

Dietary Patterns, Asthma, and Lung Function in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

Yueh-Ying Han, PhD¹, Elina Jerschow, MD², Erick Forno, MD, MPH¹, Simin Hua, MHS³, Yasmin Mossavar-Rahmani, PhD³, Krista M. Perreira, PhD⁴, Daniela Sotres-Alvarez⁵, Majid Afshar, MD, MS⁶, Naresh M. Punjabi, MD, PhD⁷, Bharat Thyagarajan, MD, PhD⁸, Nitin Shivappa, PhD^{9,10,11}, James R. Hébert, ScD^{9,10,11}, Robert C. Kaplan, PhD³, Juan C. Celedón, MD, DrPH, ATSF¹

¹ Division of Pediatric Pulmonary Medicine, UPMC Children's Hospital of Pittsburgh, University of Pittsburgh, Pittsburgh, Pennsylvania

² Department of Medicine, Albert Einstein College of Medicine, Bronx, New York

³ Department of Epidemiology & Population Health, Albert Einstein College of Medicine, Bronx, New York

⁴ Department of Social Medicine, University of North Carolina School of Medicine

⁵ Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina

⁶ Public Health Sciences, Loyola University Chicago

⁷ School of Medicine, Johns Hopkins University

⁸ Department of Laboratory Medicine and Pathology, University of Minnesota

⁹ Department of Epidemiology and Biostatistics, ¹⁰Cancer Prevention and Control Program, and

¹¹Connecting Health Innovations, Columbia, South Carolina

Corresponding Author:

Juan C. Celedón, MD, DrPH, ATSF
Division of Pediatric Pulmonary Medicine
UPMC Children's Hospital of Pittsburgh
4401 Penn Avenue, Pittsburgh, PA 15224
Phone: 412.692.8429; Fax: 412.692.7636
Email: juan.celedon@chp.edu

Author Contributions: Conception and study design: Y-Y.H., E.J., R.C.K., YM-R, and J.C.C.; data collection and recruitment: K.M.P., D. S.-A., M.A., N.M.P., B.T., data analysis and interpretation: Y-Y.H., E.F., S.H., Y.M-R., N.S., and J.R.H.; drafting of the manuscript for intellectual content: Y-Y.H., E.J., E.F., N.S., J.R.H., R.C.K., and J.C.C. All authors approved the final version of the manuscript prior to submission. Drs. Han and Celedón had full access to all of the data and take responsibility for the integrity and accuracy of the analysis. None of the funding sponsors had any role in study design, data analysis, or manuscript preparation or approval.

Sources of Funding: Dr. Han's contribution was supported by grant MD011764 from the U.S. National Institutes of Health (NIH). Dr. Forno's contribution was supported by grant HL125666 from the U.S. NIH. Dr. Celedón's contribution was supported by grants HL117191, HL119952 and MD011764 from the U.S. NIH. The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) was carried out as a collaborative study supported by contracts from the National Heart, Lung, and Blood Institute (NHLBI) to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235),

Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following Institutes/Centers/Offices contribute to the HCHS/SOL through a transfer of funds to the NHLBI: National Center on Minority Health and Health Disparities, the National Institute of Deafness and Other Communications Disorders, the National Institute of Dental and Craniofacial Research, the National Institute of Diabetes and Digestive and Kidney Diseases, the National Institute of Neurological Disorders and Stroke, and the Office of Dietary Supplements.

Conflicts of Interest: Dr. Celedón has received research materials from Merck and GSK (inhaled steroids), and Pharmavite (vitamin D and placebo capsules), to provide medications free of cost to participants in NIH-funded studies, unrelated to the current work. Dr. James R. Hébert owns controlling interest in Connecting Health Innovations LLC (CHI), a company that has licensed the right to his invention of the dietary inflammatory index (DII) from the University of South Carolina. Dr. Nitin Shivappa is an employee of CHI. Dr. Jerschow received a research grant from Cumberland Inc., and serves on the Advisory Board for Sanofi-Aventis US LLC, unrelated to the current work. The other authors report no competing financial interests exist.

Running Head: Dietary patterns and asthma in the HCHS/SOL

Subject Category List: 1.15 Epidemiology: Adult Asthma: Risk Factors (Etiology)

Key Words: Dietary Inflammatory Index, AHEI-2010, Asthma, Asthma Symptoms, Lung function, HCHS/SOL

Word Count: 3,655

Online Data Supplement: This article has an online data supplement, which is accessible from this issue's table of content online at www.atsjournals.org

Abstract

Rationale: Dietary patterns may alter immune responses and increase asthma risk or affect lung function.

Objectives: To examine whether a pro-inflammatory diet (assessed by the energy-adjusted Dietary Inflammatory Index, (E-DII®) or high dietary quality (assessed by the Alternative Healthy Eating Index, AHEI-2010) are associated with current asthma, current asthma symptoms, and lung function in Hispanic adults.

Methods: Cross-sectional study of 12,687 adults aged 18 to 76 years who participated in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). The E-DII and AHEI-2010 were calculated based on two 24-hour dietary recalls. Logistic or linear regression was used for the multivariable analysis of E-DII or AHEI-2010 scores and current asthma, asthma symptoms, and lung function measures, adjusting for age, gender, annual household income, study center, Hispanic/Latino background, smoking status, and other covariates.

Results: A higher E-DII score was associated with current asthma (odds ratio [OR] for quartile 4 vs. 1=1.35, 95% confidence interval [CI]=0.97-1.90) and asthma symptoms (OR for quartile 4 vs. 1=1.42, 95% CI=1.12-1.81). The AHEI-2010 score was not associated with current asthma or asthma symptoms. Among adults without asthma, a higher E-DII score was associated with lower FEV₁ and FVC, and a higher AHEI-2010 score was associated with higher FEV₁ and FVC.

Conclusions: Our findings suggest that a pro-inflammatory diet increases the risk of asthma and asthma symptoms in Hispanic adults. An anti-inflammatory diet (indicated by a lower E-DII or a higher AHEI-2010 score) may positively influence lung function in Hispanic adults without asthma.

Asthma affects ~26 million people in the U.S.(1) The burden from asthma is more variable among Hispanic subgroups than across other broadly defined racial or ethnic groups (2). The prevalence of asthma (3-5) or asthma morbidity (6) is highest in Puerto Ricans and lowest in Mexican Americans or Central Americans (3, 7). Indeed, Puerto Ricans have the highest prevalence of physician-diagnosed asthma among adults in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) (8). Dietary patterns may partly explain this finding, as Puerto Ricans have lower dietary intake of fruits and vegetables than members of other Hispanic subgroups in HCHS/SOL (9).

An imbalanced diet could modulate allergic airway inflammation by affecting innate and adaptive immune responses (10, 11). Two evidence-based dietary indices, the Dietary Inflammatory Index (DII®) (12) and the Alternative Healthy Eating Index (AHEI)-2010 (13), can be used to study the health effects of dietary patterns, which can account for the combined effects of nutrients and vitamins. In a population-based study of U.S. residents, we previously showed that a higher DII score (indicating a pro-inflammatory diet) is associated with current wheeze in adults and atopic asthma in children (14). Consistent with dietary effects on airway diseases, a higher AHEI-2010 score (reflecting a better diet quality) has been associated with improved symptoms and better control in French adults with asthma (15) and with lower risk of chronic obstructive pulmonary disease (COPD) in U.S. adults (16).

To date, no study has examined the relation between dietary patterns and asthma or lung function among adults in well-defined Hispanic subgroups. We examined whether such dietary patterns are associated with asthma, asthma symptoms, and lung function among Hispanics in HCHS/SOL.

Methods

Subject Recruitment and Study Population

HCHS/SOL is a population-based cohort study of 16,415 adults aged 18 to 74 years who self-identified as having Hispanic/Latino background at screening visits of households in four U.S. field centers (Chicago, IL; Miami, FL; Bronx, NY; and San Diego, CA) (17). The goals of HCHS/SOL are to describe the prevalence of risk and protective factors for chronic conditions via a baseline examination (performed between 2008 and 2011) including questionnaire interview and physical examination (17), and a yearly telephone follow-up assessment. The sample design and cohort selection have been previously described (18). In brief, a stratified two-stage probability sample of household addresses was selected in each of the four centers to provide a representative sample of the target population. Based on census block groups, both stages oversampled strata that had a higher proportion of Hispanic residents, to increase the likelihood that a selected address yielded a Hispanic/Latino household. The study oversampled the 45-74 years age group (n=9714, 59.2%) to facilitate examination of target outcomes. This study was approved by the Institutional Review Boards at the data coordinating center (University of North Carolina) and at each center, and all participants gave written informed consent.

