Research Square

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# Correlation of hemoglobin, albumin, lymphocyte, and platelet (HALP) score with the probability of dyslipidemia in adults ≥ 20 years old: NHANES 2005- 2018 results

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## Abstract

# Purpose

Insulin resistance, proinflammatory adipokines, oxidative stress, and inflammation are critical mechanisms of dyslipidemia. The hemoglobin albumin lymphocyte and platelet (HALP) score, a comprehensive measure, has remained utilized in this prognostic assessment of numerous diseases, yet it has been infrequently applied to dyslipidemia. This study uses a cross-sectional design to explore the relationship between the HALP score and dyslipidemia.

# Methods

Data from individuals aged 20 and above were gathered from the National Health and Nutrition Examination Surveys (NHANES) database (2005–2018). Multivariable logistic regression models identified covariates and calculated odds ratios with 95% confidence intervals. Restricted cubic splines examined potential linear relationships, and stratified analyses based on HALP score and dyslipidemia were conducted. ROC curves assessed the model's predictive performance, including HALP groups, and nomograms were developed to estimate dyslipidemia risk.

# Results

Regression models stratified by HALP score quartiles (Q1 < 37.31, 37.31 < Q2 ≤ 51.15, 51.15 < Q3 ≤ 69.68, 69.68 < Q4) revealed that participants in Q2, Q3, and Q4 had higher odds of dyslipidemia compared to Q1, confirmed by a test for trend. The model, including HALP, hypertension, chronic kidney disease, age, education, poverty-to-income ratio, smoking behavior, race, gender, and body mass index, showed the highest diagnostic accuracy for dyslipidemia. Subgroup analyses showed no robust interrelations.

# Conclusion

This large-scale investigation demonstrates a curvilinear positive correlation bridging HALP score and dyslipidemia in U.S. adults.

## Introduction

“Dyslipidemia” is a broad label that encompasses all conditions of lipid metabolism[1]. It is a substantial danger determinant for heart vessel illness and cerebrovascular accidents [2]. From 2015 to 2018, lipid abnormalities increased from 17–38% within the U.S. [1]. Epidemiological information indicates that lipid abnormalities may increase the likelihood of an ischemic stroke [3]. Consequently, determining adjustable elements to forecast accurately in individuals who have dyslipidemia is of great clinical relevance.

The initiation and advancement of dyslipidemia are complex and frequently linked to elevated lack of exercise, energy consumption, and overactivation of proinflammatory cytokine release [4] [5]. Anemia and clotting disorders may worsen inflammation, whereas lymphocytes mitigate inflammation. [6]. Serum albumin is commonly utilized for research objectives and in a healthcare environment to indicate dietary well-being [7]. The hemoglobin, albumin, lymphocyte, and platelet (HALP) score has become recognized as an immune-related nutritional marker that includes a set of commonly assessed indicators to offer a unified score that reflects the general health condition of patients [9]. This score is a reliable predictor of outcome for different forms of cancer, encompassing colon, stomach, and liver cancer [10] [11] [12].

HALP has appeared in recent literature as a novel predictive indicator for various conditions over the past few years. However, research on the effect of HALP scores on the likelihood of dyslipidemia among the broader public is restricted. To tackle this knowledge deficiency, we conducted the current investigation to assess the relationships between HALP scores and the likelihood of dyslipidemia in general populations.

## Substances and approaches

# Research Group

In this cross-sectional examination, patient records were sourced from the National Health and Nutrition Examination Surveys (NHANES) database from 2005 to 2018. NHANES uses an advanced, multi-step stratified probability sampling approach grounded on chosen districts, neighborhoods, residences, and individuals inside those dwellings to evaluate the dietary and health condition of the community-dwelling population across the U.S. NCHS-certified specialists carried out interviews in the participants' residences. Comprehensive medical assessments, such as blood sampling, were performed at mobile exam centers (MECs). Information on the study execution can be reached online: https://www.cdc.gov/nchs/nhanes/index.htm (January 25th, 2024). Furthermore, the Supplementary Material section presents the unprocessed data retrieved from the database. This study employed a dataset comprising 100,519 participants from seven cycles of NHANES conducted in the United States between 2005 and 2018. After excluding participants under 20 years of age (n = 30,441) and individuals with absent or insufficient data on dyslipidemia (n = 23,424), HALP score (n = 25,898), and covariates (n = 5,966), an overall count of 14,790 subjects were incorporated into the final evaluation. Figure 1 provides a flowchart outlining the entire sample selection process. The NCHS Ethics Review Committee authorized this research, and all participants provided informed consent.

# Assessment of HALP score

Within the NHANES database, blood specimens were gathered throughout assessments within the MECs, and laboratory analyses were conducted to determine HALP score-related indices, such as serum hemoglobin (Hb), albumin (ALB), lymphocyte, and platelet levels. The HALP score was computed

employing the following formula: Hb (g/l) × ALB (g/l) × lymphocytes ($10^9$/l) / platelets ($10^9$/l). Based on prior research, we classified the HALP score into four tiers based on quartiles: <37.31, 37.31–51.15, 51.15–69.68, and > 69.68[13] [14].

# Definition of dyslipidemia

Dyslipidemia was characterized by a TC concentration of ≥ 200 mg/dl, low-density lipoprotein (LDL) concentration of ≥ 130 mg/dl, high-density lipoprotein (HDL) concentration of < 40 mg/dl, or triglyceride (TG) concentration of ≥ 150 mg/dl, TC/HDL ratio concentration of ≥ 6, an LDL/HDL ratio concentration of > 2.5, and a TG/HDL ratio concentration of > 2 [15].

# Data Analysis

All data in the research were quantitatively evaluated utilizing R language software (version 4.3.1) under the standards set by the Centers for Disease Control and Prevention (CDC). We also used Empowerstats to analyze data. We utilized mean ± standard error for continuous metrics and occurrence (proportion) for categorical metrics. Disparities among qualitative factors were assessed using the chi-squared analysis, whereas continuous factors adhering to a standard distribution were evaluated with the Student's t-test. The correlation between the HALP score and dyslipidemia was examined utilizing multivariable logistic regression modeling. The HALP score was converted into qualitative factors based on quartiles, and the linear progression assessment and trend *P* value were computed to assess the uniformity of the association. Three models were constructed for this research: Model 1, an unadjusted model without accounting for any factors; Model 2, controlled for race, age, and gender; and Model 3, which persisted in changing over CKD, alcohol consumption, Whether or not have been treated for anemia, BMI, gender, age, race, diabetes, lymphocyte, Hb, platelet, ALB, hypertension, monocyte, WBC, RBC, ALT, AST, calcium, sodium, potassium, calorie, education, marital status, PIR and smoking behavior. A restricted cubic spline was used to explore whether a linear correlation existed between the HALP score and dyslipidemia. Furthermore, to examine if interactions and consistency existed among subgroups, we conducted stratified analyses by subgroups for gender, age, CKD, race, alcohol consumption, BMI, education, marital status, smoking status, PIR, diabetes, hypertension, and smoking behavior. Variables including HALP group, BMI, age, alcohol consumption, education, PIR, smoking behavior, gender, hypertension, diabetes, race, marital status, and CKD were selected for model construction. The nomogram was employed to visualize the system. The framework's effectiveness was evaluated using the ROC curve, the calibration plot, and the decision curve analysis. R (version 4.3.1) was utilized for all analytical computations at the significance threshold established at a two-sided $P < 0.05$. A *P* value below 0.05 was deemed analytically noteworthy.

