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Lung function, COPD and Alternative Healthy Eating Index (AHEI-2010) in US adults

Kirstie Ducharme-Smith[1], Gustavo Mora-Garcia[2], Francisca de Castro Mendes[3], Maria Stephany Ruiz-Diaz[4], Andre Moreira[5], Rodrigo Villegas[6], Vanessa Garcia-Larsen[7]

1 PhD Student, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, US
2 Assistant Professor and Head of Department, Department of Family Medicine and Public Health, Faculty of Medicine, Universidad de Cartagena, Cartagena de Indias, Colombia
3 Visiting Scholar, Program in Human Nutrition, Department of International Health, The Johns Hopkins Bloomberg School of Public Health, Baltimore, US
4 General Director, Center for Innovation and Research in Diabetes and Metabolism – INNOVATID-, Cartagena de Indias, Colombia
5 Serviço de Imunologia Básica e Clínica, Departamento de Patologia, Faculdade de Medicina; EPI Unit - Instituto de Saúde Pública, Universidade do Porto, Porto, Portugal
6 Assistant Professor and Head of the Biostatistics Unit, School of Public Health, University of Chile, Santiago, Chile
7 Assistant Professor in Human Nutrition, Program in Human Nutrition, Department of International Health, The Johns Hopkins Bloomberg School of Public Health, Baltimore, USA

Corresponding author:

Dr Vanessa Garcia-Larsen, BSc MSc MEd PhD
Program in Human Nutrition, Department of International Health
The Johns Hopkins Bloomberg School of Public Health
Suite 2546, 615 N Wolfe Street, Baltimore, MD, 21205, USA
e-mail vgla@jhu.edu

Summary: In this nationally representative population-based study of US adults, diet quality measured by the Alternative Healthy Eating Index (AHEI-2010) was low. A better diet quality was associated with higher FEV_1, FVC and lower prevalence of spirometric restriction.

Abstract:

Background: There is a large burden of chronic obstructive pulmonary disease (COPD) in the United States (US). The purpose of this study was to investigate the association between diet quality with lung function, airway restriction, and spirometrically defined COPD in a nationally representative sample of US adults.

Methods: Adults (19-70 years of age) from the National Health and Nutrition Examination Survey (NHANES) 2007-2012 cycles were included (N=10,428). Diet quality was determined using the Alternative Healthy Eating Index (AHEI-2010). Pre-bronchodilator measurements of forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and the FEV_1/FVC were described. Calibrated lower limit of normal (LLN) estimates were derived to determine prevalence of airway restriction (FVC<LLN) and COPD (FEV_1/FVC Ratio<LLN). Population-weighted linear and logistic regression models were used to investigate the association of AHEI-2010 and respiratory outcomes.

Results: The average AHEI was 45.3 (±12.2), equivalent to meeting 41% of the daily recommendations for optimal diet quality. Those in the highest quartile of AHEI had better FEV_1 (adjusted [a]β:47.92, 95% CI 2.27, 93.57) and FVC (aβ: 80.23, 95% CI 34.03, 126.42; p-value interaction (*) of AHEI and smoking >0.05) compared to those in quartile 1. Higher AHEI was also associated with lower odds of airway restriction (OR: 0.23, 95% CI 0.08, 0.67; p-value AHEI*ethnicity >0.05).

Conclusions: Diet quality was independently associated with better FEV_1, FVC, and with lower odds of spirometric restriction. These findings highlight the need for research to further elucidate the possible beneficial role of diet in the preservation of lung function.

Introduction:

Poor lung function and chronic obstructive pulmonary disease (COPD) are major threats to public health in the United States (US). In 2016, COPD was the third leading cause of disability adjusted life years (DALY) [1]. In 2014 and 2015, 6.4% of adults in the US aged 40 years or older had been diagnosed with COPD and these individuals were more likely to have heart disease, cancer and diabetes [2]. The prevalence of COPD is higher among individuals with lower income and on public insurance [2], placing around 11.8% of U.S. adults with poverty (in 2018) at increased risk for the development of COPD [3].

The major risk factors for poor lung function are older age and having a history of smoking, however this only accounts for around half of the cases of COPD [4]. Increasing epidemiological evidence has demonstrated that dietary intake can impact lung health [5, 6]. Evidence from cohort studies among European adults has demonstrated that higher fruit intake is associated with slower lung function decline [5–8]. Current evidence in US adults suggests that consumption of fruits and vegetables is associated with reduced incidence of COPD, and that higher fiber intake is associated with better lung function [9, 10]. In addition to individual dietary components, overall diet quality has been associated with lung health in US adults. The Alternative Healthy Eating Index (AHEI-2010), an 11-component index that measures diet quality (higher score = better diet quality), was associated with decreased incidence of self reported or newly diagnosed COPD in women from the Nurses Health Study from 1984 – 2000 [11]. However, no studies in the US have investigated the association between AHEI-2010 with lung function and spirometrically defined COPD.

Therefore, the purpose of this study was to investigate the association of diet quality as measured by the AHEI-2010, and outcomes of lung function, spirometrically defined airway restriction and COPD in U.S. men and women who participated in the National Health and Nutrition Examination Survey (NHANES) 2007-2012.

Materials and Methods:

Study sample

The NHANES survey is an ongoing cross-sectional study carried out in representative samples of the US population [12]. Spirometry data was collected in NHANES cycles 2007-2008, 2009-2010, and 2011-2012. Individuals between 19-70 years of age who completed at least one 24-hour dietary recall and underwent the spirometry examination in the NHANES 2007-2012 cycles were included in the current study.

Lung function and COPD measures

Presence of asthma (ever, current) and bronchitis (ever, current) was collected via self-report from the Medical Conditions questionnaire [13]. Pre-bronchodilator measures of forced expiratory volume (FEV_1) and forced vital capacity (FVC) and in a subset of individuals, post-bronchodilator measures were also performed [14]. Measurements were collected in the standing position; nose clips were worn to prevent air leaks and participants were instructed to take their deepest breath possible and then blow air into the mouthpiece out as hard and fast as possible for a minimum of 6 seconds of exhalation. Testing continued until participants were able to achieve a reproducible spirogram, or until a maximum of eight spirometry curves had been collected, or until the participant could not continue [14]. Quality of each valid spirometry measure was registered following the American Thoracic Society (ATS) collection standards. Only measurements that were graded A (Exceeds ATS data collection standards) or B (Meets ATS data collection standards) were included in the current analyses analysis [15].

The European Respiratory Society Global Lung Function Initiative predictive equations were utilized to determine percent predicted values for lung function measures based on age, height, sex and ethnicity [16]. Lower limit of normal (LLN) values were calculated to define spirometric restriction (FVC < LLN), and COPD (FEV_1/FVC < LLN) [17]. As pre-bronchodilator spirometry to derive norms for lung function reduces sensitivity compared to a post-bronchodilator gold standard, we adjusted these values by a constant to improve validity of the test, as recommended by Kato et al. [18].

Diet Quality

The AHEI-2010 score was calculated using estimates of daily food and nutrient intake obtained either from one (n=10,428) or averaged over two repeated 24-hour recall questionnaires (n=9,224; 88%). The AHEI-2010 score is based on 11 components of dietary intake scored from 0-10 (worst to best) with total score ranging between 0 and 110 (non-adherence to perfect adherence). Scores increase with higher intakes of fruit, vegetables, whole grains, nuts and legumes, omega-3 fatty acids, polyunsaturated fatty acids and moderate consumption of alcohol. Scores decrease with higher intakes of SSB, red/processed meat, trans-fat, sodium and heavy consumption of alcohol. Individual food components were scored following criteria by Chiuve et al [19] from which the AHEI-2010 score was derived.