Dietary Assessment

Dietary patterns were assessed using two 24-hour dietary recalls. The first dietary recall was administered in-person at the time of the baseline interview. The second dietary recall was

mostly administered during a phone call (about 15% were administered in-person) and performed within 45 days of the baseline interview. Participants estimated portion sizes with the use of food models (in-person) or a food-amount booklet (for telephone interviews). Both 24-hour dietary recalls were conducted using the Nutrition Data System for Research (NDSR) software (version 11) developed by the Nutrition Coordinating Center (NCC) at the University of Minnesota, which employs the multiple pass method (details at <http://www.ncc.umn.edu/>). The NDSR contains over 18,000 foods, 8,000 brand name products, and many ethnic foods supplements and vitamins. The program provides values for 158 nutrients, nutrient ratios, and other food components. NDSR calculates nutrient intake and presents the data in several formats, including daily nutrient totals.

The dietary inflammatory index (DII®). The DII was first created to quantify the overall effects of diet on chronic inflammation. The development and validation of the DII have been previously described (12, 14, 19). In brief, peer-reviewed literature published between 1950 and 2010 was evaluated, and 1,943 articles linking inflammation to 45 individual food parameters (mostly micro- and macro-nutrients) were identified and scored. Points were assigned to each of these parameters according to whether they increased, decreased, or had no effect on six biomarkers of inflammation. Based on the study design and total number of research articles, an overall inflammatory effect score was calculated for each food parameter. The dietary data are first linked to a regionally representative world database, which contains standard means and deviations for the 45 food parameters from 11 populations around the world (12). The z scores are then converted to centered proportions which are then multiplied by food parameter-specific inflammation effect score to obtain food parameter-specific DII

scores. These are then summed to get the overall DII score. The DII thus reflects a robust literature base and standardization of individual intakes to global reference values.

Of the 45 DII food parameters, 29 were available in HCHS/SOL, as follows: carbohydrates; proteins; fiber; cholesterol; total, *trans*, saturated, monounsaturated (MUFA), and polyunsaturated fats (PUFAs); omega-3 and omega-6 PUFAs; niacin; vitamins A, B1, B2, B6, B12, C, D, and E; iron; magnesium; zinc; selenium; folic acid; β -carotene; caffeine; alcohol; and total energy. Higher (i.e. more positive) scores indicate a more pro-inflammatory diet, and more negative scores indicate a more anti-inflammatory diet. To control for total energy intake, the energy-adjusted DII (E-DII) score was calculated per 1,000 calories of food consumed (using a calorie-adjusted version of the global database for comparison). The mean of two E-DII scores calculated separately from the two dietary recalls was used for the analysis. A separate E-DII score accounting for 24-hour dietary supplements was also calculated.

Alternative Healthy Eating Index (AHEI-2010). The AHEI was created in 2002 and updated in 2010, as an alternative to the Healthy Eating Index (HEI) that assesses the degree to which participants adhere to U.S. Dietary Guidelines. It was based on a comprehensive review of the relevant literature to include foods and nutrients predictive of chronic diseases, including cardiovascular disease, diabetes, and cancer(13). In HCHS/SOL, the AHEI-2010 was calculated using data from two 24-hour dietary recalls, as previously described (20). The AHEI-2010 is derived using the following 11 components: vegetables without potatoes, whole fruit (not including fruit juice), whole grains, sugar sweetened beverages and fruit juices, nuts and legumes, red/processed meats, *trans*-fats, long-chain (omega-3) fat, PUFA, sodium, and alcohol. Each component was created by adding the corresponding NDSR food subgroups. Predicted

usual intake amounts for each component were then estimated using the National Cancer Institute method (21). The AHEI-2010 score is the sum of the 11 individual components' scores, each with a range from 0 (worst) and 10 (best). Hence, AHEI-2010 takes values from 0 to 110: higher scores represent healthy eating habits (higher intake of vegetables, whole fruit, whole grains, polyunsaturated fatty acids, nuts, and long chain omega-3 fats and lower intake of red/processed meats, *trans* fat, refined grains, and sugar sweetened drinks), and lower scores represent unhealthy eating habits.

Outcomes

Current asthma was defined by a positive answer to all following questions: "Have you ever had asthma?"; "Was it diagnosed by a doctor or other health care professional?"; and "Do you still have it?". For the analysis of current asthma, controls were those responding "No" to any of these questions. Current asthma symptoms were independent of a physician's diagnosis of asthma and were defined by a positive answer to either of these questions: "In the last 12 months, have you had wheezing or whistling in your chest at any time?" or "In the last 12 months, have you been awakened from sleep either by coughing (apart from a cough associated with a cold or chest infection) or by shortness of breath or a feeling of tightness in your chest?". For the analysis of current asthma symptoms, controls were those answering "No" to both questions. Atopy was defined by a positive answer to any of the following questions: "When you are near animals (such as cats, dogs, or horses) or near feathers (including pillows, quilts or comforters) or in a dusty or moldy part of the house, do you ever get a runny or stuffy nose or start to sneeze, or get itching or watering eyes?", "When you are

near trees, grass, or flowers, or when there is a lot of pollen in the air, do you ever get a runny or stuffy nose or start to sneeze, or get itching or watering eyes?”, and “Have you ever had hay fever (allergy involving the nose and/or eyes)?”.

Pulmonary function testing was performed according to American Thoracic Society recommendations (22). Standard digitized spirometric measurements of timed pulmonary function, forced expiratory volume in 1 second (FEV₁), forced vital capacity (FVC), and their ratio (FEV₁/FVC) were obtained using the SensorMedics model 1022 dry-rolling seal volume spirometer (SensorMedics/Viasys, Yorba Linda, CA). Percent predicted values for lung function measures were calculated based on spirometry reference equations from HCHS/SOL (23).

Statistical Analysis

Because of the complex design of HCHS/SOL, sampling weights, stratification, and clusters provided in the HCHS/SOL dataset were incorporated into the analysis, to obtain proper estimates and their standard errors. Two-sided Wald chi-square tests and t-tests were used for bivariate analyses of binary and continuous variables, respectively. ANOVA was used to compare mean E-DII or AHEI-2010 score across Hispanic/Latino subgroups. Logistic and linear regression were used for the multivariable analysis of the E-DII or AHEI-2010 scores and the outcomes of interest (current asthma, current asthma symptoms, and lung function), which was adjusted for known or potential confounders. All multivariable models were adjusted for age, gender, Hispanic/Latino background (Cuban, Mexican, Puerto Rican, and others [including Dominicans, Central Americans, South Americans, other Hispanics, and those with more than one heritage- these subgroups had small sample size and similar effect estimates on bivariate

analyses, and were thus grouped together]], study center, annual household income, body mass index (BMI), level of total physical activity (low, moderate, and high, based on the global physical activity questionnaire [GPAQ]

http://www.who.int/chp/steps/resources/GPAQ_Analysis_Guide.pdf), family history of asthma, place of birth (born in the U.S. or a U.S. territory), smoking status (never, former, current), and pack-years of cigarette smoking. Given the number of covariates, we assessed multicollinearity by examining the variance inflation factor and tolerance, which were <5 and >0.1 , respectively, in all models. Model fitness was assessed using standard approaches.

All statistical analyses were conducted using the SAS® SURVEY procedure and SAS® 9.4 software (SAS Institute Inc., Cary, NC).

Results

Of the 16,415 HCHS/SOL participants, 16,289 and 15,424 had data for the 1st and 2nd dietary recall, respectively. We excluded unreliable dietary recalls (according to the interviewer) and extreme observed daily energy intake (defined as below sex-specific 1st percentile or above the 99th percentile). Of the 14,160 participants with both valid dietary recalls, 1,473 individuals were further excluded due to lack information on asthma or key covariates. Thus, 12,687 subjects were included in the current analysis (Figure E1).

The overall prevalence of current asthma in the 12,687 study participants was 6.8%. The weighted distribution of the characteristics of these participants are shown in Table 1.

