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Diet, asthma, and severe asthma exacerbations in a prospective study of Puerto Rican youth

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Abstract

Background: Poor diet quality may contribute to the disproportionate asthma burden in Puerto Rican youth.

Objective: To examine whether an unhealthy diet at one or two study visits conducted over ~5 years is associated with asthma, severe asthma exacerbations, and worse lung function in Puerto Rican youth.

Methods: Prospective study of 406 Puerto Rican youth aged 6–14 years at a baseline visit and 9–20 years at a follow-up visit. As in prior work, diet was assessed using a dietary score ranging from −2 to +2. Our exposure of interest was an unhealthy diet, defined as a non-positive dietary score (0 to −2) at one or both visits. Our outcomes of interest were asthma (defined as physician-diagnosed asthma and ≥1 episode of wheeze in the year prior to the second visit), ≥1 severe asthma exacerbation in the year prior to the second visit, and change in percent predicted lung function measures (FEV_1, FVC, and FEV_1/FVC) between the first and second visits.

Results: In a multivariable analysis, an unhealthy diet at both visits was associated with increased odds of asthma (adjusted odds ratio [aOR]=3.38, 95% confidence interval [CI]=1.74 to 6.57) and severe asthma exacerbations (aOR=2.65, 95% CI=1.16 to 6.03), but not with change in lung function.

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Conflicts of interest: Dr. Celedón has received research materials from GSK and Merck (inhaled steroids) and Pharmavite (vitamin D and placebo capsules), to provide medications free of cost to participants in NIH-funded studies, unrelated to this work. The other authors have no conflicts of interest to declare.

Conclusions: An unhealthy diet at both visits was associated with increased odds of asthma and severe asthma exacerbations compared with a healthy diet at both visits. Our findings support health policies promoting a healthy diet in Puerto Rican youth, a population at high risk for asthma.

Keywords

unhealthy diet; asthma; asthma exacerbations; lung function; Puerto Rican; children; youth

INTRODUCTION

Asthma, a major public health problem, affects nearly 6 million children in the United States[1]. Changes in dietary patterns may have contributed to the high asthma burden in industrialized nations such as the United States[2].

Diet could cause or worsen childhood asthma by affecting innate and adaptive immune responses, ultimately leading to allergic airway inflammation. A Mediterranean diet, rich in antioxidants such as vegetables, fruits and nuts, and a low intake of meat and poultry, has been associated with decreased risks of asthma and morbidity from asthma[3]. In contrast, a "Western" diet (high in refined sugars and processed foods and low in fruits and vegetables) has been linked to asthma and worse asthma outcomes in children[2]. Moreover, frequent consumption of sweetened drinks has been associated with childhood asthma[4, 5].

In the United States, Puerto Ricans living in the island of Puerto Rico and the U.S. mainland are disproportionately affected with childhood asthma[6]. Dietary patterns may partly explain this finding, as Puerto Ricans have been shown to have lower dietary intake of fruits and vegetables but high consumption of sodas and fried foods[7, 8]. Moreover, we previously showed that a healthy diet is associated with decreased odds of asthma in a cross-sectional study of Puerto Rican children[9].

To date, no study has prospectively examined the relation between diet quality and asthma or asthma outcomes in Puerto Rican youth. On the basis of the published literature and our previous cross-sectional findings, we hypothesized that an unhealthy diet would be associated with asthma, worse lung function, and severe asthma exacerbations in Puerto Rican children and adolescents. We tested this hypothesis in a prospective study of Puerto Rican youth followed from ages 6 to 14 years to ages 9 to 20 years.

METHODS

Study population

Subject recruitment and the study protocol for the Prospective Study of Puerto Rican Youth and Asthma Study (PROPRA) have been described elsewhere[10]. All PROPRA participants completed an initial study visit at age 6 to 14 years and a follow-up study visit at age 9 to 20 years. In brief, 678 children ages 6 to 14 years with (n=351) and without (n=327) asthma were recruited for the Puerto Rico Genetics of Asthma and Lifestyle (PR-GOAL) study from March 2009 through June 2010 from randomly selected households in San Juan and Caguas (Puerto Rico) using a multistage probabilistic sampling design[11]. All