Potential confounders

Demographic information was collected via questionnaires, in the home, by trained interviewers using Computer-Assisted Personal Interviewing (CAPI) system [20]. The demographic questionnaire included self-reported information on age, race, sex, language, education, income and physical activity.

Current cigarette use and recent tobacco use were obtained via self-report. This information and urinary cotinine was utilized to determine smoking status [21, 22]. Participants who indicated, "I have never smoked, not even a puff" in response to the question 'Cigarettes smoked in entire life' or who had a urinary cotinine value <1 ng/mL were classified as never smokers [22]. Those who reported any amount of time to the question 'How long since quit smoking cigarettes' or who had a urinary cotinine value 1-10 ng/mL were classified as former smokers [22]. In addition, those who reported they "Did not know" to the previous question and also reported "Not at all" in response to the question 'Do you now smoke cigarettes' were also classified as former smokers. Participants who responded "Every day" or "Some days" to the question 'Do you now smoke cigarettes' or who had a urinary cotinine value >10 ng/mL were classified as current smokers [22]. Physical activity data was collected via self-report. Participants were classified as 'physically active' if they reported engaging moderate physical activity for 150 minutes per week or vigorous physical activity for 75 minutes per week [23].

Anthropometric data, including height and weight were measured in all survey participants [24]. Standing height was collected with a stadiometer and was recorded in centimeters. Weight was measured using a digital scale and was recorded in kilograms. Body mass index was calculated as weight (kilograms) over squared height (meters^2), and classification of weight status was determined as underweight - <18.5 kg/m^2, normal– 18.5 – 24.9 kg/m^2, overweight – 25 – 29.9 kg/m^2, or obese - ≥30 kg/m^2.

Analyses:

Continuous variables were examined to determine distribution of sample characteristics and presented as means with standard deviation. Non-normally distributed data were presented as medians with interquartile range. Categorical variables were presented as numbers with percentages. Participants were excluded from analysis if they had unrealistic reporting of caloric intake determined by kilocalorie/basal metabolic rate ratio (Kcal/BMR) ratio <0.5th percentile or >99.5th percentile [25]. Among the remaining sample, quartile AHEI-2010 scores were calculated based on the sample distribution within each NHANES cycle year. Demographic and dietary intake was summarized over the total sample and as stratified by quartile AHEI-2010 score. Dietary data are compared to the U.S. Department of Agriculture 2015-2020 Dietary Guidelines for Americans to provide context to the results [26].

NHANES sample weights [27] were utilized to determine prevalence estimates of airway restriction and COPD. Population-weighted linear regression models were used to assess the association between quartile diet quality score and lung function measures (pre-bronchodilator FEV_1, FVC and FEV_1/FVC ratio) among the entire sample (N=10,428) and in sub-groups based on race/ethnicity or smoking status. The analyses were tested and met the assumption for linearity between the standard residuals and the predictor variables. Population-weighted logistic regression models were used to assess the association between quartile diet quality, COPD (FEV_1/FVC <LLN) and spirometric restriction (FVC <LLN) among the entire sample (N=10,428), and in sub-groups based on race/ethnicity or smoking status. Potential confounders

were explored between diet quality (per quartile increase) and COPD with the addition of individual AHEI-2010 components.

Regression models adjusted for several confounding factors. Model 1 controlled for age (years), sex (male, female) and height (cm). Model 2 controlled for age (years), sex (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), smoking status (non-smoker, former smoker, current smoker) and whether the participant was physically active (yes, no). Interactions between AHEI and smoking, and AHEI and ethnicity were investigated for each outcome under study. Subgroup analyses by race/ethnicity and by smoking status were also carried out, adjusting for the covariates described in Model 2. Additional analyses adjusting individually by each AHEI food group, and by dietary patterns (derived from Principal Component Analysis) were also carried out. Statistical significance was identified as p-value<0.05. Stata 14 was used for all analyses [28].

Results:

There were 10,428 individuals with quality spirometry measures who had plausible dietary intake (Figure 1). The general characteristics of the participants included in the study, as well as their outcome and dietary data are summarised in Table 1. The average age of participants was 42.9 years (± 14.7); the majority of participants identified as Non-Hispanic White (n=4,452, 43%), spoke English (n=9,008, 86%) and had graduated high school (n=5,673, 54%). Around half of participants had an annual household income <55K and only 31% (n=3,275) were considered physically active. Although half of the participants (n=5,006) were identified as never-smokers based on self-report and urinary cotinine values <1 ng/mL, around one-third of participants (n=3,292) were found to be current smokers based on self-report and urinary cotinine values >10 ng/mL (Table 1). Significant differences in demographic characteristics were found by quartile diet quality score (p-value<0.001 for all). Individuals with higher diet quality scores (Quartile 4) were more likely to be older, female, Non-Hispanic White, educated, moderately active and non-smokers compared to individuals with lower diet quality scores (Quartile 1).

The average BMI of participants is considered overweight (29.03± 6.82) and 37% (n=3,887) of participants were classified as obese. Around 15% (n=1,501) of participants self-reported having a history of asthma and 8% (n=782) reported current asthma. Only 5% (n=483) of participants self-reported having a history of bronchitis and 2% (n=205) reported current bronchitis. The average pre-bronchodilator FEV_1, FVC and FEV_1/FVC ratio were 3.2 L (± 0.9 L), 4.0 L (± 1.1 L), 79% (± 8%), respectively. Lung function measures were, on average, normal compared to the percent predicted values for age, height, sex and ethnicity. Prevalence of airway restriction was 1.6% and COPD was 4.6%. Significant differences in physical measures were found by quartile diet quality score. Individuals with higher quality diet scores (Quartile 4) were less likely to be overweight/obese (p<0.001), less likely to have self-reported asthma (p<0.01) or bronchitis (p<0.001), tended to have higher lung function measures (p<0.001) and were less likely to have airway restriction (p=0.072) and COPD (p<0.001) than those with lower diet quality scores. Demographic characteristics of study participants with airway restriction and COPD can be found in Supplemental Table 1. Participants with spirometrically defined lung function outcomes tended to be older, have lower household income and were determined to be current smokers compared with the total sample. Individuals with airway restriction were more likely to be male and identify as Non-Hispanic Black, whereas individuals with COPD were more likely to be female and identify as Non-Hispanic White compared with the total sample.

Participants reported consuming an average of 2,129 Kcal/day (±826), with carbohydrates contributing to half of total energy intake (Table 1). Intake was low for fruits (0.36 servings/day vs. recommended 4 servings/day), vegetables (0.86 servings/day vs. recommended 5 servings/day), whole grains (6.4 grams/day vs. recommended 75-90 grams/day based on sex) and polyunsaturated fatty acid (7.1% of total calories vs. recommended 10% of total calories) but high for sugar-sweetened beverages (1.21 servings/day vs. 1 serving/day limit), red/processed meat (2.15 servings/day vs. 1.5 serving/day limit) and sodium (3267 mg/day vs. 2,300 mg/day limit) [26]. Utilizing the 11-dietary components, the average AHEI-2010 score of participants was 45.3 (±12.2) [17]. There were significant differences in all dietary components of participants by quartile diet quality score ($p<0.001$ for all). Individuals with higher diet quality scores consumed more fruit, vegetables, whole grains, nuts, legumes, omega-3 fatty acids, polyunsaturated fatty acids than those with lower scores. Conversely individuals with lower diet quality scores consumed more sugar sweetened beverages, red/processed meat, trans fat, sodium and alcohol than those with lower diet quality scores.

