

Platelet-to-HDL-Cholesterol Ratio as a Predictor of New-Onset Diabetes in Rheumatoid Arthritis: A Prospective Cohort Study

Yu Xie

Xingyi People's Hospital

Houli Liao

Xingyi People's Hospital

Lei Zhang

Xingyi People's Hospital

Shuli Wei

Xingyi People's Hospital

Hongxia Yu

Xingyi People's Hospital

Ting Zhao

Xingyi People's Hospital

Xuehui Zheng

Xingyi People's Hospital

Huixia Liu

Xingyi People's Hospital

Jingzhi Xie

xjzhwd@163.com

Xingyi People's Hospital

Research Article

Keywords: New-onset diabetes, Rheumatoid arthritis, Platelet-to-HDL-C ratio, CHARLS, Prospective cohort study, Random forest

Posted Date: September 30th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10785354/v1>

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Additional Declarations: No competing interests reported.

Abstract

Objectives

Patients with rheumatoid arthritis (RA) are at an increased risk of new-onset diabetes due to chronic inflammation and metabolic dysregulation. The platelet-to-high-density lipoprotein cholesterol ratio (PHR), which integrates thrombotic propensity and lipid metabolism, may serve as a novel biomarker for predicting diabetes, yet its utility in RA populations remains uninvestigated.

Methods

This national prospective cohort study included 3,029 patients with rheumatoid arthritis (RA) aged ≥ 45 years without baseline diabetes from the China Health and Retirement Longitudinal Study (CHARLS). Participants were categorized based on their diabetes status during follow-up. Multivariable logistic regression models were used to assess the association between PHR and diabetes, while restricted cubic splines (RCS) were employed to explore non-linear relationships. Subgroup analyses were performed to examine effect modifications by age, body mass index (BMI), and gender. Random forest (RF) algorithms were utilized to evaluate the predictive importance of PHR, and receiver operating characteristic (ROC) curves were used to assess model performance, with a 70% training/30% validation data split.

Results

A total of 534 new-onset diabetes cases were identified in our study. Elevated PHR independently predicted the risk of diabetes: each 5-unit increase in PHR was associated with a 5% higher adjusted odds ratio (OR=1.05, 95% CI: 1.02–1.08). Restricted cubic spline (RCS) analysis revealed a threshold effect at PHR=0.48: exceeding this threshold significantly increased the risk (OR=1.12 per unit increase, 95% CI: 1.01–2.16, $p=0.01$), whereas values below this threshold showed no significant association (OR=0.78, $p=0.54$). Subgroup analyses revealed greater susceptibility, particularly in individuals aged ≥ 60 years (OR=1.07, $p=0.008$) and those with BMI ≥ 30 kg/m² (OR=1.24, $p=0.01$). Random forest (RF) analysis confirmed the discriminative ability of PHR, with area under the curve (AUC) values of 0.77 (training set) and 0.62 (validation set).

Conclusions

In middle-aged and older patients with rheumatoid arthritis (RA), the platelet-to-HDL-C ratio (PHR) exhibits a non-linear, threshold-dependent association with new-onset diabetes. These findings support the integration of PHR into metabolic surveillance protocols for RA patients to guide targeted diabetes prevention strategies.

Introduction

Rheumatoid arthritis (RA), a systemic autoimmune disease characterized by chronic synovial inflammation, is increasingly acknowledged as a metabolic disruptor that elevates the risk of new-onset type 2 diabetes mellitus (T2DM) (1). Epidemiological studies have shown that RA patients have a 40–50% higher incidence of T2DM compared with the general population, independent of traditional cardiometabolic risk factors (2, 3). This association is mediated by persistent low-grade inflammation, insulin resistance driven by pro-inflammatory cytokines (e.g., TNF- α , IL-6), and glucocorticoid therapy (2, 4). Despite these advances, reliable biomarkers for the early identification of RA patients at high risk of T2DM remain elusive, which hinders the implementation of targeted preventive strategies.

Emerging evidence underscores the interplay between platelet activation and metabolic dysregulation in chronic inflammatory diseases (5, 6). The platelet-to-HDL-C ratio (PHR), a novel hematologic marker, combines thrombotic propensity (via platelet count) and lipid metabolic status (via HDL-C) (7–9). Elevated PHR has been shown to possess prognostic value in cardiovascular diseases and non-alcoholic fatty liver disease (NAFLD), which may reflect the synergistic effects of oxidative stress, endothelial dysfunction, and insulin resistance (10–12). Mechanistically, activated platelets release pro-inflammatory mediators (e.g., CD40 ligand, P-selectin) that exacerbate systemic inflammation, whereas HDL-C exerts anti-inflammatory effects and insulin-sensitizing properties by regulating glucose uptake in skeletal muscle (8, 10). We therefore hypothesize that PHR could act as a composite biomarker capturing both inflammatory burden and metabolic derangements in RA patients, thereby predicting the risk of T2DM.

