (χ^2 = 104.11, p < 0.001). Because the paired classification table is not shown, relative risk and odds-ratio estimates are not presented here.

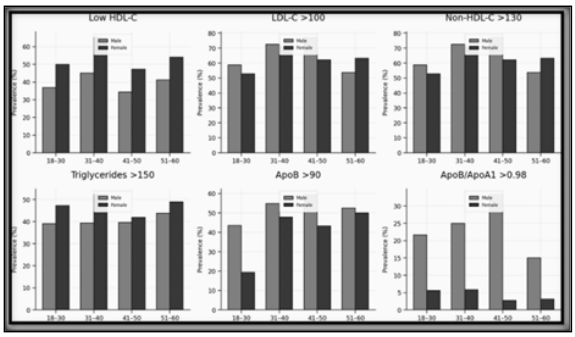

Figure 3: Age and sex wise trend of overall dyslipidemia prevalence across four age groups (18–30, 31–40, 41–50, and 51–60 years).

Dyslipidemia and association with glycemic status

While conventional lipid abnormalities such as elevated LDL C, non HDL C, and triglycerides were common across both sexes, apolipoprotein based markers (ApoB and particularly the ApoB/ApoA1 ratio) consistently identified higher atherogenic burden among males, with the greatest disparity observed in the 41-50 year age group. These findings suggest that apolipoprotein indices may improve discrimination of cardiometabolic risk beyond traditional lipid measures. In sex-wise logistic regression, any dyslipidemia was more common among males than females (OR 2.13, 95% CI 1.52–2.98). [Figure 3; Table 4]

Dyslipidemia prevalence increased across glycaemic categories: normoglycemia, 109 (42.1%); prediabetes, 120 (62.2%); and diabetes, 103 (78.6%), with a significant trend across groups (p < 0.001). [Figure 4]

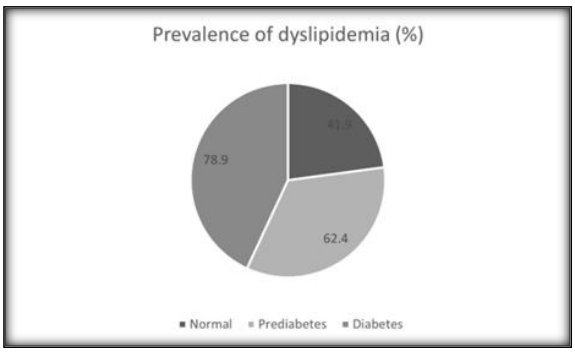

Figure 4: Overall dyslipidemia prevalence by glycemic status.

Individual lipid abnormalities-including LDL C ≥100 mg/dL, triglycerides ≥150 mg/dL, low HDL C, non HDL C >130 mg/dL, ApoB >90 mg/dL, and elevated ApoB/ApoA1 ratio-also showed significant stepwise increases from normoglycemia to diabetes. [Table 3]

Table 3: Overall dyslipidemia prevalence by glycemic status.

Lipid Parameter	Normoglycemia n (%) (n=259)	Prediabetes n (%) (n=193)	Diabetes n (%) (n=131)	χ^2 (trend)	p-value
Total Cholesterol ≥200 mg/dL	51 (19.7%)	47 (24.4%)	50 (38.2%)	18.7	<0.001
Triglycerides ≥150 mg/dL	55 (21.2%)	57 (29.5%)	61 (46.6%)	26.4	<0.001
LDL-C ≥100 mg/dL	90 (34.7%)	96 (49.7%)	89 (67.9%)	42.9	<0.001
Low HDL-C*	69 (26.7%)	63 (32.7%)	60 (45.6%)	17.2	<0.001

Non-HDL Cholesterol >130 mg/dL	59 (22.8%)	60 (31.2%)	64 (49.2%)	31.6	<0.001
Apolipoprotein B >90 mg/dL	62 (24.1%)	64 (33.1%)	69 (52.4%)	34.1	<0.001
ApoB/ApoA1 Ratio >0.98	32 (12.3%)	35 (18.3%)	46 (34.8%)	29.8	<0.001
Any dyslipidemia (≥1 abnormality)	109 (42.1%)	120 (62.2%)	103 (78.6%)	55.7	<0.001

Logistic regression showed that male sex, increasing age, prediabetes, and diabetes remained independent predictors of dyslipidemia. [Table 4,5]

Table 4: Sex-wise logistic regression for dyslipidemia (reference: female).