The association between diet quality and pre-bronchodilator lung function measures is shown in Table 2. Compared to those within the lowest quartile group, individuals in the second, third, or fourth quartile had higher FEV_1, FVC and FEV_1/FVC ratio when controlling for age, sex and height (Model 1). After controlling for all additional confounders and accounting for the interaction of smoking and AHEI (Model 2) these associations remained statistically significant for FEV_1 and FVC (β-coefficient for the highest vs. lowest quartile of AHEI 47.92, 95% CI 2.27, 93.57; and β-coefficient 80.23, 95% CI 34.03, 126.42, respectively). The adjusted associations of

AHEI with FEV_1 and FVC remained statistically significant when accounting for the interaction of ethnicity and AHEI (Model 3) on FEV_1 (β-coefficient for the highest vs. lowest quartile of AHEI 95.52, 95% CI 41.74, 149.31) and on FVC (β-coefficient for the highest vs. lowest quartile of AHEI 119.49, 95% CI 69.67, 169.31). The adjusted subgroup analyses by race/ethnicity showed no evidence of association between diet quality and any of the race subgroups. Among never smokers (n=5,066), former smokers (n=2,070) and current smokers (n=3,292), individuals in the highest quartile of AHEI had higher FVC compared to those in the lowest quartile group. There was no evidence of interaction between AHEI and ethnicity in this subgroup analysis.

The population-weighted-logistic regression models between diet quality and airway restriction (FVC<LLN), and COPD (FEV_1/FVC<LLN) are shown in Table 3. Compared to those in the lowest quartile group, individuals in the second, third, or fourth quartile had lower odds of airway restriction and COPD when controlling for age, sex and height (Model 1). When controlling for additional covariates and for the interaction of smoking with AHEI (Model 2), this association was attenuated and was no longer statistically significant. When adjusting for all potential confounders an accounting for the interaction of race/ethnicity and AHEI (Model 3), those in the highest quartile of AHEI intake were less likely to have airway restriction (OR 0.23, 95% CI 0.08, 0.67). Adjusted sub-group analyses by race/ethnicity showed no evidence of association between AHEI and any of the three race/ethnicity subgroups. Subgroup analyses by smoking status no evidence of association between diet quality and airway restriction or COPD. Higher quartile AHEI-2010 score remained significantly associated with airway restriction when individually controlling for nuts/legumes, red/processed meat, omega-3 fatty acids, sodium and alcohol (Supplemental Table 2). However, this association was attenuated to the null when

individually controlling for fibre (p-value = 0.17), fruit (p-value=0.20), vegetables (p-value=0.13), SSB (p-value=0.20), trans fat (p-value=0.48) and PUFA (p-value=0.08). Individual adjustment with AHEI-2010 components did not modify the association between diet quality and COPD. Additional adjustment for dietary patterns are shown in Supplemental Table 3. The association between AHEI with airway restriction or COPD remained statistically significant after adjustment by the fruit, fibre and legumes pattern.

Discussion:

In this population-based study representative of the general population of US adults, we found that diet quality, as measured by the AHEI-2010, was low. The average AHEI-2010 score was 45.3 (±12.2), which is equivalent to meeting 41% of the daily recommendations to achieve an optimal diet quality (out of a total of 110) [19]. Higher diet quality (higher AHEI-2010) was positively and statistically significantly associated with higher FEV_1, and FVC independent of a variety of relevant confounding factors [4, 29], and of interaction of AHEI and smoking habit, or AHEI and race/ethnicity on lung function outcomes. Adjusted sub-group analyses indicated the strongest associations in former or current smokers. To our knowledge, this is the first observational study of a nationally representative sample of US adults to report an association between AHEI-2010 score and spirometrically defined lung function outcomes.

Evidence has demonstrated that several components of diet considered to be healthy (e.g. fruits, antioxidants) have consistently been associated with better lung function (FEV_1, FVC) in adults from observational studies [9]. In European cohorts, higher intake of fruit was associated with slower lung function decline [7]. The beneficial properties of fruit include fiber and dietary flavonoids. Low fiber intake has been associated with reduced lung function measures in US adults [30]. Whereas, higher intake of anthocyanin flavonoids, widely found in dark-pigmented fruits, has also been associated with slower lung function decline in a longitudinal analysis of older adults from the Veteran Affairs Normative Ageing Study in the US [31]. Beyond individual dietary components, other studies have associated dietary patterns with lung function measures. Dietary patterns considered prudent (rich in fruits, vegetables and oily fish) have been positively associated with FEV_1 in a large cohort of adults from the UK participating in the Hertfordshire Cohort Study between 1998-2004 [32], Whereas, dietary patterns considered refined (high in fast food and snack foods) have been negatively associated with FEV_1 and FVC in a national estimate of Korean women between 2007-2011 [33].

In addition to lung function measures, higher diet quality was associated with decreased prevalence of airway restriction and trended toward reduced prevalence of COPD in this sample. Higher intake of dietary flavonoids has been associated with lower prevalence of spirometrically defined airway restriction in a cohort study of European adults between 2008-2009 [34]. Evidence from this same cohort study did not identify significant associations between principle component analysis identified dietary patterns and COPD ($FEV_1/FVC<LLN$) [35]. Whereas other studies have demonstrated associations between dietary patterns and self-reported COPD. Dietary patterns considered prudent (rich in fruits, vegetables and oily fish) have been associated with decreased risk of self-reported COPD in prospective study of US men [36]. In the Nurses' Health Study and the Health Professionals Follow-up Study, Varraso et al showed that higher AHEI-2010 scores were associated with decreased incidence of self-reported doctor diagnosed COPD [11]. These differences may be partly explained by the definitions used to ascertain COPD. In NHANES, spirometrically defined COPD ($FEV_1/FVC < LLN$) was utilized, which is known to be more specific.

The mechanism between diet and lung function is hypothesized to relate to antioxidant properties of certain nutrients including Vitamins A, C, E, beta-carotene and omega-3 fatty acids [37–40]. These nutrients are mostly found in fruits and vegetables as well as fatty-fish [41], all foods that contribute to higher diet quality scores. Foods that contribute to lower diet quality scores, such as SSB, red/processed meat, trans fat and sodium have all been associated with overweight/obesity [42–44], another risk factor for markers of poor lung function and prevalence of COPD [45, 46]. Intake of sugar-sweetened beverages were associated with increased risk of both airway restriction and COPD in this sample. In addition, diet quality was associated with airway restriction controlling for BMI classification suggesting that low quality foods not only displace intake of higher quality antioxidant containing foods but may even be contributing to inflammatory processes independent of weight status.

