

# Life's Crucial 9 Score as a Novel Role for Chronic Obstructive Pulmonary Disease Screening

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**Purpose:** This study aims to investigate the association between the Life's Crucial 9 (LC9) score and chronic obstructive pulmonary disease (COPD) in middle-aged and older adults.

**Patients and Methods:** We screened the NHANES database for data from 2007–2018. Logistic regression analysis and subgroup analysis were used to explore the association between LC9 score and COPD in middle-aged and older adults. Additionally, restricted cubic spline (RCS) was plotted to visually depict the dose-response relationship between the two.

**Results:** A total of 12,030 participants were included, of whom 815 had COPD. After multivariate adjustment, the LC9 score was found to be inversely associated with COPD diagnosis. The RCS visually demonstrated a linear decreasing relationship between the two. Furthermore, subgroup analysis revealed no significant interaction across different subgroups, except for education level.

**Conclusion:** The LC9 score is linearly and inversely associated with COPD diagnosis. Higher LC9 scores are associated with a lower COPD diagnosis in individuals aged 40 and above.

**Keywords:** COPD, middle-aged and older adults, life's crucial 9, diagnosis, cardiovascular health

## Introduction

The concept of “Life's Essential Metrics” was introduced by the American Heart Association (AHA) in 2010 as a critical framework for defining cardiovascular health.<sup>1</sup> Initially launched as Life's Simple 7 (LS7), the metrics included: blood glucose, blood pressure, cholesterol levels, smoking, alcohol consumption, body mass index (BMI), and physical activity.<sup>1</sup> In 2022, sleep health was added the framework, updating the metric to Life's Essential 8 (LE8).<sup>1,2</sup> By 2024, Circulation published research highlighting mental health as a vital component of cardiovascular well-being, expanding the framework to Life's Essential 9 to incorporate this dimension.<sup>3</sup> Nowadays, the LC9 score is an ideal indicator to quantify CVH. Moreover, several studies have shown that life element also serve as predictors of other diseases. Tang et al showed that LE8 scores were positively correlated with bone mineral density and negatively correlated with osteoporosis, regardless of age or gender.<sup>4</sup> Chen et al found that higher LE8 scores are associated with a reduced risk of periodontitis.<sup>5</sup>

Chronic Obstructive Pulmonary Disease (COPD) is a common respiratory disorder characterized by symptoms such as cough, sputum production, and wheezing. It often leads to complications like heart disease and respiratory failure, resulting in adverse outcomes.<sup>6</sup> According to statistics, COPD is now the third leading cause of death worldwide, with 33 million deaths in 2019 alone.<sup>7</sup> Additionally, COPD imposes a substantial and unevenly distributed economic burden globally, with 90% of COPD-related deaths occurring in low- and middle-income countries. Notably, China and the



United States face the most severe economic burdens due to high prevalence rates, healthcare costs, and productivity losses linked to COPD.<sup>7</sup> Research estimates that COPD will result in losses of \$43.26 trillion between 2020 and 2050, equivalent to 0.11% of global GDP annually in taxes.<sup>7</sup> Therefore, COPD diagnosis and early intervention are very important.

Mental health is currently a major public issue, especially depressive symptoms. According to World Health Organization (WHO) statistics, more than 350 million people worldwide suffer from depression, and approximately 1 million people commit suicide each year.<sup>8</sup> In particular, the global prevalence of major depressive disorder in older persons is 13.3%, which is increasing year after year.<sup>9</sup> It is expected to contribute significantly to the global disease burden by 2030.<sup>10</sup> Furthermore, there is an interplay between depressive symptoms and COPD. Depressive symptoms may be an underlying etiology of COPD, and COPD is more likely to be comorbid with depressive symptoms.<sup>11,12</sup> Compared to LE8 and LS7, the LC9 score integrates mental health components. Utilizing the LC9 score to investigate COPD allows for a more comprehensive reflection of the true association between these factors.