## Results

# Attributes of attendees

This study involved 14,790 attendees with ages ≥ 20 years old, of which 50.85% were women and 49.15% were men. Initial attributes of attendees categorized by HALP score quartile groups are presented in Table 1 and Supplement Table 1; variations among quartiles were quantitatively meaningful ($P < 0.05$) for HDL, smoking behavior, TG, LDL, TC, TC/HDL, lymphocyte, Hb, platelet, ALB, monocyte, WBC, RBC, ALT, AST, calcium, sodium, potassium, calorie, LDL/HDL, TG/HDL, dyslipidemia, HDL group, TG group, gender, hypertension, LDL group, TC group, TC/HDL group, LDL/HDL group, TG/HDL group, CKD, race, alcohol consumption, age, whether or not have been treated for anemia, BMI, education, marital status and PIR. Compared to the HALP group (< 37.31), the HALP group (> 69.68) were generally younger and male, having dyslipidemia, having not accepted anemia treatment, and smoking had greater levels of HALP score.

Table 1
The characteristics of participants

| Characteristics | HALP scores | | | | *P value* |
|---|---|---|---|---|---|
| | < 37.31 | 37.31–51.15 | 51.15–69.68 | > 69.68 | |
| | (n = 3842) | (n = 4331) | (n = 3984) | (n = 2633) | |
| Dyslipidemia | | | | | < 0.001 |
| No | 3706 (96.460%) | 4144 (95.682%) | 3720 (93.373%) | 2379 (90.353%) | |
| Yes | 136 (3.540%) | 187 (4.318%) | 264 (6.627%) | 254 (9.647%) | |
| Diabetes | | | | | 0.194 |
| No | 3502 (91.150%) | 3980 (91.896%) | 3649 (91.591%) | 2382 (90.467%) | |
| Yes | 340 (8.850%) | 351 (8.104%) | 335 (8.409%) | 251 (9.533%) | |
| Hypertension | | | | | < 0.001 |
| No | 2404 (62.572%) | 2929 (67.629%) | 2808 (70.482%) | 1802 (68.439%) | |
| Yes | 1438 (37.428%) | 1402 (32.371%) | 1176 (29.518%) | 831 (31.561%) | |
| Smoking Behavior | | | | | < 0.001 |
| No | 2244 (58.407%) | 2457 (56.731%) | 2092 (52.510%) | 1216 (46.183%) | |
| Yes | 1598 (41.593%) | 1874 (43.269%) | 1892 (47.490%) | 1417 (53.817%) | |
| Alcohol Consumption | | | | | < 0.001 |
| No | 1419 (36.934%) | 1328 (30.663%) | 1081 (27.134%) | 643 (24.421%) | |
| Yes | 2423 (63.066%) | 3003 (69.337%) | 2903 (72.866%) | 1990 (75.579%) | |
| BMI(kg/m2) | | | | | < 0.001 |
| < 25 | 1145 (29.802%) | 1305 (30.132%) | 1132 (28.414%) | 749 (28.447%) | |
| 25 ~ 30 | 1152 | 1439 | 1394 | 957 | |

Note: Mean ± SD for continuous variables, *P value* was calculated using logistic regression model, % for categorical variables, *P value* was calculated using chi-square test; HALP, hemoglobin albumin lymphocyte and platelet; BMI, body mass index.

| Characteristics | HALP scores | | | | *P value* |
|---|---|---|---|---|---|
| | < 37.31 | 37.31–51.15 | 51.15–69.68 | > 69.68 | |
| | (n = 3842) | (n = 4331) | (n = 3984) | (n = 2633) | |
| | (29.984%) | (33.226%) | (34.990%) | (36.346%) | |
| > 30 | 1545 (40.213%) | 1587 (36.643%) | 1458 (36.596%) | 927 (35.207%) | |
| Gender | | | | | < 0.001 |
| Male | 1163 (30.271%) | 1845 (42.600%) | 2345 (58.860%) | 1916 (72.769%) | |
| Female | 2679 (69.729%) | 2486 (57.400%) | 1639 (41.140%) | 717 (27.231%) | |
| Age (year) | | | | | < 0.001 |
| 20 ~ 40 | 1061 (27.616%) | 1372 (31.679%) | 1421 (35.668%) | 1009 (38.321%) | |
| 40 ~ 60 | 1250 (32.535%) | 1459 (33.687%) | 1279 (32.103%) | 833 (31.637%) | |
| > 60 | 1531 (39.849%) | 1500 (34.634%) | 1284 (32.229%) | 791 (30.042%) | |
| Race | | | | | < 0.001 |
| Non-Hispanic White | 516 (13.431%) | 661 (15.262%) | 661 (16.591%) | 476 (18.078%) | |
| Mexican American | 335 (8.719%) | 454 (10.483%) | 438 (10.994%) | 253 (9.609%) | |
| Other Hispanic | 1721 (44.794%) | 1991 (45.971%) | 1731 (43.449%) | 1085 (41.208%) | |
| Non-Hispanic Black | 964 (25.091%) | 799 (18.448%) | 708 (17.771%) | 506 (19.218%) | |
| Other Races | 306 (7.965%) | 426 (9.836%) | 446 (11.195%) | 313 (11.888%) | |

Note: Mean ± SD for continuous variables, *P value* was calculated using logistic regression model, % for categorical variables, *P value* was calculated using chi-square test; HALP, hemoglobin albumin lymphocyte and platelet; BMI, body mass index.

# HALP Score and dyslipidemia

The multivariable binary regression model, illustrated in Table 2, demonstrates the relationship between the HALP score and the likelihood of dyslipidemia. In Model 3, the quartile range of HALP scores was positively linked to the probability of experiencing dyslipidemia. This positive association was more

evident in individuals with a reduced incidence of dyslipidemia compared to the HALP group (< 37.31) according to quartile stratification in HALP group (37.31–51.15) (OR 1.152, 95% CI 0.898–1.478), HALP group (51.15–69.68) (OR 1.593, 95% CI 1.224–2.073), and HALP group (> 69.68) (OR 2.357, 95% CI 1.738–3.198) and was further validated by a trend analysis within each model employing HALP group (< 37.31) as a reference for this ($P$ < 0.001). We additionally employed restricted cubic spline to assess the relationship between the two; as depicted in Fig. 2, When the HALP score is below 80.5, there exists a positive correlation between dyslipidemia and HALP score, whereas when the HALP score exceeds 80.5, they exhibit a negative correlation. Additionally, there exists a non-linear correlation between dyslipidemia and HALP scores. ($P$ for non-linear < 0.001). When the HALP score is less than 49.5, the OR value is less than 1. When the HALP score is more than 49.5, the OR value is greater than 1.