Strengths

AHEI-2010 is widely considered as a reliable indicator of the quality of diet of Americans and has been reported to be associated with several outcomes of non-communicable disease. Our study is the first to examine the association of AHEI-2010 and lung function in a sample of U.S. adults, using high quality spirometry only, and calibrating the measures of pre-bronchodilator spirometry to improve the validity and reliability of the estimates of LLN. In addition, the analysis of data from NHANES offers a population-based estimate that is powered to detect associations even controlling for a number of confounding factors. In terms of cigarette use, urine cotinine was used to identify current smoking status allowing for a more accurate assessment of this strongly associated factor with lung function beyond self-report.

Limitations

Although the findings of study contribute epidemiological evidence supporting the relationship between diet quality and lung function, this study is only a cross-sectional analysis and therefore cannot establish temporality between the exposure and the outcome. In NHANES, dietary intake was ascertained with the use of a 24-hour recall questionnaire, which has some limitations, the most common of which are under-reporting of usual food intake, often explained by underreporting of portion sizes consumed. To address these issues, the NHANES dietary survey was carried out using a multiple pass system. This system is known to improve reporting of dietary intake [47] by enquiring about intake in three main stages. First, participants are asked to name all the foods they consumed in the past day; then they are asked more details about each food listed, including preparations used for their consumption. The final step is to enquire about portion sizes. The NHANES survey uses a set of measures specifically designed for the study's setting, with a target population of non-institutionalized civilians [13]. Highly trained dietary interviewers administer the 24-hour recall questionnaires, which ensured that as much relevant detail as possible was provided, further attenuating issues around misreporting of dietary intake. The 24-hour recall questionnaire is commonly used in national surveys, as it provides accurate estimates of mean intakes in specific groups (e.g. age, sex, ethnicity) in large population samples like that of NHANES [47]. However, the instrument has the additional limitation of providing information on dietary intake in a single day. In our study, 88% of participants contributed two 24-hour recall questionnaires, which helped to account for some variability in the diet. Despite we acknowledge that our estimates of diet quality might not represent a reflection of long-term dietary habits in the studied population.

Conclusion:

This cross-sectional secondary analysis of adults 19-70 years in the U.S. revealed that diet quality scores as measured by the AHEI-2010 were unsurprisingly low. Adults with higher diet quality scores had higher lung function measures and lower odds of airway restriction but not airway obstruction. These findings warrant replication in longitudinal studies to confirm if a better diet quality can contribute to preserve lung function and slowdown lung function decline in adults from the general population.

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Table 1. Characteristics of Participants Stratified by Quartile AHEI-2010 Score from NHANES Cycles 2007-2012 (N=10,428)

		Quartile AHEI-2010 Score*			
	Total Sample N=10428	Quartile 1 n=2608	Quartile 2 n=2607	Quartile 3 n=2608	Quartile 4 n=2605
Demographics, N (%)					
Age, Mean ± SD	42.9 ± 14.7	38.1 ± 14.0	41.0 ± 14.3	44.2 ± 14.6	48.2 ± 13.9
Male Sex	5123 (49.1)	1649 (63.2)	1336 (51.3)	1206 (46.2)	932 (35.8)
Race					
Non-Hispanic White	4452 (42.7)	1155 (44.3)	1065 (40.9)	1056 (40.5)	1176 (45.1)
Non-Hispanic Black	2185 (21.0)	665 (25.5)	581 (22.3)	520 (19.9)	419 (16.1)
Hispanic	2918 (28.0)	623 (23.9)	789 (30.3)	819 (31.4)	687 (26.4)
Other	873 (8.3)	165 (6.3)	172 (6.6)	213 (8.2)	323 (12.4)
Language					
English	9008 (86.4)	2356 (90.3)	2220 (85.2)	2172 (83.3)	2260 (86.8)
Spanish	1420 (13.6)	252 (9.7)	387 (14.8)	436 (16.7)	345 (13.2)
Education					
≤High-School	183 (1.8)	83 (3.2)	57 (2.2)	32 (1.2)	11 (0.4)
>High School	5673 (54.4)	1165 (44.7)	1322 (50.7)	1432 (54.9)	1754 (67.3)
Unknown	4572 (43.8)	1360 (52.2)	1228 (47.1)	1144 (43.9)	840 (32.3)
Income					
0-<25K	2611 (25.0)	782 (30.0)	710 (27.2)	641 (24.6)	478 (18.4)
25K-<55K	2948 (28.3)	821 (31.5)	747 (28.7)	753 (28.9)	627 (24.1)
≥55K	1165 (11.2)	289 (11.1)	269 (10.3)	295 (11.3)	312 (12.0)
Unknown	3704 (35.5)	716 (27.5)	881 (33.8)	919 (35.2)	1188 (45.6)

		Quartile AHEI-2010 Score			
	Total Sample N=10428	Quartile 1 n=2608	Quartile 2 n=2607	Quartile 3 n=2608	Quartile 4 n=2605
Physically Active †	3275 (31.4)	1016 (39.0)	890 (34.1)	755 (29.0)	614 (23.6)
Smoking Status ‡					
Non-Smoker	5066 (48.6)	973 (37.3)	1183 (45.4)	1385 (53.1)	1525 (58.5)
Former Smoker	2070 (19.8)	391 (15.0)	519 (19.9)	516 (19.8)	644 (24.7)
Current Smoker	3292 (31.6)	1244 (47.7)	905 (34.7)	707 (27.1)	436 (16.7)
Exam Data					
Height (cm), Mean ± SD	168.2 ± 10.0	170.7 ± 9.5	168.4 ± 10.1	167.3 ± 10.1	166.3 ± 9.7
BMI (kg/m^2), Mean ± SD	29.03 ± 6.82	29.15 ± 7.36	29.42 ± 6.80	29.01 ± 6.74	28.53 ± 6.31
Classification, N (%)					
Underweight	139 (1.3)	44 (1.7)	35 (1.3)	30 (1.2)	30 (1.2)
Normal	2972 (28.5)	793 (30.4)	675 (25.9)	716 (27.5)	788 (30.3)
Overweight	3430 (32.9)	815 (31.3)	849 (32.6)	891 (34.2)	875 (33.6)
Obese	3887 (37.3)	956 (36.7)	1048 (40.2)	971 (37.2)	912 (35.0)
Questionnaire Data					
Asthma, N (%)					
Ever Asthma	1,501 (14.4)	420 (16.1)	382 (14.7)	367 (14.1)	332 (12.7)
Current Asthma	782 (7.5)	219 (8.4)	198 (7.6)	181 (6.9)	184 (7.1)
Bronchitis, N (%)					
Ever Bronchitis	483 (4.6)	122 (4.7)	123 (4.7)	116 (4.5)	122 (4.7)
Current Bronchitis	205 (2.0)	65 (2.5)	52 (2.0)	41 (1.6)	47 (1.8)

