Original Research
A Plant-Centered Diet is Inversely Associated with Radiographic Emphysema: Findings from the CARDIA Lung Study

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Running Head: **Plant-Centered Diets and Emphysema Risk**

Key Words: dietary intake; plant-centered diet; emphysema; smoking; life course

Abbreviations: **APDQS:** A Priori Diet Quality Scores; BMI: Body Mass Index; **CARDIA**: Coronary Artery Risk Development in Young Adults; **CRF:** Cardiorespiratory fitness; **CT:** computed tomography; **FEV1:** Forced Expiratory Volume in one second; **FVC**: forced vital capacity

Citation: Jackson MK, Choi Y, Eisenberg E, et al. A plant-centered diet is inversely associated with radiographic emphysema: findings from the CARDIA Lung Study. *Chronic Obstr Pulm Dis*. 2023; Published online November 6, 2023.
doi: https://doi.org/10.15326/jcopdf.2023.0437

This article has an online supplement.

ABSTRACT

Chronic obstructive pulmonary disease (COPD) is a significant public health concern and intercepting the development of emphysema is vital for COPD prevention. Smokers are a high-risk population for emphysema with limited prevention strategies. We aimed to determine if adherence to a nutritionally rich plant-centered diet among young ever-smokers is associated with reduced risk of future radiographic emphysema. We studied participants from the Coronary Artery Risk Development in Young Adults (CARDIA) Lung Prospective Cohort Study who were 18-30 years old at enrollment and followed for 30 years. We analyzed 1,706 adults who reported current or former smoking by year 20. Repeated measures of diet history were used to calculate A Priori Diet Quality Scores (APDQS), and categorized into quintiles, with higher quintiles representing higher nutritionally rich plant-centered food intake. Emphysema was assessed at year 25 (n=1,351) by computed tomography (CT). Critical covariates were selected, acknowledging potential residual confounding. Emphysema was observed in 13.0% of the cohort, with a mean age of 50.4 ± 3.5 years. The prevalence of emphysema was 4.5% in the highest APDQS quintile (nutritionally rich), compared with 25.4% in the lowest quintile. After adjustment for multiple covariates, including smoking, greater adherence to a plant-centered diet was inversely associated with emphysema (highest vs lowest quintile odds ratio: 0.44, 95% CI 0.19-0.99, p_{trend}=0.008). To conclude, longitudinal adherence to a nutritionally rich plant-centered diet was associated with decreased risk of emphysema development in middle adulthood, warranting further examination of diet as a strategy for emphysema prevention in a high-risk smoking population.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) affects over 15 million Americans and is a leading cause of death in the United States [1]. Emphysema, a key manifestation of chronic lung disease, is characterized by irreversible structural changes to the lung and carries important implications for long-term lung health, even in patients without an established COPD diagnosis. There is increasing recognition that emphysema is an important independent clinical predictor of worse respiratory outcomes, including respiratory symptoms and quality of life, even in the absence of airflow limitation on spirometry [2]. Therefore, emphysema may represent a clinically significant intermediate phenotype of impaired lung health [3] and a critical window for early interventions to intercept future respiratory complications. However, modifiable factors to intercept development of emphysema have not been identified.

While smoking remains the primary environmental risk factor for the development of emphysema, smoking cessation interventions have resulted in long-term quit success rates in only up to 25% of patients [4,5]. These data highlight that these strategies alone are insufficient to optimize respiratory health among smokers, and that a simultaneous focus on other treatable traits is greatly needed to mitigate the adverse health effects of tobacco use across the life course. Notably, individual adherence to healthy dietary patterns may serve as a potential strategy for preserving lung health in these exposed populations.

Emerging data provides support for the role of diet in lung health among individuals with competing risk factors such as lifetime tobacco exposure. In one study, smokers without respiratory disease with greater adherence to a Western diet pattern (increased red and cured meat and sweets; low fruits, vegetables, legumes, and fish consumption) were at an increased risk of impaired lung function [6]. In addition, we have shown that as early as adolescence, adherence to a higher quality diet is associated with significantly decreased environmental tobacco-associated respiratory symptoms [7]. As respiratory symptoms—including cough/phlegm and wheeze—among young adults have been associated with greater odds of future radiographic emphysema [8], these data emphasize a potential role for diet as an early modifiable risk factor for the lifetime risk of chronic lung disease.