Table 2
Association between HALP scores and Dyslipidemia

| Models | HALP groups | OR[95% CI] | *P value* |
|---|---|---|---|
| Model 1 | < 37.31 | Reference | |
| | 37.31–51.15 | 1.230 (0.982, 1.540) | 0.07207 |
| | 51.15–69.68 | 1.934 (1.565, 2.390) | < 0.00001 |
| | > 69.68 | 2.909 (2.348, 3.606) | < 0.00001 |
| *P for trend* | < 0.001 | | |
| Model 2 | < 37.31 | Reference | |
| | 37.31–51.15 | 1.048 (0.835, 1.317) | 0.68439 |
| | 51.15–69.68 | 1.419 (1.140, 1.768) | 0.00177 |
| | > 69.68 | 1.943 (1.549, 2.437) | < 0.00001 |
| *P for trend* | < 0.001 | | |
| Model 3 | < 37.31 | Reference | |
| | 37.31–51.15 | 1.152 (0.898, 1.478) | 0.26547 |
| | 51.15–69.68 | 1.593 (1.224, 2.073) | 0.00053 |
| | > 69.68 | 2.357 (1.738, 3.198) | < 0.00001 |
| *P for trend* | 0.001 | | |
| Model 1: Not adjusted for any other variables. | | | |
| Model 2: Adjusted for age, gender and race. | | | |
| Model 3: Adjusted for chronic kidney disease, alcohol consumption, whether or not have been treated for anemia, body mass index, gender, age, race, diabetes, lymphocyte, hemoglobin, platelet, albumin, hypertension, monocyte, white blood cell, red blood cell, alanine aminotransferase, aspartate aminotransferase, calcium, sodium, potassium, calorie, education, marital status, Poverty Income Ratio, smoking behavior | | | |
| OR Odds ratio; CI Confidence interval. | | | |

# Stratified Analysis

As illustrated in Fig. 3, we categorized gender, age, CKD, race, alcohol consumption, BMI, education, marital status, smoking status, PIR, diabetes, hypertension, and smoking behavior to examine the consistency of the relationship between HALP score and dyslipidemia and the existence or non-existence of interplay. In stratified assessments, notable interplays were identified between HALP score and gender (*P* for interrelation = 0.0281), BMI (*P* for interrelation < 0.0001), marital status (*P* for interrelation = 0.0391), PIR (*P* for interrelation = 0.0013), and the relationship was stable.

# ROC curves for the incidences of HALP Score and Dyslipidemia

Figure 4 compares AUC values between the three models to establish their predictive power for dyslipidemia. Model 1 includes the HALP group, and model 2 consists of the HALP group, race, age, education, marital status, gender, and PIR. Model 3 comprises the HALP group, hypertension, CKD, age, education, PIR, smoking behavior, race, gender, and BMI. Our study showed that model 3 had a higher AUC value than the other models for predicting dyslipidemia (AUC: 0.738). The differences in AUC values between them were statistically significant (all $P < 0.05$). These findings showed that model 3 outperformed other models and had a better discrimination ability and accuracy for predicting dyslipidemia. The nomogram was developed to offer a graphical aid for estimating the likelihood of dyslipidemia occurrences. (C index = 0.738). A perpendicular line is drawn from the upper section of the nomogram using different variables to ascertain the corresponding score. The individual scores for each variable are summed to calculate the overall score, and the relevant complete probability score is determined at the base of the nomogram (Fig. 5). The calibration plot demonstrated the alignment between forecasted likelihoods and actual results. The *P* value for the fit test for Hoslem Lemeshow is 0.467, which suggests vital forecasting precision (Fig. 6). The decision curve analysis (DCA) demonstrated that the predictive model was beneficial across a range of probability thresholds. (Fig. 7).

# Discussion

Within this investigation, we investigated the connection between HALP scores and dyslipidemia. The data demonstrated a positive link between HALP scores and dyslipidemia. A reduced risk of dyslipidemia was associated with lower HALP scores. We also investigated the HALP score's efficacy in dyslipidemia anticipation, which demonstrated that the HALP score held the potential for forecasting. Furthermore, a HALP score exceeding 49.5 was found to be associated with an elevated risk of dyslipidemia among people. However, the related risk significantly reduces when the HALP score surpasses 80.5.

The HALP score has become an immune nutritional marker that delivers an integrated combined score that reflects patients' general health status [9]. It is also an excellent predictive factor for multiple cancers, like gastric, colorectal, and hepatocellular carcinoma. [10] [11] [12]. However, this prognostic value of the HALP score about dyslipidemia has not been extensively studied, and predictions have been rare. Zheng Y et al. [26] revealed that individuals with CHD with reduced HALP scores had a seemingly increased likelihood of all-cause mortality. Pan, H et al. [14] indicated that the HALP score showed an independent relationship associated with cardiovascular and all-cause mortality risks. In this present investigation, we also found a positive relationship between the HALP score and dyslipidemia, and the HALP score might offer predictive value for dyslipidemia. Dyslipidemias are among the most prevalent chronic conditions that are detected and treated [27]. They are traditionally defined by elevated serum cholesterol levels and triglycerides, with disturbances in concentrations of associated lipoprotein

classes [27]. A review article on potential mechanisms of dyslipidemia and obesity showed that insulin resistance, pro-inflammatory adipokines, vitamin D deficiency, oxidative stress, and inflammation are essential mechanisms associated with dyslipidemia [28]. Furthermore, nutritional factors are also crucial in developing and managing dyslipidemia [29]. Drawing upon prior proof, we demonstrated that the HALP score helps assess inflammation levels, and evaluating dietary conditions might provide a convenient and thorough prediction of dyslipidemia. Nevertheless, our present investigation did not reveal a significant superiority of the HALP score in predictive capability compared to individual indicators. Hence, forthcoming prospective cohort studies must validate its potential predictive efficacy.

We investigated and showed that the HALP score was distinctly linked to dyslipidemia. Further analyses showed that a positive correlation between dyslipidemia and the HALP score is evident, transitioning to a negative correlation once the HALP score surpasses 80.5. Moreover, a non-linear relationship is discernible between dyslipidemia and HALP scores. Following the HALP score calculation formula, a consistent trend was observed wherein serum levels of Hb, ALB, and lymphocytes showed an upward trajectory with increasing HALP scores. In contrast, platelet levels exhibited a concurrent decrease. Elevated hemoglobin levels, a key indicator in the HALP score, have been linked to unfavorable lipid profiles. Studies indicate that smoking, a known risk factor for dyslipidemia, can increase hemoglobin concentrations [30] [31]. Albumin and lipoproteins are believed to give rise to hyperlipemia through a simultaneous increase in their production and a reduction in their breakdown[32]. A retrospective study showed that thrombocytopenia may induce dyslipidemia[33]. The pathways of lipid synthesis and accumulation promote a pro-inflammatory phenotype in macrophages and T lymphocytes[33], whereas inflammation has been identified as a potential cause of bleeding in thrombocytopenia[34] [35].