COPD is a systemic disease closely related to multiple other diseases.<sup>13</sup> Life element have been proven to be closely related to CVH.<sup>1-3,14</sup> Currently, the LC9 score is recognized as the latest ideal indicator for quantifying CVH.<sup>3</sup> However, the relationship between the LC9 score and COPD diagnosis has not been studied yet. Therefore, our study aims to explore the association between LC9 scores and COPD diagnosis based on the contents of the National Health and Nutrition Examination Survey (NHANES) database. This study provides references for clinical practice and personal lifestyle choices, with the goal of improving the quality of life and overall health of individuals.

## Research Design and Methods

### Study Population

The NHANES database (<https://wwwn.cdc.gov/nchs/nhanes/Default.aspx>) is a public database that is rich in content, authentic and reliable, with a nationally representative sample obtained through a stratified multi-stage probability sampling design (a combination of multistage stratified sampling, oversampling, and weight adjustment). The database follows a two-year cycle, conducting annual surveys of approximately 5000 individuals nationwide each year. And all participants signed an informed consent form provided by the NHANES Ethics Review Board.

We selected participants from the NHANES database from 2007 to 2018 (N=75,402). The following exclusion criteria were applied: 1) missing LC9 data (N=2738); 2) age <40 years (N=44,873); 3) pregnancy (N=11); 4) tumors (N=2836); 5) other missing data (N=12,964). Ultimately, a total of 12,030 participants were included for analysis, of which 815 had COPD (Figure 1).

