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ORIGINAL RESEARCH

Association Between Dietary Selenium Intake and Chronic Obstructive Pulmonary Disease: A Cross-Sectional Study from the National Health and Nutrition Examination Survey 1999–2018

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Background: Chronic obstructive pulmonary disease (COPD) is a widespread respiratory condition characterized by chronic inflammation. Selenium, an essential trace element, possesses anti-inflammatory and antioxidant properties. However, the diet is often complex, and the absence of one nutrient may indicate a concurrent deficiency in others. Therefore, inadequate dietary selenium intake may suggest deficiencies in other elements. Despite its potential benefits, there is a scarcity of evidence regarding the association between dietary selenium intake and COPD.

Purpose: This study aims to investigate the potential association between dietary selenium intake and COPD among American adults.

Patients and Methods: This cross-sectional study analyzed data from the National Health and Nutrition Examination Survey conducted in the United States from 1999 to 2018. Multivariate logistic regression, restricted cubic spline analyses, subgroup analysis, and sensitivity analysis were conducted to assess the correlation between dietary selenium intake and COPD.

Results: A total of 39,654 participants were included in the study. The adjusted odds ratio (OR) for COPD in the highest selenium intake group (T3, > 122.0 μg/day) was 0.80 (95% CI: 0.71–0.91, $p < 0.001$) compared to the lowest intake group (T1, < 81.6 μg/day). Dietary selenium intake exhibited a linear negative correlation with COPD. Among participants reporting selenium supplementation, a similar negative association persisted.

Conclusion: This study observed a negative correlation between dietary selenium intake and COPD among American adults, indicating a possible association between higher selenium intake and a lower risk of COPD.

Keywords: cross-sectional study, chronic obstructive pulmonary disease, COPD, dietary selenium intake, National Health and Nutrition Examination Survey, NHANES

Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent chronic inflammatory disorder affecting the airways, distinguished by persistent airflow limitation and airway obstruction.[1] Currently, COPD is causing significant economic losses on a global scale, primarily attributed to its high prevalence, considerable morbidity, and mortality rates.[2,3] Research has shown that the risk factors for the disease include exogenous factors such as smoking and nutritional status,[4] as well as endogenous factors like genetics.[1] These aspects promote inflammation and oxidative stress in the lungs, leading to the development of COPD.[5] Therefore, early identification of COPD susceptibility factors is crucial for effective prevention. Given the fundamental role of dietary factors in nutritional status and their close association with COPD development,[6] trace elements may play a significant role in lung health maintenance.[7,8]

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Selenium, a crucial non-metallic trace element in the human body, plays a fundamental role in the synthesis of various antioxidant selenoproteins, including glutathione peroxidase.[9] This element exerts antioxidant and anti-inflammatory properties that can effectively suppress oxidative stress responses systemically. Numerous studies have shown that dietary selenium intake enhances immunity,[10,11] fights infection,[12] and exerts protective effects against autoimmune thyroid diseases,[13] lung cancer,[14] bladder cancer,[15] prostate cancer and other diseases.[16] However, clinical studies have reported that selenium intake not only does not benefit patients with cardiovascular disease,[17] but also increases the risk of diabetes.[18] Previous research has demonstrated that COPD patients exhibit lower serum selenium levels compared to healthy control groups,[19] and their symptoms can be partly alleviated through selenium supplementation.[20,21] Nevertheless, these studies mainly concentrate on selenium supplements among COPD patients, rather than the dietary selenium consumption of the general population. Additionally, the diet is often a complex mixture, and the deficiency of one nutrient may indicate the lack of others. Therefore, inadequate dietary selenium intake could be a sign of deficiencies in other elements. Despite selenium's potential health benefits, research on the relationship between dietary selenium intake and COPD is still lacking.

To investigate the correlation between dietary selenium intake and COPD, we conducted evaluation among American adults using data from the National Health and Nutrition Examination Survey (NHANES), a comprehensive population-based survey conducted in the United States between 1999 and 2018.

Methods

Study Population

The study obtained its data from the National Center for Health Statistics (NCHS), which is part of the US Centers for Disease Control and Prevention (CDC). NHANES, conducted nationwide, is specifically designed to assess the health and nutritional status of a representative sample of the non-institutionalized US population, offering a comprehensive snapshot of the country's health landscape.[22] Detailed population and sampling survey methods can be found on the NHANES website. It's worth noting that the NHANES survey protocol has been reviewed and approved by the Ethics Review Committee of the NCHS in the United States. Furthermore, written informed consent was obtained from all participants involved. Considering the Ethical Review Methods for Life Science and Medical Research Involving Human Beings, we have discovered that Article 32 of these regulations explicitly exempts research from needing ethical approval under specific conditions. As stated in Article 32: Ethical approval is not required for research that meets the criteria of (a) using legally obtained public data, or data generated by observation and not interfering with public behavior; and (b) using anonymized informational data to conduct the research. Since this study was based on anonymized publicly available deidentified data and informed consent was waived, ethical approval and consent were not required, so the Ethics Review Committee of the Second People's Hospital of Banan District exempted the study (ethic number:2022–004). The study was conducted in accordance with the Helsinki Declaration (revised in 2013).

We recruited a total of 55,081 adults aged 20 years and older from 10 cycles of the NHANES study. Participants with incomplete COPD questionnaire data or dietary selenium assessment data, as well as those in a pregnant state, were excluded. Individuals with missing or incomplete data regarding demographics, risk behaviors, comorbid conditions, or dietary intake were excluded from the study. Given the large sample size, missing covariates were excluded directly. The exclusion process is visually represented in Figure 1. A total of 39,654 participants were finally included in the analysis.

Variables

COPD, as diagnosed by self-report, served as the primary outcome variable in this study.[23] Three self-administered questionnaires were used to verify disease status: "Have you been told you have chronic bronchitis?", "Have you been told you have emphysema?", and "Have you been told you have COPD?". Participants who answered "yes" to any of these questions were placed in the COPD group; those who answered "no" were placed in the non-COPD group.