In stratified analysis, substantial correlations emerged between the HALP score and gender, BMI, marital status, and PIR, and these associations remained consistent over time. The association between females, elevated BMI, unmarried status, and dyslipidemia is more pronounced. Increased estrogen, progesterone, and prolactin levels increase serum total cholesterol and triglyceride levels [36]. Body mass index (BMI) is a ubiquitous metric for quantifying obesity across clinical and public health domains. The presence of obesity is intricately linked with the occurrence of dyslipidemia [37] [38]. Based on previous literature focusing on adult populations in the United States, a direct correlation exists between elevated BMI and dyslipidemia [39]. Furthermore, being single significantly increases the cardiovascular risk associated with obesity [40]. Obesity constitutes an epidemic of modern times, intricately intertwined with dyslipidemia [38].

This is a cross-sectional study, potentially offering some insights into the causative relationship between HALP scores and dyslipidemia. Our research sourced data from the NHANES database, selecting a group of individuals with sufficient representativeness via multi-stage sophisticated sampling techniques. Furthermore, the four components comprising the HALP score are easily measurable and hold substantial clinical utility. Nonetheless, the current study is subject to certain limitations. On the one hand, despite our attempts to adjust for possible interfering variables to the fullest extent possible, we cannot eliminate the influence of other potential covariates. Our sample was also extracted from a

database in the United States. Thus, its generalizability to other populations may be limited. In conclusion, further research is essential for exploring the influence of HALP scores in clinical settings.

## Conclusions

This investigation demonstrates a distinct correlation between the HALP score and the likelihood of dyslipidemia. Furthermore, it provides some insights into the latent profit of the HALP score in predicting dyslipidemia, yet further exploration into its utility and reliability is warranted.

# Supplement instrument

The definitions of covariates were listed in the Supplement instruction.

## Abbreviations

HALP score, the hemoglobin albumin lymphocyte and platelet (HALP) score;

Hb, hemoglobin;

ALB, albumin;

TC, total cholesterol;

LDL, low-density lipoprotein;

HDL, high-density lipoprotein;

TG, triglyceride;

CKD, chronic kidney disease;

BMI, Body mass index;

WBC, white blood cell;

RBC, red blood cell;

ALT, alanine aminotransferase;

AST, aspartate aminotransferase;

PIR, household poverty-to-income ratio;

eGFR, glomerular filtration rate;

# Declarations

## Data availability statement

The primary findings elucidated within the investigation are incorporated in this manuscript/supplementary materials, and further inquiries might be referred to the corresponding author/s.

## Ethical declaration

The NCHS Ethics Review Board reviewed and authorized this research about individual participants. The participants' authorized guardian or nearest kin provided written authorization for involvement in this research. Additionally, documented permission was secured from the individual(s) to release any possibly recognizable visuals or data included in this manuscript.

## Authorization for disclosure

Not Applicable.

## Access to data and resources

The data utilized and/or examined in this research is available from the corresponding author upon a reasonable request. Comprehensive data details is available at https://wwwn.cdc.gov/nchs/nhanes/ (January 25$^{th}$, 2024).


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## Authors’ contributions

Ying Li designed this study and performed the experiments. Yuzhe Huang examined the findings, provided interpretations, and wrote the manuscript. All contributors were engaged in the study's design and manuscript revision.


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## Competing interests

The researchers declare that the research was carried out without any affiliations or financial agreements that might give rise to a possible conflict of interest.

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# Tables

**Table 1** The characteristics of participants

| Characteristics | HALP scores | | | | *P value* |
|---|---|---|---|---|---|
| | <37.31 | 37.31–51.15 | 51.15–69.68 | >69.68 | |
| | (n = 3842) | (n =4331) | (n = 3984) | (n = 2633) | |
| Dyslipidemia | | | | | <0.001 |
| No | 3706 (96.460%) | 4144 (95.682%) | 3720 (93.373%) | 2379 (90.353%) | |
| Yes | 136 (3.540%) | 187 (4.318%) | 264 (6.627%) | 254 (9.647%) | |
| Diabetes | | | | | 0.194 |
| No | 3502 (91.150%) | 3980 (91.896%) | 3649 (91.591%) | 2382 (90.467%) | |
| Yes | 340 (8.850%) | 351 (8.104%) | 335 (8.409%) | 251 (9.533%) | |
| Hypertension | | | | | <0.001 |
| No | 2404 (62.572%) | 2929 (67.629%) | 2808 (70.482%) | 1802 (68.439%) | |
| Yes | 1438 (37.428%) | 1402 (32.371%) | 1176 (29.518%) | 831 (31.561%) | |
| Smoking Behavior | | | | | <0.001 |
| No | 2244 (58.407%) | 2457 (56.731%) | 2092 (52.510%) | 1216 (46.183%) | |
| Yes | 1598 (41.593%) | 1874 (43.269%) | 1892 (47.490%) | 1417 (53.817%) | |
| Alcohol Consumption | | | | | <0.001 |
| No | 1419 (36.934%) | 1328 (30.663%) | 1081 (27.134%) | 643 (24.421%) | |
| Yes | 2423 (63.066%) | 3003 (69.337%) | 2903 (72.866%) | 1990 (75.579%) | |
| BMI(kg/m2) | | | | | <0.001 |
| <25 | 1145 (29.802%) | 1305 (30.132%) | 1132 (28.414%) | 749 (28.447%) | |
| 25~30 | 1152 (29.984%) | 1439 (33.226%) | 1394 (34.990%) | 957 (36.346%) | |
| >30 | 1545 (40.213%) | 1587 (36.643%) | 1458 (36.596%) | 927 (35.207%) | |
| Gender | | | | | <0.001 |

| | | | | | |
|---|---|---|---|---|---|
| Male | 1163 (30.271%) | 1845 (42.600%) | 2345 (58.860%) | 1916 (72.769%) | |
| Female | 2679 (69.729%) | 2486 (57.400%) | 1639 (41.140%) | 717 (27.231%) | |
| Age (year) | | | | | <0.001 |
| 20~40 | 1061 (27.616%) | 1372 (31.679%) | 1421 (35.668%) | 1009 (38.321%) | |
| 40~60 | 1250 (32.535%) | 1459 (33.687%) | 1279 (32.103%) | 833 (31.637%) | |
| >60 | 1531 (39.849%) | 1500 (34.634%) | 1284 (32.229%) | 791 (30.042%) | |
| Race | | | | | <0.001 |
| Non-Hispanic White | 516 (13.431%) | 661 (15.262%) | 661 (16.591%) | 476 (18.078%) | |
| Mexican American | 335 (8.719%) | 454 (10.483%) | 438 (10.994%) | 253 (9.609%) | |
| Other Hispanic | 1721 (44.794%) | 1991 (45.971%) | 1731 (43.449%) | 1085 (41.208%) | |
| Non-Hispanic Black | 964 (25.091%) | 799 (18.448%) | 708 (17.771%) | 506 (19.218%) | |
| Other Races | 306 (7.965%) | 426 (9.836%) | 446 (11.195%) | 313 (11.888%) | |

Note: Mean ± SD for continuous variables, *P value* was calculated using logistic regression model, % for categorical variables, *P value* was calculated using chi-square test; HALP, hemoglobin albumin lymphocyte and platelet; BMI, body mass index.