participants had four Puerto Rican grandparents. Cases were children with asthma (defined as physician-diagnosed asthma and ≥1 episode of wheeze in the previous year) and controls were children who had neither physician-diagnosed asthma nor wheeze in the previous year. From February 2014 to May 2017, we conducted another study in 543 Puerto Rican youth aged 9 to 20 years old, the Epigenetic Variation and Childhood Asthma in Puerto Ricans study (EVA-PR), using a similar approach to that used in PR-GOAL[12]. Of the 543 participants in EVA-PR, 406 had participated in PR-GOAL and were thus included in the current analysis of asthma. Of these 406 subjects, 340 also had spirometry at both study visits (i.e., in PR-GOAL and EVA-PR) and were thus included in the current analysis of lung function. The study was approved by the IRBs of the University of Puerto Rico and the University of Pittsburgh. Written parental consent and child assent were obtained for participants under 18 years old, and written consent was obtained from participants 18 years and older.

Study procedures

All participants completed a protocol including administration of questionnaires and spirometry at both the baseline and follow-up visits. One of the child's caretakers (usually the mother) completed a questionnaire adapted from that used in the Collaborative Study of the Genetics of Asthma[13], containing information about demographics, the child's general and respiratory health, and family history. Dietary intake was assessed using a semiquantitative 75-items food-frequency questionnaire (FFQ) on the child's food consumption in the prior week. This FFQ was previously shown to have good validity and reproducibility in a Hispanic population in Costa Rica[14]. As previously described[9], a dietary score was created including food groups that were significantly associated with decreased (vegetables and grains, healthy food groups) or increased (dairy and sweets/soda/snacks, unhealthy food groups) odds of asthma[9]. Participants were assigned 1 positive point for high consumption of an item (vegetables or grains) in the healthy food group and 1 negative point for consumption of an item in the unhealthy food groups (dairy or sweets). Thus, the dietary score ranges from −2 ("unhealthiest diet") to +2 ("healthiest diet"). An unhealthy diet was defined as a non-positive score (0, −1, or −2), and a healthy diet was defined as a positive score (+1 or +2).

Height and weight were measured to the nearest centimeter and kilogram, respectively. Spirometry was conducted with an EasyOne spirometer (NDD Medical Technologies, Andover, Mass) according to American Thoracic Society and European Respiratory Society recommendations modified for children[15]. The best results for forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) were selected for data analysis. Percent predicted values for lung function measures at each visit were calculated using the Global Lung Function Initiative [GLI] equations, which account for age, sex, and height[16].

Statistical analysis

Four dietary groups were created based on dietary patterns at the two study visits, as follows: a healthy diet at both study visits (reference group), an unhealthy diet at the first visit but not at the second visit (first visit only), an unhealthy diet at the second visit but not at the first visit (first visit only), and an unhealthy diet at both visits. Our main exposure

of interest was an unhealthy diet at one or both study visits. In secondary analyses, we examined low consumption of each food group (vegetables, grains, sweets, and dairy) at one or both study visits, with cutoffs for each food group chosen as previously described[9].

Our outcomes of interest were asthma (defined as physician-diagnosed asthma and ≥1 episode of wheeze in the year prior to the second visit), severe asthma exacerbations (defined as ≥1 visit to the emergency department/urgent care for asthma or ≥1 hospitalization for asthma) in the year prior to the second visit, and change in percent predicted lung function measures (FEV_1, FVC, and FEV_1/FVC [which already account for age and sex]) between the baseline and follow-up visits.

Wald chi-square tests and analysis of variance were used for the bivariate analyses of categorical and continuous variables, respectively. Pairwise two-sided multiple comparison analysis within group for continuous variables was based on the Dwass, Steel, Critchlow-Fligner (DSCF) method or the Tukey's Studentized Range (HSD) test, as appropriate. Logistic or linear regression was used for the multivariable analysis. A stepwise approach was used to build the multivariable models. All models were adjusted for the time interval between visits, and those for asthma or severe asthma exacerbations were additionally adjusted for age and sex. Other covariates considered for inclusion in the multivariable models were parental education (at least one parent had completed high school at both study visits vs. others), annual household income (≥$15,000 per year at both visits vs. others), change in body mass index (BMI) z-score between visits, use of inhaled corticosteroids in the six months prior to the second study visit, time spent outdoors (moderate amount or more at both visits vs. others), current second-hand smoke exposure at the second study visit, and residential proximity to a road (previously defined as being in the first to third quartiles of residential distance to a major road[17]) at both visits vs. others. Covariates that were associated with the outcome at $P < 0.05$ or that changed the effect estimate (odds ratio or β) by ≥10% were included in the final models. After the final models were built, we tested for an interaction between an unhealthy diet at one or both visits and selected covariates (sex, use of inhaled corticosteroids in the six months prior to the second study visit, and asthma status) on the outcomes of interest.