Dietary selenium intake is the main predictor variable. It was obtained through two rounds of 24-hour dietary recall interviews. Participants, excluding those from the 1999–2000 and 2001–2002 cycles, underwent both interviews. During the first recall, respondents completed a test conducted at the NHANES mobile testing center, followed by a telephone

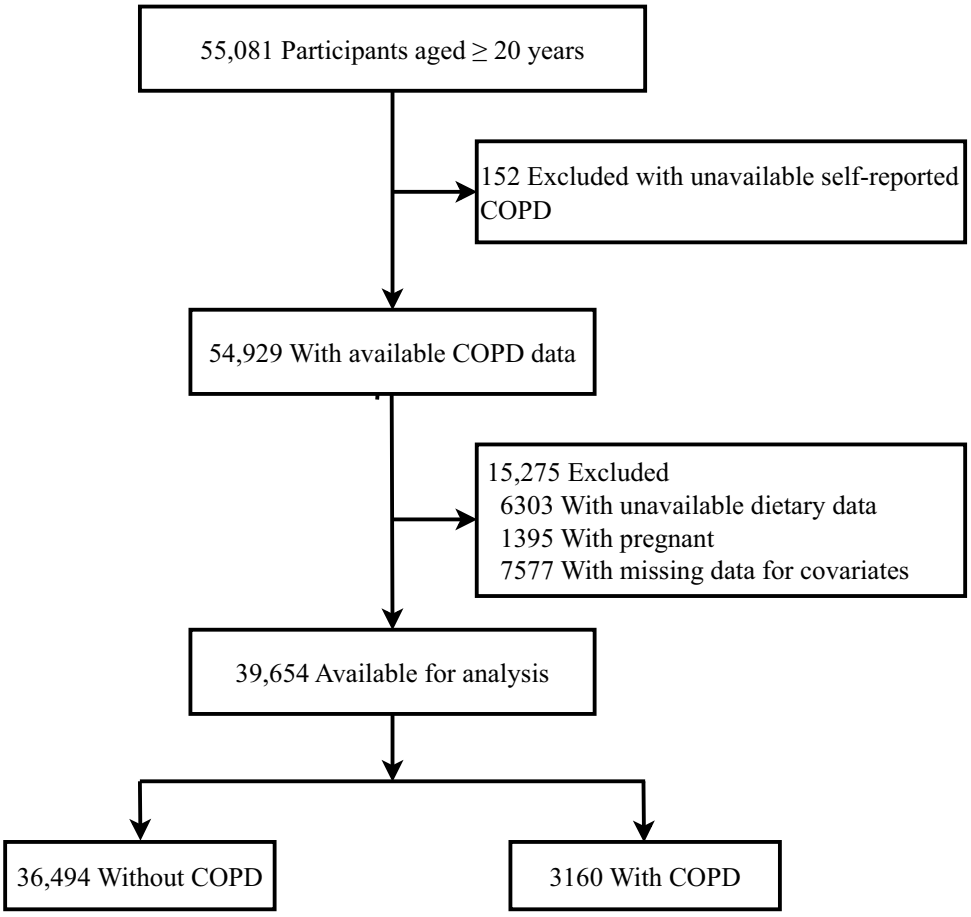

Figure 1 Flowchart depicting the screening and enrollment process for study participants.
Abbreviation: COPD, chronic obstructive pulmonary disease.

interview conducted between 3 and 10 days later during the second recall. To ensure data completeness and accuracy, this analysis utilized the average dietary selenium intake from the two interviews. In cases where data from the second interview was missing, data from the first interview was used as a substitute.

In the NHANES database, data on dietary supplements were collected during household interviews. From 2007 to 2018, participants were asked if they had taken dietary supplements in the past 30 days, and detailed information on the supplements was provided. To calculate the average daily intake of nutrients from supplements, researchers divided the total intake of all supplements by 30 days. The total selenium intake was calculated by adding dietary intake and supplement intake.

Covariates were selected based on literature review and clinical experience,[23,24] including sex, age, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other), education level (< 9 years, 9–12 years, > 12 years), marital status (married, living with partner or living alone), ratio of income to poverty (PIR) (low: ≤ 1.3, medium: > 1.3 to 3.5, high: > 3.5),[25] smoking status (never, former, or current), drinking status (defined as significant alcohol intake for ≥ 12 glasses of alcohol per year, and non-significant alcohol intake otherwise), body mass index (BMI, kg/m^2), complications (diabetes, hypertension), dietary supplement intake and total daily energy intake. Total energy was obtained from two 24-hour dietary recalls. We used questionnaires to assess a history of diabetes and hypertension.

Statistical Analysis

This study conducted secondary analysis on publicly available datasets, and statistical analysis was performed following the survey methods and NHANES analysis guidelines. Categorical variables were described using numbers (percentages), and inter-group comparisons were conducted using the chi-square test. Continuous variables were described as

mean ± standard deviation (SD) if normally distributed, or as median and interquartile range (IQR) if skewed. We developed a multivariable logistic regression model to estimate the odds ratio (OR) and corresponding 95% confidence interval (95% CI), examining the association between selenium intake and COPD. The model consisted of three parts: an unadjusted model, a minimally adjusted model (including age, sex, race/ethnicity), and a fully adjusted model (including age, sex, race/ethnicity, marital status, PIR, education level, BMI, physical activity, smoking and drinking status, hypertension, diabetes, dietary supplements, and total energy intake). To confirm the results obtained as continuous variables in unadjusted and multivariable adjusted models, we calculated *p*-values for trends. To explore the potential nonlinear association between dietary selenium intake and COPD, we utilized a restricted cubic spline (RCS) model, treating selenium intake as a continuous variable with four knots (5th, 35th, 65th, and 95th percentiles) to capture smoothed curves. Additionally, we conducted subgroup analyses considering variables including sex, age, education level, marital status, PIR and BMI. To assess subgroup heterogeneity and interactions, logistic regression models were employed, and likelihood ratio tests were performed. In addition to dietary intake, supplements are also an important source of selenium. To investigate the effect of supplemental selenium on COPD, we conducted an additional analysis among participants who consumed selenium supplements (> 0.01 μg/day).