**Table 2 Association between HALP scores and Dyslipidemia**

| Models | HALP groups | OR[95% CI] | *P value* |
|---|---|---|---|
| Model 1 | <37.31 | Reference | |
| | 37.31–51.15 | 1.230 (0.982, 1.540) | 0.07207 |
| | 51.15–69.68 | 1.934 (1.565, 2.390) | <0.00001 |
| | >69.68 | 2.909 (2.348, 3.606) | <0.00001 |
| *P for trend* | <0.001 | | |
| Model 2 | <37.31 | Reference | |
| | 37.31–51.15 | 1.048 (0.835, 1.317) | 0.68439 |
| | 51.15–69.68 | 1.419 (1.140, 1.768) | 0.00177 |
| | >69.68 | 1.943 (1.549, 2.437) | <0.00001 |
| *P for trend* | <0.001 | | |
| Model 3 | <37.31 | Reference | |
| | 37.31–51.15 | 1.152 (0.898, 1.478) | 0.26547 |
| | 51.15–69.68 | 1.593 (1.224, 2.073) | 0.00053 |
| | >69.68 | 2.357 (1.738, 3.198) | <0.00001 |
| *P for trend* | 0.001 | | |

Model 1: Not adjusted for any other variables.

Model 2: Adjusted for age, gender and race.

Model 3: Adjusted for chronic kidney disease, alcohol consumption, whether or not have been treated for anemia, body mass index, gender, age, race, diabetes, lymphocyte, hemoglobin, platelet, albumin, hypertension, monocyte, white blood cell, red blood cell, alanine aminotransferase, aspartate aminotransferase, calcium, sodium, potassium, calorie, education, marital status, Poverty Income Ratio, smoking behavior

OR Odds ratio; CI Confidence interval.

# Figures

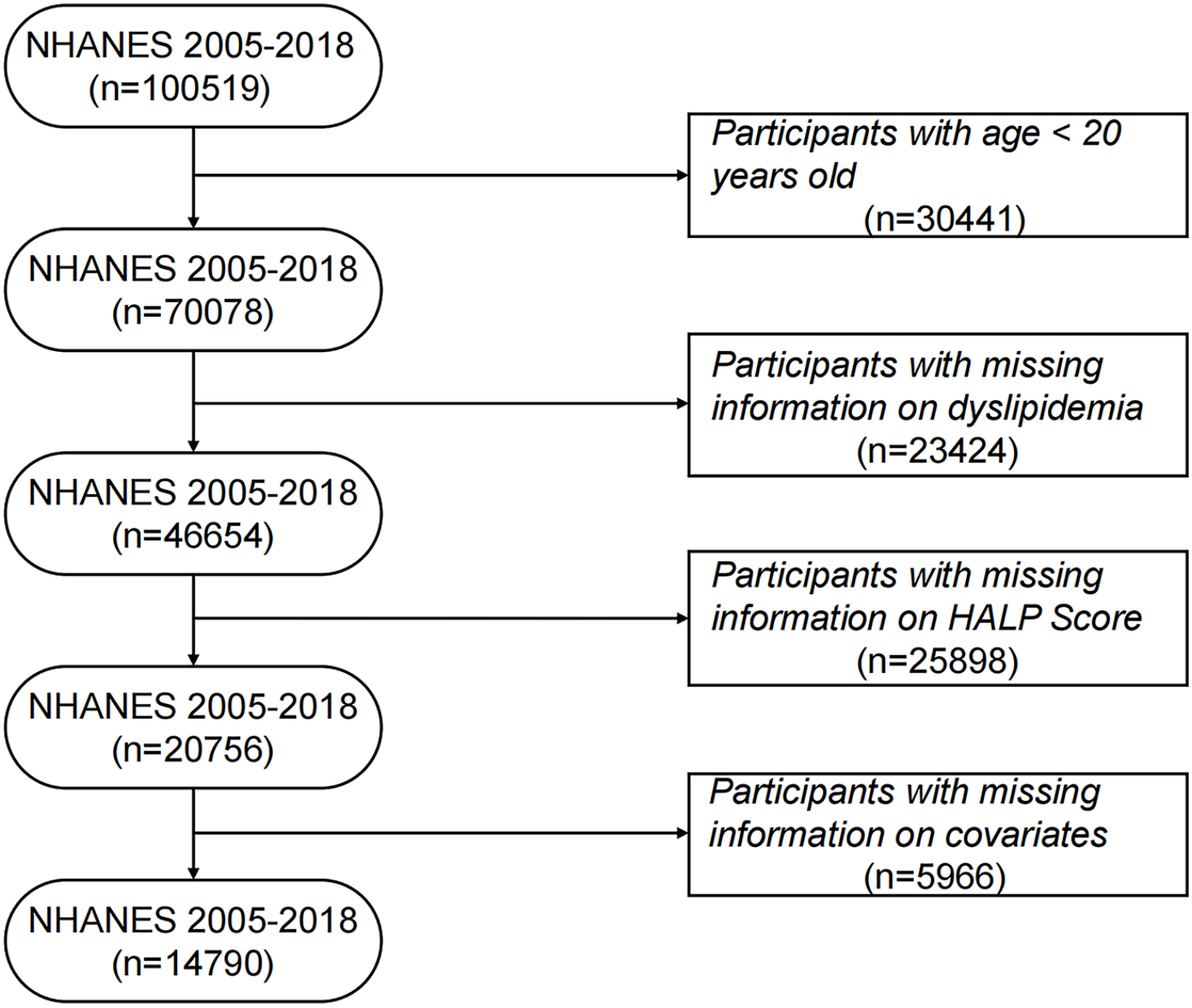



**Figure 1**

Flow chart of sample selection from the NHANES 2005–2018 (n= 14,790). NHANES, National Health and Nutrition Examination Survey.