A recent analysis of data from a large, multi-center longitudinal cohort study, Coronary Artery Risk Development in Young Adults (CARDIA), demonstrated that a nutritionally rich plant-centered diet was protective against cardiovascular-related morbidity and mortality [9]. Diets higher in fruits and vegetables have also been associated with improved lung outcomes, including reduced wheeze in children [10], better lung function in adults [11], and lower prevalence of asthma in both adults and children [12]. However, few studies have evaluated the effect of dietary patterns on emphysema. In this study, we examined the association between adherence to a nutritionally rich plant-based diet and emphysema in early to mid-adulthood using the A Priori Diet Quality Score (APDQS), a novel diet quality assessment tool that accurately assesses the intake of the most nutritious plant-centered foods without excluding animal products. The objective of this analysis was to determine the extent to which adherence to a nutritionally rich

plant-centered diet—via the APDQS—in ever-smoker young adults is associated with future development of radiographic emphysema.

METHODS

Study population and design

Population: This study is a secondary analysis of the CARDIA study, a multicenter, prospective cohort of 5,115 adult Black and White men and women from four geographically diverse US cities [13]. Participants at baseline were aged 18 to 30 years, who were followed for 30 years with 71% retention at year 30. The study protocol has been published elsewhere [13]. For the present study, we included ever-smoker participants (defined as self-reported smoking at any time point prior to year 20) due to the low prevalence of emphysema in never smokers within this population. For the outcome of emphysema, we restricted the population to those who had computed tomography (CT) measurements available at year 25. As additional analyses were conducted as a part of this investigation, those with absence of spirometry (missing for Years 0, 2, or 5, in combination with missing for Years 20 or 30) were also excluded (n=42). Flow diagram for of participant inclusion is included in **Figure 1**. All participants provided written informed consent at all examinations, and research protocols were approved by institutional review boards at the CARDIA coordinating center and each field center. University of Alabama at Birmingham Institutional Review Board (IRB-981106002) reviewed and approved the CARDIA study prior to data collection.

Assessment of Plant-based Diet Quality Score: Diet was assessed at baseline, year 7, and year 20 via the validated CARDIA diet history [14]. The APDQS utilizes CARDIA's comprehensive dietary data to generate an evenly weighted score incorporating 46 food groups and was calculated as previously described [9,15]. Unlike other measures of diet quality, the APDQS emphasizes greater consumption of plant-based foods with the highest nutritional value over nutritionally poor plant-based foods, while also accounting for animal product quality. Therefore, plant-based foods such as fruits, avocado, green and yellow vegetables, and whole grains contribute to a higher score, while higher intakes of plant-based foods like fried potatoes, grain desserts, margarine, and fruit juice would result in lower scores [9]. Scores range from 0 to 132, with higher numbers indicating greater adherence to a high-quality diet.

Assessment of outcome variable: The primary outcome was the presence of radiographic emphysema. Radiographic emphysema was detected by visual assessment of year 25 CT scans utilizing methods as previously described [8,16]. Briefly, all CT scans were reviewed by an initial reader (Reader 1) and classified as having paraseptal emphysema, centrilobular emphysema, both, or neither. All CT scans classified as having emphysema were reviewed by a second reader (Reader 2) in addition to a random sample of 10% of the remaining CT scans. Disagreements between Readers 1 and 2 were adjudicated by a third reader (Reader 3).

Other Covariates: Baseline demographic information and clinical data were obtained from the CARDIA database and included sex, age (years), maximal educational attainment (highest grade completed), race (Black; White), smoking and pack year history, anthropometrics, and energy

intake (kcal). Smoking status was assessed every year. Previous studies in this cohort have demonstrated misclassification between self-reported cigarette smoking and Year 0 serum cotinine measurements to be low [17]. Spirometry, performed using standard procedures per American Thoracic Society guidelines [18] to assess lung function, is reported at baseline. Body mass index (BMI) was calculated as weight/height squared (kg/m^2) derived from measurements by trained technicians. Cardiorespiratory fitness (CRF; treadmill time, seconds), history of asthma and field center were also recorded.

Statistical Analyses: For the purposes of this analysis, APDQS assessed at years 0, 7, and 20, for which updated information were available, were cumulatively averaged over follow-up and divided into quintiles. Baseline descriptive statistics were reported according to quintiles of the APDQS, and statistical significance was tested using ANOVA for continuous variables and chi-square tests for categorical variables.