Lipid parameter	OR (male vs female)	95% CI	Interpretation
Total Cholesterol ≥200 mg/dL	1.37	0.95–1.98	Not statistically significant
Triglycerides ≥150 mg/dL	1.38	0.97–1.96	Borderline ↑ risk in males
LDL-C ≥100 mg/dL	1.72	1.24–2.39	Significantly higher in males
Low HDL-C*	1.11	0.79–1.56	No gender difference
Non-HDL Cholesterol >130 mg/dL	1.30	0.91–1.86	Not significant
Apolipoprotein B >90 mg/dL	1.20	0.85–1.71	Not significant
ApoB/ApoA1 Ratio >0.98	1.42	0.94–2.15	Borderline ↑ risk in males
Any dyslipidemia (≥1 abnormality)	2.13	1.52–2.98	~2-fold higher risk in males

Table 5: Adjusted logistic regression (outcome: any dyslipidemia).

Predictor	Adjusted OR (95% CI)	Interpretation
Male sex	~1.4–1.6	Independent risk factor
Prediabetes	~2.2	Strong metabolic effect
Diabetes	~5.1	Dominant driver
Age (per year or group)	Significant	Cumulative effect

Age-wise trend analyses were performed using the Cochran-Armitage chi-square test for trend across four ordered age categories (18-30, 31-40, 41-50, and 51-60 years) showed significance with p-value<0.001.

Diabetes was the strongest determinant, with adjusted ORs ranging from ~2.6 to 4.0 across lipid markers. [Table 6]

Table 6: Age-wise trend analysis of dyslipidaemia(reference: prediabetes Degrees of freedom (df) = 3 for all age-wise trend analyses) and Odds ratios for dyslipidaemia in diabetes. A p-value < 0.05 was considered statistically significant for all age groups.

Lipid parameter	χ^2 for trend	p-value	Prediabetes a OR (95% CI)	p-value	Diabetes aOR (95% CI)	p-value
Total Cholesterol ≥200 mg/dL	41.2	<0.001	1.34 (1.05–1.72)	0.018	2.58 (1.98–3.36)	<0.001
Triglycerides ≥150 mg/dL	48.6	<0.001	1.52 (1.18–1.96)	0.001	3.12 (2.40–4.06)	<0.001
LDL-C ≥100 mg/dL	42.9	<0.001	1.86 (1.45–2.39)	<0.001	3.98 (2.98–5.31)	<0.001
Low HDL-C	31.7	<0.001	1.31 (1.02–1.69)	0.036	2.44 (1.86–3.20)	<0.001
Non-HDL Cholesterol >130 mg/dL	46.9	<0.001	1.54 (1.19–2.00)	0.001	3.21 (2.45–4.22)	<0.001
Apolipoprotein B >90 mg/dL	49.1	<0.001	1.58 (1.22–2.05)	0.001	3.67 (2.77–4.86)	<0.001
ApoB/ApoA1 Ratio >0.98	37.3	<0.001	1.61 (1.15–2.25)	0.006	4.12 (2.93–5.80)	<0.001
Any dyslipidemia (≥1 abnormality)			2.24 (1.73–2.91)	<0.001	5.16 (3.89–6.83)	<0.001

Cardiometabolic risk: Cardiometabolic risk increased markedly with age: 18-30 years: 15 (18.3%), 31-40 years: 48 (31.4%), 41-50 years: 85 (50.0%), and 51-60 years: 112 (62.9%). [Figure 5] Males had higher cardiometabolic risk than females: 159 (52.0%) vs 101 (36.5%). The sex difference persisted across all age groups. In multivariable modelling, cardiometabolic risk increased in a dose response fashion with age (OR 1.68 to 4.12 relative to ages 18-30). [Table 7]

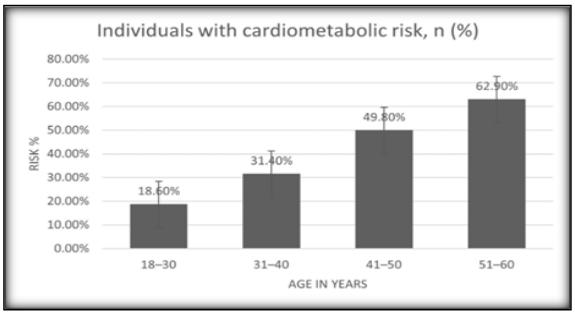

Figure 5: Age-wise distribution of cardiometabolic risk.

Table 7: Age-by-sex distribution of cardiometabolic risk and adjusted odds ratios.