However, critical knowledge gaps remain. First, no longitudinal studies have evaluated the predictive value of the platelet-to-HDL-C ratio (PHR) for type 2 diabetes mellitus (T2DM) in rheumatoid arthritis (RA) populations—particularly in middle-aged and older adults, who face compounded risks due to age-related metabolic decline and RA-associated comorbidities. Second, existing diabetes risk scores lack RA-specific adjustments, which may underestimate inflammation-driven diabetogenesis (13). Third, the dose-response relationship between PHR trajectories and new-onset T2DM has not been characterized in this vulnerable population.

To address these gaps, we conducted a nationwide prospective cohort study using data from the China Health and Retirement Longitudinal Study (CHARLS), focusing on adults aged ≥ 45 years with RA but without baseline diabetes. Our primary objective was to investigate the association between baseline PHR and new-onset T2DM in patients with RA. This study may inform the development of cost-effective, RA-tailored risk stratification tools, ultimately guiding personalized strategies for diabetes prevention.

Methods and materials

Data source and study population

The China Health and Retirement Longitudinal Study (CHARLS) is a nationwide, dynamic cohort study designed to investigate the social, economic, and health status of Chinese residents aged ≥ 45 years, as well as long-term changes in healthcare utilization and insurance coverage (14, 15). Launched in 2011,

CHARLS recruited participants and conducted follow-up surveys in 2013, 2015, 2018, and 2020. Employing a multistage stratified probability proportional sampling method, CHARLS obtained a representative sample covering 150 counties and 450 villages. Detailed descriptions of the study design and data processing procedures have been published previously (30). This study was approved by the Institutional Review Board (IRB) of Peking University (IRB number: 00001052–11014), and written or verbal informed consent was obtained from all participants prior to each interview.

In the present study, we used the 2015 CHARLS dataset to explore the association between the platelet-to-HDL-C ratio (PHR) and diabetes, as blood and urine biomarkers were available in the 2011 and 2015 survey waves. Notably, the cross-sectional design of the 2015 CHARLS provides comprehensive data on the epidemiological characteristics of chronic diseases and their underlying biological mechanisms, making it well-suited to test our hypothesis. Briefly, the 2015 CHARLS dataset included 21,095 participants. Participants were excluded if they had unknown sex, unknown age or age < 40 years, were non-fasting, or had missing data on fasting glucose, glycated hemoglobin (HbA1c), platelet count, or white blood cell count. Ultimately, 3,029 patients with rheumatoid arthritis (RA) were included in the analysis, consisting of 534 new-onset diabetes cases and 2,495 non-diabetic controls.

Given that the proportion of missing data for other covariates ranged from 0% to 7.18% (considered acceptable), we performed missing data imputation using random forest-based multivariate imputation. The imputed datasets were used as the primary analytical datasets, while the original dataset was retained as a validation dataset.

Assessment of PHR, RA and diabetes

The platelet-to-HDL-C ratio (PHR) was calculated as platelet count (in $10^9/L$) divided by HDL cholesterol (HDL-C) level (in mmol/L). Diabetes was defined by meeting one or more of the following diagnostic criteria (16): fasting plasma glucose (FPG) ≥ 126 mg/dL; HbA1c $\geq 6.5\%$; self-reported physician-diagnosed diabetes; or current use of anti-diabetic medications.

Definition of covariates

A comprehensive set of covariates was included in our analysis, encompassing demographic variables, lifestyle factors, health examination results, and chronic disease histories. Demographic variables included age, educational attainment (categorised as literate or illiterate), marital status (classified as married/cohabiting or other), and gender (male or female). Illiterate participants were defined as those who had not completed primary school education.

Lifestyle factors included sleep duration (categorised as <6 hours, 6–8 hours, or >8 hours), napping habit (yes or no), smoking status (current, never, or former smoker), and alcohol consumption frequency (classified as >1 time per month, <1 time per month, or never).

Chronic diseases included in the analysis were hypertension, depression, and hyperuricemia. Body Mass Index (BMI), hypertension, and depression were assessed and categorised according to the

methodology reported in a prior study (31). Hyperuricemia and lipid profiles—including low-density lipoprotein (LDL, mg/dL), total cholesterol (TC, mg/dL), triglycerides (TG, mg/dL), and high-density lipoprotein (HDL, mg/dL)—were also included as per the framework established in previous studies.

Statistical analysis

Participants were stratified into two groups according to their diabetes status. Comparative analyses across PHR tertiles were performed using analysis of variance (ANOVA), Kruskal-Wallis test, or Chi-square test, depending on the variable type (continuous, ordinal, or categorical). The association between PHR and diabetes was evaluated via logistic regression analysis, with three nested models constructed sequentially: Model 1: Unadjusted model; Model 2: Adjusted for age, gender, marital status, and body mass index (BMI); Model 3: Further adjusted for chronic diseases (including systolic blood pressure [SBP], diastolic blood pressure [DBP], hypertension, chronic lung disease, and heart disease) and lipid profiles (low-density lipoprotein [LDL], high-density lipoprotein [HDL], total cholesterol [TC], and triglycerides [TG]). A trend test was conducted to assess the linear relationship between PHR and diabetes.