All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Table E1 in the Online Repository shows a comparison of the baseline characteristics of the 406 subjects who participated in both study visits (and were thus included in this analysis) versus the 272 subjects who were excluded from this analysis because they did not participate in the second study visit. Compared with subjects included in the current analysis, those excluded were slightly older and less likely to have asthma, and had a higher percent predicted FEV_1. There were no significant differences in dietary score, percent predicted FVC or FEV_1, or any other characteristic between subjects who were and were not included in the current analysis.

Table 1 shows a comparison of the main baseline characteristics of participating children across the four dietary groups. Compared with 171 subjects with a healthy diet at both study visits, those who had an unhealthy diet at the first study visit only (n=86), an unhealthy diet at the second study visit only (n=77), and an unhealthy diet at both visits (n=72) were each significantly more likely to have asthma. Moreover, participants who had an unhealthy diet at the second visit only were more likely to have a higher BMI z-score and at least one parent who had completed high school than those who had an unhealthy diet at the first visit only. Compared with subjects who consumed a healthy diet at both study visits, those who consumed an unhealthy diet at both study visits were more likely to have lower percent predicted FEV_1 and FVC.

Table 2 shows the results of the unadjusted and adjusted analyses of an unhealthy diet at one or both study visits and asthma at the second study visit. In a multivariable analysis adjusting for age, sex, parental education, outdoor activity, ICS use in the six months prior to the second visit, change in BMI z- score between study visits, and the time interval between study visits, subjects who consumed an unhealthy diet at the first study visit only and subjects who consumed an unhealthy diet at both study visits had 2.46 times to 3.38 times significantly higher odds of asthma than those who consumed a healthy diet at both study visits. In this analysis, subjects who consumed an unhealthy diet at visit 2 only had 1.76 times higher odds of asthma than those who consumed a healthy diet at both visits, but this was not statistically significant (P=0.09).

Table 3 shows the results of the unadjusted and adjusted analyses of the relation between an unhealthy diet at one or both visits and severe asthma exacerbations among 225 subjects with asthma (cases). In a multivariable analysis adjusting for age, sex, parental education, ICS use in the six months prior to the second study visit, and the time interval between study visits, an unhealthy diet at the first visit only was not significantly associated with severe asthma exacerbations, but an unhealthy diet at both visits and an unhealthy diet at the second visit only were significantly associated with 2.65 times to 3.12 times increased odds of severe asthma exacerbations in the year prior to the second visit. In this analysis, use of inhaled corticosteroids in the 6 months prior to the second visit was significantly associated with 3.5 times higher odds of ≥1 severe asthma exacerbation in the year prior to the second visit.

Next, we examined the relation between an unhealthy diet at one or both visits and change in percent predicted lung function measures (which already account for age and sex) between study visits. In a multivariable analysis adjusting for parental education, second-hand smoke, change in BMI z-score between study visits, asthma status, and time interval between study visits, an unhealthy diet at one visit or at both visits was not significantly associated with change in lung function measures (Table 4).

In a sensitivity analysis, we replaced change in BMI z-score between study visits with baseline BMI z-score or waist circumference z-score at the first study visit in the multivariable models of asthma and lung function, obtaining similar results (data not shown).

We found no significant modification of the estimated effects of an unhealthy diet on asthma or severe asthma exacerbations by sex or ICS use prior to the second study visit. Similarly, there was no significant modification of the estimated effect of an unhealthy diet on lung function by asthma status (P>0.10 in all instances).

In secondary analyses, we examined whether a low intake of each of the nutrient groups considered for the dietary score (dairy, sweets/soda/snacks, vegetables, and grains) at one or both study visits is associated with the outcomes of interest. In a multivariable analysis, low intake of vegetables or low intake of grains at the second visit only was not significantly associated with asthma, but low intake of vegetables and low intake of grains at the first study visit were significantly associated with increased odds of asthma, with similar but non-significant trends for low intake of grains and low intake of vegetables at both visits (P=0.06–0.07, Table 5). In this analysis, neither low intake of dairy products nor low intake of sweets was significantly associated with asthma. Table E2 shows the results of the analysis of low intake of each of the nutrient groups and severe asthma exacerbations. In a multivariable analysis, low intake of grains at the first visit only or at both visits was not significantly associated with severe asthma exacerbations, but low intake of grains at the second visit was significantly associated with 1.22 times increased odds of ≥1 severe asthma exacerbation in the year prior to the second visit. Low intake of the other nutrients (vegetables, dairy products, and sweets) was not significantly associated with severe asthma exacerbations.