Compared to subjects without current asthma, those with current asthma were more likely to

be older, female, Puerto Rican, current smokers, atopic, recruited at the Bronx study center, and covered by health insurance, and more likely to have: a family history of asthma, higher annual household income, BMI, and pack-years of smoking, but less physical activity and lower lung function. The E-DII was significantly higher and the AHEI-2010 was significantly lower in subjects with current asthma than in those without current asthma. We found a moderate correlation between the E-DII and AHEI-2010 scores in subjects with (coefficient correlation, $r = -0.58$, $P < 0.01$) and without ($r = -0.53$, $P < 0.01$) asthma (Figure 1). The distribution of mean E-DII and AHEI-2010 scores in each Hispanic/Latino subgroup is shown in Figure 2. Participants of Puerto Rican descent had significantly higher mean E-DII ($P < 0.01$) and lower mean AHEI-2010 ($P < 0.01$) than participants in other Hispanic/Latino subgroups.

Table 2 present the results of the multivariable analysis of E-DII or AHEI-2010 scores (as quartiles) and current asthma and asthma symptoms. In this analysis, subjects whose E-DII score was in the second to fourth quartiles had significantly higher odds of current asthma symptoms than those whose E-DII score was in the first quartile (e.g., odds ratio [OR] for quartile 4 vs. 1=1.42, 95% CI=1.12-1.81, P for trend < 0.01). Similarly, subjects whose E-DII score was in the third and fourth quartiles had increased odds of current asthma (with P for linear trend < 0.05). In this analysis, subjects of Mexican, Dominican, Central American, and South American heritage or who had more than one heritage had lower odds of current asthma than Cubans (e.g., OR for Mexicans vs. Cubans=0.49, 95% CI=0.28-0.86). In contrast, Puerto Ricans had higher odds of current asthma than Cubans (OR=1.72, 95% CI=1.01-2.92). Similar results were found in multivariable models including the E-DII or AHEI-2010 as continuous variables (Table E1). Our findings for E-DII scores and asthma or asthma symptoms were unchanged

when we used an E-DII version that accounted for 24-hour intake of dietary supplements (Table E2).

In a multivariable analysis adjusting for Hispanic/Latino background and other covariates, AHEI-2010 scores were not significantly associated with current asthma or asthma symptoms. We found no significant modification of the estimated effects of E-DII or AHEI-2010 scores on current asthma or asthma symptoms by age, gender, BMI, or Hispanic/Latino subgroup.

To assess potential misclassification of COPD as asthma, we repeated the multivariable analysis of current asthma and asthma symptoms after stratification by smoking status. In this analysis, E-DII scores remained associated with current asthma (P for linear trend < 0.05 , Table 3) and asthma symptoms (Table E3) among never and former smokers. Among never and former smokers, Mexicans and others (including Dominicans, Central and South Americans, and those with more than one heritage) had lower odds of current asthma than Cubans. In the multivariable analysis among current smokers, E-DII scores were not significantly associated with current asthma or asthma symptoms (Table 3 and Supplemental Table 1). Among current smokers, Puerto Ricans had significant higher odds of current asthma than Cubans (Table 3). AHEI-2010 scores were not significantly associated with current asthma or asthma symptoms among study participants, regardless of smoking status.

In an exploratory analysis, we examined individual components of the AHEI-2010 score and current asthma or asthma symptoms. In this analysis, each one-point increment in the score for whole grains was significantly associated with 10% decreased odds of current asthma,

while each one-point increment in the score for % *Trans* fats from energy or sodium was associated with 3%-18% decreased odds of current asthma symptoms (Table E4).

Table 4 shows the results of the multivariable analysis of E-DII or AHEI-2010 scores (as ordinal variables, in quartiles) and lung function, which was stratified by current asthma on the basis of findings from previous studies. Among subjects without current asthma, each quartile increment in the E-DII score was significantly associated with 0.71% to 0.58% decrements in % predicted FEV₁ ($\beta = -0.71$, 95% CI= -1.02, -0.41) and % predicted FVC ($\beta = -0.58$, 95% CI= -0.88, -0.29). In contrast, each quartile increment in the AHEI-2010 score was significantly associated with 0.77% to 0.55% increments in % predicted FEV₁ ($\beta = 0.77$, 95% CI= 0.40, 1.14) and % predicted FVC ($\beta = 0.55$, 95% CI= 0.17, 0.92). In subjects with current asthma, neither E-DII scores nor AHEI-2010 scores were significantly associated with lung function measures.

Discussion

To our knowledge, this is the first population-based study of dietary patterns and asthma or lung function among adults in well-defined Hispanic/Latino subgroups. We found that a higher E-DII score -but not the AHEI-2010 score- was associated with current asthma and asthma symptoms. Among adults without asthma, a higher E-DII score was associated with lower FEV₁ and FVC, while a higher AHEI-2010 score was associated with higher FEV₁ and FVC. Thus, the E-DII and AHEI-2010 yielded consistent results for lung function -but not for asthma- among Hispanics in HCHS/SOL.

The DII or E-DII have been positively correlated with inflammatory biomarkers such as CRP (19), interleukin (IL)-6 (24, 25), and tumor necrosis factor alpha (TNF- α) (25). Consistent with our findings, a case-control study of 160 Australian adults reported that a higher DII was associated with asthma, lower FEV₁, and higher serum IL-6 (24). On the other hand, a cross-sectional study of 22,294 U.S. adults found that a higher DII score was associated with current wheeze but not with current asthma (14). As in the current study, that prior study found that the DII was associated with lower FEV₁ and FVC in adults without current wheeze or asthma (14), but not in those with current wheeze or asthma. The negative results for lung function among subjects with asthma in that study and in this report may be due to reduced statistical power due to small sample size, or to reduced effects of diet on lung function in subjects with asthma and airway inflammation.

A higher DII generally reflects higher intake of saturated and trans fats, and a high-fat diet has been shown to modify the gut microbiome, leading to an increased proportion of invasive bacteria and decreased concentration of short-chain fatty acids (SCFAs), which could alter immune responses and lead to asthma (26, 27). A high-fat and high refined-carbohydrate diet also leads to excess energy intake, and ultimately obesity, which has been associated with asthma and lower lung function (28). On the other hand, nutrients that contribute to a lower DII (i.e. beta-carotene, riboflavin, vitamin C, and fiber) are mainly derived from fruits and vegetables, and a higher intake of fruits and vegetables has been linked to lower risk of asthma and allergies, perhaps through down-regulation of Th2 immune responses and antioxidant effects (29). Moreover, high-fiber intake can affect the gut microbiome and has been associated with lower risk of allergic diseases (30, 31).

The AHEI-2010, a measure of diet quality based on foods and nutrients predictive of chronic disease risk (13), has been inversely associated with CRP (32) and IL-6 levels (33). Consistent with our negative results for the AHEI-2010 and asthma, the U.S.-based Nurses' Health Study showed that high AHEI-2010 scores were associated with decreased risk of COPD but not with adult-onset asthma (16). In contrast to our negative results for the AHEI-2010 and asthma symptoms, two reported that a higher AHEI-2010 score was associated with improved symptoms and better disease control in adults with asthma (15, 34). One of those studies also showed an inverse association between the AHEI-2010 and asthma symptoms or control in never smokers, but not in former or current smokers (which may be due to greater difficulty in detecting dietary effects on asthma in current smokers at risk of COPD (34)).

Among the components included in the AHEI-2010, higher intake of whole grains and lower intake of % *Trans* fat from energy or sodium were associated with lower odds of asthma or asthma symptoms in HCHS/SOL. This is consistent with our previous findings in Puerto Rican children, in whom frequent consumption of vegetables and grains, along with less frequent consumption of dairy products and sweets or snacks, was associated with lower risk of asthma in all subjects, as well as with higher FEV₁ and FVC in subjects without asthma (35, 36). In further support of a protective role of a "healthy diet" against asthma, a pilot trial of 90 adults with persistent asthma reported that a six-month healthy eating intervention based on Dietary Approaches to Stop Hypertension (DASH) recommendations (emphasizing intake of vegetables, fruits and whole grains, while limiting intake of saturated fats and sugar-sweetened beverages) was associated with improved asthma control (37).