To validate the robustness of the observed association, multiple sensitivity analyses were performed: (1) PHR was treated as a continuous variable in the fully adjusted model (instead of tertiles) to confirm the linear association with diabetes; (2) regression models were constructed based on PHR median and additional quantiles; (3) a restricted cubic spline (RCS) analysis with three knots was used to explore potential nonlinear relationships between PHR and diabetes risk, with the Wald ratio test employed to assess nonlinearity. Subgroup analyses were conducted to identify potentially vulnerable subgroups and explore joint effects, while interaction terms were included to evaluate potential effect modification. Random forest analysis was also performed to assess the predictive importance of PHR for new-onset diabetes in patients with rheumatoid arthritis (RA).

All statistical analyses were performed using R software (version 4.0.2). A two-tailed P value < 0.05 was considered statistically significant.

Results

Baseline Characteristics of the Study Population

A total of 3,029 participants were included in the study, comprising 2,495 individuals in the non-diabetic group and 534 in the diabetic group. Comparisons between the two groups are presented in Table 1. The overall mean age of participants was 60.1 years, which differed significantly between the groups ($p < 0.001$). Females accounted for 59.1% of the study population, with no statistically significant difference between the two groups ($p = 0.064$). The majority of participants had primary school education (93.6%), were married (82.4%), and resided in rural areas (94.9%). The prevalence of smoking was 35.9%, alcohol consumption was 23.6%, and the mean sleep duration was 6.0 hours—none of these variables differed significantly between groups. Systolic and diastolic blood pressures were significantly higher in the

diabetic group compared with the non-diabetic group ($p < 0.001$ and $p = 0.004$, respectively). The overall mean body mass index (BMI) was 23.7, with a statistically significant difference between the two groups ($p < 0.001$). Levels of glucose, triglycerides (TG), and low-density lipoprotein (LDL) were higher in the diabetic group, while high-density lipoprotein (HDL) levels were lower (all $p < 0.001$). The prevalence of hypertension was higher in the diabetic group than in the non-diabetic group (44.7% vs. 24.7%, $p < 0.001$). The overall mean platelet-to-HDL-C ratio (PHR) was 4.5, which was significantly different between the two groups ($p < 0.001$).

PHR and New-Onset Diabetes in RA

As shown in Table 2, the platelet-to-HDL-C ratio (PHR) was significantly associated with the risk of new-onset diabetes in patients with rheumatoid arthritis (RA). In Model 1, each 5-unit increment in PHR was associated with a 7% higher risk of new-onset diabetes (odds ratio [OR] = 1.07, 95% confidence interval [95% CI]: 1.01–1.11). After adjusting for confounders in Model 2 (OR = 1.05, 95% CI: 1.02–1.08) and further adjustment in Model 3 (OR = 1.05, 95% CI: 1.02–1.08), this association remained statistically significant. When PHR was categorized into tertiles, T3 (highest tertile) was associated with a higher risk than T1 (lowest tertile) in Model 1 (OR = 1.07, 95% CI: 1.04–1.11) and Model 2 (OR = 1.07, 95% CI: 1.04–1.11), whereas the association was attenuated in Model 3 (OR = 1.04, 95% CI: 1.01–1.08).

Threshold Effect Analysis of PHR in Predicting New-Onset Diabetes

Restricted cubic spline (RCS) analysis revealed a significant non-linear association between the platelet-to-HDL-C ratio (PHR) and new-onset diabetes (Figure 1). The two-piecewise linear regression model identified an inflection point at PHR = 0.48. For PHR > 0.48, the adjusted odds ratio (OR) was 1.12 (95% confidence interval [95% CI]: 1.01–2.16, $p = 0.01$), indicating a significant increase in the risk of new-onset diabetes (Table 3). For PHR < 0.48, the adjusted OR was 0.78 (95% CI: 0.39–1.94, $p = 0.54$), with no statistically significant association observed. The log-likelihood ratio test confirmed the presence of this threshold effect ($p = 0.001$).

Subgroup Analysis

Subgroup analyses demonstrated that the association between the platelet-to-HDL-C ratio (PHR) and new-onset diabetes was statistically significant in participants aged ≥ 60 years (OR=1.07, 95% CI: 1.02–1.12, $p=0.008$) and those with body mass index (BMI) ≥ 30 kg/m² (obesity; OR=1.24, 95% CI: 1.05–1.45, $p=0.01$). This association also remained significant in both males (OR=1.04, 95% CI: 1.01–1.08, $p=0.04$) and females (OR=1.05, 95% CI: 1.01–1.10, $p=0.01$) (Supplementary Table 1).