As the sample size was solely determined by available data, no prior statistical power estimates were obtained. All analyses were performed using R 3.3.2 statistical software (http://www.R-project.org, The R Foundation) and Free Statistics software version 1.9 (Beijing Free Clinical Medical Technology Co., LTD). A two-tailed of $p < 0.05$ was regarded statistically significant.

Results

Baseline Characteristics

Table 1 presents an overview of the baseline demographics and characteristics of the 39,654 individuals included in the study. The average age was 50.0 (± 17.9) years, with males representing 50.2% and females accounting for 49.8%. Notably, 3,160 (8.0%) participants self-reported COPD. Participants with higher dietary selenium intake generally consisted of those who were young, male, non-Hispanic white, married or living with a partner, and had the habit of drinking but not smoking. Higher dietary selenium intake was also associated with higher education levels and family income, supplement usage, increased energy intake, and lower rates of hypertension and diabetes.

Table 1 Population Characteristics by Categories of Dietary Selenium Intake

Characteristics	Dietary Selenium Intake[a] (μg/d)				
	Total	T1	T2	T3	*p* value
		(< 81.6)	(81.6–122.0)	(> 122.0)	
No.	39,654	13,217	13,215	13,222	
Age (year)	50.0 ± 17.9	53.3 ± 18.5	50.6 ± 17.9	46.0 ± 16.5	< 0.001
Sex, %					< 0.001
Male	19,924 (50.2)	4282 (32.4)	6331 (47.9)	9311 (70.4)	
Female	19,730 (49.8)	8935 (67.6)	6884 (52.1)	3911 (29.6)	
Race/ethnicity, %					< 0.001
Non-Hispanic white	18,599 (46.9)	6117 (46.3)	6343 (48.0)	6139 (46.4)	
Non-Hispanic black	8164 (20.6)	3010 (22.8)	2638 (20.0)	2516 (19.0)	
Mexican-American	6557 (16.5)	2157 (16.3)	2155 (16.3)	2245 (17.0)	
Other	6334 (16.0)	1933 (14.6)	2079 (15.7)	2322 (17.6)	
Marital status, %					< 0.001
Married or living with a partner	23,938 (60.4)	7385 (55.9)	8098 (61.3)	8455 (63.9)	
Living alone	15,716 (39.6)	5832 (44.1)	5117 (38.7)	4767 (36.1)	
Education level (year), %					< 0.001
< 9	4225 (10.7)	1892 (14.3)	1329 (10.1)	1004 (7.6)	
9–12	15,001 (37.8)	5349 (40.5)	4791 (36.3)	4861 (36.8)	
> 12	20,428 (51.5)	5976 (45.2)	7095 (53.7)	7357 (55.6)	

(*Continued*)

Table 1 (Continued).

Characteristics	Dietary Selenium Intake[a] (μg/d)				
	Total	T1	T2	T3	*p* value
		(< 81.6)	(81.6–122.0)	(> 122.0)	
PIR, %					< 0.001
Low	11,876 (29.9)	4522 (34.2)	3715 (28.1)	3639 (27.5)	
Medium	15,186 (38.3)	5219 (39.5)	5088 (38.5)	4879 (36.9)	
High	12,592 (31.8)	3476 (26.3)	4412 (33.4)	4704 (35.6)	
BMI (kg/m^2)	29.1 ± 6.8	29.0 ± 6.9	29.1 ± 6.7	29.1 ± 6.9	< 0.001
Physical activity, %					< 0.001
Sedentary	20,569 (51.9)	7522 (56.9)	6964 (52.7)	6083 (46.0)	
Moderate	9671 (24.4)	3183 (24.1)	3351 (25.4)	3137 (23.7)	
Vigorous	9414 (23.7)	2512 (19.0)	2900 (21.9)	4002 (30.3)	
Smoking status, %					< 0.001
Never	21,099 (53.2)	7188 (54.4)	7118 (53.9)	6793 (51.4)	
Former	10,119 (25.5)	3173 (24.0)	3531 (26.7)	3415 (25.8)	
Current	8436 (21.3)	2856 (21.6)	2566 (19.4)	3014 (22.8)	
Drinking status, %					< 0.001
Non-significant alcohol intake	10,604 (26.7)	4623 (35.0)	3457 (26.2)	2524 (19.1)	
Significant alcohol intake	29,050 (73.3)	8594 (65.0)	9758 (73.8)	10,698 (80.9)	
Hypertension, %					< 0.001
No	28,089 (70.8)	8881 (67.2)	9242 (69.9)	9966 (75.4)	
Yes	11,565 (29.2)	4336 (32.8)	3973 (30.1)	3256 (24.6)	
Diabetes, %					< 0.001
No	34,797 (87.8)	11,401 (86.3)	11,541 (87.3)	11,855 (89.7)	
Yes	4857 (12.2)	1816 (13.7)	1674 (12.7)	1367 (10.3)	
COPD, %					< 0.001
No	36,494 (92.0)	11,942 (90.4)	12,169 (92.1)	12,383 (93.7)	
Yes	3160 (8.0)	1275 (9.6)	1046 (7.9)	839 (6.3)	
Dietary supplements, %					< 0.001
No	23,471 (59.2)	7779 (58.9)	7619 (57.7)	8073 (61.1)	
Yes	16,183 (40.8)	5438 (41.1)	5596 (42.3)	5149 (38.9)	
Total energy (kcal/d)	1920 (1449 2522)	1365 (1076, 1700)	1919 (1596, 2296)	2664 (2169, 3255)	< 0.001

Note: [a]Dietary selenium intake was divided to three tertiles: T1 (< 81.6 μg /day); T2 (81.6–122.0 μg /day); T3 (> 122.0 μg /day).
Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; PIR, ratio of income to poverty.