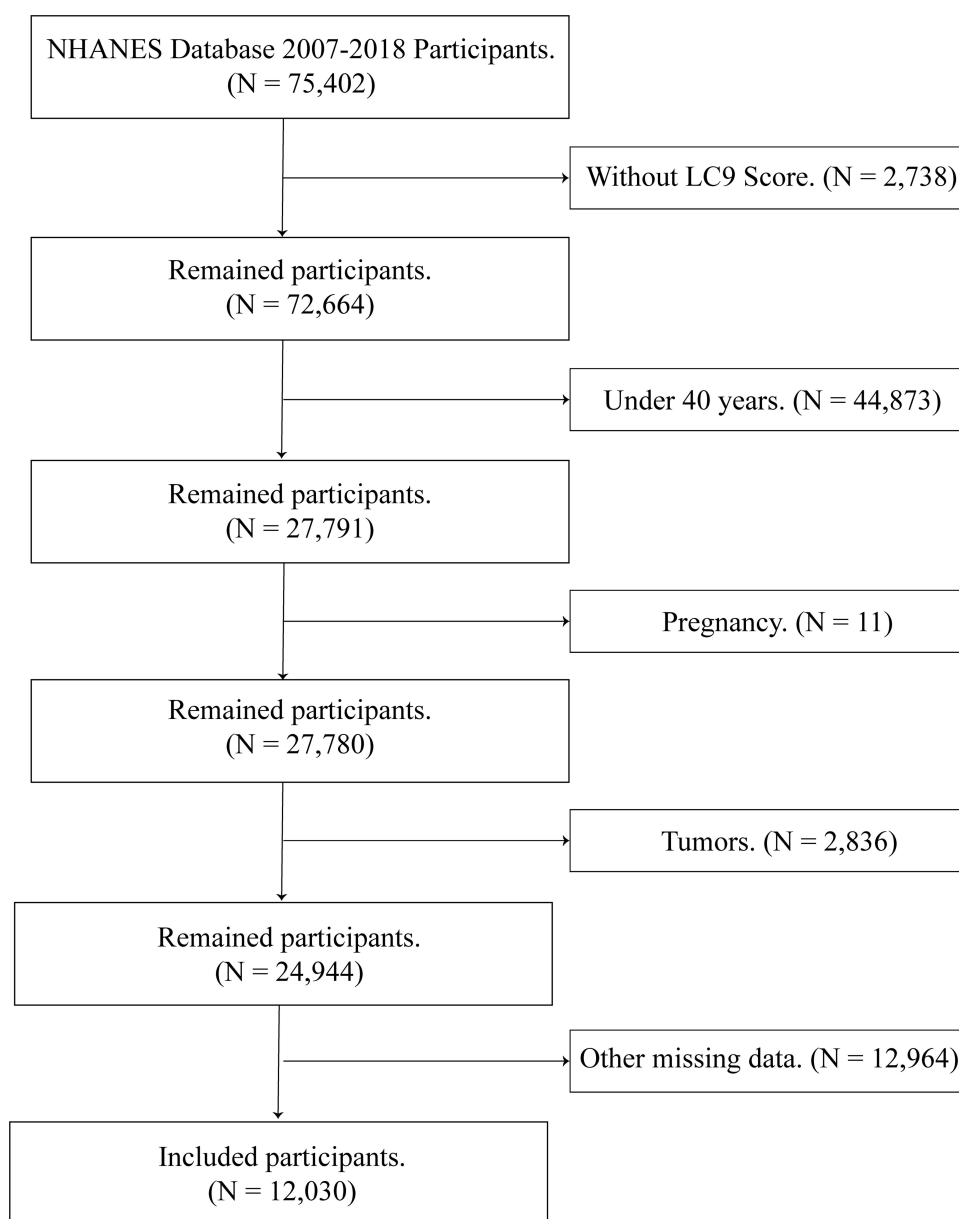
### Definition of COPD

COPD was primarily identified based on pulmonary function tests, COPD questionnaire reports (MCQ160G, MCQ160P), and medication use. Additionally, these criteria have been widely applied in NHANES-related studies.<sup>15-18</sup> Therefore, meeting one of the following three criteria is sufficient to classify a participant as having COPD. The criteria are as follows:

1. FEV1/FVC < 0.7 after inhalation of a bronchodilator.
2. The patient has a prior diagnosis of emphysema/COPD made by a physician.
3. Aged over 40 years, with a history of smoking or chronic bronchitis, and use of medications for COPD (including leukotriene modifiers, inhaled corticosteroids, selective phosphodiesterase-4 inhibitors, and mast cell stabilizers).

### Description of LC9 Scores

Gaffey et al clearly defined LC9, which more accurately quantifies cardiovascular health than LS7 and LE8.<sup>3</sup> The LC9 includes four health behavioral factors (physical activity, tobacco, diet, and sleep) and five health factors (weight, cholesterol, blood glucose, blood pressure, and psychological health). According to the characteristics of the NHANES database and previous related studies, the LC9 score in this study was calculated as follows: LC9 score = the mean of the



**Figure 1** Participant screening flowchart.

sum of the LE8 score and the depressive symptom score.<sup>2,19–21</sup> Depressive symptom scores were determined from the Patient Health Questionnaire 9 (PHQ-9) scores. Depression scores were categorized as 100, 75, 50, 25, and 0, corresponding to 0–4, 5–9, 10–14, 15–19, and 20–27 on the PHQ-9 scale, respectively.<sup>19</sup> The LC9 score is categorized as high (80–100), moderate (50–79), or low (0–49).<sup>3</sup> The higher the score, the better the state of cardiovascular health.<sup>2,20</sup> Detailed scoring criteria for each factor can be found in the [Supplementary File 2](#).

## Research Variables

Based on previous literature, we included variables that may affect the association between LC9 score and COPD. Demographic variables include age (40–64 years or  $\geq 65$  years), sex (male or female), race (White or Other), and marriage (Married/Living with Partner, Widowed/Divorced/Separated, or Never married). Socioeconomic variables include education (Less than high school, High school diploma, or More than high school), poverty income ratio

(PIR) (<1.3, 1.3–3.5, or >3.5), and household insurance (Yes or No). The PIR ranges from 0 (no family income) to 5 (family income is at least five times the federal annual poverty level).