Random forest analysis

We also performed Random Forest (RF) analysis to assess the predictive importance of the platelet-to-HDL-C ratio (PHR) for new-onset diabetes in patients with rheumatoid arthritis (RA). Both the average decrease in Gini coefficient and accuracy from the RF algorithm confirmed the importance of PHR (Figures 2 and 3). Subsequently, the study population was split into a training set and a validation set at

a 7:3 ratio. When PHR was incorporated into the model, the area under the receiver operating characteristic (ROC) curve (AUC) of the training set was 0.77, indicating favorable predictive performance of the model. In the validation set, the AUC was 0.62 (Supplementary Figures 1 and 2).

Discussion

This nationwide prospective cohort study provides novel evidence regarding the predictive value of the platelet-to-HDL-C ratio (PHR) for new-onset diabetes in middle-aged and older adults with rheumatoid arthritis (RA). Our key findings are summarized as follows: (1) Elevated PHR was independently associated with an increased risk of diabetes, with each 5-unit increment corresponding to a 5% increase in adjusted odds (OR = 1.05, 95% CI: 1.02–1.08); (2) A non-linear threshold effect was observed: when PHR > 0.48, each additional unit was associated with a 12% higher risk of diabetes (OR = 1.12, 95% CI: 1.01–2.16, $p = 0.01$), whereas no significant association was detected below this inflection point (OR = 0.78, 95% CI: 0.39–1.94, $p = 0.54$); (3) Subgroup analyses revealed amplified associations in participants aged ≥ 60 years (OR = 1.07, 95% CI: 1.02–1.12, $p = 0.008$) and those with BMI ≥ 30 kg/m² (OR = 1.24, 95% CI: 1.05–1.45, $p = 0.01$); (4) Machine learning (random forest) analysis confirmed the predictive importance of PHR, with an area under the curve (AUC) of 0.77 in the training set. These findings advance our understanding of metabolic dysregulation in RA and propose PHR as a pragmatic biomarker for diabetes risk stratification in this population.

Our observation that PHR predicts diabetes risk aligns with emerging evidence on hematologic indices in metabolic disorders (17–19). A prior study reported that the platelet count/HDL-C ratio predicted new-onset diabetes in the general population (HR = 1.17 per standard deviation increase), though this association had not been validated in RA cohorts (16). Mechanistically, this relationship may stem from PHR's dual reflection of pro-thrombotic/inflammatory states (via platelet count) and impaired reverse cholesterol transport (via low HDL-C levels) (20). Notably, our threshold analysis (inflection point at PHR = 0.48) extends previous linear models by identifying a critical value beyond which diabetes risk escalates. This non-linearity parallels findings in cardiovascular research, where PHR > 0.6 was associated with abrupt endothelial dysfunction in coronary artery disease—suggesting shared pathophysiological pathways between macrovascular complications and metabolic disturbances in RA.

The association between PHR and diabetes in RA may be mediated through three interconnected pathways. First, chronic inflammation drives platelet activation via interleukin-6 (IL-6)-mediated upregulation of thrombopoietin, leading to the release of pro-diabetic mediators (e.g., CD40 ligand, serotonin) that impair pancreatic β -cell function and promote hepatic gluconeogenesis (2). Second, HDL-C deficiency—a hallmark of RA-related dyslipidemia—compromises its anti-inflammatory capacity to neutralize oxidized LDL and suppress adipose tissue macrophage infiltration, thereby exacerbating insulin resistance (21). Third, oxidative stress generated by platelet-mitochondrial interactions may directly damage pancreatic islets, as evidenced by reduced β -cell mass in RA murine models exposed to platelet-derived microparticles (21). Our identified threshold (PHR = 0.48) likely marks the tipping point

where these pathological mechanisms overwhelm compensatory responses (e.g., adiponectin upregulation).

The clinical implications of our findings are threefold. First, PHR offers practical advantages over conventional biomarkers: it is calculated from routine complete blood count (CBC) and lipid profile results, without incurring additional costs—a key consideration in resource-limited settings, where 94.9% of our cohort resided in rural areas. Second, the identified high-risk subgroups (age ≥ 60 years, BMI ≥ 30 kg/m²) align with the “metabolically unhealthy RA” phenotype, characterized by accelerated aging and ectopic fat deposition. For these patients, PHR monitoring could guide intensified lifestyle interventions (e.g., Mediterranean diet, resistance training), which have been shown to concurrently improve platelet reactivity and HDL functionality. Third, the machine learning-derived AUC of 0.77 surpasses that of traditional diabetes risk scores (e.g., FINDRISC, AUC ≈ 0.70) in RA populations, supporting the integration of PHR into RA-specific diabetes risk assessment algorithms (13).