Multivariable logistic regression models for binary outcome were used to evaluate associations between APDQS quintile of the averaged dietary data and year 25 radiographic emphysema. This averaging approach, previously used in CARDIA cohorts[9], allows for minimization of random within-person error, better reflects the cumulative, long-term dietary effect and preserves sample size. The primary model was adjusted for age, sex, race (Black and White), field center (Birmingham, Chicago, Minneapolis, and Oakland), maximal educational attainment, baseline height, averaged total energy intake (years 0, 7, 20), averaged BMI (years 0, 2, 5, 7, 10, 15, and 20), and life-time pack years of smoking (years 0, 2, 5, 7, 10, 15, and 20). Maximal educational

attainment was used as a surrogate for socioeconomic status, to be consistent with previous CARDIA analyses. As a sensitivity analysis, the model was further adjusted for CRF and asthma as potential mediating factors for emphysema. Potential effect modification by pack years of smoking was evaluated by testing the statistical significance of a multiplicative interaction term of the APDQS as a continuous variable with <10, 10-20, and >20 pack years of smoking. All analysis was conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Study population

Of the original CARDIA cohort, 1,351 ever-smokers (ever reported current or former smoking at any exam between year 0 and year 20) were available for analysis. The baseline mean (SD) APDQS in this analytic population was 64.6 ± 12.7. Among ever smokers, 999 (73.9%) had dietary information at all three measures, 310 (22.9%) had two measurements, and 42 (3.1%) had only one measurement. Dietary intake consistently tracked over time. For example, Year 0 APDQS had a correlation about 0.62 and 0.58 with Year 7 and Year 20 APDQS, respectively. The correlation between Year 7 and Year 20 was 0.60. **Table 1** shows baseline (Year 0) characteristics of study participants according to quintiles of the baseline APDQS. Smoking history at enrollment (never, former, current) was similar across APDQS quintiles. Those with a higher APDQS were more likely to be older, female, self-identify as White, obtained a higher educational level, and have higher activity levels and CRF. Participants with a higher APDQS

also had lower BMI, lower total energy intake, fewer mean pack-years of smoking over 20 years and higher forced expiratory volume in one second (FEV1) and forced vital capacity (FVC).

ADPQS and radiographic emphysema

Of the 1,351 ever-smokers who completed year 25 CT scans, emphysema was observed in 13.0% (n=175). The mean age of those with emphysema was 50.4 ± 3.5 years. The prevalence of emphysema was 4.5% in the highest APDQS quintile, compared with 25.4% in the lowest quintile (**Figure 2**).

In unadjusted analyses of highest vs lowest quintile, ADPQS was inversely associated with radiographic emphysema (OR: 0.14, 95% CI 0.07-0.26). After adjusting for covariables, this inverse relationship persisted (OR 0.44, 95% CI 0.19-0.99 for the highest vs. lowest quintile). For each one SD higher APDQS, there was a 34% (OR 0.66, 95% CI: 0.49−0.90) lower odds of emphysema (**Table 2**). Further adjustment for CRF or current asthma status, both individually and together, did not considerably alter the findings (data not shown).

There was no significant interaction between APDQS and category of pack-year smoking history (<10 pack-year, 10-20 pack year, and >20 pack-year) in the development of incident emphysema (p for interaction=0.20), with no significant differences between the diet quintiles within each strata (**Table 3**).

DISCUSSION

In this longitudinal study of young adult ever-smokers, we found that long-term consumption of a nutritionally rich plant-centered diet was associated with a lower risk of future radiographic emphysema, independent of an influence of smoking history. Participants with the highest adherence to a plant-centered diet had a 56% lower risk of emphysema, compared with those with the lowest adherence. These associations were evident even after adjustment for established demographic, co-morbid, and lifestyle factors that contribute to lung health. Notably, our study captured a population undergoing a critical transition from young to middle adulthood, for whom adherence to a plant-centered dietary pattern may represent an important early modifiable factor for the lifetime risk of chronic lung disease.

Emphysema is characterized by *irreversible* structural change to the lung, emphasizing the importance of preventing its development [19]. The presence of emphysema among smokers, even in the absence of obstruction on spirometry, is an important independent clinical predictor of worse respiratory outcomes [2]. However, given the dependence on CT imaging to establish the presence of emphysema, very few prior studies have examined modifiable risk factors impacting the development and progression of this disease among a high-risk smoking population. Prior studies have relied primarily on self-report and have usually combined emphysema and chronic bronchitis to create a composite outcome of COPD. In contrast, our study's unique availability of CTs in middle age allowed for the ability to detect associations between diet and radiographically demonstrated structural changes in the lung.