Association Between Dietary Selenium Intake and Chronic Obstructive Pulmonary Disease

When considering dietary selenium intake as a categorical variable (tertiles), we constructed three logistic regression models to investigate its association with COPD (Table 2). Across all models, we observed a higher risk of COPD in the group with the highest dietary selenium intake, followed by the moderate intake group, showing a consistent trend ($p < 0.001$). After adjusting age, sex, race/ethnicity, marital status, PIR education level, BMI, smoking and drinking status, physical activity, diabetes, hypertension, dietary supplements, total energy (Model 3), compared to the reference T1 (< 81.6 μg/day) group, the ORs for the T2 (81.6–122.0 μg/day) and T3 (> 122.0 μg/day) groups were 0.89 (95% CI: 0.81–0.98) and 0.80 (95% CI: 0.71–0.91), respectively, with all *p*-values < 0.05.

The relationship between dietary selenium intake and COPD was elucidated through RCS analysis, illustrating the fitting curve between dietary selenium intake and COPD (Figure 2). The results revealed a linear association between the variables (non-linearity $p = 0.531$) following adjustments in Model 3. The impact across various levels of dietary selenium intake was found to be consistent.

Subgroup Analyses

We further investigated potential associations between dietary selenium intake and COPD across various demographic factors, including sex, age, education level, marital status, PIR, and BMI. Consistent patterns were observed across all

Table 2 Association Between Dietary Selenium Intake and COPD

Dietary Selenium Intake	No.	Event (%)	Model 1[a]		Model 2[b]		Model 3[c]	
			OR (95% CI)	*p* value	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Tertiles (μg/d)								
T1 (< 81.6)	13,217	1275 (9.6)	1(Reference)		1(Reference)		1(Reference)	
T2 (81.6–122.0)	13,215	1046 (7.9)	0.81 (0.74–0.88)	<0.001	0.89 (0.81–0.97)	0.008	0.89 (0.81–0.98)	0.018
T3 (> 122.0)	13,222	839 (6.3)	0.63 (0.58–0.69)	<0.001	0.84 (0.76–0.93)	0.001	0.80 (0.71–0.91)	<0.001
Trend test				<0.001		<0.001		<0.001

Note: [a]Crude model. [b]Adjusted for age, sex, race/ethnicity. [c]Adjusted for age, sex, race/ethnicity, marital status, ratio of income to poverty, education level, body mass index, physical activity, smoking and drinking status, hypertension, diabetes, dietary supplements, total energy.
Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio; T, Tertiles.

subgroups after adjusting for all covariates. To visually represent these findings, we included a Forest plot (Figure 3). Specifically, dietary selenium intake was linked to COPD, with a stronger association observed among individuals aged below 60 years (OR, 0.76; 95% CI, 0.65–0.90) and a weaker association among those aged 60 years and above (OR, 0.82; 95% CI, 0.68–0.98). Moreover, higher levels of education were significantly inversely correlated with COPD (OR,

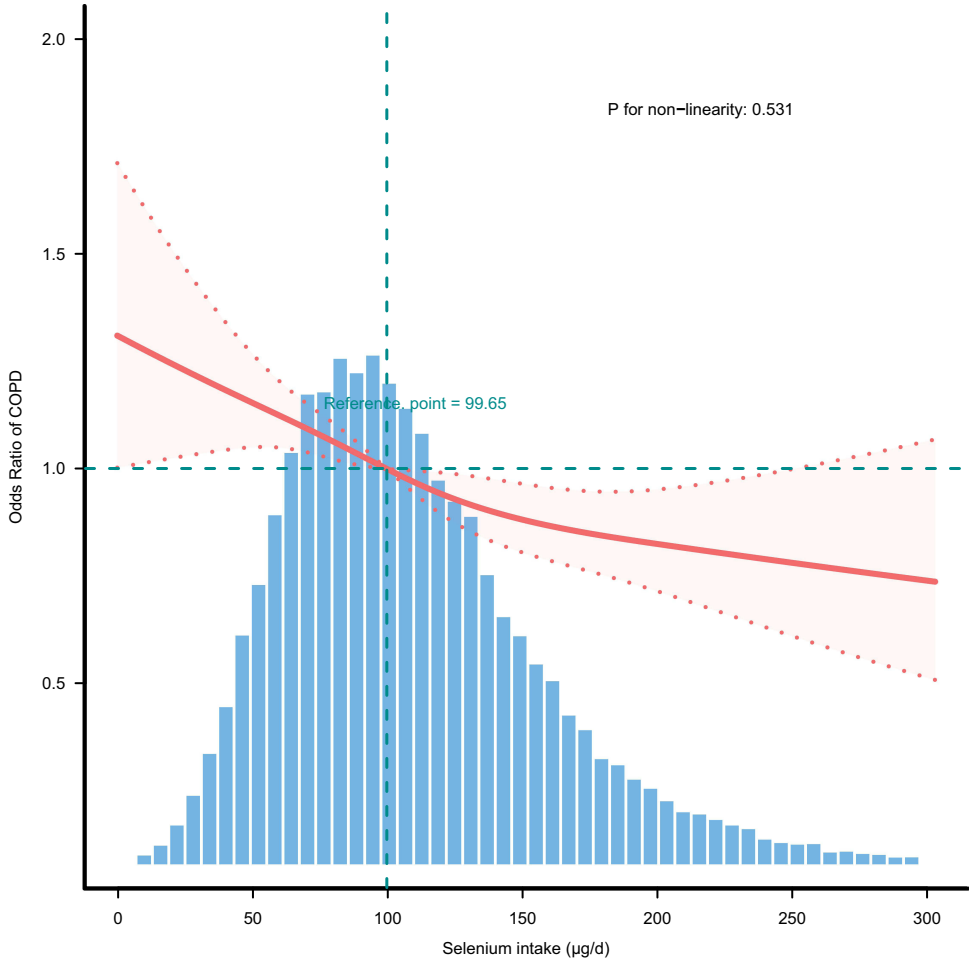

Figure 2 Restricted cubic spline plot between dietary selenium intake and odds ratio of COPD. The bar chart illustrates the distribution of the population. Solid and dashed lines denote predicted values with 95% confidence intervals. Reference.point, the median selenium intake. Data represents 99% of the sample. Adjusted for age, sex, race/ethnicity, marital status, education level, body mass index, ratio of income to poverty, physical activity, smoking and drinking status, hypertension, diabetes, total energy intake.
Abbreviation: COPD, chronic obstructive pulmonary disease.