Our stratified analyses revealed stronger PHR-diabetes associations in older adults (≥ 60 years) and obese individuals (BMI ≥ 30 kg/m²). Aging synergizes with RA-related inflammation via the senescence-associated secretory phenotype (SASP), where senescent platelets release increased transforming growth factor- $\beta 1$ (TGF- $\beta 1$) that impairs insulin receptor substrate-1 phosphorylation (22). Concurrently, adipose tissue expansion in obesity creates a pro-thrombotic milieu via leptin-driven platelet hyperactivity and HDL-C glycation—potentially explaining the 24% higher risk per PHR unit in this subgroup. Interestingly, despite known gender differences in RA pathophysiology, PHR’s predictive performance remained consistent across males (OR = 1.04, 95% CI: 1.01–1.08, $p = 0.04$) and females (OR = 1.05, 95% CI: 1.01–1.10, $p = 0.01$), underscoring its robustness as a gender-neutral biomarker.

Several limitations of this study warrant acknowledgment. First, residual confounding may persist despite multivariable adjustments, as dietary patterns and disease-modifying antirheumatic drug (DMARD) regimens were not fully captured in the CHARLS database. Second, single-timepoint PHR measurement prevented evaluation of temporal variability—an important gap, given that platelet counts fluctuate with RA disease activity. Third, the absence of oral glucose tolerance tests (OGTT) as a diabetes diagnostic criterion may have underestimated incident diabetes rates. Additionally, due to the lack of baseline data on glucocorticoid use in CHARLS, we were unable to assess the potential impact of glucocorticoids on new-onset diabetes, despite their well-established role in inducing hyperglycemia and insulin resistance in RA patients. Future studies should: (1) Validate PHR thresholds in multiethnic RA cohorts using continuous glucose monitoring; (2) Explore dynamic changes in PHR during IL-6 inhibitor therapy, which concurrently modulates platelet function and lipid metabolism; (3) Investigate whether PHR-guided interventions (e.g., low-dose aspirin, niacin) reduce diabetes incidence in high-risk RA patients.

Conclusion

In a large prospective cohort of middle-aged/older RA patients, elevated PHR is an independent predictor of new-onset diabetes, with a non-linear association and critical threshold of 0.48. Traditional epidemiology combined with machine learning strengthens PHR's biological and clinical validity, supporting its inclusion in routine RA metabolic surveillance (especially high-risk subgroups) and informing mechanistically targeted diabetes prevention trials.

Declarations

Authors' contributions

Jingzhi Xie made significant contributions to the study design and manuscript revision. Yu Xie and Houli Liao contributed to manuscript writing and data analysis. We also acknowledge the contributions of the other authors to manuscript preparation and data collection. All authors have read and approved the final version of the manuscript for submission.

Ethics and informed consent

This study involving human participants was reviewed and approved by the Institutional Review Board (IRB) of Peking University (IRB number: 00001052–11014). All participants provided written informed consent prior to study participation. All methods were performed in compliance with the Declaration of Helsinki and relevant ethical guidelines and regulations.

Acknowledgements

The authors would like to thank the data collection teams, as well as the administrators and staff of the China Health and Retirement Longitudinal Study (CHARLS), for making the data and related reports available via the CHARLS official website, which enabled the completion of this study. We also express our gratitude to all participants from the CHARLS cohort who volunteered to participate in this research.

Conflict of interest

All the authors declare that they have no conflicts of interest.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://charls.pku.edu.cn/>.

Funding

This article has no fund support.

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Tables

Table1 baseline characteristics of enrolled individuals divided by diabetes status

	Overall	Non-diabetes	Diabetes	p
n	3029	2495	534	
Age, year	60.1 (8.9)	59.8 (8.9)	61.4 (8.8)	<0.001
Gender (%)				
Female	1789 (59.1)	1454 (58.3)	335 (62.7)	0.064
Male	1240 (40.9)	1041 (41.7)	199 (37.3)	
Education level (%)				0.344
Primary school	2835 (93.6)	2328 (93.3)	507 (94.9)	
High school	175 (5.8)	150 (6.0)	25 (4.7)	
College	19 (0.6)	17 (0.7)	2 (0.4)	
Marital status (%)				
Married	2496 (82.4)	2058 (82.5)	438 (82.0)	0.848
Unmarried	533 (17.6)	437 (17.5)	96 (18.0)	
Location (%)				
City	154 (5.1)	117 (4.7)	37 (7.0)	0.04
Village	2873 (94.9)	2378 (95.3)	495 (93.0)	
Smoking, (%)	1087(35.9)	905(36.3)	182(34.1)	0.338
Drinking, (%)	716 (23.6)	613 (24.6)	103 (19.3)	0.017
Sleep duration, hour	6.0 (2.0)	6.0 (2.0)	6.0 (1.9)	0.723
Systolic blood pressure, mmHg	130.5 (21.9)	129.6 (21.8)	134.7 (21.6)	<0.001
Diastolic blood pressure, mmHg	75.4 (12.2)	75.1 (12.1)	76.8 (12.5)	0.004
BMI	23.7 (4.0)	23.4 (3.8)	25.1 (4.7)	<0.001
Glucose, mg/dL	109.4 (31.9)	104.3 (21.4)	133.6 (54.3)	<0.001
TG, mmol/L	1.5 (1.3)	1.4 (1.2)	1.8 (1.7)	<0.001
HDL, mmol/L	1.3 (0.4)	1.4 (0.4)	1.2 (0.4)	<0.001
LDL, mg/dL	117.6 (34.8)	116.8 (34.2)	121.0 (37.4)	0.012
CRP, mmol/L	2.8 (7.1)	2.7 (7.0)	3.4 (7.5)	0.045
Hypertension (%)	846 (28.2)	609 (24.7)	237 (44.7)	<0.001
Cancer (%)	39 (1.3)	29 (1.2)	10 (1.9)	0.266