Our data supports a potentially protective role of diet specifically for emphysema and is unique compared to prior studies that have examined diet and COPD without accounting for structural changes in the lung[20,21]. Notably, very few studies have had the opportunity to leverage objective CT measurements of lung structure in relation to nutrition. One study found intake of low-fat dairy products was associated with less severe measures of CT-define emphysema in 3,271 subjects enrolled in the MESA (Multi-Ethnic Study of Atherosclerosis) trial (P=0.02 and 0.01 for α, a measure of emphysema, and apical versus basilar distribution of emphysema, respectively) [22], but to our knowledge dietary *patterns* and objective measures of emphysema have not been evaluated. Therefore, our findings fill an important gap in the literature and support diet patterns as a strategy for preventing emphysema development.

Although exact mechanisms for the association between the consumption of a nutritionally-rich plant-centered diet and emphysema are unknown, recent animal studies have shown diets high in fiber (a key characteristic of plant-centered diets) attenuate pathological changes associated with emphysema progression and inflammatory response in cigarette-exposed mice [23]. In particular, fiber supplementation modulated the diversity of the gut microbiome and increased the production of anti-inflammatory metabolites including short-chain fatty acids (SCFA), which are known to significantly influence systemic inflammation [24] through activation of G-protein receptors, inhibiting histone deacetylase, and serving as energy substrates for immune-regulating cells [25]. In another study of mice exposed to cigarette smoke, an intervention of fecal microbiota transplantation and a high-fiber diet resulted in protective effects on the lung. The high-fiber diet significantly decreased macrophages and lymphocytes in bronchoalveolar lavage fluid (BAL),

and interleukin-6 (IL-6) and interferon-gamma (IFN-γ) were decreased in BAL and serum. Both the fecal microbiota transplant and the high-fiber diet attenuated the development of emphysema and protected against alveolar destruction and cellular apoptosis [26]. Similarly, human studies have demonstrated that a high-fiber diet is associated with reduced blood-based inflammatory biomarkers [27]; however, a greater understanding of specific mechanisms by which consumption of a plant-centered diet may protect against emphysema is needed.

We found it notable that 13% of all participants already had emphysema noted on CT at a relatively young age (range 42-56 years old), concurring with previous findings of respiratory impairments in smokers without spirometric COPD [28]. Further research on the specific critical windows—during which dietary exposures have greatest impact on lung health—is essential to develop public health dietary recommendations for children and young adults with the goal of preventing future adverse respiratory outcomes. Since structural outcomes of emphysema and physiologically apparent outcomes (such as lung function decline or airflow obstruction) are often clinically discordant and may represent divergent pathways of pathology, this will be an important area of future investigation.

This study has several key strengths. To our knowledge, this is the first prospective study to assess the relationship between a healthy diet pattern and radiographically demonstrated emphysema. In addition, we had a prolonged follow-up period with high retention of participants, which provides insight into treatable traits for smoking-related respiratory outcomes during the critical transition of young to middle adulthood—a stage where smoking-related

respiratory diseases typically begin to manifest. Importantly, the APDQS provides multiple real-world achievable pathways to healthy eating. Another defining feature included the rigorous assessment of smoking status, repeated annually, with previous evaluations demonstrating a strong relationship between baseline smoking reports and cotinine levels [17,29]. Finally, the utilization of CT imaging provided objective outcomes and avoided potential misclassification associated with a self-reported diagnosis of emphysema.

A few limitations are worth noting. The observational study design hinders arriving at any causal conclusions; replication in an independent cohort would strengthen causal inferences. Diet was self-reported and is subject to recall bias. While we used a subset of the CARDIA cohort and our baseline APDQS scores were similar to previous examinations of the larger CARDIA cohort [9], there is limited use of the APDQS score outside the CARDIA cohort [30,31] and is an area of future examination. In addition, despite adjustment for multiple covariates (including smoking), residual confounding cannot be excluded. While adjusted results remained significant, a wide confidence interval indicates a lack of precision in our findings, warranting future prospective studies with a larger sample size to ensure the reliability, strength of association, and generalizability of our findings. While the contribution of smoking, the strongest known risk factor for emphysema, was accounted for in both the adjusted model and by testing for interaction, other key factors, such as air pollution and other social determinants of health, should be accounted for in future studies. Furthermore, the dose-response relationship between diet and decreased incidence of emphysema was maintained, suggesting a true relationship. Additionally, the CARDIA cohort is composed of Black and White participants, thus the

generalizability of the results to other races/ethnicities is limited. We limited our analyses to current and past smokers, limiting the generalizability to all populations, yet capturing an appropriate at-risk population, as prevalence of emphysema was very low among non-smokers. Lastly, though the scope of this work was limited to radiographic outcomes, there is value to explore additional respiratory-related outcomes (e.g., lung function trajectories, mortality, etc.) in this cohort.