Age group (years)	Female, n (%)	Male, n (%)	Adjusted OR	95% CI	p-value
18–30	5 (13.9%)	10 (21.7%)	1	Reference	—
31–40	17 (24.6%)	31 (36.9%)	1.68	1.12–2.51	0.01
41–50	32 (43.2%)	53 (55.2%)	2.74	1.86–4.03	<0.001
51–60	47 (48.0%)	65 (81.3%)	4.12	2.78–6.11	<0.001

Male sex was associated with approximately two-fold higher odds of cardiometabolic risk. In the forest plot analysis, cardiometabolic risk increased sharply with age and was higher in males than females, consistent with the regression results (adjusted OR 1.89; $p < 0.001$). [Figure 6]

LDL-C and ApoB concordance/discordance: Among all participants, LDL-C-centric assessment frequently underestimated atherogenic particle burden. Using the cutoffs LDL-C ≥100 mg/dL and ApoB >90 mg/dL, 129 (22.1%) showed discordance characterized by normal LDL-C with elevated ApoB. [Table 8]

Table 8: LDL-C and ApoB concordance status (individual level).

Concordance category	Number of individuals	Proportion (%)
Concordant normal	288	49.4%
Concordant high	157	26.9%
Discordant: LDL normal / ApoB high	129	22.1%
Discordant: LDL high / ApoB normal	9	1.5%
Total analyzed	583	100.0%

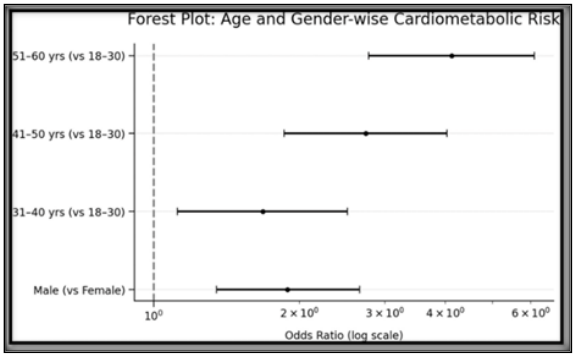

Figure 6: Forest plot of adjusted odds ratios (ORs) with 95% confidence intervals for cardiometabolic risk (defined as HbA1c ≥5.7% plus ≥1 atherogenic lipid abnormality: LDL-C ≥100 mg/dL, non-HDL-C >130 mg/dL, or ApoB >90 mg/dL). Reference categories were female sex and age group 18–30 years.

These individuals could be missed by LDL-C-based assessment alone. Concordant elevation of LDL-C and ApoB was present in 157 (26.9%). Discordance with high LDL-C but normal ApoB was uncommon, occurring in 9 (1.5%). Overall, discordance was frequent, highlighting the potential value of ApoB-based risk stratification. [Figure 7]

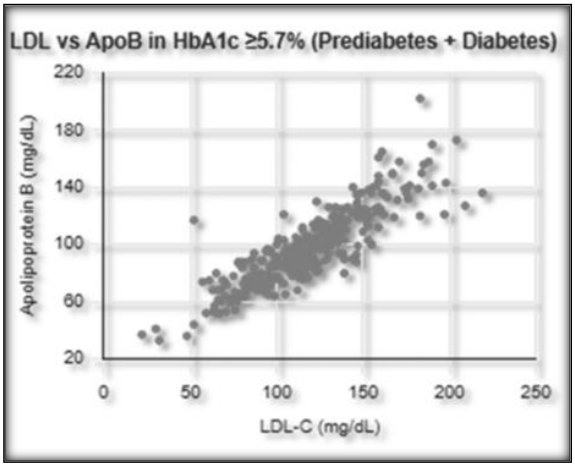

Figure 7: Quadrant plot of LDL-C and ApoB among all participants (clinical cutoffs: LDL-C 100 mg/dL; ApoB 90 mg/dL). Concordant normal: LDL-C ≤100 mg/dL and ApoB ≤90 mg/dL; Concordant high: LDL-C >100 mg/dL and ApoB >90 mg/dL; Discordant (LDL-C ≤100 mg/dL/ApoB >90 mg/dL): particle-rich, cholesterol-depleted LDL (potential hidden risk); Discordant (LDL-C >100 mg/dL/ApoB ≤90 mg/dL): less common.