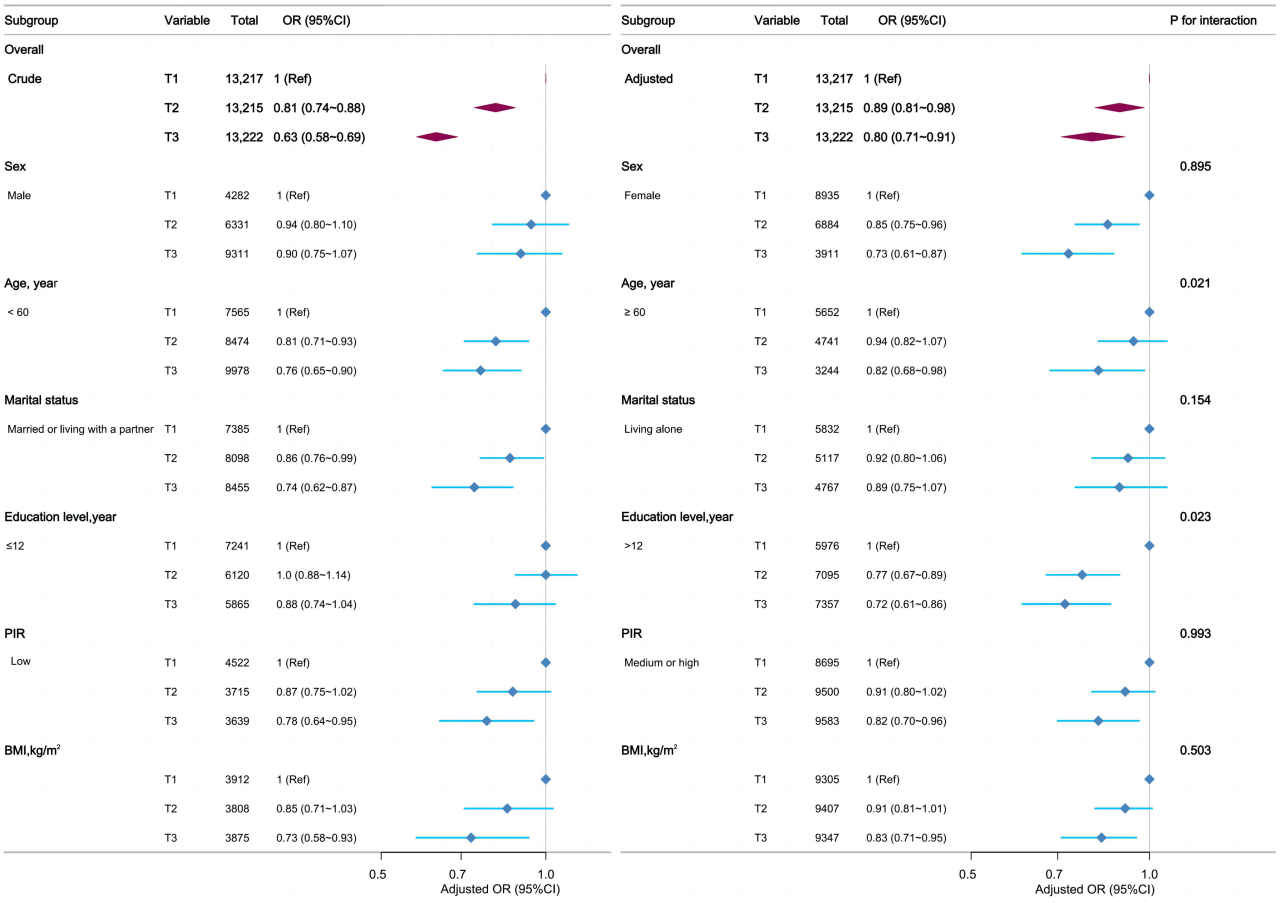

Figure 3 Forest plot illustrating the multivariable-adjusted association between dietary selenium intake and COPD. Each square represents the OR, and the horizontal lines represent the 95% CI. The top of the plot represents the overall summary estimate. Adjustments were made for age, sex, race/ethnicity, marital status, education level, body mass index, ratio of income to poverty, physical activity, smoking and drinking status, hypertension, diabetes, total energy intake.

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; PIR, ratio of income to poverty; dietary selenium intake tertiles (μg /day): T1 (< 81.6); T2 (81.6–122.0); T3 (> 122.0).

0.72; 95% CI, 0.61–0.80), while this correlation attenuated in lower education strata (OR, 0.88; 95% CI, 0.74–1.04). Despite observing a statistically significant interaction between age and education level (p for interaction < 0.05), the clinical relevance of this finding remains uncertain due to the implications of multiple testing and the similarity in the direction of the associations.

Sensitivity Analysis

In addition to dietary intake, supplements play a significant role in providing selenium. Therefore, we also investigated the association between selenium supplement intake and COPD. Out of the 39,654 participants included in this study, 2,906 individuals increased their selenium intake (≥ 0.01 μg/day) through these supplements. The study population taking dietary selenium supplements was divided into tertiles. Compared to T1 (< 19.8 μg/day), the adjusted OR for COPD in T2 (19.8–54.6 μg/day) and T3 (> 54.6 μg/day) were 0.94 (95% CI: 0.66–1.32, $p = 0.704$) and 0.85 (95% CI: 0.61–1.20, $p = 0.361$), respectively. Similarly, when total selenium intake was categorized into tertiles, the adjusted OR for COPD in T2 (120.0–177.5 μg/day) was 0.65 (95% CI: 0.46–0.91, $p = 0.013$) and in T3 (> 177.5 μg/day) was 0.77 (95% CI: 0.52–1.14, $p = 0.195$). For more detailed information, please consult Table 3.