Chronic Lung Diseases (%)	456 (15.1)	361 (14.6)	95 (17.8)	0.066
Heart Disease (%)	471 (15.7)	351 (14.2)	120 (22.7)	<0.001
PHR	4.5 (2.4)	4.4 (2.4)	5.0 (2.4)	<0.001

Table 2 PHR (per 5-unit increment/tertiles) and new-onset diabetes in RA patients

	Model 1	Model 2	Model 3
	OR, 95%CI	OR, 95%CI	OR, 95%CI
PHR as continuous	1.07(1.01,1.11)	1.05(1.02,1.08)	1.05(1.02,1.08)
PHR as category			
T1	Ref	Ref	Ref
T2	1.02 (0.98,1.05)	1.05 (1.01,1.08)	1.0 (0.97,1.98)
T3	1.07 (1.04,1.11)	1.07 (1.04,1.11)	1.04 (1.01,1.08)

Table 3 PHR threshold effect for new-onset diabetes (two-piecewise linear regression)

Stroke	Adjust OR (95 % CI)	P value
PHR		
Fitting by standard linear model	1.05(1.02,1.08),	0.01
Fitting by two-piecewise linear model		
Inflection point		
>0.48	1.12(1.01,2.16)	0.01
<0.48	0.78(0.39,1.94)	0.54
Log-likelihood ratio		0.001