	Total Sample N=10428	Quartile AHEI-2010 Score Quartile 1 n=2608	Quartile 2 n=2607	Quartile 3 n=2608	Quartile 4 n=2605
Spirometry Data §ll					
Prebronchodilator Values, Mean ± SD					
FEV_1 (L)	3.2 ± 0.9	3.4 ± 0.9	3.2 ± 0.9	3.1 ± 0.9	3.0 ± 0.8
FVC (L)	4.0 ± 1.1	4.3 ± 1.0	4.1 ± 1.1	3.9 ± 1.0	3.8 ± 1.0
FEV_1/FVC Ratio (%)	79.0 ± 7.7	79.3 ± 8.0	79.6 ± 7.5	79.0 ± 7.5	78.3 ± 7.5
Percent Predicted Values, Mean ± SD					
FEV_1 (%)	98.4 ± 15.3	97.0 ± 15.1	98.5 ± 14.9	98.9 ± 15.3	99.3 ± 15.6
FVC (%)	102.0 ± 14.2	101.0 ± 13.7	101.9 ± 14.0	102.4 ± 14.4	102.8 ± 14.7
FEV_1/FVC Ratio (%)	96.2 ± 8.3	95.7 ± 8.6	96.4 ± 8.1	96.3 ± 8.1	96.3 ± 8.2
Airway Restriction, N (%)	304 (1.6)	91 (3.5)	78 (3.0)	76 (2.9)	59 (2.3)
COPD, N (%)	440 (4.6)	146 (5.6)	107 (4.1)	99 (3.8)	88 (3.4)
Total Intake, Mean ± SD					
Calories	2129 ± 826	2420 ± 907	2167 ± 824	2030 ± 781	1896 ± 683
Fat, %	32.7 ± 7.6	32.1 ± 7.6	32.4 ± 7.2	32.7 ± 7.6	33.6 ± 8.0
Protein, %	16.1 ± 4.3	15.4 ± 4.3	15.7 ± 4.1	16.4 ± 4.3	16.8 ± 4.3
CHO, %	49.8 ± 9.7	49.5 ± 10.1	50.4 ± 9.4	49.8 ± 9.7	49.6 ± 9.6

		Quartile AHEI-2010 Score			
	Total Sample N=10428	Quartile 1 n=2608	Quartile 2 n=2607	Quartile 3 n=2608	Quartile 4 n=2605
Fiber, g/day	16.9 ± 9.0	13.5 ± 7.3	15.6 ± 8.1	17.4 ± 8.7	21.2 ± 10.1
AHEI-2010 Components, Median (IQR)					
Fruit, servings/d	0.36 (0.00, 1.05)	0.00 (0.00, 0.40)	0.23 (0.00, 0.83)	0.46 (0.02, 1.12)	0.94 (0.32, 1.72)
Vegetable, servings/d	0.86 (0.43, 1.44)	0.65 (0.31, 1.15)	0.79 (0.40, 1.28)	0.92 (0.48, 1.47)	1.16 (0.65, 1.81)
Whole Grains, g/d	6.4 (0.0, 18.3)	0.0 (0.0, 9.1)	4.1 (0.0, 14.5)	7.2 (0.0, 18.5)	15.6 (4.4, 30.3)
SSB, servings/d	1.21 (0.00, 2.84)	2.65 (1.47, 4.73)	1.80 (0.77, 3.29)	0.87 (0.00, 2.17)	0.00 (0.00, 0.58)
Nuts & Legumes, servings/d	0.46 (0.00, 1.75)	0.00 (0.00, 0.24)	0.26 (0.00, 1.27)	0.77 (0.05, 2.01)	1.51 (0.64, 2.86)
Red/Processed Meat, servings/d	2.15 (0.85, 3.95)	3.86 (2.32, 5.86)	2.55 (1.32, 4.20)	1.83 (0.78, 3.17)	0.96 (0.04, 2.02)
Trans fat, % Kcal	0.5 (0.4, 0.6)	0.6 (0.4, 0.7)	0.5 (0.4, 0.6)	0.5 (0.3, 0.6)	0.4 (0.3, 0.5)
Omega-3, mg/d	48.0 (20.0, 107.5)	35.0 (13.5, 67.5)	45.0 (20.5, 87.0)	52.5 (23.5, 129.5)	71.5 (27.5, 220.0)
PUFA, % Kcal	7.1 (5.6, 8.9)	6.1 (4.7, 7.5)	6.8 (5.4, 8.3)	7.4 (5.9, 9.1)	8.5 (6.7, 10.5)
Sodium, g/d	3.27 (2.44, 4.31)	3.81 (2.86, 4.89)	3.37 (2.50, 4.35)	3.12 (2.34, 4.08)	2.88 (2.23, 3.75)
Alcohol, drinks/d	0.00 (0.00, 0.55)	0.00 (0.00, 1.04)	0.00 (0.00, 0.53)	0.00 (0.00, 0.49)	0.00 (0.00, 0.44)
AHEI-2010 Score**, Mean ± SD	45.3 ± 12.2	29.4 ± 5.8	40.7 ± 2.6	49.2 ± 2.8	62.0 ± 6.6

*Differences in characteristics by quartile AHEI-2010 score were explored by chi-square tests for categorical variables and one-way analysis of variance for continuous characteristics. All components except for airway restriction (p-value=0.072) were significantly different by quartile AHEI-2010 score (p-value<0.001).

†Physical activity data: N=10,427 (Missing 1). Physically active was defined as engaging in 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity activity per week.

‡Current Smokers reported never smoking or have urinary cotinine value >10 ng/mL. Former smokers reported they had quit smoking or have urinary cotinine value 1-10 ng/mL. Never smokers reported never smoking or have a urinary cotinine value <1 ng/mL.

§Spirometry measures obtained in the entire sample (N=10,428). Lung function outcomes determined in participants with lung function measures less than the lower limit of normal (LLN). Airway restriction defined as FVC<LLN. Chronic obstructive pulmonary disease (COPD) defined as FEV_1/FVC<LLN.
ll NHANES sample weights were utilized to determine prevalence estimates of airway restriction and COPD
**AHEI-2010 score ranges from 0-110 (higher = better diet quality). Score increases with higher intakes of Fruit, Vegetable, Whole Grains, SSB, Nuts & Legumes, Omega-3, PUFA, and moderate alcohol consumption. Score decreases with higher intakes of Red/Processed Meat, Trans fat, Sodium and excessive Alcohol.

Table 2. Adjusted Associations between Quartile Diet Quality [AHEI-2010] score and Pre-Bronchodilator Lung Function Outcomes

	Lung Function Measures*		
	FEV_1 (mL)	FVC (mL)	FEV_1/FVC Ratio (%)
Total Sample (N=10,428)			
Model 1 †			
Quartile 1 (3.0 – 37.5)	Reference	Reference	Reference
Quartile 2 (35.5 – 46.0)	**91.3 (45.4, 137.3)**	**82.3 (35.7, 128.9)**	**0.81 (0.15, 1.47)**
Quartile 3 (43.7 – 55.4)	**102.2 (63.1, 141.2)**	**106.7 (58.6, 154.7)**	**0.64 (0.09, 1.19)**
Quartile 4 (52.5 – 94.6)	**167.7 (122.5, 212.9)**	**180.7 (131.2, 230.1)**	**0.77 (0.06, 1.49)**
Model 2 ‡			
Quartile 1 (3.0 – 37.5)	Reference	Reference	Reference
Quartile 2 (35.5 – 46.0)	14.82 (-45.53, 75.17)	16.02 (-45.37, 77.40)	0.19 (-0.48, 0.85)
Quartile 3 (43.7 – 55.4)	10.46 (-35.91, 56.83)	33.96 (-17.56, 85.49)	0.01 (-0.69, 0.71)
Quartile 4 (52.5 – 94.6)	**47.92 (2.27, 93.57)**	**80.23 (34.03, 126.42)**	-0.11 (-0.79, 0.58)
Interaction of AHEI and smoking status (p-value)	0.532	0.231	0.585
Model 3 ‡‡			
Quartile 1 (3.0 – 37.5)	Reference	Reference	Reference
Quartile 2 (35.5 – 46.0)	**78.66 (9.86, 147.46)**	**76.86 (16.66, 137.07)**	0.52 (-0.22, 1.26)
Quartile 3 (43.7 – 55.4)	**63.17 (10.13, 116.21)**	**80.31 (23.27, 137.35)**	0.07 (-0.58, 0.73)
Quartile 4 (52.5 – 94.6)	**95.52 (41.74, 149.31)**	**119.49 (69.67, 169.31)**	0.04 (-0.74, 0.83)
Interaction of AHEI and race/ethnicity (p-value)	0.109	**0.029**	0.355