Discussion

The presence of co-existing diseases contributes to the elevated prevalence and mortality rates of COPD. Consequently, comprehensive identification of the risk factors for COPD is crucial for early prevention and timely intervention of the

Table 3 Association Between Selenium Dietary Supplement Intake and COPD

Selenium Intake (μg/d)	No.	Event (%)	Model 1[a]		Model 2[b]		Model 3[c]	
			OR (95% CI)	*p* value	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Supplement								
T1 (< 19.8)	827	76 (9.2)	1(Reference)		1(Reference)		1(Reference)	
T2 (19.8–54.6)	962	87 (9.0)	0.98 (0.71–1.36)	0.915	0.89 (0.64–1.24)	0.509	0.94 (0.66–1.32)	0.704
T3 (> 54.6)	1117	98 (8.8)	0.95 (0.69–1.30)	0.751	0.83 (0.60–1.14)	0.246	0.85 (0.61–1.20)	0.361
Trend test				0.746		0.249		0.356
Total								
T1 (< 120.0)	969	114 (11.8)	1(Reference)		1(Reference)		1(Reference)	
T2 (120.0–177.5)	968	75 (7.7)	0.63 (0.46–0.86)	0.003	0.64 (0.46–0.87)	0.005	0.65 (0.46–0.91)	0.013
T3 (> 177.5)	969	72 (7.4)	0.60 (0.44–0.82)	0.001	0.67 (0.48–0.95)	0.023	0.77 (0.52–1.14)	0.195
Trend test				0.001		0.014		0.143

Note: Of the 39,654 participants ultimately included in this study, 2906 participants increased their selenium intake (≥ 0.01mg/day) through these supplements. [a]Crude model. [b]Adjusted for age, sex, race/ethnicity. [c]Adjusted for age, sex, race/ethnicity, marital status, education level, body mass index, ratio of income to poverty, physical activity, smoking and drinking status, hypertension, diabetes, total energy intake.

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio; T, Tertiles.

disease, ultimately mitigating excessive medical resource utilization and alleviating the financial burden on nations. Our study revealed a negative linear association between dietary selenium intake and COPD, indicating that higher selenium intake may be associated with a lower risk of COPD. The dietary intake of selenium holds promise as a protective factor in the prevention and management of COPD.

Various studies observed that selenium may have an effect on COPD. Both a cross-sectional study involving 479 British individuals and another involving 2,460 Chinese community residents found a positive correlation between selenium and lung function.[26,27] Furthermore, a longitudinal study in the United States examined lung function among 1,641 men over an average of three years and reported that selenium was associated with a reduced decline in FEF_{25-75} among current smokers.[28] Another clinical cohort study in Portugal, including 45 patients, found lower plasma selenium levels in those with COPD.[19] Additionally, numerous randomized double-blind controlled trials have indicated that selenium supplementation, either orally or intravenously, has the potential of alleviating specific symptoms in COPD patients.[20,21,29] Despite the accumulating evidence above, the impact of dietary selenium intake on COPD remains underexplored.

Recently, only two large-scale studies have been conducted on the American population, suggesting a potential beneficial effect of elevated serum selenium concentrations on lung health.[30,31] However, these studies, which relied on data from 1988 to 1994, did not delve into the specific linkage between dietary selenium intake and COPD. Hence, our study aimed to bridge this knowledge gap by employing updated clinical data to conduct a comprehensive analysis of dietary selenium intake. Through multivariable logistic regression and RCS analysis, we identified an inverse association between dietary selenium intake and COPD. Selenium intake typically comes from the consumption of foods such as fish, meat, poultry, wheat, bread, grains, and selenium supplements.[32] Our findings reveal a beneficial role for selenium in the management of COPD, thus underscoring the importance of considering dietary selenium intake based on its potential benefits for respiratory health.

Although the association between dietary selenium intake and COPD remains unclear at present, these observations are bolstered by relevant evidence. Selenium, a crucial component of antioxidant proteins like glutathione peroxidase, exerts a favorable influence on the therapy, alleviation, and prognosis of various oxidative stress-related diseases.[33] For instance, in rheumatoid arthritis, dietary selenium intake may alleviate joint pain and injury.[34] Similarly, selenium treatment shows promise in relieving pain and controlling the disease in patients with pancreatitis.[35] The impact of selenium on oxidative stress in the respiratory system is mediated by the antioxidant activity of glutathione peroxidase 1 (GPX1). Cellular and animal studies have demonstrated that decreased selenium intake leads to reduced GPX1 activity, increased oxidative stress in the lung,[36] and excessive mucus synthesis.[37] Oxidative stress and excessive mucus production are closely linked to the pathogenesis of chronic inflammatory airway diseases, such as asthma and

COPD.[38,39] Therefore, we postulate that selenium's antioxidant and anti-inflammatory properties may underlie its beneficial impact on COPD.

Notably, the stratified analysis revealed a stronger association between dietary selenium intake and COPD among individuals aged below 60 years compared to those aged 60 years and above. This finding suggests that selenium plays a more direct role in maintaining lung health among younger and middle-aged adults. However, there may be a decline in selenium absorption and utilization efficiency with age, possibly attributed to weakened gastrointestinal function.[40] Additionally, comorbidities and complex medication regimens among older adults may further impair the protective effect of selenium against COPD.[41] On the other hand, the study also demonstrated a significant inverse relationship between educational level and COPD, which attenuated as education level decreased. The result possibly indicated that individuals with lower education levels face greater health challenges and lifestyle limitations, contributing to an increased COPD risk.[42] Although a statistical interaction between sex and educational level was observed, the clinical significance of this finding remains to be validated.

Given the substantial role of selenium supplements in overall selenium intake, a sensitivity analysis was conducted to investigate the relationship between selenium supplementation and COPD. The results revealed a negative correlation between the combined intake of selenium from both dietary and supplemental sources and the occurrence of COPD. Future studies on detailed mechanisms underlying selenium's role in COPD are warranted to further elucidate this association.