In summary, there is a substantial need for identifying treatable traits for patients with a history of smoking to improve lung health outcomes. In this study, we demonstrated that adherence to a nutritionally rich plant-centered diet during early and middle adulthood was significantly associated with decreased odds of radiographic emphysema later in the life course. Adherence to a nutritionally rich plant-centered dietary pattern may represent a potential early target to influence the lifetime risk of chronic lung disease.

and consulting fees from Astra-Zeneca, and consulting fees from CVS Caremark, Aptus Health, Boston Scientific, and Boston Consulting Group.

Sonali Bose has received funding from the National Institutes of Health. She also receives research support from 4D Medical and the American Lung Association.

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Table 1. Baseline characteristics of participants according to quintiles of the Y0 APDQS among ever smokers, N=1351

	Total participants	APDQS					P-value[a]
		Quintile 1 (n=274)	Quintile 2 (n=270)	Quintile 3 (n=277)	Quintile 4 (n=271)	Quintile 5 (n=259)	
APDQS, mean±SD	64.6±12.7	47.7±4.4	57.2±2	63.8±2.1	71.6±2.6	83.8±5.5	
Age Y0, mean±SD, y	25.5±3.5	23.9±3.8	25.4±3.4	25.5±3.5	25.8±3.2	26.7±2.9	<0.001
Female, no (%)	789 (58.4)	142 (51.8)	151 (55.9)	150 (54.2)	157 (57.9)	189 (73.0)	<0.001
Self-identified race, no (%)							
Black	609 (45.1)	190 (69.3)	172 (63.7)	132 (47.7)	82 (30.3)	33 (12.7)	<0.001
White	742 (54.9)	84 (30.7)	98 (36.3)	145 (52.4)	189 (69.7)	226 (87.3)	
Maximal educational attainment, mean±SD, grades[b]	15.3±2.6	14.1±2.3	14.5±2.4	15.2±2.6	15.8±2.5	16.8±2.2	<0.001
Study center, no (%)							
Birmingham	275 (20.4)	78 (28.47)	80 (29.63)	56 (20.22)	36 (13.28)	25 (9.65)	<0.001
Chicago	311 (23.0)	67 (24.5)	55 (20.4)	57 (20.6)	69 (25.5)	63 (24.3)	
Minneapolis	412 (30.5)	84 (30.7)	76 (28.2)	81 (29.2)	90 (33.2)	81 (31.3)	
Oakland	353 (26.1)	45 (16.4)	59 (21.9)	83 (30.0)	76 (28.0)	90 (34.8)	
Height, mean±SD, cm	170±9.2	169±9.4	170±9.6	170±9.3	171±9.4	169±8.2	0.33
BMI, mean±SD, kg/m^2	24.5±4.8	25.2±5.6	24.7±5.1	24.8±4.8	24.2±4.4	23.7±3.8	0.007
Smoking, no (%)							
Never	219 (16.4)	48 (17.8)	51 (19.1)	47 (17.0)	43 (16.2)	30 (11.7)	<0.001
Former	396 (29.7)	44 (16.3)	59 (22.1)	81 (29.4)	89 (33.6)	123 (48.1)	
Current	719 (53.9)	178 (65.9)	157 (58.8)	148 (53.6)	133 (50.2)	103 (40.2)	
Pack-years smoking at Y0, mean±SD, pack-years	4.2±5.4	4.4±5.6	4.6±5.6	4.3±5.4	3.9±5.4	4.0±5.0	0.53
Pack-years smoking throughout Y20, mean±SD, pack-years	10.4±11.1	13±11.7	12.2±12.5	10.4±11.2	8.7±9.8	7.4±9.1	<0.001
Total energy intake, mean±SD, kcal	2838±1309	3221±1414	2924±1392	2894±1347	2661±1225	2470±992	<0.001
Physical activity, mean±SD, EU[c]	418±292	357±264	359±274	404±279	452±286	524±322	<0.001
Cardiorespiratory fitness, mean±SD, treadmill time, second	579±164	557±174	548±165	568±162	607±161	618±147	<0.001
History of asthma, no (%)	71 (5.3)	12 (4.4)	14 (5.2)	13 (4.7)	20 (7.4)	12 (4.6)	0.53
FEV1, median (IQR), ml	3460 (2970–4070)	3335 (2860–4000)	3320 (2890–3940)	3470 (2980–4130)	3630 (3110–4300)	3550 (3160–4020)	<0.001
FVC, median (IQR), ml	4180 (3580–5010)	4000 (3360–4830)	4040 (3460–4740)	4080 (3550–5120)	4360 (3790–5290)	4270 (3820–5060)	<0.001