We found a moderate correlation between the E-DII and AHEI-2010 scores, and both indices were associated with lung function in subjects without asthma. However, only the E-DII was associated with asthma or asthma symptoms, and may thus be a better indicator of dietary patterns leading to airway inflammation than the AHEI-2010. Of interest, adjustment for either the E-DII or the AHEI-2010 in multivariable models had little impact on the positive association between Puerto Rican ethnicity and asthma or the inverse association between Mexican ethnicity and current asthma. This suggests that risk or protective factors other than diet (e.g., psychosocial stressors, access to and quality of healthcare, and racial ancestry)(2) explain this “Hispanic paradox” for asthma.

We recognize several study limitations. First, we cannot examine temporal relationships between dietary indices and asthma or lung function in a cross-sectional analysis. Second, 24-hour dietary recalls may not reflect day-to-day or seasonal variability in dietary patterns. However, we obtained similar results in multivariable analyses with additional adjustment for the season in which 24-h dietary recalls were obtained (Table E5). Moreover, both the DII (38) and AHEI (39) are relatively consistent over calendar seasons. Third, data were lacking on a few parameters (i.e., flavones, anthocyanidins) in the dietary recalls and could not be included in the E-DII calculations. Whether the 29 parameters included in this analysis fully capture variation in dietary inflammatory patterns warrants further investigation. Fourth, our analysis was adjusted for only one indicator of socioeconomic status (annual household income), as we could not include both income and health insurance in the same multivariable models due to collinearity. However, we obtained similar results in multivariable models adjusting for health insurance coverage instead of annual income (Table E6). Lastly, we had no data on some

potential confounders or modifiers of the relation between diet and asthma, including objective measures of atopy (i.e., skin test reactivity to allergens), or outdoor air pollution. Finally, we lack statistical power to conduct analyses stratified by Hispanic or Latino subgroup.

In summary, our findings for the E-DII suggest that a pro-inflammatory diet increases the risk of asthma and asthma symptoms in Hispanic adults. Moreover, our results for the E-DII and the AHEI-2010 suggest that healthy dietary patterns positively influence lung function in Hispanic adults without asthma.

Acknowledgements

The authors thank the staff and participants of HCHS/SOL for their important contributions.

Table 1. Main characteristics of study participants, by current asthma

Characteristics	No current asthma n=11,725	Current asthma n=962
Age (years)	41.4 ± 0.3	43.6 ± 0.8
Female gender	6911 (51.0)	727 (66.7)
Hispanic/Latino background		
Dominican	982 (9.1)	92 (9.4)
Central American	1278 (7.5)	53 (3.9)
Cuban	1662 (20.0)	128 (19.1)
Mexican	5048 (41.2)	184 (16.4)
Puerto Rican	1570 (12.8)	442 (44.9)
South American	875 (5.6)	29 (2.7)
Other or more than one heritage	321 (3.8)	34 (3.5)
Study Center		
Bronx, NY	2430 (24.4)	451 (50.3)
Chicago, IL	3229 (17.6)	210 (13.6)
Miami, FL	2945 (29.6)	172 (24.5)
San Diego, CA	3121 (28.3)	129 (11.6)
Educational attainment		
No high school diploma or GED	4223 (30.0)	377 (32.7)
At most a high school diploma or GED	3045 (28.5)	342 (27.2)
Greater than high school (or GED) education	4443 (41.5)	343 (40.1)
Have health insurance coverage	5605 (48.2)	702 (72.0)
Annual household income < \$30,000	7857 (64.0)	742 (73.7)
Family history of asthma	2124 (19.9)	458 (49.6)
Atopy	4590 (38.1)	763 (78.2)
Body mass index (kg/m ²)	29.2 ± 0.1	32.5 ± 0.3
Physical Activity		
Low	5139 (40.7)	464 (45.8)
Moderate	5285 (45.3)	417 (44.4)
High	1301 (14.0)	81 (9.8)
Smoking status		
Never	7439 (63.9)	529 (54.0)
Former	2270 (17.0)	192 (22.2)
Current	2016 (19.1)	241 (23.8)
Cigarette pack-years	4.8 ± 0.2	7.5 ± 0.8
Born in 50 US States/DC	1797 (20.3)	301 (35.4)
Energy-adjusted Dietary inflammatory index (E-DII)	0.23 ± 0.03	0.67 ± 0.08
Alternative healthy eating index 2010 (AHEI-2010)	48.1 ± 0.2	44.5 ± 0.4
%predicted FEV ₁ *	95.3 ± 0.2	81.0 ± 1.5

%predicted FVC*	96.0 ± 0.2	87.7 ± 1.1
%predicted FEV ₁ /FVC*	99.1 ± 0.1	91.5 ± 1.1

Results are shown as mean ± standard error (SE) for continuous variables, and as N (%) for binary variables.

*n=11,817

Table 2. Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma and current asthma symptoms

	Current asthma (n=962)	Current asthma symptoms (n=2,085)
Predictors	Odds Ratio (95% confidence interval)	
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.08 (0.76, 1.52)	1.32 (1.03, 1.69)
Quartile 3	1.33 (0.97, 1.82)	1.37 (1.10, 1.71)
Quartile 4	1.35 (0.97, 1.90)*	1.42 (1.12, 1.81)*
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.28, 0.86)	0.74 (0.51, 1.08)
Puerto Rican	1.72 (1.01, 2.92)	1.02 (0.74, 1.43)
Others	0.61 (0.40, 0.92)	0.90 (0.68, 1.19)
AHEI-2010		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.11 (0.84, 1.48)	0.96 (0.75, 1.23)
Quartile 3	0.90 (0.64, 1.28)	0.85 (0.62, 1.16)
Quartile 4	0.94 (0.61, 1.43)	0.88 (0.63, 1.21)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.27, 0.89)	0.76 (0.52, 1.11)
Puerto Rican	1.74 (1.02, 2.94)	1.02 (0.72, 1.42)
Others	0.61 (0.40, 0.92)	0.91 (0.68, 1.21)

All models adjusted for adjusted for age, gender, study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, and pack-years of cigarette smoking.

Effect estimates (odds ratios) with $P < 0.05$ are shown in bold typeface

* P for trend <0.05

Table 3. Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma, stratified by smoking status

Predictors	Current asthma	
	Never/former smokers (n=10,430)	Current smokers (n=2,257)
Odds (95% confidence interval)		
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	0.98 (0.67, 1.46)	1.35 (0.69, 2.64)
Quartile 3	1.37 (0.94, 1.99)	1.13 (0.58, 2.18)
Quartile 4	1.40 (0.92, 2.14)*	1.18 (0.63, 2.21)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.51 (0.28, 0.93)	0.50 (0.19, 1.31)
Puerto Rican	1.47 (0.84, 2.57)	3.51 (1.38, 8.93)
Other or more than one heritage	0.54 (0.35, 0.84)	1.20 (0.54, 2.64)
AHEI-2010		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.02 (0.70, 1.49)	1.44 (0.87, 2.37)
Quartile 3	0.89 (0.57, 1.39)	0.87 (0.44, 1.70)
Quartile 4	0.91 (0.55, 1.52)	1.09 (0.37, 3.22)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.51 (0.27, 0.97)	0.53 (0.19, 1.52)
Puerto Rican	1.48 (0.85, 2.58)	3.73 (1.44, 9.63)
Other or more than one heritage	0.54 (0.35, 0.85)	1.19 (0.53, 2.69)

All models adjusted for adjusted for age, gender, Hispanic/Latino background, study center, health insurance coverage, body mass index, physical activity, family history of asthma, place of birth, and pack-years of cigarette smoking.

Effect estimates (odds ratios) with P < 0.05 are shown in bold typeface

*P for trend <0.05

Table 4. Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) scores^a and lung function measures

	E-DII	AHEI-2010
Lung function measures	β (95% confidence interval) ^a	
All Participants (n=11,817)		
%predicted FEV ₁	-0.75 (-1.07, -0.42)	0.76 (0.31, 1.20)
%predicted FVC	-0.58 (-0.87, -0.29)	0.55 (0.16, 0.94)
%predicted FEV ₁ /FVC	-0.18 (-0.42, 0.06)	0.23 (-0.05, 0.51)
Participants without asthma (n=10,948)		
%predicted FEV ₁	-0.71 (-1.02, -0.41)	0.77 (0.40, 1.14)
%predicted FVC	-0.58 (-0.88, -0.29)	0.55 (0.17, 0.92)
%predicted FEV ₁ /FVC	-0.11 (-0.30, 0.08)	0.21 (-0.01, 0.43)
Participants with asthma (n=869)		
%predicted pre-bronchodilator FEV ₁	-0.80 (-2.73, 1.14)	-0.24 (-2.52, 2.05)
%predicted pre-bronchodilator FVC	-0.12 (-1.52, 1.29)	-0.43 (-2.00, 1.15)
%predicted pre-bronchodilator FEV ₁ /FVC	-1.05 (-2.53, 0.44)	0.56 (-1.26, 2.37)

All models adjusted for study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, pack-years of cigarette smoking, and (in all participants) current asthma.