Strengths and Limitations

The strength of this study resides in its substantial sample size, utilization of individual-level data, and construction of a reliable multivariate logistic regression model. This comprehensive analysis considers both dietary selenium intake and supplementation, adjusting for multiple confounders. The findings offer valuable insights into the potential role of selenium in COPD prevention and treatment strategies, adding to the existing knowledge base in this crucial area. However, there are also limitations that warrant caution. Initially, due to the nature of acquiring dietary selenium intake through the 24-hour recall method, it is impractical to entirely eliminate recording errors and recall biases. Conversely, we opted against utilizing food frequency surveys due to their limited ability to capture comprehensive information on food types and quantities consumed.[43] Additionally, as a secondary analysis of open databases, this study may be susceptible to interference from residual confounding effects, including genetic factors, despite the adjustment for numerous confounding factors. Lastly, this cross-sectional study can only describe phenomena, and causal or consequential associations cannot be inferred. Therefore, future longitudinal studies are crucial to deeply explore the causal link between dietary selenium intake and COPD.

Conclusion

Our study observed a negative correlation between dietary selenium intake and COPD among American adults, indicating a possible association between higher selenium intake and a lower risk of COPD. However, further research is warranted to confirm these findings.

Data Sharing Statement

Data of publicly available datasets was analyzed in this study. All data are available on the National Health and Nutrition Examination Survey (NHANES) website (https://www.cdc.gov/nchs/nhanes/).

Ethics Approval

This is an observational study. The studies involving human participants were reviewed and approved by the NCHS Ethics Review Board (ERB).

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Disclosure

The authors declare no competing interests in this work.

References

1. Agustí A, Celli BR, Criner GJ, et al. Global Initiative for Chronic Obstructive Lung Disease 2023 Report: GOLD Executive Summary. *Am J Respir Crit Care Med*. 2023;207(7):819–837. doi:10.1164/rccm.202301-0106PP
2. Safiri S, Carson-Chahhoud K, Noori M, et al. Burden of chronic obstructive pulmonary disease and its attributable risk factors in 204 countries and territories, 1990–2019: results from the Global Burden of Disease Study 2019. *BMJ*. 2022:378:e069679. 10.1136/bmj-2021-069679
3. Christenson SA, Smith BM, Bafadhel M, Putcha N. Chronic obstructive pulmonary disease. *Lancet*. 2022;399(10342):2227–2242. doi:10.1016/S0140-6736(22)00470-6
4. Beijers RJHCG, Steiner MC, Schols AMWJ. The role of diet and nutrition in the management of COPD. *Eur Respir Rev*. 2023;32(168):230003. doi:10.1183/16000617.0003-2023
5. Barnes PJ. Cellular and molecular mechanisms of chronic obstructive pulmonary disease. *Clin Chest Med*. 2014;35(1):71–86. doi:10.1016/j.ccm.2013.10.004
6. Schols AM, Ferreira IM, Franssen FM, et al. Nutritional assessment and therapy in COPD: a European Respiratory Society statement. *Eur Respir J*. 2014;44(6):1504–1520. doi:10.1183/09031936.00070914
7. Hirayama F, Lee AH, Oura A, Mori M, Hiramatsu N, Taniguchi H. Dietary intake of six minerals in relation to the risk of chronic obstructive pulmonary disease. *Asia Pac J Clin Nutr*. 2010;19(4):572–577.
8. Fekete M, Csípő T, Fazekas-Pongor V, et al. The Effectiveness of Supplementation with Key Vitamins, Minerals, Antioxidants and Specific Nutritional Supplements in COPD-A Review. *Nutrients*. 2023;15(12):2741. doi:10.3390/nu15122741
9. Hariharan S, Dharmaraj S. Selenium and selenoproteins: it's role in regulation of inflammation. *Inflammopharmacol*. 2020;28(3):667–695. doi:10.1007/s10787-020-00690-x
10. Razaghi A, Poorebrahim M, Sarhan D, Björnstedt M. Selenium stimulates the antitumour immunity: insights to future research. *Eur J Cancer*. 2021;155:256–267. doi:10.1016/j.ejca.2021.07.013
11. Bjørklund G, Shanaida M, Lysiuk R, et al. Selenium: an Antioxidant with a Critical Role in Anti-Aging. *Molecules*. 2022;27(19):6613. doi:10.3390/molecules27196613
12. Alexander J, Tinkov A, Strand TA, Alehagen U, Skalny A, Aaseth J. Early Nutritional Interventions with Zinc, Selenium and Vitamin D for Raising Anti-Viral Resistance Against Progressive COVID-19. *Nutrients*. 2020;12(8):2358. doi:10.3390/nu12082358
13. Toulis KA, Anastasilakis AD, Tzellos TG, Goulis DG, Kouvelas D. Selenium supplementation in the treatment of Hashimoto's thyroiditis: a systematic review and a meta-analysis. *Thyroid*. 2010;20(10):1163–1173. doi:10.1089/thy.2009.0351
14. Yang J, Qian S, Na X, Zhao A. Association between Dietary and Supplemental Antioxidants Intake and Lung Cancer Risk: evidence from a Cancer Screening Trial. *Antioxidants (Basel)*. 2023;12(2):338. doi:10.3390/antiox12020338
15. Amaral AFS, Cantor KP, Silverman DT, Malats N. Selenium and bladder cancer risk: a meta-analysis. *Cancer Epidemiol Biomarkers Prev*. 2010;19(9):2407–2415. doi:10.1158/1055-9965.EPI-10-0544
16. Brinkman M, Reulen RC, Kellen E, Buntinx F, Zeegers MP. Are men with low selenium levels at increased risk of prostate cancer? *Eur J Cancer*. 2006;42(15):2463–2471. doi:10.1016/j.ejca.2006.02.027
17. Stranges S, Marshall JR, Trevisan M, et al. Effects of selenium supplementation on cardiovascular disease incidence and mortality: secondary analyses in a randomized clinical trial. *Am J Epidemiol*. 2006;163(8):694–699. doi:10.1093/aje/kwj097
18. Stranges S, Marshall JR, Natarajan R, et al. Effects of long-term selenium supplementation on the incidence of type 2 diabetes: a randomized trial. *Ann Intern Med*. 2007;147(4):217–223. doi:10.7326/0003-4819-147-4-200708210-00175
19. Santos MC, Oliveira AL, Viegas-Crespo AM, et al. Systemic markers of the redox balance in chronic obstructive pulmonary disease. *Biomarkers*. 2004;9(6):461–469. doi:10.1080/13547500400024768
20. El-Attar M, Said M, El-Assal G, Sabry NA, Omar E, Ashour L. Serum trace element levels in COPD patient: the relation between trace element supplementation and period of mechanical ventilation in a randomized controlled trial. *Respirology*. 2009;14(8):1180–1187. doi:10.1111/j.1440-1843.2009.01622.x
21. Isbaniah F, Wiyono WH, Yunus F, Setiawati A, Totzke U, Verbruggen MA. Echinacea purpurea along with zinc, selenium and vitamin C to alleviate exacerbations of chronic obstructive pulmonary disease: results from a randomized controlled trial. *J Clin Pharm Ther*. 2011;36(5):568–576. doi:10.1111/j.1365-2710.2010.01212.x
22. Zipf G, Chiappa M, Porter KS, Ostchega Y, Lewis BG, Dostal J. National health and nutrition examination survey: plan and operations, 1999–2010. *Vital Health Stat 1*. 2013;56:1–37.
23. Liu Z, Su Y, Chen Q, et al. Association of Dietary intake of vitamin E with chronic obstructive pulmonary disease events in US adults: a cross-sectional study of NHANES 2013–2018. *Front Nutr*. 2023;10:1124648. doi:10.3389/fnut.2023.1124648
24. Chai X, Chen Y, Li Y, Chi J, Guo S. Lower geriatric nutritional risk index is associated with a higher risk of all-cause mortality in patients with chronic obstructive pulmonary disease: a cohort study from the National Health and Nutrition Examination Survey 2013–2018. *BMJ Open Respir Res*. 2023;10(1):e001518. doi:10.1136/bmjresp-2022-001518
25. What We Eat In America (WWEIA) Database | ag Data Commons. Accessed January 2, 2024. Available from: https://data.nal.usda.gov/dataset/what-we-eat-america-wweia-database.
26. Pearson P, Britton J, McKeever T, et al. Lung function and blood levels of copper, selenium, vitamin C and vitamin E in the general population. *Eur J Clin Nutr*. 2005;59(9):1043–1048. doi:10.1038/sj.ejcn.1602209