Figures

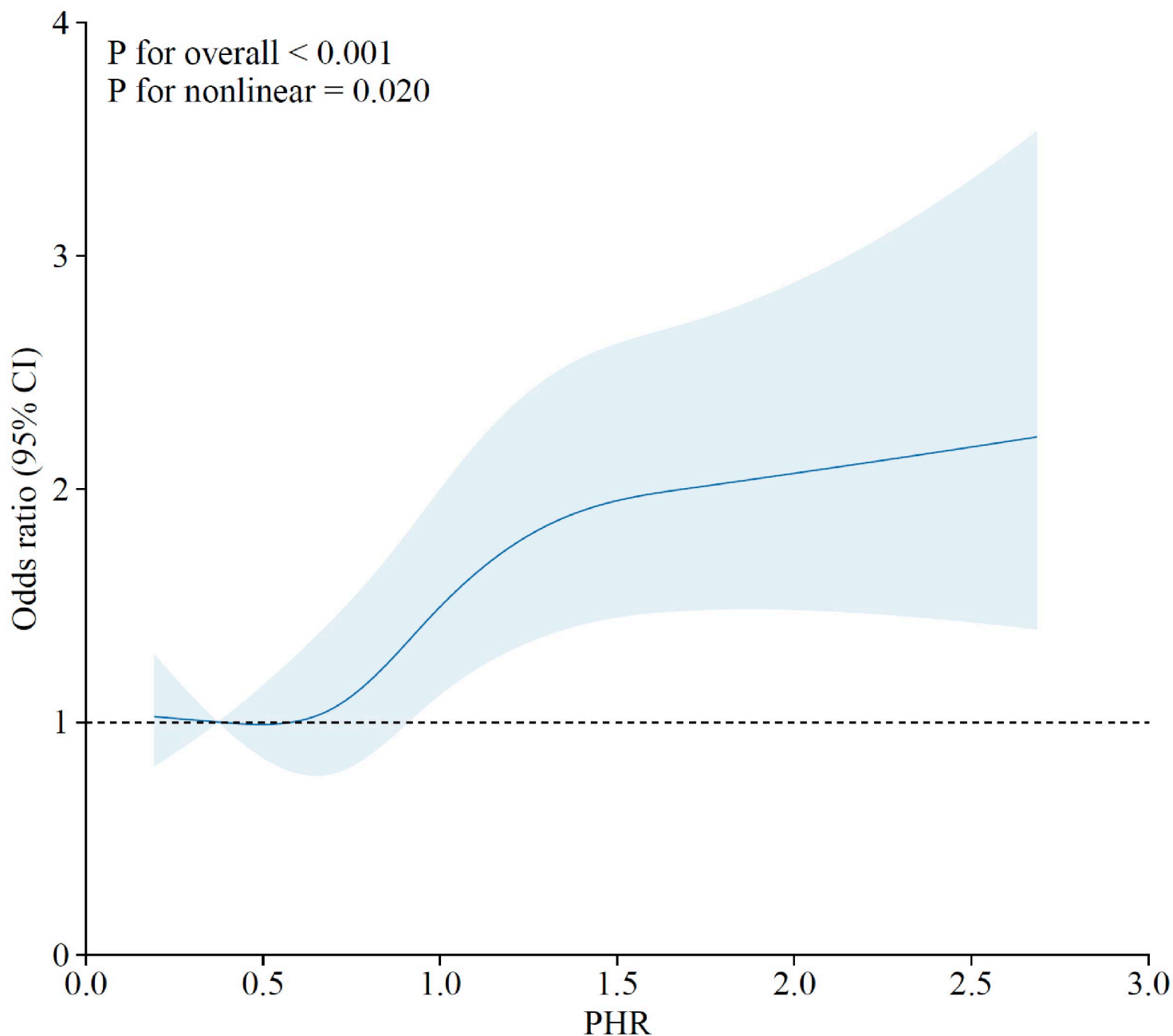


Figure 1

Restricted cubic spline (RCS) plot of PHR and new-onset diabetes mellitus (DM). This RCS plot illustrates the association between PHR and the odds of new-onset DM, demonstrating a statistically significant nonlinear relationship.

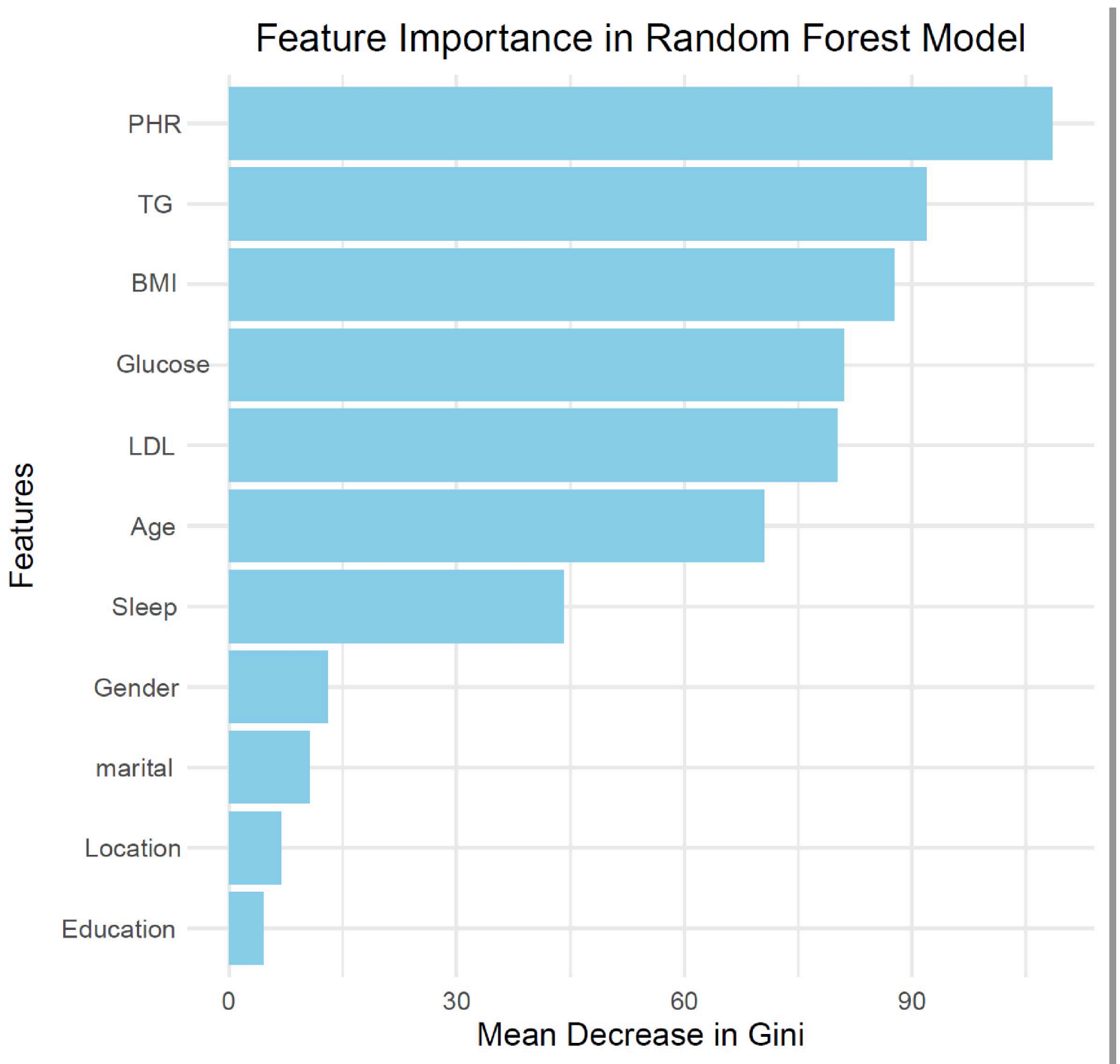


Figure 2

Mean Decrease in Gini Index in the random forest model.