β indicates the estimated effect of a one-quartile increment in the DII or the AHEI-2010 on the corresponding lung function measure. β s with $P < 0.05$ in bold typeface

Figure Legends

Figure 1. Correlation between the energy-adjusted Dietary Inflammatory Index (E-DII) and the Alternative Healthy Eating Index 2010 (AHEI-2010), by current asthma.

Figure 2. Distribution of Energy-adjusted Dietary Inflammatory Index (E-DII, upper panel) and Alternative Healthy Eating Index 2010 (AHEI-2010, lower panel) scores by Hispanic/Latino subgroup

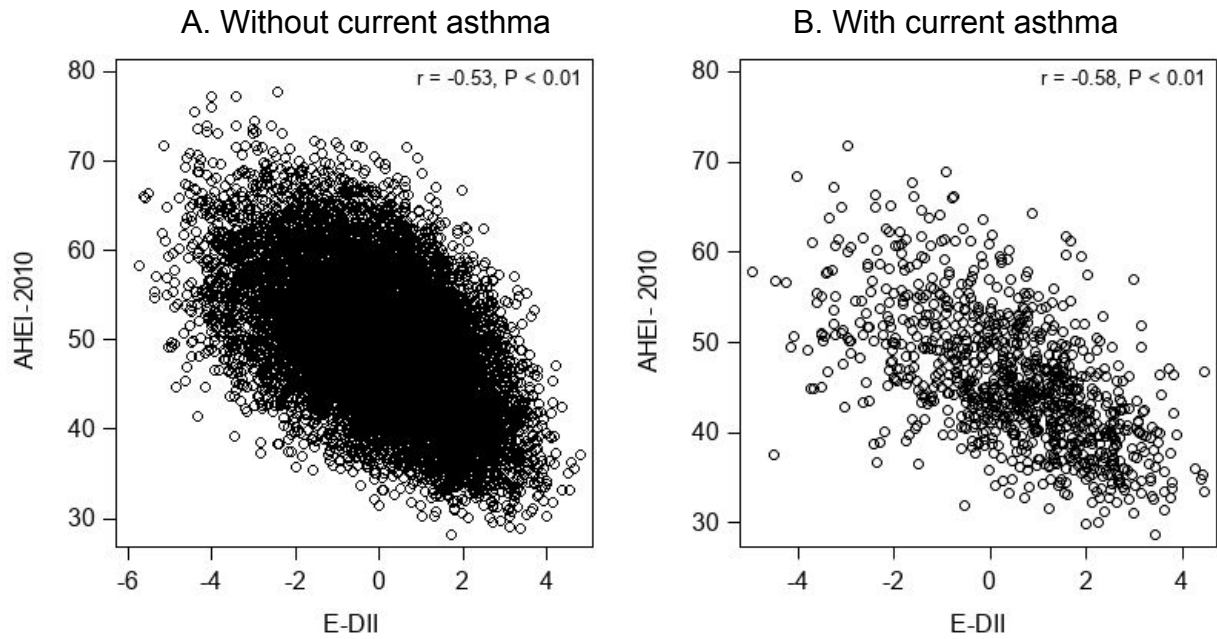
References

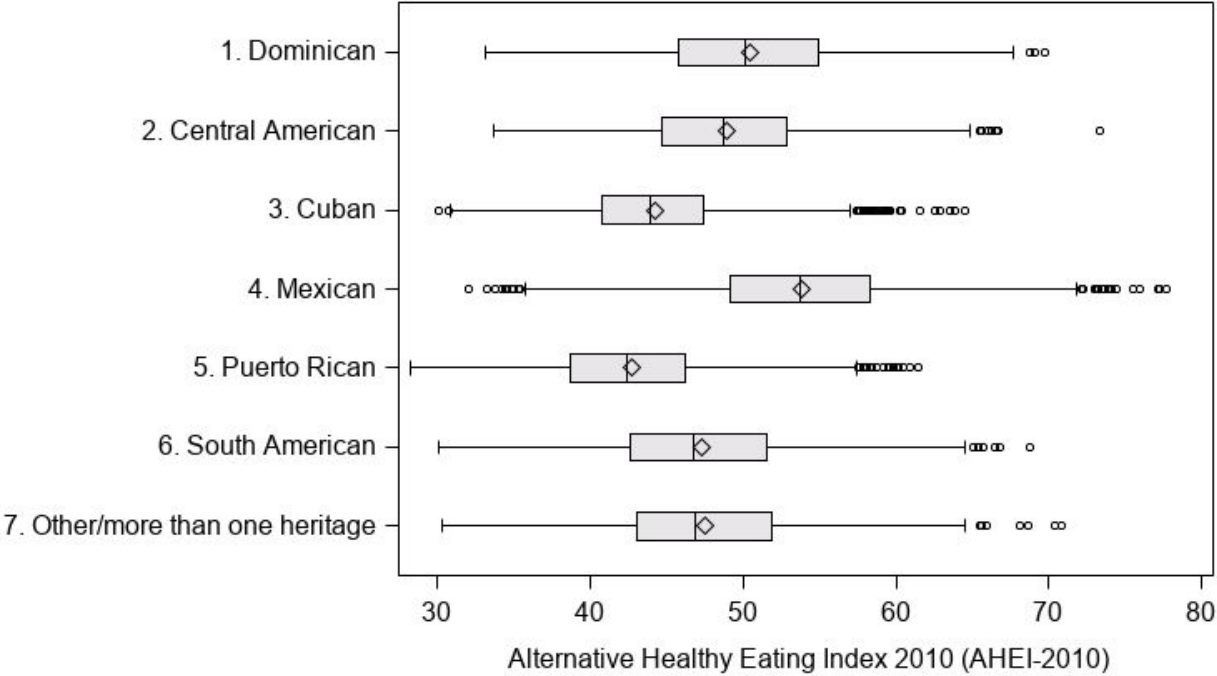
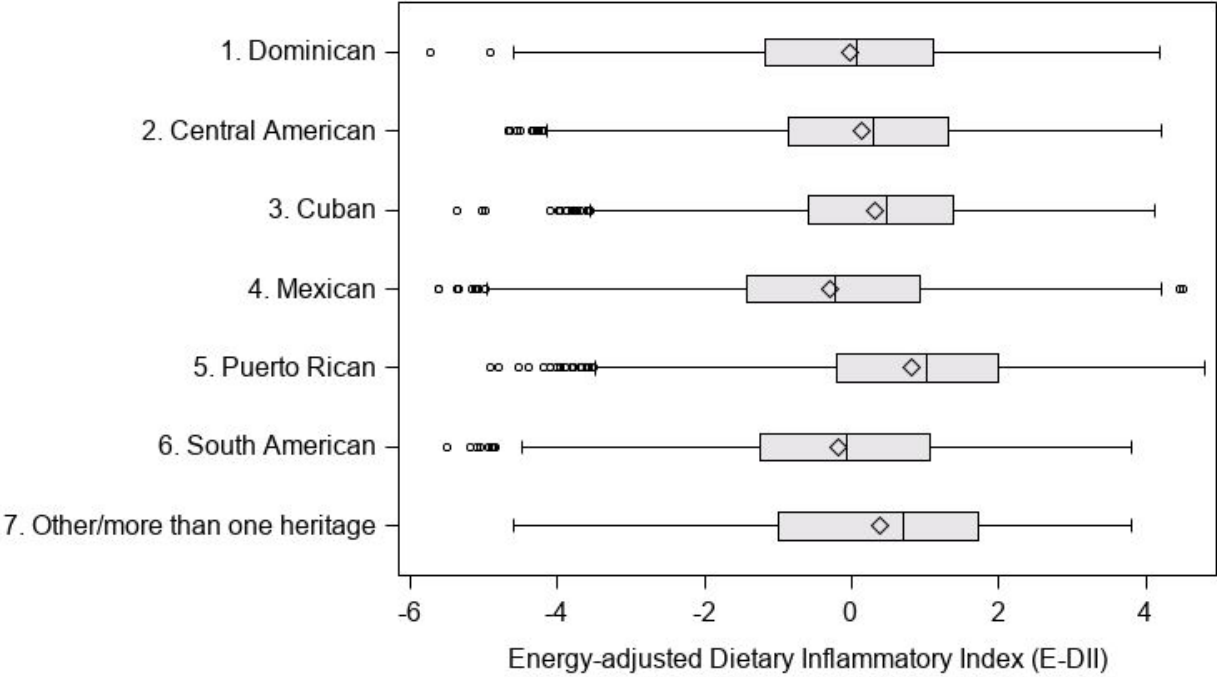
1. Centers for Disease Control and Prevention. Summary Health Statistics: National Health Interview Survey, 2017. In: U.S. Department of Health and Human Services, editor. Atlanta, GA 2017.
2. Rosser FJ, Forno E, Cooper PJ, Celedon JC. Asthma in Hispanics. An 8-year update. *Am J Respir Crit Care Med* 2014; 189: 1316-1327.
3. Leong AB, Ramsey CD, Celedon JC. The challenge of asthma in minority populations. *Clin Rev Allergy Immunol* 2012; 43: 156-183.
4. Subramanian SV, Jun HJ, Kawachi I, Wright RJ. Contribution of race/ethnicity and country of origin to variations in lifetime reported asthma: evidence for a nativity advantage. *Am J Public Health* 2009; 99: 690-697.
5. Moorman JE, Zahran H, Truman BI, Molla MT, Centers for Disease C, Prevention. Current asthma prevalence - United States, 2006-2008. *MMWR Suppl* 2011; 60: 84-86.
6. Dumanovsky T, Matte TD. Variation in adult asthma prevalence in Hispanic subpopulations in New York City. *J Asthma* 2007; 44: 297-303.
7. Lara M, Akinbami L, Flores G, Morgenstern H. Heterogeneity of childhood asthma among Hispanic children: Puerto Rican children bear a disproportionate burden. *Pediatrics* 2006; 117: 43-53.
8. Barr RG, Aviles-Santa L, Davis SM, Aldrich TK, Gonzalez F, 2nd, Henderson AG, Kaplan RC, LaVange L, Liu K, Loreda JS, Mendes ES, Ni A, Ries A, Salathe M, Smith LJ. Pulmonary Disease and Age at Immigration among Hispanics. Results from the Hispanic Community Health Study/Study of Latinos. *Am J Respir Crit Care Med* 2016; 193: 386-395.
9. Siega-Riz AM, Sotres-Alvarez D, Ayala GX, Ginsberg M, Himes JH, Liu K, Loria CM, Mossavar-Rahmani Y, Rock CL, Rodriguez B, Gellman MD, Van Horn L. Food-group and nutrient-density intakes by Hispanic and Latino backgrounds in the Hispanic Community Health Study/Study of Latinos. *Am J Clin Nutr* 2014; 99: 1487-1498.
10. Julia V, Macia L, Dombrowicz D. The impact of diet on asthma and allergic diseases. *Nat Rev Immunol* 2015; 15: 308-322.
11. Han YY, Forno E, Holguin F, Celedon JC. Diet and asthma: an update. *Curr Opin Allergy Clin Immunol* 2015; 15: 369-374.
12. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hebert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutr* 2014; 17: 1689-1696.
13. Chiuve SE, Fung TT, Rimm EB, Hu FB, McCullough ML, Wang M, Stampfer MJ, Willett WC. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr* 2012; 142: 1009-1018.