## Statistical Analysis

This study included data from six cycles of the NHANES database. Appropriate weights (wtddr1) were selected based on the study factors and outcomes, and all subsequent statistical analyses were conducted on weighted data. All statistical analyses were performed using R software version 4.3.2, with a two-sided  $P < 0.05$  considered statistically significant. All study variables were converted into categorical variables and presented as percentages. The chi-square test was used for between-group comparisons. Logistic regression analysis was employed to evaluate the odds ratios (OR) of COPD diagnosis associated with the LC9 score, and 95% confidence intervals (CI) were calculated.

We constructed three models for analysis. The crude model did not adjust for any factors. Model 1 adjusted for age, sex, race, marriage, and education. Model 2 adjusted for PIR and household insurance based on Model 1. And subgroup analyses by age, sex, race, marriage, household insurance, and education level assessed whether the above relationships were affected by underlying factors. Additionally, we explored whether the dose-response relationship between the two was affected by nonlinearity using a restricted cubic spline (RCS) function. The interpretation criteria for the results were as follows:

- a.  $P$  overall  $< 0.05$  and  $P$  for nonlinearity  $< 0.05$ , indicating that the indicator is associated with the outcome and the relationship is nonlinear.
- b.  $P$  overall  $< 0.05$  and  $P$  for nonlinearity  $> 0.05$ , indicating that the indicator is associated with the outcome, but nonlinearity cannot be proven, suggesting a linear relationship to some extent.<sup>22–25</sup>
- c.  $P$  overall  $> 0.05$  and  $P$  for nonlinearity  $< 0.05$ , this situation does not exist in reality.
- d.  $P$  overall  $> 0.05$  and  $P$  for nonlinearity  $> 0.05$ , indicating that the indicator is not correlated with the outcome and there is no nonlinearity.

## Results

### Baseline Characteristics

We included a total of 12,030 participants, among which 815 had COPD. As shown in Table 1, COPD is commonly found in individuals aged 40–64, whites, those who are married or living with a partner, have higher education levels, and have household insurance. The distribution across different PIR levels is similar. The higher incidence in whites may be due to the fact that the NHANES database data comes from the US population, which is predominantly white. The LC9 score is currently the most comprehensive and ideal international indicator for assessing CVH. As shown in Table 1, the proportion of COPD patients is highest when the LC9 score is at the moderate level (50–79) and lowest at the high level (80–100).

### Association Between the LC9 Score and COPD

We categorized the LC9 score into low (0–49), moderate (50–79), and high (80–100) levels and explored the potential dose-response relationship between the LC9 score and COPD diagnosis from a class variable perspective in multiple models. We found a linear decreasing relationship between the LC9 score and COPD diagnosis, regardless of age, sex, or socioeconomic status ( $P$  for trend  $< 0.0001$ ). In the fully adjusted model, compared to individuals with low LC9 scores, those with moderate LC9 scores showed an approximately 49% reduction in COPD diagnosis risk (OR 0.51, 95% CI (0.41, 0.65)), while high LC9 scores were associated with a 76% reduction (OR 0.24, 95% CI (0.14, 0.39)). The additional 27% risk reduction observed in the high vs moderate LC9 score groups was statistically significant ( $P < 0.0001$ ), with a pronounced linear trend ( $P$  for trend  $< 0.0001$ ) (Table 2). Meanwhile, we plotted the RCS to visualize the dose-response relationship between the two from a continuous variable perspective. As shown in Figure 2, the OR for COPD diagnosis equals 1 at an LC9 score of 67.2, indicating no increased or decreased risk at this threshold. Overall, the relationship between LC9 scores and COPD risk follows a monotonically decreasing curve. As the LC9 score increases,