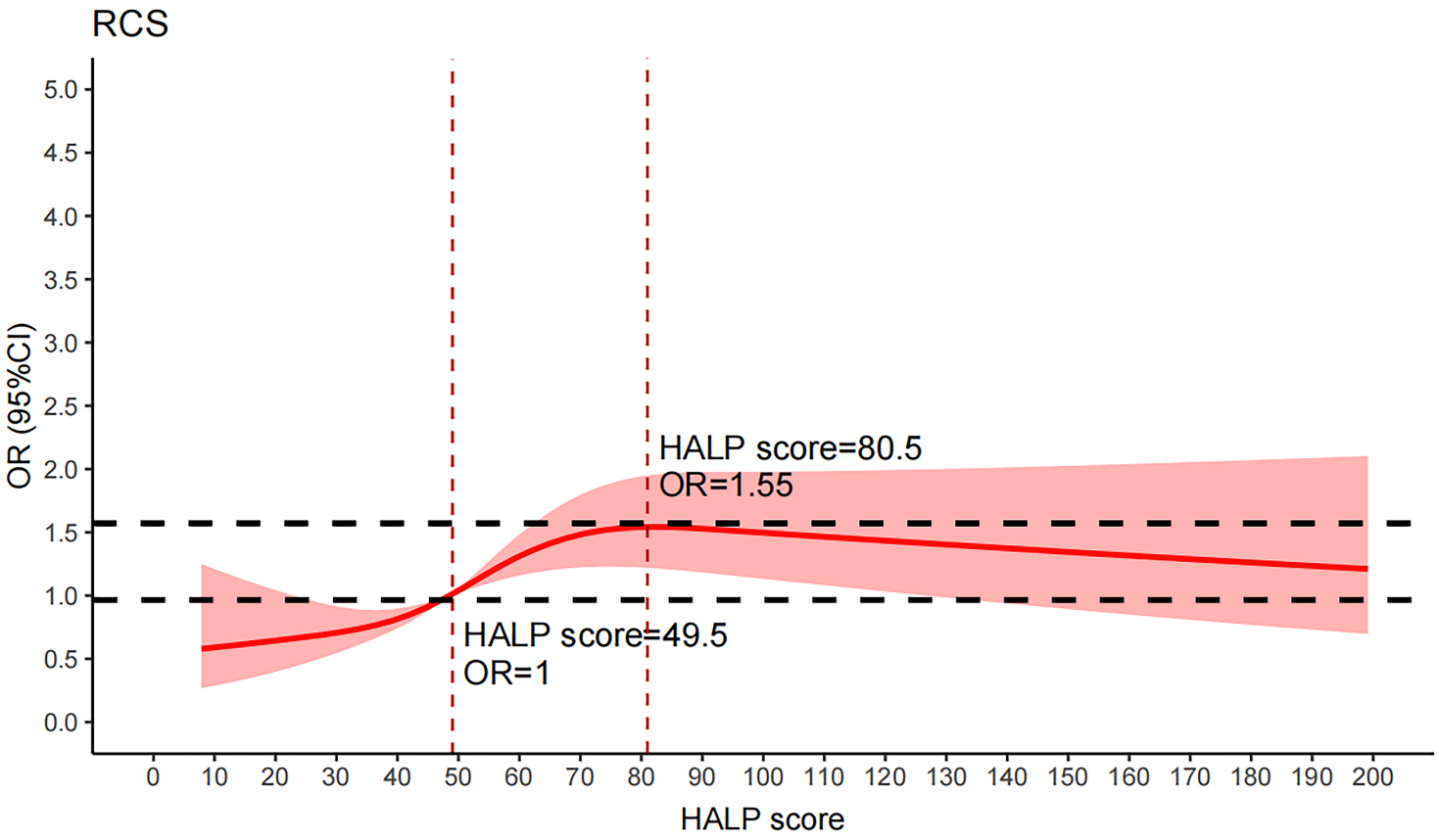
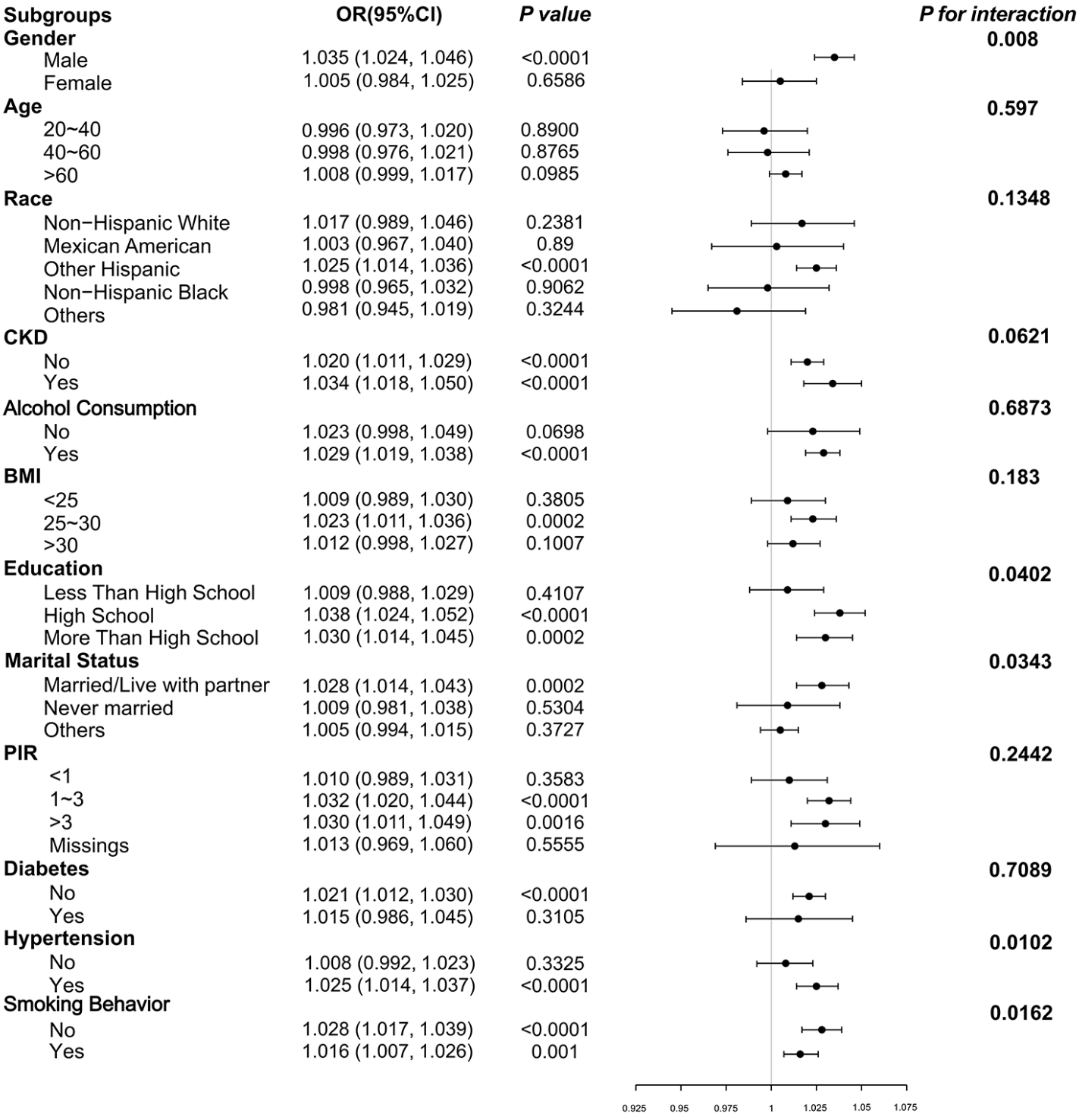



**Figure 2**

Restricted cubic spline analysis of HALP score and dyslipidemia.




## Figure 3

Subgroup analysis for the association between HALP score and dyslipidemia.