	Lung Function Measures*		
	FEV$_1$ (mL)	FVC (mL)	FEV$_1$/FVC Ratio (%)
Sub-Group Analysis by Race/Ethnicity §ll			
Non-Hispanic White (n=4,452)	64.43 (2.09, 126.78)	106.94 (48.24, 165.64)	-0.18 (-1.15, 0.79)
Interaction of AHEI and smoking status (p-value)	0.484	0.107	0.496
Non-Hispanic Black (n=2,185)	58.99 (-25.91, 143.89)	69.88 (-20.36, 160.12)	0.30 (-1.24, 1.84)
Interaction of AHEI and smoking status (p-value)	0.586	0.568	0.258
Hispanic (n=2,918)	11.05 (-65.82, 87.93)	14.98 (-70.38, 100.33)	-0.08 (-0.87, 0.71)
Interaction of AHEI and smoking status (p-value)	**0.011**	0.306	**0.039**
Sub-Group Analysis by Smoking Status §**			
Never Smoker (n=5,066)	19.03 (-38.23, 76.30)	**76.84 (19.40, 134.28)**	**-0.99 (-1.87, -0.10)**
Interaction of AHEI and race/ethnicity (p-value)	0.872	0.730	0.236
Former Smoker (n=2,070)	85.60 (-15.69, 186.88)	**106.76 (5.79, 207.72)**	-0.05 (-1.26, 1.16)
Interaction of AHEI and race/ethnicity (p-value)	0.174	0.276	0.477
Current Smoker (n=3,292)	**160.18 (54.41, 265.95)**	**165.72 (61.31, 270.13)**	0.93 (-0.74, 2.61)
Interaction of AHEI and race/ethnicity (p-value)	0.117	0.491	0.322

*Beta-coefficients (95%CI) obtained from separated weighted linear regression model between diet quality and various lung function measures. Diet quality quartile ranges are summarized across all NHANES cycle years (2007-2012) and may overlap as the quartiles were generated based on the sample distribution within each NHANES cycle year (2007-2008, 2009-2010, 2011-2012). Bolded values indicated statistical significance (p<0.05).

† Model 1 – Quartile AHEI-2010 score adjusted for age (years), sex (male, female) and height (cm).

‡ Model 2 – Quartile AHEI-2010 score adjusted for age (years), sex (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), physically active (yes, no), and the interaction between AHEI and smoking status (non-smoker, former smoker, current smoker)

‡‡ Model 3 – Quartile AHEI-2010 score adjusted for age (years), sex (male, female), height (cm), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), physically active (yes, no), smoking status (non-smoker, former smoker, current smoker), and the interaction between AHEI and ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other)

§ Quartile 4 vs. Quartile 1 beta-coefficients presented for sub-group analyses by race/ethnicity and smoking status.
ll Sub-group analysis by race/ethnicity adjusted for the covariates described in Model 2 (excluding race/ethnicity)
** Sub-group analysis by smoking status adjusted for the covariates described in Model 2 (excluding smoking status)

Table 3. Adjusted Associations between Quartile Diet Quality [AHEI-2010] score and Airway Restriction and COPD (N=10,428)

	Lung Function Outcomes*	
	Airway Restriction (FVC < LLN)	COPD (FEV_1/FVC < LLN)
Total Sample (N=10428)		
Model 1 †		
Quartile 1 (3.0 – 37.5)	Reference	Reference
Quartile 2 (35.5 – 46.0)	**0.65 (0.41, 1.03)**	**0.56 (0.40, 0.79)**
Quartile 3 (43.7 – 55.4)	**0.60 (0.39, 0.94)**	**0.60 (0.45, 0.81)**
Quartile 4 (52.5 – 94.6)	**0.43 (0.28, 0.65)**	**0.46 (0.32, 0.67)**
Model 2 ‡		
Quartile 1 (3.0 – 37.5)	Reference	Reference
Quartile 2 (35.5 – 46.0)	0.81 (0.39, 1.71)	0.52 (0.22, 1.24)
Quartile 3 (43.7 – 55.4)	0.64 (0.30, 1.35)	0.93 (0.40, 2.17)
Quartile 4 (52.5 – 94.6)	0.67 (0.35, 1.26)	0.73 (0.35, 1.51)
Interaction AHEI and Smoking status (p-value)	0.816	0.692
Model 3 ‡‡		
Quartile 1 (3.0 – 37.5)	Reference	Reference
Quartile 2 (35.5 – 46.0)	0.38 (0.13, 1.08)	**0.60 (0.40, 0.91)**
Quartile 3 (43.7 – 55.4)	0.44 (0.18, 1.07)	0.81 (0.57, 1.15)
Quartile 4 (52.5 – 94.6)	**0.23 (0.08, 0.67)**	0.69 (0.46, 1.02)
Interaction AHEI and Race/ethnicity (p-value)	0.302	0.850
Sub-Group Analysis by Race/Ethnicity §ll		
Non-Hispanic White (n=4,452)	0.43 (0.05, 3.73)	0.85 (0.31, 2.35)
Interaction AHEI and smoking status (p-value)	Not testable	0.282
Non-Hispanic Black (n=2,185)	0.74 (0.35, 1.57)	0.65 (0.13, 3.17)
Interaction AHEI and smoking status (p-value)	0.370	0.222
Hispanic (n=2,918)	0.41 (0.06, 2.85)	0.75 (0.13, 4.27)
Interaction AHEI and smoking status (p-value)	Not testable	Not testable

	Lung Function Outcomes*	
	Airway Restriction (FVC < LLN)	COPD (FEV_1/FVC Ratio < LLN)
Sub-Group Analysis by Smoking Status §**		
Never Smoker (n=5,066)	0.62 (0.08, 5.12)	0.85 (0.29, 2.48)
Interaction AHEI and Race/Ethnicity (p-value)	Not testable	0.110
Former Smoker (n=2,070)	1.81 (0.12, 27.9)	0.96 (0.41, 2.23)
Interaction AHEI and Race/Ethnicity (p-value)	Not testable	Not testable
Current Smoker (n=3,292)	0.37 (0.09, 1.49)	0.64 (0.32, 1.31)
Interaction AHEI and Race/Ethnicity (p-value)	Not testable	0.692

*Odds Ratio [OR] (95%CI) obtained from separated weighted logistic regression model between diet quality and various lung function outcomes identified by lung function measures below the lower limit of normal (LLN). Diet quality quartile ranges are summarized across all NHANES cycle years (2007-2012) and may overlap as the quartiles were generated based on the sample distribution within each NHANES cycle year (2007-2008, 2009-2010, 2011-2012). Bolded values indicated significance ($p<0.05$).