**Table 1** Baseline Characteristics of the Study Population

Variable	Total	Non-COPD	COPD	P
Age group (%)				< 0.0001
40–64	8363(75.73)	7895(76.45)	468(65.15)	
≥65	3667(24.27)	3320(23.55)	347(34.85)	
Sex (%)				0.05
Female	6208(52.82)	5849(53.25)	359(46.49)	
Male	5822(47.18)	5366(46.75)	456(53.51)	
Race (%)				< 0.0001
Other	6626(26.99)	6324(27.59)	302(18.08)	
White	5404(73.01)	4891(72.41)	513(81.92)	
Marriage (%)				0.02
Married/Living with Partner	7599(68.48)	7134(68.72)	465(64.91)	
Never married	1016(7.56)	956(7.66)	60(6.03)	
Widowed/Divorced/Separated	3415(23.96)	3125(23.62)	290(29.06)	
Education (%)				< 0.0001
High school diploma	2844(24.79)	2630(24.61)	214(27.45)	
Lower than high school	2844(14.37)	2593(13.87)	251(21.76)	
More than high school	6342(60.84)	5992(61.52)	350(50.79)	
Poverty income ratio (%)				< 0.0001
<1.3	3388(17.53)	3075(16.89)	313(26.94)	
1.3–3.5	4576(33.98)	4268(33.72)	308(37.94)	
>3.5	4066(48.49)	3872(49.39)	194(35.12)	
Household insurance (%)				0.19
No	1911(12.37)	1825(12.52)	86(10.22)	
Yes	10119(87.63)	9390(87.48)	729(89.78)	
Life's Crucial 9(%)				< 0.0001
Low (0–49)	1300(8.85)	1115(8.19)	185(18.43)	
Moderate (50–79)	8628(69.20)	8050(68.99)	578(72.20)	
High (80–100)	2102(21.96)	2050(22.81)	52(9.37)	

**Table 2** Association Between the Life's Crucial 9 (LC9) Score and Chronic Obstructive Pulmonary Disease (COPD) Diagnosis

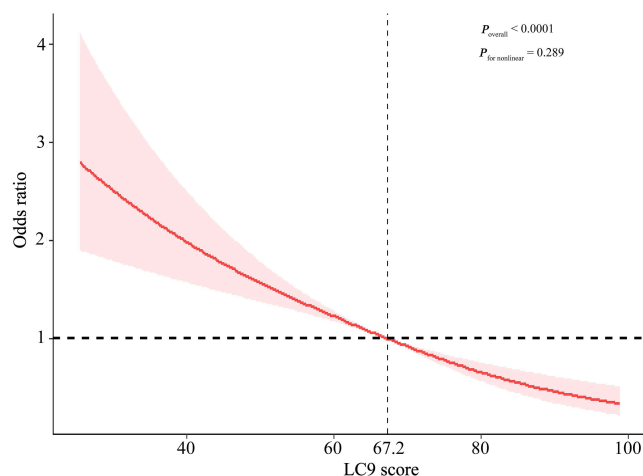
	Crude Model	P	Model 1	P	Model 2	P
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
LE9 score						
Low (0–49)	Reference	/	Reference	/	Reference	/
Moderate (50–79)	0.47(0.37,0.59)	<0.0001	0.46(0.37,0.59)	<0.0001	0.51(0.41,0.65)	<0.0001
High (80–100)	0.18(0.12,0.29)	<0.0001	0.20(0.13,0.33)	<0.0001	0.24(0.14,0.39)	<0.0001
P for trend	<0.0001	/	<0.0001	/	<0.0001	/

**Notes:** Crude model: No adjustment for any factor. Model 1: Adjusted for age, sex, race, marriage and education. Model 2: Adjusted for age, sex, race, marriage, education, PIR and household insurance.

the risk of COPD diagnosis progressively declines, demonstrating a significant linear inverse association ( $P$  overall<0.0001,  $P$  for nonlinear=0.289).

## Subgroup Analysis

We further explored whether there was an interaction effect between the relationship between LC9 score and COPD diagnosis across subgroups. The results showed that there was no interaction effect between the subgroups of sex, age, race, PIR, and household insurance, except for education level ( $P$  for interaction>0.05, Table 3). However, in the



**Figure 2** The linear relationship between LC9 score and COPD diagnosis.

education level grouping, we found that there was no decreasing relationship between the LC9 score and COPD diagnosis in individuals with a high school education level ( $P$  for trend = 0.46, in Table 3). Similarly, the household insurance grouping revealed that this relationship was also absent in individuals without insurance ( $P$  for trend = 0.10, in Table 3).