14. Han YY, Forno E, Shivappa N, Wirth MD, Hebert JR, Celedon JC. The Dietary Inflammatory Index and Current Wheeze Among Children and Adults in the United States. *J Allergy Clin Immunol Pract* 2018; 6: 834-841 e832.
15. Andrianasolo RM, Kesse-Guyot E, Adjibade M, Hercberg S, Galan P, Varraso R. Associations between dietary scores with asthma symptoms and asthma control in adults. *Eur Respir J* 2018; 52.
16. Varraso R, Chiuve SE, Fung TT, Barr RG, Hu FB, Willett WC, Camargo CA. Alternate Healthy Eating Index 2010 and risk of chronic obstructive pulmonary disease among US women and men: prospective study. *BMJ* 2015; 350: h286.
17. Sorlie PD, Aviles-Santa LM, Wassertheil-Smoller S, Kaplan RC, Daviglius ML, Giachello AL, Schneiderman N, Raij L, Talavera G, Allison M, Lavange L, Chambless LE, Heiss G. Design and implementation of the Hispanic Community Health Study/Study of Latinos. *Ann Epidemiol* 2010; 20: 629-641.
18. Lavange LM, Kalsbeek WD, Sorlie PD, Aviles-Santa LM, Kaplan RC, Barnhart J, Liu K, Giachello A, Lee DJ, Ryan J, Criqui MH, Elder JP. Sample design and cohort selection in the Hispanic Community Health Study/Study of Latinos. *Ann Epidemiol* 2010; 20: 642-649.
19. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, Tabung F, Hebert JR. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). *Public Health Nutr* 2014; 17: 1825-1833.
20. Mattei J, Sotres-Alvarez D, Daviglius ML, Gallo LC, Gellman M, Hu FB, Tucker KL, Willett WC, Siega-Riz AM, Van Horn L, Kaplan RC. Diet Quality and Its Association with Cardiometabolic Risk Factors Vary by Hispanic and Latino Ethnic Background in the Hispanic Community Health Study/Study of Latinos. *J Nutr* 2016; 146: 2035-2044.
21. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: the NCI method. *Stat Med* 2010; 29: 2857-2868.
22. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, van der Grinten CP, Gustafsson P, Jensen R, Johnson DC, MacIntyre N, McKay R, Navajas D, Pedersen OF, Pellegrino R, Viegi G, Wanger J, Force AET. Standardisation of spirometry. *Eur Respir J* 2005; 26: 319-338.
23. LaVange L, Davis SM, Hankinson J, Enright P, Wilson R, Barr RG, Aldrich TK, Kalhan R, Lemus H, Ni A, Smith LJ, Talavera GA. Spirometry Reference Equations from the HCHS/SOL (Hispanic Community Health Study/Study of Latinos). *Am J Respir Crit Care Med* 2017; 196: 993-1003.
24. Wood LG, Shivappa N, Berthon BS, Gibson PG, Hebert JR. Dietary inflammatory index is related to asthma risk, lung function and systemic inflammation in asthma. *Clin Exp Allergy* 2015; 45: 177-183.

25. Tabung FK, Steck SE, Zhang J, Ma Y, Liese AD, Agalliu I, Hingle M, Hou L, Hurley TG, Jiao L, Martin LW, Millen AE, Park HL, Rosal MC, Shikany JM, Shivappa N, Ockene JK, Hebert JR. Construct validation of the dietary inflammatory index among postmenopausal women. *Ann Epidemiol* 2015; 25: 398-405.
26. Shore SA, Cho Y. Obesity and Asthma: Microbiome-Metabolome Interactions. *Am J Respir Cell Mol Biol* 2016; 54: 609-617.
27. Budden KF, Gellatly SL, Wood DL, Cooper MA, Morrison M, Hugenholtz P, Hansbro PM. Emerging pathogenic links between microbiota and the gut-lung axis. *Nat Rev Microbiol* 2017; 15: 55-63.
28. Wood LG. Diet, Obesity, and Asthma. *Ann Am Thorac Soc* 2017; 14: S332-S338.
29. Han YY, Blatter J, Brehm JM, Forno E, Litonjua AA, Celedon JC. Diet and asthma: vitamins and methyl donors. *Lancet Respir Med* 2013; 1: 813-822.
30. McAleer JP, Kolls JK. Contributions of the intestinal microbiome in lung immunity. *Eur J Immunol* 2018; 48: 39-49.
31. Trompette A, Gollwitzer ES, Yadava K, Sichelstiel AK, Sprenger N, Ngom-Bru C, Blanchard C, Junt T, Nicod LP, Harris NL, Marsland BJ. Gut microbiota metabolism of dietary fiber influences allergic airway disease and hematopoiesis. *Nat Med* 2014; 20: 159-166.
32. Fagnoli JL, Fung TT, Olenczuk DM, Chamberland JP, Hu FB, Mantzoros CS. Adherence to healthy eating patterns is associated with higher circulating total and high-molecular-weight adiponectin and lower resistin concentrations in women from the Nurses' Health Study. *Am J Clin Nutr* 2008; 88: 1213-1224.
33. Akbaraly TN, Shipley MJ, Ferrie JE, Virtanen M, Lowe G, Hamer M, Kivimaki M. Long-term adherence to healthy dietary guidelines and chronic inflammation in the prospective Whitehall II study. *Am J Med* 2015; 128: 152-160 e154.
34. Li Z, Kesse-Guyot E, Dumas O, Garcia-Aymerich J, Leynaert B, Pison C, Le Moual N, Romieu I, Siroux V, Camargo CA, Nadif R, Varraso R. Longitudinal study of diet quality and change in asthma symptoms in adults, according to smoking status. *Br J Nutr* 2017; 117: 562-571.
35. Han YY, Forno E, Brehm JM, Acosta-Perez E, Alvarez M, Colon-Semidey A, Rivera-Soto W, Campos H, Litonjua AA, Alcorn JF, Canino G, Celedon JC. Diet, interleukin-17, and childhood asthma in Puerto Ricans. *Ann Allergy Asthma Immunol* 2015; 115: 288-293 e281.
36. Han YY, Forno E, Alvarez M, Colon-Semidey A, Acosta-Perez E, Canino G, Celedon JC. Diet, Lung Function, and Asthma Exacerbations in Puerto Rican Children. *Pediatr Allergy Immunol Pulmonol* 2017; 30: 202-209.
37. Ma J, Strub P, Lv N, Xiao L, Camargo CA, Jr., Buist AS, Lavori PW, Wilson SR, Nadeau KC, Rosas LG. Pilot randomised trial of a healthy eating behavioural intervention in uncontrolled asthma. *Eur Respir J* 2016; 47: 122-132.