DISCUSSION

In a longitudinal study, an unhealthy diet at the first study visit or at the two study visits (conducted over ~5 years) was significantly associated with asthma in a cohort of Puerto Rican youth living in Puerto Rico. In this cohort, an unhealthy diet at the second study visit or at both study visits was associated with severe asthma exacerbations. Moreover, low consumption of grains or vegetables at the first visit was associated with increased odds of asthma, while low intake of grains at the second visit was associated with severe asthma exacerbations. To our knowledge, this is the first prospective study of diet quality and asthma, severe asthma exacerbations, and lung function in school-aged children and adolescents.

A growing body of evidence suggests that a healthy diet -rich in fruits and vegetables, whole grains, and polyunsaturated fatty acids- has beneficial effects on respiratory health and asthma[2]. Indeed, two systematic reviews and metanalyses[18, 19] showed that a “Mediterranean” diet and high consumption of vegetables and fruits are associated with lower risk of childhood asthma. Moreover, a multi-center cross-sectional study of 143,967 children from 11 Latin American countries found that high consumption of fruits and vegetables was associated with lower prevalence of current wheeze, while fast food intake was associated with wheeze and symptoms of rhino-conjunctivitis and eczema[20]. In further support of potential protective effects of a healthy diet against asthma, a 6-month pilot randomized clinical trial in 90 adults showed that a diet low in saturated fats and rich in fruits and vegetables was associated with improved asthma control[21].

Consistent with our findings in a longitudinal study of youth, an unhealthy diet was linked to asthma or asthma symptoms in prior cross-sectional studies. For example, a cross-sectional study of 8,175 children showed that a higher Energy-adjusted Dietary Inflammatory Index (E-DII) (a pro-inflammatory diet) was associated with current wheeze in children with high fractional exhaled nitric oxide (atopic wheeze)[22]. Similarly, a cross-sectional study of Hispanic adults showed an association between a higher E-DII and current asthma[8].

Consistent with our results for grains or vegetables, high consumption of whole grains were previously associated with lower odds of asthma or asthma symptoms in a cross-sectional study of Hispanic adults[8], and vegetable intake was associated with lower risk of asthma in a meta-analysis of studies in children and adults[23].

Our negative findings for an unhealthy diet and lung function may be due to limited statistical power to detect modest effects (due to small sample size) or insufficient duration of follow up, as a systematic review of nutritional interventions and asthma-related outcomes found that a diet rich in antioxidants was associated with increased FEV_1 and FVC in adults[24]. On the other hand and consistent with our results, a high DII was not associated with lung function in a large cross-sectional study of U.S. children[22].

An unhealthy diet may be linked to asthma or severe asthma exacerbations through various pathways. A diet rich in saturated fats and refined sugars but low in fruits and vegetables may lead to stimulation of innate immune responses via nuclear factor-kappa B cascade, activation of T- helper cell type 2 immune responses, and oxidative stress[25]. Moreover, sweetened drinks may also cause oxidative damage and airway inflammation through increased production of advanced glycation end products[4], and a high-fat diet with low fiber intake may modify the gut microbiome, decreasing the production of short-chain fatty acids and altering immune regulation[26]. Further, a high intake of processed food, saturated fats, and carbohydrates may lead to excess energy intake and weight gain. Of interest, an unhealthy diet at the first visit only or at both visits was associated with asthma, while an unhealthy diet at the second visit only or at both visits was associated with severe asthma exacerbations, suggesting that earlier or sustained consumption of an unhealthy diet may affect asthma inception (e.g., by affecting the gut microbiome and Th1/Th2 balance) while a more recent unhealthy diet may have stronger effects on severe asthma exacerbations (e.g., through oxidative stress and airway inflammation) than on asthma *per se*.