APDQS, A Priori Diet Quality Score; BMI, body mass index; IQR, interquartile range; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; SD, standard deviation

[a] Evaluated with chi-square tests for categorical variables and ANOVA for continuous variables.

[b] Cumulative data through Y30

[c] Exercise units, physical activity score derived from the CARDIA physical activity history

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Table 2. Multivariable-adjusted ORs (95% CIs) of radiographic emphysema (Year 25) according to quintiles of the APDQS among ever smokers, N=1351

	APDQS					Per 1 SD higher APDQS [a]	*P* for trend[b]
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5		
APDQS median	53.7	60.7	67.0	73.7	82.7		
Unadjusted cumulative % (n/N)	25.4 (68/268)	17.7 (48/272)	11.1 (30/270)	6.3 (17/272)	4.5 (12/269)		
Unadjusted OR	1 (ref)	0.63 (0.42–0.96)	0.37 (0.23–0.59)	0.20 (0.11–0.34)	0.14 (0.07–0.26)	0.42 (0.34–0.52)	<0.001
MV model OR[c]	1 (ref)	0.61 (0.37–1.00)	0.63 (0.36–1.12)	0.41 (0.21–0.83)	0.44 (0.19–0.99)	0.66 (0.49–0.90)	0.008

[a] 1 SD was 13

[b] Derived by testing a continuous APDQS variable in the model

[c] Logistic regression model adjusted for age, sex, race (Black and White), center (Birmingham, Chicago, Minneapolis, and Oakland), maximal educational attainment, baseline height, averaged total energy intake (Years 0, 7, 20), averaged BMI (Years 0, 2, 5, 7, 10, 15, and 20), and life-time pack years of smoking (Years 0, 2, 5, 7, 10, 15, and 20).

Table 3. Multivariable-adjusted ORs (95% CIs)[a] of incident emphysema (Year 25) according to quintiles of the APDQS among ever smokers, stratified by pack-year of smoking, N=1351

		APDQS						
		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Per 1 SD higher APDQS[b]	*P* for trend[c]
<10 pack year smoking (n=823)	**Unadjusted cumulative incidence % (n/N)**	12.5 (16/128)	7.5 (11/146)	2.4 (4/166)	2.3 (4/176)	1.9 (4/207)		
	MV model OR	1 (ref)	0.59 (0.22-1.61)	0.28 (0.07-1.08)	0.44 (0.11–1.86)	0.64 (0.12-3.29)	0.57 (0.29−1.11)	0.10
10-20 pack year smoking (n=289)	**Unadjusted cumulative incidence % (n/N)**	29.0 (22/76)	25.0 (17/68)	21.2 (11/52)	9.8 (5/51)	7.1 (3/42)		
	MV model OR	1 (ref)	0.71 (0.31−1.65)	0.68 (0.26-1.83)	0.42 (0.12-1.53)	0.34 (0.08−1.51)	0.71 (0.43−1.17)	0.17
>20 pack year smoking (n=239)	**Unadjusted cumulative incidence % (n/N)**	46.9 (30/64)	34.5 (20/58)	28.9 (15/52)	17.8 (8/45)	25.0 (5/20)		
	MV model OR	1 (ref)	0.48 (0.20-1.17)	0.59 (0.22-1.56)	0.29 (0.09-0.92)	0.52 (0.13-2.10)	0.68 (0.40−1.14)	0.14

APDQS, A Priori Diet Quality Score; BMI, body mass index; SD, standard deviation; MV, multivariable; OR, odds ratio

[a] Logistic regression model adjusted for age, sex, race (Black and White), center (Birmingham, Chicago, Minneapolis, and Oakland), maximal educational attainment, baseline height, averaged total energy intake (Years 0, 7, 20), averaged BMI (Years 0, 2, 5, 7, 10, 15, and 20), and life-time pack years of smoking (Years 0, 2, 5, 7, 10, 15, and 20). P for interaction = 0.20 derived by testing a multiplicative interaction term of the APDQS as a continuous variable with three categories of life-time pack years of smoking in the model.