38. Tabung FK, Steck SE, Zhang J, Ma Y, Liese AD, Tylavsky FA, Vitolins MZ, Ockene JK, Hebert JR. Longitudinal changes in the dietary inflammatory index: an assessment of the inflammatory potential of diet over time in postmenopausal women. *Eur J Clin Nutr* 2016; 70: 1374-1380.
39. Jahns L, Johnson LK, Scheett AJ, Stote KS, Raatz SK, Subar AF, Tande D. Measures of Diet Quality across Calendar and Winter Holiday Seasons among Midlife Women: A 1-Year Longitudinal Study Using the Automated Self-Administered 24-Hour Recall. *J Acad Nutr Diet* 2016; 116: 1961-1969.





Online Data Supplement

Dietary patterns, asthma, and lung function in the Hispanic Community Health Study / Study of Latinos (HCHS/SOL)

Yueh-Ying Han, PhD¹, Elina Jerschow, MD², Erick Forno, MD, MPH¹, Simin Hua, MHS³, Yasmin Mossavar-Rahmani, PhD³, Krista M. Perreira, PhD⁴, Daniela Sotres-Alvarez⁵, Majid Afshar, MD, MS⁶, Naresh M. Punjabi, MD, PhD⁷, Bharat Thyagarajan, MD, PhD⁸, Nitin Shivappa, PhD^{9,10,11}, James R. Hébert, ScD^{9,10,11}, Robert C. Kaplan, PhD³, Juan C. Celedón, MD, DrPH, ATSF¹

¹ Division of Pediatric Pulmonary Medicine, UPMC Children's Hospital of Pittsburgh, University of Pittsburgh, Pittsburgh, Pennsylvania

² Department of Medicine, Albert Einstein College of Medicine, Bronx, New York

³ Department of Epidemiology & Population Health, Albert Einstein College of Medicine, Bronx, New York

⁴ Department of Social Medicine, University of North Carolina School of Medicine

⁵ Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina

⁶ Public Health Sciences, Loyola University Chicago

⁷ School of Medicine, Johns Hopkins University

⁸ Department of Laboratory Medicine and Pathology, University of Minnesota

⁹ Department of Epidemiology and Biostatistics, ¹⁰Cancer Prevention and Control Program, and

¹¹Connecting Health Innovations, Columbia, South Carolina

Corresponding author: Juan C. Celedón, MD, DrPH, ATSF

Division of Pediatric Pulmonary Medicine

UPMC Children's Hospital of Pittsburgh

4401 Penn Avenue, Pittsburgh, PA 15224

Phone: 412.692.8429; Fax: 412.692.7636

Email: juan.celedon@chp.edu

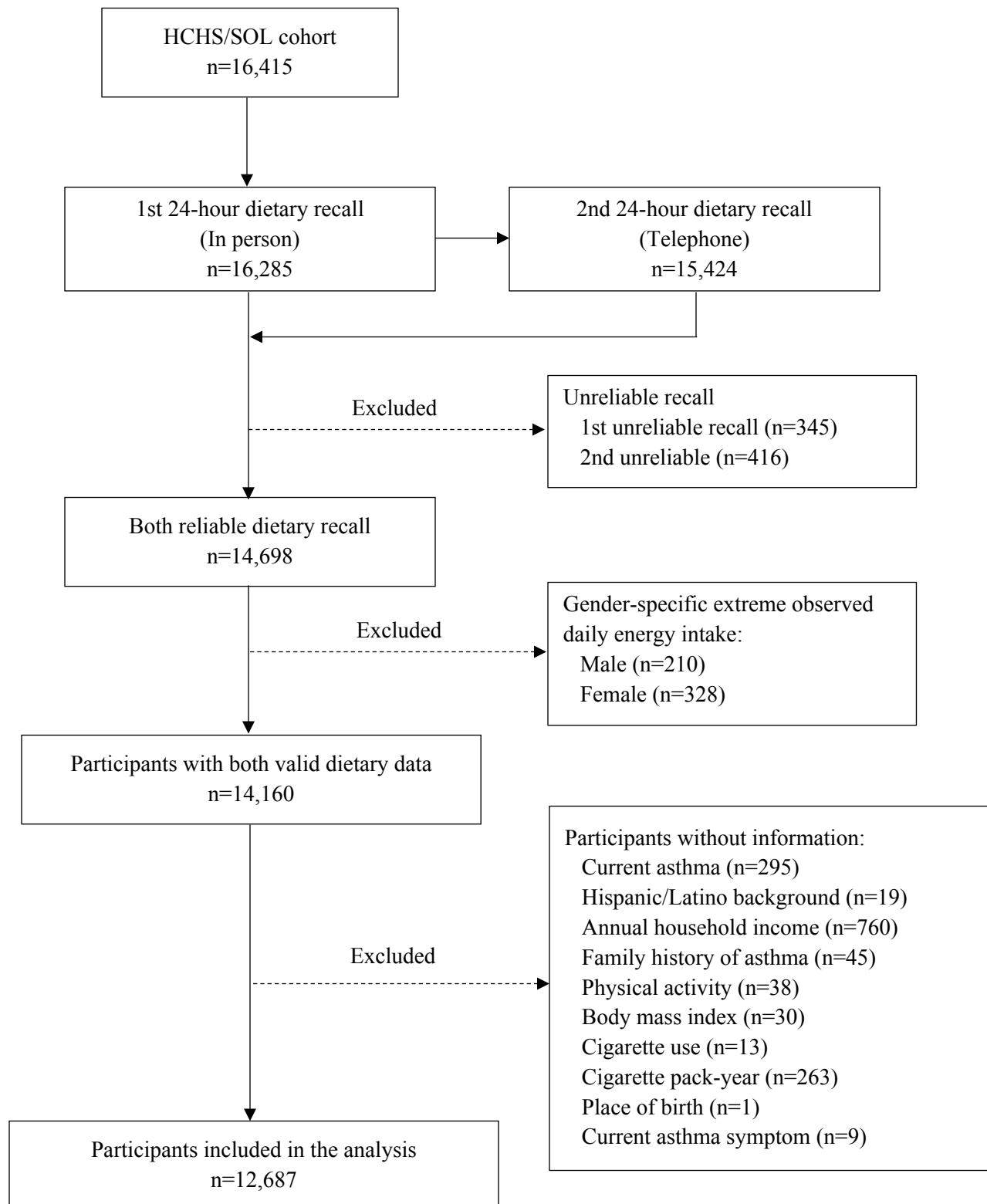
Figure E1- Flowchart for selection of participants included in the current analysis

Table E1 - Multivariable analysis of the relation between the energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma and current asthma symptoms

Predictors	Current asthma (n=962)	Asthma symptoms (n=2,085)
	Odds Ratio (95% confidence interval)	
E-DII (continuous)	1.07 (1.00, 1.15)	1.08 (1.02, 1.13)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.28, 0.86)	0.74 (0.51, 1.08)
Puerto Rican	1.70 (1.00, 2.90)	1.01 (0.73, 1.41)
Others	0.61 (0.40, 0.92)	0.90 (0.68, 1.18)
AHEI-2010 (continuous)	0.99 (0.96, 1.02)	0.99 (0.97, 1.00)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.51 (0.28, 0.94)	0.79 (0.54, 1.15)
Puerto Rican	1.67 (0.99, 2.46)	0.99 (0.70, 1.39)
Others	0.62 (0.41, 0.95)	0.93 (0.70, 1.24)

All models adjusted for adjusted for age, gender, study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, and pack-years of cigarette smoking. Odds ratio with P < 0.05 in bold typeface.