We acknowledge additional study limitations. First, dietary intake was assessed on the basis of one FFQ at each visit, which may not account for day-to-day or seasonal variability in dietary patterns. However, this FFQ was previously shown to perform well in representing long-term dietary intake in a Hispanic population[14]. Second, we lack data on dietary patterns in early life, which may affect immune responses and asthma risk. However, unhealthy dietary patterns tend to persist through various life stages[27]. Third, food frequency questionnaires were completed by parents of youth younger than 18 years, and thus recall bias, social desirability bias, and inaccurate reporting are possible. However, questionnaires completed by parents of young children have been previously shown to be accurate[28]. Fourth, selection bias is also possible in observational studies, yet this is an unlikely explanation for our results since there was no significant difference in diet

quality between subjects who were and were not included in the current analysis. Fifth, our definition of severe asthma exacerbations may have missed prescription of systemic steroids in a physician's office. However, the vast majority of children who are hospitalized or visit the ED/urgent care for asthma in Puerto Rico receive systemic steroids, and parents are more likely to recall such events than a steroid prescription from a primary care physician (a relatively infrequent event among our participants, due to lack of adequate health insurance necessitating use of an acute healthcare setting for asthma attacks). Finally, reverse causation" may explain the association between use of inhaled corticosteroids (ICS) and severe asthma exacerbations at the second visit (due to increased asthma severity among children using ICS). Although less likely, reverse causation may also explain the link between an unhealthy diet and severe asthma exacerbations (if children with severe asthma exacerbations were more inclined to consume an unhealthy diet at the second visit only). Alternatively, a recently unhealthy diet may be needed to cause airway inflammation and thus severe asthma exacerbations.

In summary, our findings suggest that an unhealthy diet increases the risk of asthma and severe asthma exacerbations in Puerto Rican youth. Our results further support health policies aimed to promote a healthy diet in Puerto Rican school-aged children and adolescents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

OR	odds ratio
CI	confidence interval
FEV_1	forced expiratory volume-one second
FVC	forced vital capacity

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Highlights Box

What is already known about this topic?

Cross-sectional studies have reported an association between an unhealthy diet and asthma, asthma symptoms, and lung function in children and adolescents.

What does this article add to our knowledge?

In this study, an unhealthy diet at two study visits conducted over ~5 years was associated with asthma and severe asthma exacerbations in Puerto Rican youth, a high-risk population.

How does this study impact current management guidelines?

Our results suggest that physicians caring for children with asthma should promote a healthy diet in school-aged children and adolescents as part of their clinical management.

Table 1.

Characteristics of study participants at the baseline study visit by dietary groups.

All participants (n=406)	Healthy diet at both visits (n=171)	Unhealthy diet at baseline visit (n=86)	Unhealthy diet at follow-up visit (n=77)	Unhealthy diet at both visits (n= 72)
Asthma cases	76 (44.4)	54 (62.8)	45 (58.4)	48 (66.7)‡
Age (years)	10 (8, 13)	10 (8, 12)	10 (8, 11)	9 (7, 11)
Male sex	87 (50.9)	40 (46.5)	48 (62.3)	40 (55.6)
BMI z- score	0.72 ± 1.02	0.57 ± 1.17	1.09 ± 1.23	0.69 ± 1.19‡
At least one parent had completed high school	143 (83.6)	59 (68.6)	68 (88.3)	59 (81.9)‡
Annual household income <$15,000/ year	91 (55.5)	58 (69.9)	48 (64.9)	49 (70.0)
Spent at least a moderate amount of time outdoors	129 (75.4)	67 (77.9)	53 (68.8)	56 (77.8)
Current exposure to second-hand smoke	54 (31.6)	32 (37.2)	31 (40.3)	33 (46.5)
Residential proximity (within 441 meters) to a major road	132 (77.7)	66 (76.7)	54 (70.1)	56 (77.8)
Lung function measures				
% Predicted FEV_1	97.1 ± 13.9	92.7 ± 17.5	95.2 ± 14.7	87.8 ± 16.0‡
% Predicted FVC	104.5 (93.0, 112.6)	100.6 (91.6, 110.1)	103.4 (95.9, 116.3)	96.9 (86.8, 107.8)‡
% Predicted FEV_1/ FVC	94.0 (87.9, 99.8)	93.9 (86.7, 99.1)	92.1 (85.1, 96.9)	90.9 (85.8, 98.1)
Time interval between visits (years)	5.2 (4.8, 6.1)	5.2 (4.7, 6.1)	5.0 (4.5, 5.8)	5.0 (4.5, 6.2)
≥1 severe asthma exacerbation in the prior year†	35 (46.1)	26 (48.2)	24 (53.3)	30 (62.5)
Use of inhaled corticosteroids in the prior six months†	29 (28.2)	19 (35.2)	16 (35.6)	13 (27.1)

BMI= Body mass index; FEV_1 = forced expiratory volume in the first second; FVC = forced vital capacity.