DISCUSSION

The present study describes the age- and sex-wise distribution of the study population and highlights important demographic characteristics. The near-equal gender distribution observed is consistent with large Indian hospital-based and insurance-claim datasets, where males and females are almost equally represented among adult healthcare users.[12,13] A predominance of participants in the 31-60-year age group (>85%) aligns with previous epidemiological studies from India, where middle-aged and older adults constitute the majority of healthcare-seeking populations due to the increasing burden of noncommunicable diseases.[12] The absence of a

statistically significant association between age group and sex supports prior evidence demonstrating similar age distribution across genders in adult populations.[12]

The study demonstrates a higher detection rate of dysglycemia using ADA HbA1c criteria compared with WHO fasting plasma glucose (FPG) criteria. While fasting glucose identified age-related increases in diabetes prevalence, HbA1c detected a substantially larger pool of individuals with prediabetes, including younger adults who may otherwise remain undiagnosed. These findings are particularly relevant in the Indian context, where diabetes onset occurs earlier and progression is more rapid.[2,14] Differences between HbA1c and fasting glucose may be attributable to biological and clinical factors such as anemia and hemoglobinopathies, which were not evaluated in this study.[15] Prior studies in Asian Indian populations have reported similar discordance, suggesting that HbA1c may identify individuals with dysglycemia not captured by fasting glucose thresholds.[15] HbA1c identified a greater proportion of diabetes in older age groups compared to fasting glucose, consistent with previous epidemiological data.[2,16]

Additionally, the detection of prediabetes across all age groups highlights the utility of HbA1c in early identification and prevention strategies.[17] Furthermore, elevated HbA1c levels have been associated with adverse cardiovascular outcomes, supporting its relevance in risk stratification.[18] Taken together, these findings reinforce the role of HbA1c as an important screening tool, consistent with international recommendations.[17]

Sex-wise analysis showed a higher prevalence of diabetes among males, consistent with prior literature linking male sex to increased insulin resistance and visceral adiposity.[19,20] However, the substantial burden of prediabetes among females underscores the need for inclusive screening strategies. HbA1c provides practical advantages over fasting glucose, including non-fasting sampling and better reflection of long-term glycemic exposure, making it suitable for large-scale screening programs.[17,21] Early identification remains critical as timely interventions at the prediabetes stage can reduce progression to diabetes.[14,17]

This study also demonstrates a high prevalence of dyslipidemia across glycemic categories. Notably, dyslipidemia was present even in prediabetes and increased progressively with worsening glycemic status, advancing age, and male sex. These findings are consistent with existing evidence identifying dysglycemia as a key determinant of lipid abnormalities.[2,22] The observed increase in triglycerides, LDL-C, non-HDL cholesterol, and low HDL-C likely reflects progressive insulin resistance and altered hepatic lipoprotein metabolism.[23,24]

Although males exhibited a higher prevalence of dyslipidemia, this association persisted after adjustment for age and glycemic status, suggesting the contribution of sex-specific factors such as differences in body fat distribution, hormonal influences, and lifestyle patterns.[20,21] Apolipoprotein-based markers, particularly ApoB and the ApoB/ApoA1 ratio, demonstrated stronger associations with dyslipidemia severity, supporting their utility as markers of atherogenic particle burden.[25]

Cardiometabolic risk showed a clear age- and sex-related gradient, becoming markedly elevated from the prediabetes stage onward. The combination of glycemic markers with lipoprotein-based parameters such as ApoB and non-HDL cholesterol provides improved risk stratification compared with conventional lipid measures alone.[26]

In dysglycemic states, LDL-C-based assessment may underestimate atherogenic risk. ApoB reflects the total number of atherogenic lipoprotein particles and is particularly relevant in conditions such as insulin resistance and hypertriglyceridemia, where LDL particles may be cholesterol-depleted.[22-24] The observed LDL-normal/ApoB-high discordance highlights residual risk that may not be identified through LDL-C alone. These findings support the incorporation of ApoB into routine clinical assessment in individuals with prediabetes and diabetes, as recommended by contemporary guidelines.[25,26]

Strengths and Limitations: A key strength of this study is the detailed analysis across glycemic categories, age groups, and sex, allowing improved characterization of cardiometabolic risk patterns in a working-age population. The inclusion of apolipoprotein-based markers such as ApoB and ApoB/ApoA1 ratio provides additional clinical relevance beyond traditional lipid parameters.

However, the study has several limitations. The cross-sectional design precludes causal inference, and the use of convenience sampling may limit generalizability. Important confounders such as diet, physical activity, obesity measures, and medication use were not available. The absence of data on hemoglobinopathies and anemia may have influenced HbA1c interpretation. Additionally, lipoprotein(a), an important cardiovascular risk marker, was not assessed.

CONCLUSION

In conclusion, dyslipidemia was highly prevalent among working-age adults with prediabetes and diabetes and showed clear age- and sex-related patterns. Atherogenic markers, including non-HDL-C and ApoB, identified substantial lipid-related risk, and ApoB helped highlight potential residual atherogenic burden in individuals with dysglycemia. These findings support age- and sex-tailored screening strategies that integrate glycemic assessment with apolipoprotein-based measures to improve risk stratification and inform earlier preventive interventions for ASCVD in working-age populations.

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