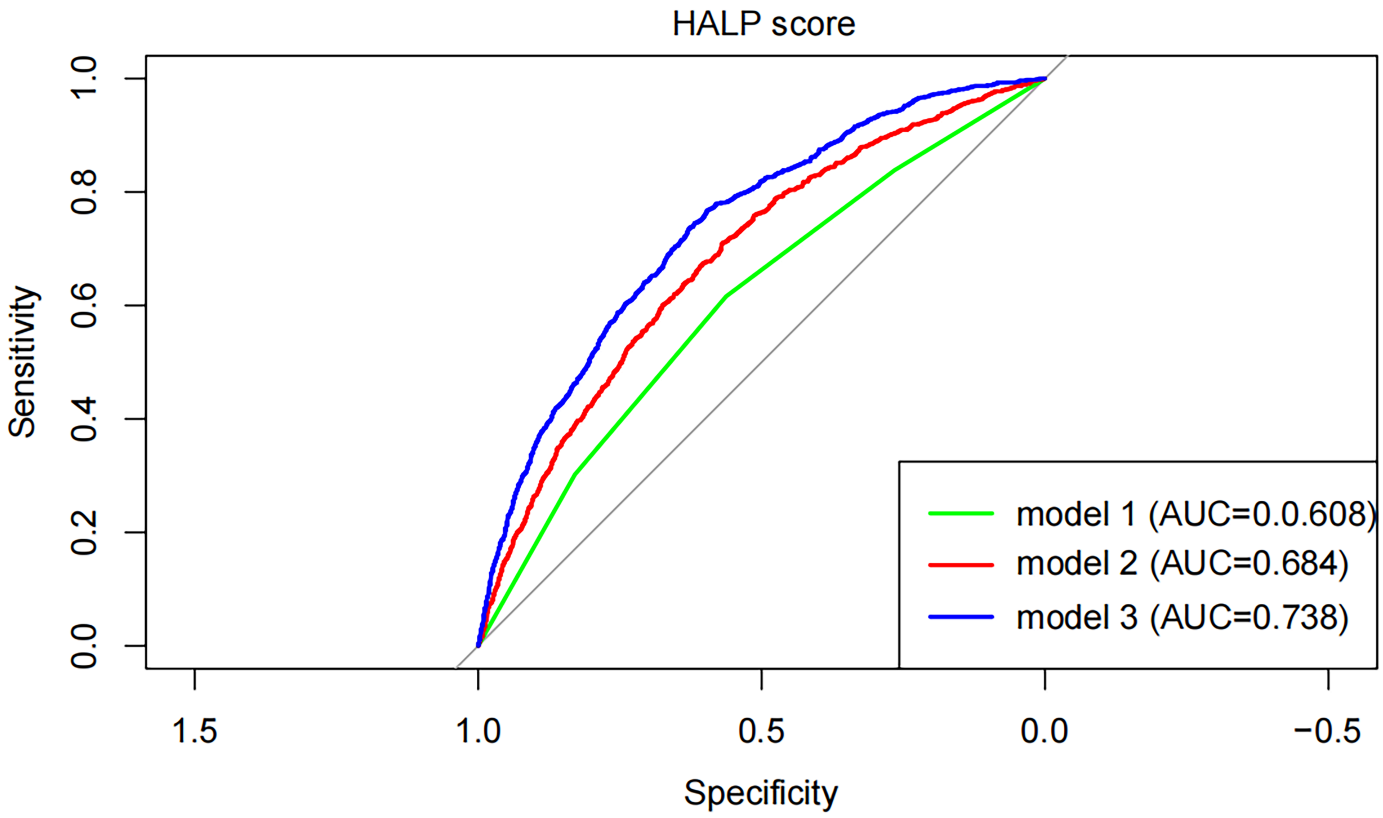
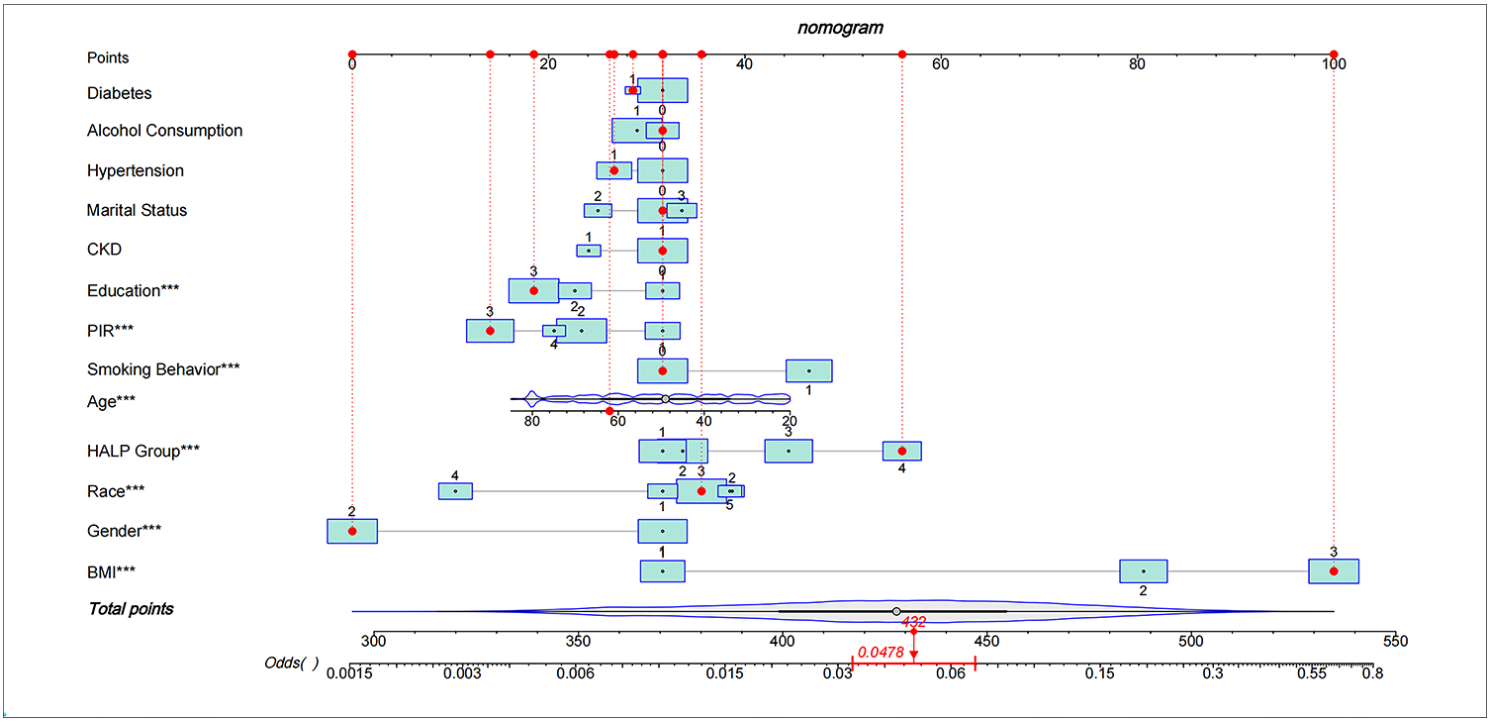