† Model 1 – Quartile AHEI-2010 score adjusted for age (years), gender (male, female) and height (cm).

‡ Model 2 – Quartile AHEI-2010 score adjusted for age (years), gender (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), physically active (yes, no), and the interaction of AHEI and smoking status (non-smoker, former smoker, current smoker)

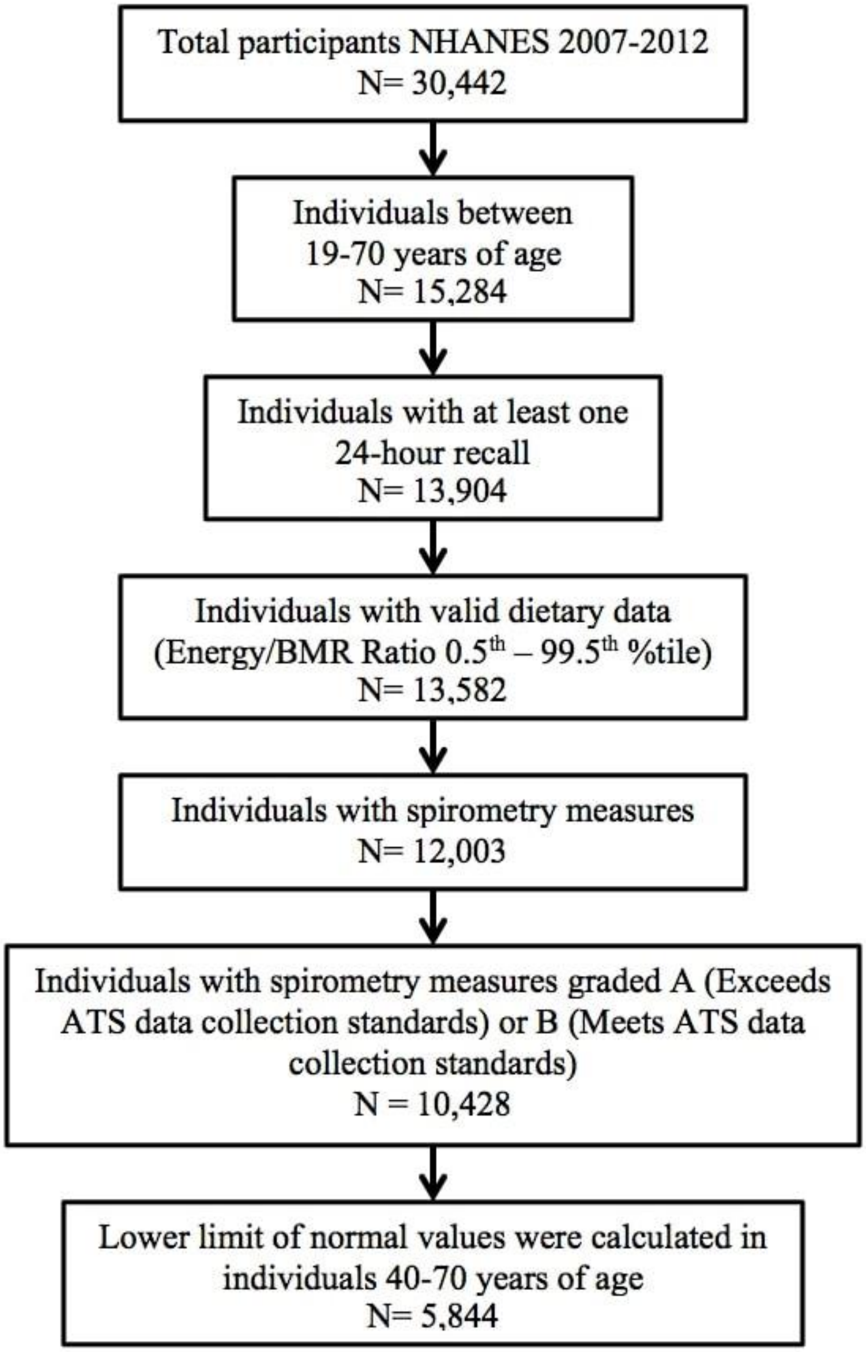
‡‡ Model 3 – Quartile AHEI-2010 score adjusted for age (years), gender (male, female), height (cm), , total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), smoking status (non-smoker, former smoker, current smoker) and physically active (yes, no), and the interaction of AHEI and race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other)

§ Quartile 4 vs. Quartile 1 ORs presented for sub-group analyses by race/ethnicity and smoking status.

ll Sub-group analysis by race/ethnicity adjusted for the covariates described in Model 2 (excluding race/ethnicity)

** Sub-group analysis by smoking status adjusted for the covariates described in Model 3 (excluding smoking status)

Figure 1. Flow Diagram of NHANES Participants included in the study



Supplemental Table 1. Demographic Characteristics of Participants with Airway Restriction (N=304) or COPD (N=440)

	Spirometrically Defined Lung Function Outcomes	
	Airway Restriction (N=304)	COPD (N=440)
Demographics, N (%)		
Age, Mean ± SD	45.7 ± 16.1	45.6 ± 15.0
Male Sex	164 (54.0)	217 (49.3)
Race		
Non-Hispanic White	48 (15.8)	272 (61.8)
Non-Hispanic Black	210 (69.1)	100 (22.7)
Hispanic	12 (4.0)	46 (10.5)
Other	34 (11.2)	22 (5.0)
Language		
English	298 (98.0)	414 (94.1)
Spanish	6 (2.0)	26 (5.9)
Education		
≤High-School	10 (3.3)	7 (1.6)
>High School	155 (51.0)	181 (41.1)
Unknown	139 (45.7)	252 (57.3)
Income		
0-<25K	91 (29.9)	153 (34.8)
25K-<55K	89 (29.3)	133 (30.2)
≥55K	26 (8.6)	45 (10.2)
Unknown	98 (32.2)	109 (24.8)

	Spirometrically Defined Lung Function Outcomes	
	Airway Restriction (N=304)	COPD (N=440)
Demographics, N (%)		
Physically Active *	83 (27.3)	154 (35.0)
Smoking Status †		
Non-Smoker	130 (42.8)	88 (20.0)
Former Smoker	53 (17.4)	85 (19.3)
Current Smoker	121 (39.8)	267 (60.7)

* Physically active was defined as engaging in 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity activity per week.

†Current Smokers reported never smoking or have urinary cotinine value >10 ng/mL. Former smokers reported they had quit smoking or have urinary cotinine value 1-10 ng/mL. Never smokers reported never smoking or have a urinary cotinine value <1 ng/mL.