Table E2 - Multivariable analysis of the relation between the energy-adjusted Dietary Inflammatory Index (E-DII) and current asthma and current asthma symptoms, adjusting for dietary supplements

	Current asthma (n=962)	Current asthma symptoms (n=2,085)
Predictors	Odds Ratio (95% confidence interval)	
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	0.98 (0.71, 1.35)	1.16 (0.92, 1.46)
Quartile 3	1.24 (0.93, 1.65)	1.38 (1.11, 1.70)
Quartile 4	1.29 (0.93, 1.80)*	1.39 (1.10, 1.76)*
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.28, 0.85)	0.75 (0.51, 1.08)
Puerto Rican	1.72 (1.01, 2.92)	1.03 (0.74, 1.43)
Others	0.61 (0.40, 0.93)	0.90 (0.69, 1.19)

All models adjusted for adjusted for age, gender, study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, pack-years of cigarette smoking, and 24hour intake of dietary supplements. Results for which $P < 0.05$ are shown in bold typeface.

*P for trend <0.05

Table E3 - Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma symptoms, by smoking status

	Never/former smokers (n=10,430)	Current smokers (n=2,257)
Predictors	Odds Ratio (95% confidence interval)	
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.26 (0.96, 1.65)	1.60 (0.96, 2.64)
Quartile 3	1.37 (1.07, 1.74)	1.43 (0.90, 2.27)
Quartile 4	1.41 (1.06, 1.86)*	1.62 (1.03, 2.55)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.77 (0.50, 1.07)	0.70 (0.31, 1.57)
Puerto Rican	1.10 (0.71, 1.71)	0.94 (0.46, 1.92)
Others	0.83 (0.59, 1.16)	1.36 (0.78, 2.35)
AHEI-2010		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	0.95 (0.74, 1.26)	1.00 (0.70, 1.42)
Quartile 3	0.83 (0.58, 1.18)	0.96 (0.60, 1.51)
Quartile 4	0.88 (0.60, 1.29)	0.85 (0.49, 1.47)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.78 (0.50, 1.23)	0.72 (0.32, 1.65)
Puerto Rican	1.08 (0.69, 1.69)	0.96 (0.46, 1.98)
Others	0.83 (0.59, 1.18)	1.35 (0.77, 2.35)

All models adjusted for adjusted for age, gender, Hispanic/Latino background, study center, health insurance coverage, body mass index, physical activity, family history of asthma, place of birth, and pack-years of cigarette smoking. Odds ratio with $P < 0.05$ are shown in bold typeface.

*P for trend <0.05

Table E4 - Multivariable analysis of the relation between Alternative Healthy Eating Index 2010 (AHEI-2010) components and current asthma

AHEI-2010 component score	Current asthma	Current asthma symptoms
AHEI-2010 component score	Odds Ratio (95% confidence interval)	
1. Vegetables without potatoes	0.92 (0.83, 1.03)	0.99 (0.92, 1.06)
2. Whole fruit (not include fruit juice),	0.94 (0.86, 1.03)	0.95 (0.89, 1.00)
3. Whole grains	0.90 (0.82, 0.98)	0.97 (0.91, 1.03)
4. Sugar sweetened beverages and fruit juice	0.99 (0.94, 1.05)	0.97 (0.92, 1.01)
5. Nuts and legumes	0.99 (0.94, 1.05)	1.00 (0.97, 1.04)
6. Red/processed meat	1.02 (0.94, 1.11)	0.99 (0.96, 1.04)
7. % <i>Trans</i> fat from energy	1.04 (0.87, 1.25)	0.82 (0.72, 0.94)
8. Long-chain n-3 fats (EPA+DHA)	0.96 (0.84, 1.10)	1.02 (0.95, 1.10)
9. % PUFA from energy	0.98 (0.83, 1.15)	1.03 (0.93, 1.13)
10. Sodium	1.01 (0.96, 1.05)	0.97 (0.93, 0.99)
11. Alcohol	1.01 (0.95, 1.08)	1.04 (0.99, 1.08)

All models adjusted for adjusted for age, gender, Hispanic/Latino background, study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, and pack-years of cigarette smoking. Odds ratio with $P < 0.05$ in bold typeface.

Table E5 – Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma and current asthma symptoms

Predictors	Current asthma (n=962)	Current asthma symptoms (n=2,085)
	Odds Ratio (95% confidence interval)	
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.08 (0.77, 1.51)	1.31 (1.02, 1.68)
Quartile 3	1.33 (0.97, 1.81)	1.37 (1.10, 1.71)
Quartile 4	1.35 (0.97, 1.88)*	1.42 (1.12, 1.80)*
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.28, 0.86)	0.74 (0.51, 1.08)
Puerto Rican	1.72 (1.01, 2.92)	1.02 (0.74, 1.43)
Others	0.61 (0.40, 0.92)	0.90 (0.69, 1.19)
AHEI-2010		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.11 (0.84, 1.47)	0.96 (0.75, 1.23)
Quartile 3	0.90 (0.64, 1.28)	0.85 (0.62, 1.16)
Quartile 4	0.94 (0.61, 1.43)	0.88 (0.63, 1.22)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.49 (0.27, 0.89)	0.76 (0.52, 1.12)
Puerto Rican	1.74 (1.02, 2.97)	1.02 (0.72, 1.42)
Others	0.61 (0.40, 0.92)	0.91 (0.69, 1.21)

All models adjusted for adjusted for age, gender, study center, annual household income, body mass index, physical activity, family history of asthma, place of birth, smoking status, pack-years of cigarette smoking, and season of data collection. Odds ratio with P < 0.05 in bold typeface.

Table E6 – Multivariable analysis of the relation between the Energy-adjusted Dietary Inflammatory Index (E-DII) or the Alternative Healthy Eating Index 2010 (AHEI-2010) and current asthma and current asthma symptoms

Predictors	Current asthma (n=962)	Current asthma symptoms (n=2,085)
	Odds Ratio (95% confidence interval)	
E-DII		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.11 (0.78, 1.56)	1.34 (1.04, 1.72)
Quartile 3	1.35 (0.98, 1.86)	1.39 (1.12, 1.74)
Quartile 4	1.37 (0.98, 1.93)*	1.44 (1.14, 1.83)*
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.58 (0.33, 1.02)	0.77 (0.53, 1.12)
Puerto Rican	1.72 (1.02, 2.87)	1.02 (0.73, 1.41)
Others	0.66 (0.44, 0.99)	0.92 (0.70, 1.21)
AHEI-2010		
Quartile 1	1.0 (reference)	1.0 (reference)
Quartile 2	1.12 (0.84, 1.49)	0.96 (0.75, 1.23)
Quartile 3	0.95 (0.67, 1.33)	0.85 (0.62, 1.16)
Quartile 4	0.93 (0.61, 1.42)	0.87 (0.63, 1.20)
Hispanic/Latino background		
Cuban	1.0 (reference)	1.0 (reference)
Mexican	0.58 (0.32, 1.05)	0.79 (0.54, 1.16)
Puerto Rican	1.74 (1.04, 2.90)	1.01 (0.72, 1.41)
Others	0.65 (0.43, 0.99)	0.93 (0.70, 1.23)

All models adjusted for adjusted for age, gender, study center, health insurance coverage, body mass index, physical activity, family history of asthma, place of birth, smoking status, and pack-years of cigarette smoking. Odds ratio with $P < 0.05$ in bold typeface.

* P for trend < 0.05