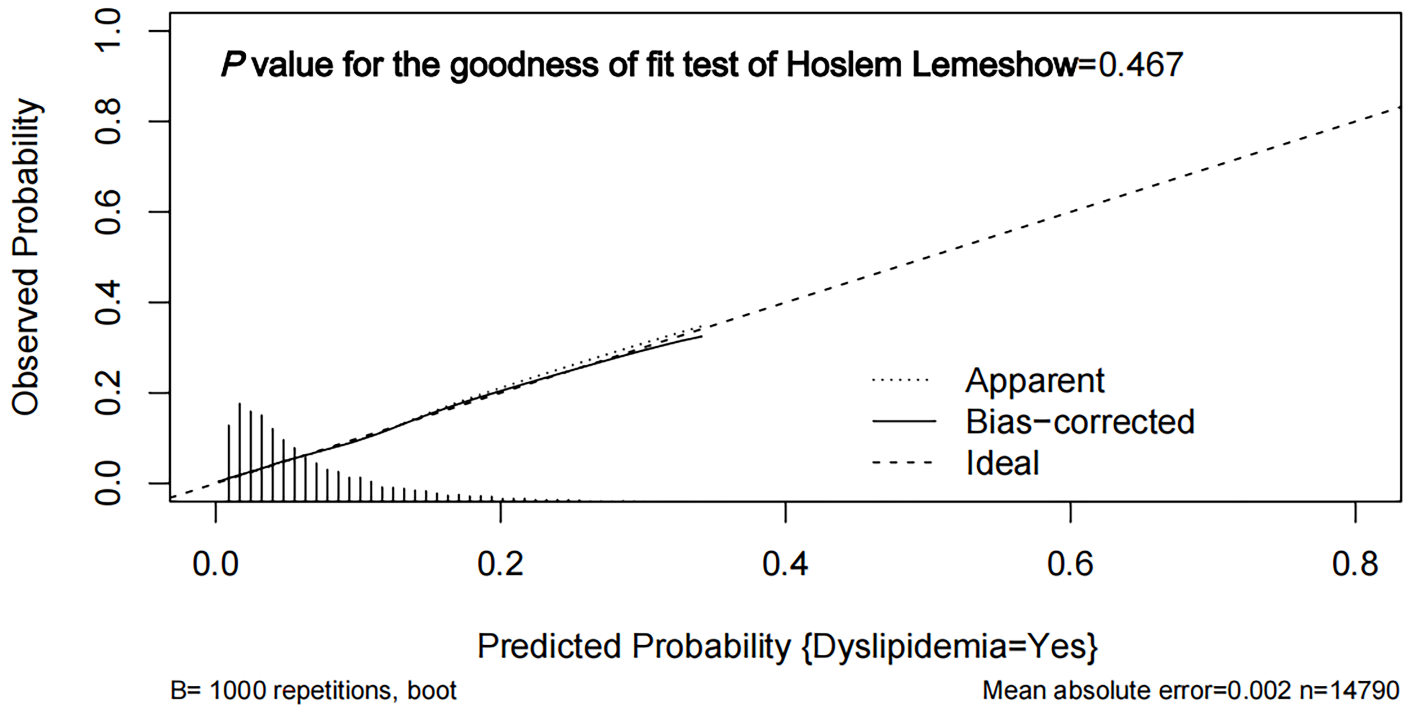

**Figure 4**

Analysis of ROC curves showing the area under the curve (AUC) for model 1, model 2, and model 3. Model 1 incorporates the HALP group. Model 2 extends the variables to include the HALP group, age, gender, race, education, marital status, and the Poverty Income Ratio (PIR). Model 3 expands the variables to include the HALP group, Body Mass Index (BMI), age, gender, race, education, marital status, PIR, smoking behavior, alcohol consumption, hypertension, diabetes, and Chronic Kidney Disease (CKD).




## Figure 5

This nomogram diagram is used to predict the risk of dyslipidemia, evaluating CKD, Hypertension, Race, Age, Education, PIR, Smoking Behavior, HALP Group, Gender, and BMI as risk factors. Each predictive factor has a scoring point, and the total score of these factors may indicate the risk of dyslipidemia.




## Figure 6

Calibration curve of nomogram

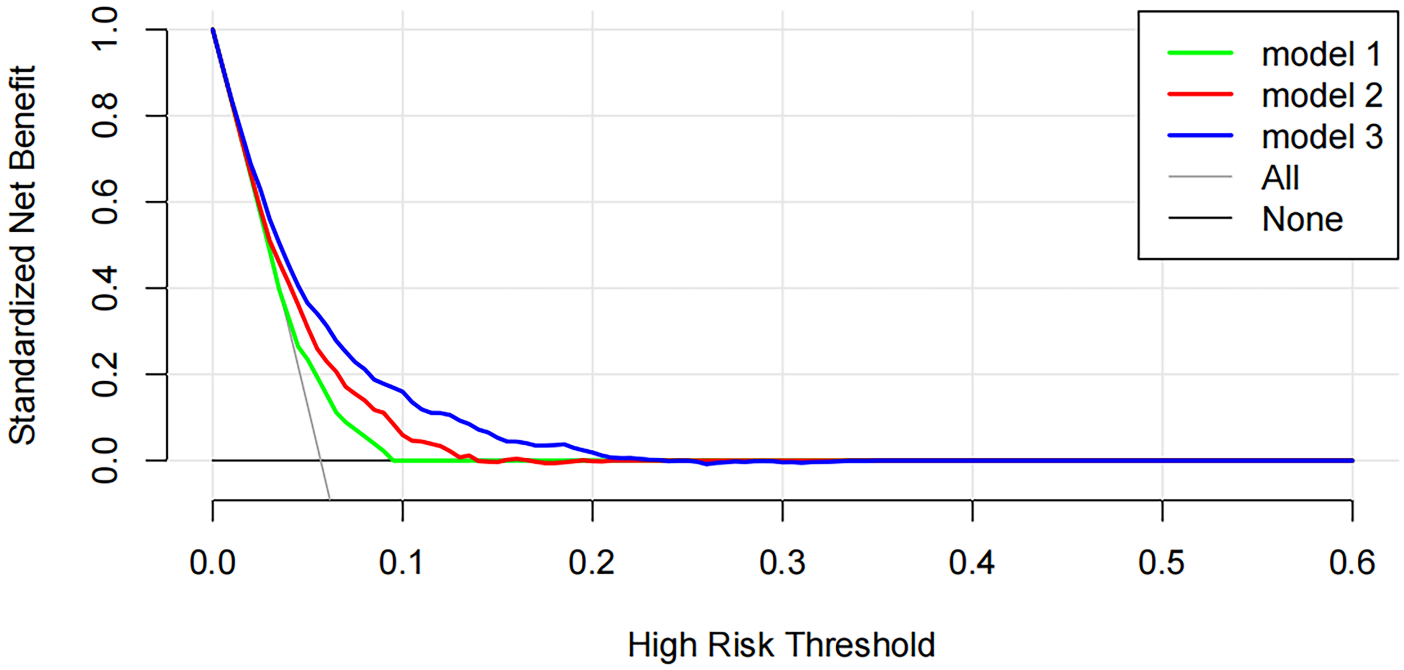



**Figure 7**

Decision curve analysis showing the net benefit curve of the line graph model. The X-axis represents the threshold probability of depression, and the Y-axis represents the net benefit. The green, red, and blue lines represent the improved predictive line graphs of model 1, model 2, and model 3, respectively.

## Supplementary Files

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

- Supplementinstruction.docx
- SupplementTable1.docx