## Discussion

We conducted the first exploration of the relationship between LC9 scores and COPD diagnosis in middle-aged and elderly individuals using cross-sectional survey data from the NHANES database from 2007 to 2018. The results showed a nonlinear decreasing relationship between LC9 score and the risk of developing COPD in middle-aged and older adults. As LC9 scores increased, COPD diagnosis risk in middle-aged and elderly individuals decreased. However, this

**Table 3** Subgroup Analysis of the Association Between the LC9 Score and COPD Diagnosis

Character	Low (0–49)	Moderate (50–79)	P	High (80–100)	P	P for trend	P for interaction
Sex							0.06
Female	Reference	0.42(0.31,0.56)	<0.0001	0.24(0.12,0.47)	<0.0001	<0.0001	
Male	Reference	0.49(0.33,0.72)	<0.001	0.12(0.07,0.21)	<0.0001	<0.0001	
Age group							0.56
40–64	Reference	0.44(0.32,0.60)	<0.0001	0.16(0.08,0.31)	<0.0001	<0.0001	
≥65	Reference	0.49(0.32,0.75)	0.001	0.26(0.13,0.50)	<0.001	<0.0001	
Race							0.52
Other	Reference	0.41(0.30,0.58)	<0.0001	0.11(0.05,0.22)	<0.0001	<0.0001	
White	Reference	0.46(0.34,0.63)	<0.0001	0.18(0.11,0.31)	<0.0001	<0.0001	
Education							0.01
High school diploma	Reference	0.67(0.41,1.09)	0.11	0.71(0.27,1.88)	0.48	0.46	
Lower than high school	Reference	0.41(0.26,0.63)	<0.001	0.08(0.02,0.27)	<0.0001	<0.0001	
More than high school	Reference	0.45(0.32,0.65)	<0.0001	0.15(0.09,0.25)	<0.0001	<0.0001	
Poverty income ratio							0.09
<1.3	Reference	0.53(0.34,0.83)	0.01	0.39(0.19,0.80)	0.01	0.01	
1.3–3.5	Reference	0.42(0.30,0.59)	<0.0001	0.12(0.02,0.59)	0.01	<0.0001	
>3.5	Reference	0.83(0.43,1.63)	0.59	0.26(0.12,0.55)	<0.001	<0.0001	
Insurance							0.42
No	Reference	0.78(0.41,1.46)	0.43	0.29(0.04,2.12)	0.22	0.1	
Yes	Reference	0.43(0.33,0.55)	<0.0001	0.17(0.11,0.27)	<0.0001	<0.0001	

relationship was not confirmed in populations with a high school education level or those without insurance coverage. Subgroup analysis indicated that education level may be a confounding factor in this relationship ( $P$  for interaction = 0.01, Table 3).

LC9 has recently been updated to describe the most ideal indicators of CVH, which are closely related to the occurrence of cardiovascular diseases (CVD).<sup>3</sup> Moreover, CVD and COPD often influence each other, with pathological and physiological connections between them, and share similar pathogenic mechanisms and risk factors.<sup>3,26,27</sup> CVD is associated with reduced exercise capacity and excessive lung inflation caused by pulmonary edema, which may lead to decreased lung function and may be linked to the development of COPD.<sup>28,29</sup> Additionally, CVD can reduce the lung tissue available for gas exchange, leading to ventilation-perfusion mismatch, which is an important cause of acute exacerbation of COPD, hospitalizations, and even death.<sup>30</sup> In addition, COPD is an independent risk factor for CVD, possibly related to the fact that COPD can cause microvascular inflammation.<sup>31</sup> A prospective study of patients undergoing microvascular evaluation showed a significant association with lung disease and smoking.<sup>32</sup> Therefore, there may also be a connection between LC9 score and COPD. Our study has confirmed the close correlation between them and has described a linear decreasing relationship between LC9 scores and COPD diagnosis risk.