27. Feng W, Huang X, Zhang C, et al. The dose–response association of urinary metals with altered pulmonary function and risks of restrictive and obstructive lung diseases: a population-based study in China. *BMJ Open*. 2015;5(5):e007643. doi:10.1136/bmjopen-2015-007643
28. Cassano PA, Guertin KA, Kristal AR, et al. A randomized controlled trial of vitamin E and selenium on rate of decline in lung function. *Respir Res*. 2015;16(1):35. doi:10.1186/s12931-015-0195-5
29. Gouzi F, Maury J, Héraud N, et al. Additional Effects of Nutritional Antioxidant Supplementation on Peripheral Muscle during Pulmonary Rehabilitation in COPD Patients: a Randomized Controlled Trial. *Oxid Med Cell Longev*. 2019;2019:5496346. doi:10.1155/2019/5496346
30. Hu G, Cassano PA. Antioxidant nutrients and pulmonary function: the Third National Health and Nutrition Examination Survey (NHANES III). *Am J Epidemiol*. 2000;151(10):975–981. doi:10.1093/oxfordjournals.aje.a010141
31. McKeever TM, Lewis SA, Smit HA, Burney P, Cassano PA, Britton J. A multivariate analysis of serum nutrient levels and lung function. *Respir Res*. 2008;9(1):67. doi:10.1186/1465-9921-9-67
32. Kieliszek M. Selenium–Fascinating Microelement, Properties and Sources in Food. *Molecules*. 2019;24(7):1298. doi:10.3390/molecules24071298
33. Rayman MP. The importance of selenium to human health. *Lancet*. 2000;356(9225):233–241. doi:10.1016/S0140-6736(00)02490-9
34. Turrubiates-Hernández FJ, Márquez-Sandoval YF, González-Estevez G, Reyes-Castillo Z, Muñoz-Valle JF. The Relevance of Selenium Status in Rheumatoid Arthritis. *Nutrients*. 2020;12(10):3007. doi:10.3390/nu12103007
35. Singh VK, Yadav D, Garg PK. Diagnosis and Management of Chronic Pancreatitis: a Review. *JAMA*. 2019;322(24):2422–2434. doi:10.1001/jama.2019.19411
36. Coursin DB, Cihla HP. Pulmonary effects of short term selenium deficiency. *Thorax*. 1996;51(5):479–483. doi:10.1136/thx.51.5.479
37. Jaspers I, Zhang W, Brighton LE, Carson JL, Styblo M, Beck MA. Selenium deficiency alters epithelial cell morphology and responses to influenza. *Free Radic Biol Med*. 2007;42(12):1826–1837. doi:10.1016/j.freeradbiomed.2007.03.017
38. Michaeloudes C, Abubakar-Waziri H, Lakhdar R, et al. Molecular mechanisms of oxidative stress in asthma. *Mol Aspects Med*. 2022;85:101026. doi:10.1016/j.mam.2021.101026
39. Kirkham PA, Barnes PJ. Oxidative stress in COPD. *Chest*. 2013;144(1):266–273. doi:10.1378/chest.12-2664
40. Roberts SB, Rosenberg I. Nutrition and aging: changes in the regulation of energy metabolism with aging. *Physiol Rev*. 2006;86(2):651–667. doi:10.1152/physrev.00019.2005
41. Genser D. Food and drug interaction: consequences for the nutrition/health status. *Ann Nutr Metab*. 2008;52(Suppl 1):29–32. doi:10.1159/000115345
42. Lutter JI, Jörres RA, Welte T, et al. Impact of Education on COPD Severity and All-Cause Mortality in Lifetime Never-Smokers and Longtime Ex-Smokers: results of the COSYCONET Cohort. *Int J Chron Obstruct Pulmon Dis*. 2020;15:2787–2798. doi:10.2147/COPD.S273839
43. Prentice RL, Mossavar-Rahmani Y, Huang Y, et al. Evaluation and comparison of food records, recalls, and frequencies for energy and protein assessment by using recovery biomarkers. *Am J Epidemiol*. 2011;174(5):591–603. doi:10.1093/aje/kwr140