[b] 1 SD was 13

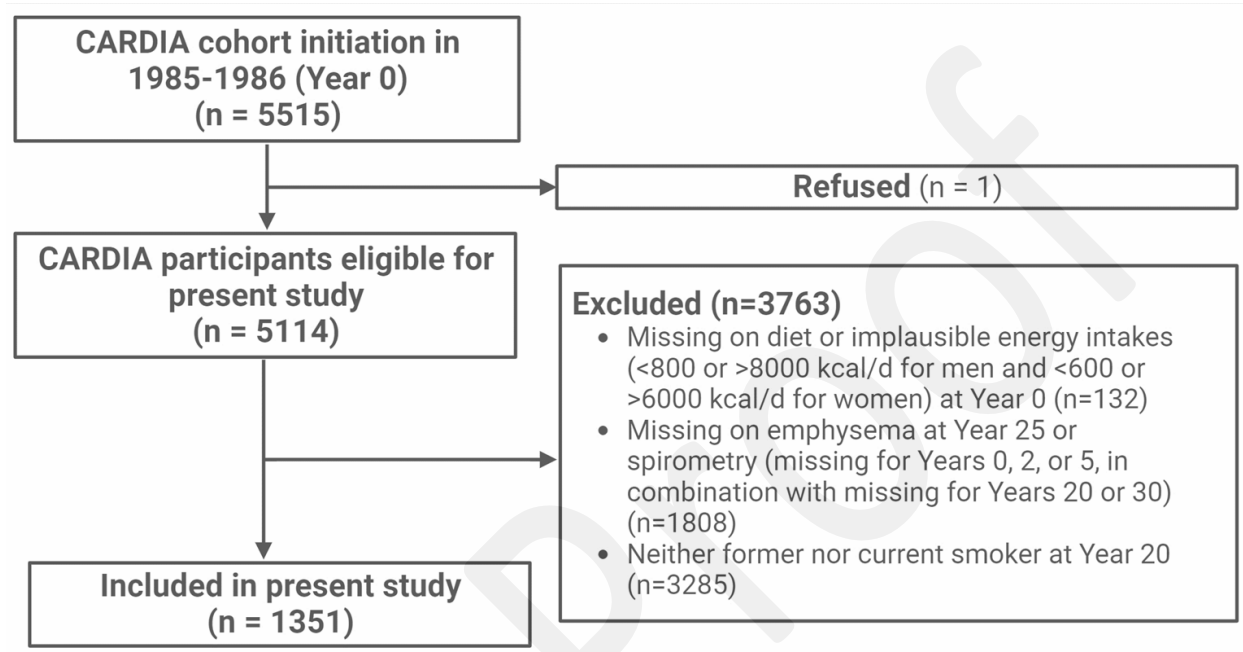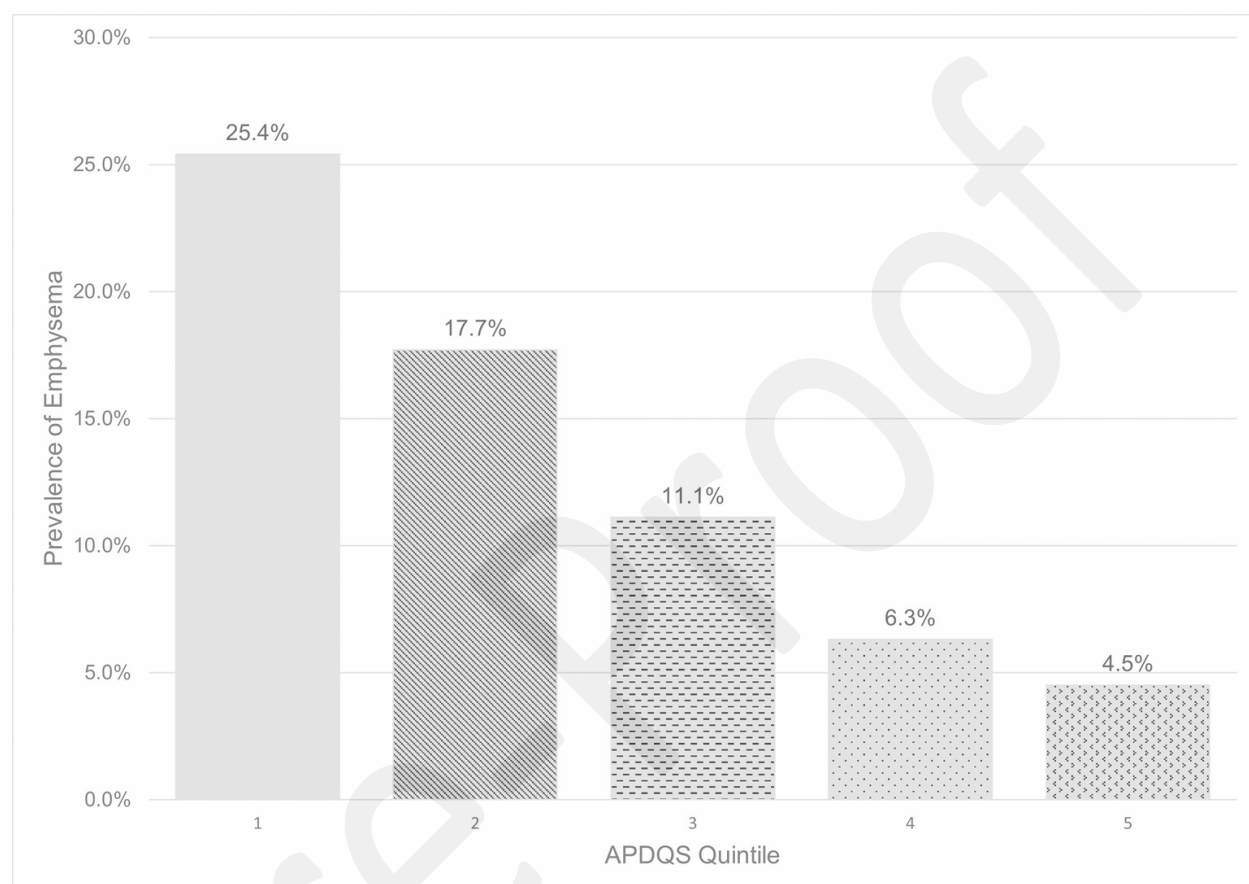[c] Derived by testing a continuous APDQS variable in the model.