LC9 scores are derived from a comprehensive assessment of four health behavior factors (physical activity, tobacco, diet, and sleep) and five health factors (weight, cholesterol, blood glucose, blood pressure, and psychological health). These nine factors are closely related to the onset of COPD, thereby establishing the relationship between LC9 scores and COPD. It is well known that COPD is caused by exposure to harmful particles, especially tobacco smoke. Tobacco smoke causes airway inflammation, oxidative stress damage, and excessive activation of tissue remodeling, leading to the development of COPD.<sup>33,34</sup> The relationship between dietary patterns and chronic diseases is a hot topic of research today, and several studies have shown that dietary patterns are strongly associated with COPD.<sup>35–37</sup> Diet significantly affects an individual's level of lung function and risk of COPD by influencing the oxidative and antioxidant balance and inflammatory state in the body.<sup>38</sup> Physical activity and COPD mutually influence each other. Regular physical activity can improve symptoms of breathlessness, health status, and exercise tolerance in COPD patients.<sup>39</sup> The level of physical activity can also predict the risk of hospitalization for acute exacerbation of COPD and all-cause mortality.<sup>40,41</sup> However, COPD patients experience symptoms such as breathlessness and fatigue, leading to a decrease in physical activity levels early in the disease, which becomes more pronounced over time.<sup>42,43</sup> Sleep has a significant impact on respiration and gas exchange. Sleep disorders may lead to changes in functional residual capacity as well as ventilation/perfusion disturbances.<sup>44,45</sup> Underweight individuals have reduced muscle mass and an increased risk of respiratory infections, which are risk factors for the development of COPD.<sup>46,47</sup> Hyperlipidemia induces inflammation in immune cells, while hyperglycemia causes mitochondrial damage leading to excessive production of reactive oxygen species (ROS) due to oxidative stress.<sup>48,49</sup> Both conditions are characterized by insulin resistance and hyperinsulinemia, which can influence parasympathetic signaling to induce bronchial hyper-responsiveness and promote tissue fibrosis.<sup>50,51</sup> Additionally, patients with hypertension have elevated levels of C-reactive protein (CRP), and the severity of COPD is associated with CRP levels in the body.<sup>52,53</sup> Furthermore, psychological health is a focal point of concern in today's society. Depression is associated with chronic stress, and patients with depression often have persistent activation of the sympathetic nervous system and increased systemic inflammatory responses, which may lead to the development of COPD.<sup>53</sup> Moreover, patients with depression may experience increased frequency of COPD exacerbation due to cognitive impairment and poor treatment adherence.<sup>54</sup>

LC9 has the same factors as LS7 and LE8 but is richer, involving cardiopulmonary, endocrine metabolic, neurological, and psychological aspects to comprehensively assess the risk of developing COPD. Prior research has demonstrated a non-linear negative correlation between LE8 scores and COPD, where individuals with higher LE8 scores exhibited a significantly lower COPD diagnosis risk (OR 0.169, 95% CI (0.115, 0.249)).<sup>55</sup> Similarly, LS7 scores showed a positive correlation with lung function and a negative association with the odds of COPD.<sup>56</sup> Mental health is closely linked to COPD risk and may serve as a potential etiological factor in COPD development.<sup>11</sup> However, both the LE8 and LS7 scores lack assessment of mental health. The LC9 score addresses this gap by incorporating a depression symptom metric. Our study demonstrated a linearly decreasing association between LC9 scores and COPD. Compared to individuals with low LC9 scores, those with high LC9 scores exhibited an approximately 76% reduction in COPD