Supplemental Table 2. Adjusted Associations between Diet Components and Pre-Bronchodilator Lung Function Outcomes

	Lung Function Outcomes*	
	Airway Restriction (FVC < LLN)	COPD (FEV_1/FVC Ratio < LLN)
Dietary Components †‡		
Fiber (per SD: 9.0 gram)	**0.80 (0.67, 0.96)**	**0.83 (0.70, 0.98)**
Fruit (per serving)	**0.74 (0.58, 0.94)**	**0.69 (0.56, 0.84)**
Vegetable (per serving)	**0.73 (0.55, 0.95)**	0.85 (0.71, 1.01)
Whole Grains, (per SD: 18.4 grams)	0.94 (0.81, 1.10)	0.90 (0.79, 1.02)
SSB (per serving)	**1.11 (1.04, 1.18)**	**1.07 (1.03, 1.11)**
Nuts & Legumes (per serving)	1.03 (0.93, 1.14)	1.01 (0.93, 1.09)
Red/Processed Meat (per serving)	1.01 (0.92, 1.12)	1.01 (0.94, 1.07)
Trans fat (per SD: 0.2%)	1.11 (0.94, 1.31)	1.06 (0.95, 1.19)
Omega-3 (per SD: 254.2 mg)	1.03 (0.92, 1.16)	1.01 (0.90, 1.13)
PUFA (per SD: 2.7%)	0.93 (0.81, 1.07)	0.92 (0.81, 1.04)
Sodium (per SD: 1.5 grams)	0.96 (0.74, 1.25)	0.94 (0.78, 1.14)
Alcohol (per serving)	0.89 (0.79, 1.02)	1.02 (0.96, 1.09)

*Odds Ratio (95%CI) obtained from separated weighted logistic regression model between dietary components and various lung function outcomes identified by lung function measures below the lower limit of normal (LLN). Bolded values indicated associations that were statistically significant ($p<0.05$).

† Models adjusted for age (years), gender (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25– 55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), smoking status (non-smoker, former smoker, current smoker) and physically active (yes, no).

‡ Select variables associated per standard deviation (fiber, whole grains, trans fat, omega-3 fatty acid, polyunsaturated fatty acid and sodium). Remaining variables associated per serving (fruit, vegetables, SSB, nuts & legumes, red/processed meat, alcohol).

Supplemental Table 3. The association of AHEI, airway restriction and COPD, with additional adjustment for dietary patterns

	Lung Function Outcomes*	
	Airway Restriction (FVC < LLN)	COPD (FEV_1/FVC Ratio < LLN)
AHEI-2010 (per quartile increase) †		
Additional Adjustment by dietary patterns‡:		
Fruit, fiber and legumes	**0.86 (0.74, 1.00)**	**0.82 (0.71, 0.96)**
Meat, trans fats and sodium	1.04 (0.85, 1.28)	1.11 (0.98, 1.27)
SSB, omega-3 and PUFA	1.03 (0.88, 1.21)	0.93 (0.82, 1.07)

*Odds Ratio (95%CI) obtained from separated weighted logistic regression model between dietary components and various lung function outcomes identified by lung function measures below the lower limit of normal (LLN). Bolded values indicated associations that were statistically significant ($p<0.05$).
† Models adjusted for age (years), gender (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25–55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), smoking status (non-smoker, former smoker, current smoker) and physically active (yes, no).
‡ Dietary patterns derived from Principal Component analysis (PCA)
Fruit, fibre and legumes explained 21.7% of total variance (fibre, total intake of fruits, whole grains, nuts and legumes)
Meat, trans fats and sodium pattern explained 15.6% of total variance (red/processed meat, trans fatty acids, and sodium)
Sugar-sweetened beverages (SSB), omega 3 fatty acids and polyunsaturated fatty acids (PUFA) explained 10.2% of total variance

Supplemental Table 1. Demographic Characteristics of Participants with Airway Restriction (N=304) or COPD (N=440)

	Spirometrically Defined Lung Function Outcomes	
	Airway Restriction (N=304)	COPD (N=440)
Demographics, N (%)		
Age, Mean ± SD	45.7 ± 16.1	45.6 ± 15.0
Male Sex	164 (54.0)	217 (49.3)
Race		
Non-Hispanic White	48 (15.8)	272 (61.8)
Non-Hispanic Black	210 (69.1)	100 (22.7)
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Other	34 (11.2)	22 (5.0)
Language		
English	298 (98.0)	414 (94.1)
Spanish	6 (2.0)	26 (5.9)
Education		
≤High-School	10 (3.3)	7 (1.6)
>High School	155 (51.0)	181 (41.1)
Unknown	139 (45.7)	252 (57.3)
Income		
0-<25K	91 (29.9)	153 (34.8)
25K-<55K	89 (29.3)	133 (30.2)
≥55K	26 (8.6)	45 (10.2)
Unknown	98 (32.2)	109 (24.8)

	Spirometrically Defined Lung Function Outcomes	
	Airway Restriction (N=304)	COPD (N=440)
Demographics, N (%)		
Physically Active *	83 (27.3)	154 (35.0)
Smoking Status †		
Non-Smoker	130 (42.8)	88 (20.0)
Former Smoker	53 (17.4)	85 (19.3)
Current Smoker	121 (39.8)	267 (60.7)

* Physically active was defined as engaging in 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity activity per week.

†Current Smokers reported never smoking or have urinary cotinine value >10 ng/mL. Former smokers reported they had quit smoking or have urinary cotinine value 1-10 ng/mL. Never smokers reported never smoking or have a urinary cotinine value <1 ng/mL.

Supplemental Table 2. Association between AHEI-2010 Score and Lung Function Outcomes, with individual AHEI-2010 components examined as additional potential confounders

	Lung Function Outcomes*	
	Airway Restriction (FVC < LLN)	COPD (FEV_1/FVC Ratio < LLN)
AHEI-2010 (per quartile increase) †‡		
Additional Adjustment by		
Fiber (per SD: 9.0 gram)	0.90 (0.78, 1.05)	1.00 (0.87, 1.15)
Fruit (per serving)	0.90 (0.77, 1.06)	1.01 (0.89, 1.13)
Vegetable (per serving)	0.89 (0.77, 1.04)	0.96 (0.84, 1.10)
Whole Grains, (per SD: 18.4 grams)	0.86 (0.73, 1.01)	0.87 (0.84, 1.10)
SSB (per serving)	0.90 (0.77, 1.06)	0.99 (0.87, 1.12)
Nuts & Legumes (per serving)	**0.82 (0.68, 0.99)**	0.92 (0.81, 1.04)
Red/Processed Meat (per serving)	**0.84 (0.71, 0.99)**	0.93 (0.80, 1.08)
Trans fat (per SD: 0.2%)	0.93 (0.77, 1.13)	0.94 (0.81, 1.08)
Omega-3 (per SD: 254.2 mg)	**0.84 (0.72, 0.98)**	0.93 (0.82, 1.05)
PUFA (per SD: 2.7%)	0.86 (0.72, 1.02)	0.96 (0.85, 1.08)
Sodium (per SD: 1.5 grams)	**0.85 (0.73, 0.99)**	0.93 (0.82, 1.05)
Alcohol (per serving)	**0.85 (0.73, 0.99)**	0.93 (0.83, 1.06)

*Odds Ratio (95%CI) obtained from separated weighted logistic regression model between AHEI-2010 score (per quartile increase) and various lung function outcomes identified by lung function measures below the lower limit of normal (LLN). Bolded values indicated significance ($p<0.05$).

† Models adjusted for age (years), gender (male, female), height (cm), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Other), total energy intake (kcal), education (<=high-school, > high school, unknown), household income (0-25K, 25–55K, ≥55K or unknown), BMI category (underweight, normal, overweight, obese), smoking status (non-smoker, former smoker, current smoker), physically active (yes, no) and individually added AHEI-2010 components.

‡ Select variables associated per standard deviation (AHEI-2010 score, fiber, whole grains, trans fat, omega-3 fatty acid, polyunsaturated fatty acid and sodium). Remaining variables associated per serving (fruit, vegetables, SSB, nuts & legumes, red/processed meat, alcohol).