Figure 1. Flow diagram of study inclusion

Figure 2. Prevalence of Radiographic Emphysema at Year 25 by APDQS Quintile

Online Supplement

Supplemental Table 1. Baseline characteristics for participants excluded and included

	Excluded (n=3,763)	Included (n=1,351)	P-value[a]
APDQS, mean±SD	61.9±13	64.6±12.7	<0.001
Age Y0, mean±SD, y	24.6±3.7	25.5±3.5	0.82
Female, no (%)	1998 (53.1)	789 (58.4)	<0.001
Self-identified race, no (%)			
Black	2028 (53.9)	609 (45.1)	<0.001
White	1735 (46.1)	742 (54.9)	
Maximal educational attainment, mean±SD, grades[b]	15.3±2.7	15.3±2.6	0.10
Study center, no (%)			
Birmingham	903 (24)	275 (20.4)	0.001
Chicago	797 (21.2)	311 (23.0)	
Minneapolis	990 (26.3)	412 (30.5)	
Oakland	1073 (28.5)	353 (26.1)	
Height, mean±SD, cm	170.5±9.6	170±9.2	0.10
BMI, mean±SD, kg/m^2	24.5±5.1	24.5±4.8	0.91
Smoking, no (%)			
Never	2637 (70.4)	219 (16.4)	<0.001
Former	280 (7.5)	396 (29.7)	
Current	827 (22.1)	719 (53.9)	
Pack-years smoking at Y0, mean±SD, pack-years	1.5±3.8	4.2±5.4	<0.001
Pack-years smoking throughout Y20, mean±SD, pack-years	3.5±7.9	10.4±11.1	<0.001
Total energy intake, mean±SD, kcal	2811±1344	2838±1309	0.53
Physical activity, mean±SD, EU[c]	420.9±303.9	418.1±291.8	0.77
Cardiorespiratory fitness, mean±SD, treadmill time, second	589.3±174.4	579.3±164.2	0.07
History of asthma, no (%)	178 (4.8)	71 (5.3)	<0.001
Emphysema at Y25	62 (3.4)	175 (13.0)	<0.001

[a] Evaluated with chi-square tests for categorical variables and ANOVA for continuous variables.
[b] Cumulative data through Y30.
[c] Exercise units, physical activity score derived from the CARDIA physical activity history.