diagnosis risk (OR 0.24, 95% CI (0.14, 0.39)). Our findings demonstrate distinct differences compared to previous studies.<sup>55,56</sup> Notably, subgroup analyses revealed a significant interaction effect of educational attainment on the relationship between LC9 and COPD diagnosis. Specifically, among individuals with high school education, no inverse dose-response relationship was observed between LC9 scores and COPD diagnosis risk ( $P$  for trend = 0.46), suggesting that mental health metrics integrated into LC9 may differentially impact COPD screening efficacy in this population. Previous studies have shown that there is an interaction between education, mental health, and COPD.<sup>11,12,57–59</sup> the prevalence of both COPD and depressive symptoms is lower in those with higher levels of education than in those with lower levels of education.<sup>57,59</sup> And there is also an impact of mental health on COPD. Studies have shown that depressive symptoms may be a cause of COPD, and COPD is also prone to comorbid depressive symptoms.<sup>11,58</sup> Therefore, the LC9 score provides a more comprehensive assessment of the relationship between CVH status and COPD. Our study found that good CVH status reduces COPD diagnosis risk.

Our study is the first to explore the relationship between LC9 scores and COPD diagnosis based on the NHANES database, which is nationally representative. Inevitably, this study also has some limitations. First, the calculation of the LC9 score includes items based on self-reported data, which may introduce recall bias and self-reporting bias. Second, our study is a cross-sectional survey, and therefore it cannot establish a causal relationship or temporal sequence between the two variables. Third, the participants in our study were over 40 years of age and the results cannot be extrapolated to those under 40 years of age. Excluding younger individuals may overlook the long-term effects of earlier exposures (eg, chronic smoking, air pollution, and occupational exposures) on lung function and COPD development, making it possible that the results may not fully reflect the role of risk factors at younger ages. Although exclusion of persons younger than 40 years of age may improve the focus and statistical power of the study, it may also limit the applicability and generalizability of the results to younger populations. Future studies may need to balance these issues in their design to ensure that the results more fully serve the public health needs of different age groups. Fourth, the determination of COPD is not exactly the gold standard in the GOLD guidelines, which may lead to biased results. However, pulmonary function tests for COPD screening can have false negatives, and some participants may be unable to complete the tests due to severe pulmonary function impairment.<sup>60</sup> To identify COPD as accurately as possible and avoid its associated harms, we adopted the criteria used in this study. These criteria are widely used in many NHANES-related studies, making their adoption reasonable.<sup>15–17</sup> Additionally, not all three components of these criteria are assessed every year in the NHANES program, so we cannot provide the frequency of cross-verification for all three components.

## Conclusion

There was a linear decreasing relationship between the LC9 score and COPD diagnosis risk in middle-aged and older adults. The LC9 score is simple and easy to obtain, providing a more comprehensive assessment of the participants compared to the LS7 and LE8 scores. This makes it more accurate in reflecting the association.

## Abbreviations

LS7, Life's Simple 7; AHA, American Heart Association; CVH, cardiovascular health; LE8, Life's Essential 8; LC9, Life's Crucial 9; COPD, Chronic Obstructive Pulmonary Disease; NHANES, National Health and Nutrition Examination Survey; PIR, poverty income ratio; OR, odds ratios; CI, confidence intervals; CVD, cardiovascular diseases; ROS, reactive oxygen species; CRP, C-reactive protein.

## Data Sharing Statement

The dataset for this study can be found on the NHANES website NHANES - National Health and Nutrition Examination Survey Homepage (cdc.gov). And we have provided that portion of the data in the [Supplementary File 1](#).

## Ethics Approval

This study was based on the NHANES database, a publicly available anonymized database, and therefore was not required to comply with ethical norms. All participants in this database have signed informed consent forms provided by

the NHANES Ethics Review Board. Meanwhile, we also obtained a waiver from Zigong First People's Hospital for the study (Ethics no. M2025-031).

## Consent for Publication

Not applicable.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article. All authors approved the manuscript. All authors have agreed to submit this manuscript to the International Journal of Chronic Obstructive Pulmonary Disease and take full responsibility for all aspects of the work.

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## Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. All authors approved the present submitted version and their institutions have no objections to the manuscript's contents.

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