This figure presents the Mean Decrease in Gini Index, a metric quantifying the importance of each predictor variable in the random forest model. It assesses the contribution of each variable to reducing impurity in decision trees, with higher values indicating greater predictive importance.

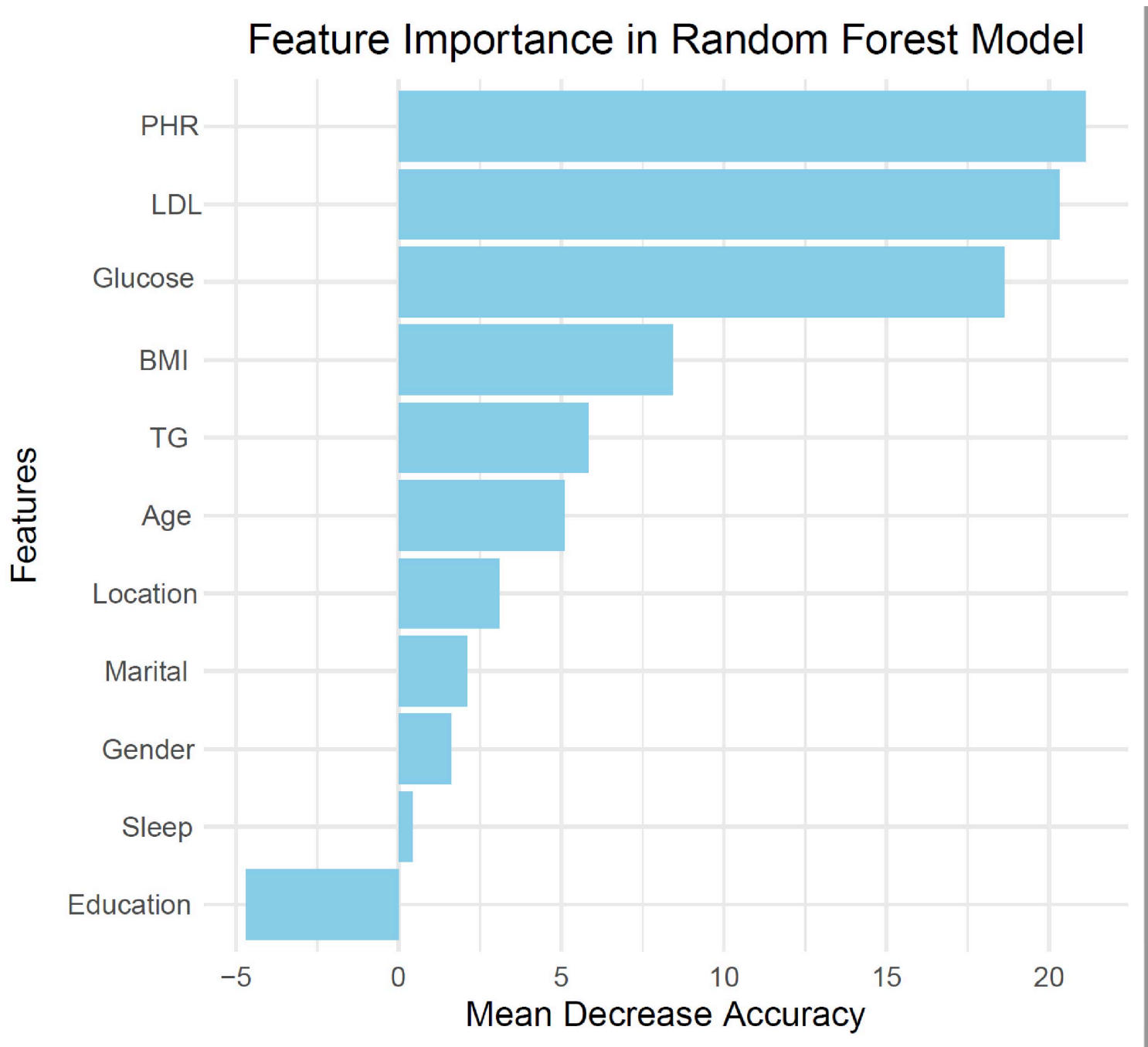


Figure 3

Mean Decrease in Accuracy in the random forest model.

This figure depicts the Mean Decrease in Accuracy, another variable importance metric reflecting the impact of each predictor on model performance. It shows the reduction in the random forest model’s accuracy when a specific feature is excluded, with higher values indicating more impactful predictors.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementarymaterial.docx](#)