*Unhealthy diet: a non-positive dietary score (0, −1, or −2) at one or both visits.

†Healthy diet: a positive score (+1 or +2) at both visits.

Values presented as N (%), mean ± SD or median (interquartile range) for non-normally distributed variables.

†In asthma cases only.

‡P< 0.05 for comparison across groups

Table 2.

Multivariable analysis of the relation between dietary group and asthma

	Unadjusted		Adjusted*	
Variable	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**
Healthy diet at both visits	reference		reference	
Unhealthy diet at the first visit only	2.27 (1.33, 3.87)	<0.01	2.46 (1.30, 4.66)	<0.01
Unhealthy diet at the second visit only	1.90 (1.10, 3.28)	0.02	1.76 (0.92, 3.37)	0.09
Unhealthy diet at both visits	2.26 (1.51, 3.38)	<0.01	3.38 (1.74, 6.57)	<0.01
At least one parent completed high school			1.42 (0.80, 2.54)	0.24
Change in BMI z-score between study visits			1.07 (0.79, 1.45)	0.67
Spent at least a moderate amount of time outdoors at both visits			1.57 (0.97, 2.56)	0.07

OR=odds ratio, CI=confidence interval; BMI=body mass index

*Model adjusted for age, sex, use of inhaled corticosteroids in the six months prior to the follow up visit, and the time interval between study visits, in addition to the covariates listed in the column.

Table 3.

Multivariable analysis of the relation between dietary groups and severe asthma exacerbations among subjects with asthma

Variable	Unadjusted		Adjusted*	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Healthy diet at both visits	reference		reference	
Unhealthy diet at first visit only	1.36 (0.64, 2.87)	0.64	1.21 (0.54, 2.71)	0.65
Unhealthy diet at second visit only	2.94 (1.36, 6.36)	<0.01	3.12 (1.35, 7.23)	<0.01
Unhealthy diet at both visits	1.93 (0.90, 4.11)	0.09	2.65 (1.16, 6.03)	0.02
At least one parent completed high school			0.41 (0.18, 0.91)	0.03
Use of inhaled corticosteroids in the 6 months prior to the second visit			3.50 (1.76, 6.97)	<0.01

OR=odds ratio, CI=confidence interval

*All models were adjusted for age, sex, and the time interval between study visits, in addition to the variables listed in the column.

Table 4.

Multivariable analysis of dietary groups and change in lung function measures

	%predicted FEV_1	%predicted FVC	%predicted FEV_1/FVC
Dietary groups	**β (95% confidence interval)**		
Healthy diet at both visits	reference	reference	reference
Unhealthy diet at first visit only	3.07 (−1.11, 7.25)	2.58 (−1.91, 7.07)	0.43 (−2.70, 3.55)
Unhealthy diet at second visit only	−0.71 (−5.07, 3.64)	−0.24 (−4.92, 4.43)	−0.34 (−3.59, 2.92)
Unhealthy diet at both visits	2.38 (−2.21, 6.98)	4.57 (−0.36, 9.50)	−0.83 (−4.26, 2.60)

FEV_1 = forced expiratory volume in the first second; FVC = forced vital capacity

All models were adjusted for asthma status, change in body mass index z-score between study visits, current exposure to secondhand smoke, parental education, and the time interval between study visits.

Table 5.

Multivariable analysis of nutrient intake at one or both study visits and asthma

	Unadjusted		Adjusted*	
Nutrient intake	**OR (95% CI)**	***P* value**	**OR (95% CI)**	***P* value**
Vegetables				
High intake at both visits (n=234)	reference		reference	
Low intake at first visit (n=59)	2.18 (1.19, 3.98)	0.01	2.46 (1.25, 4.82)	<0.01
Low intake at second visit (n=66)	1.59 (0.91, 2.78)	0.10	1.22 (0.63, 2.37)	0.56
Low intake at both visits (n=47)	1.83 (0.96, 3.49)	0.07	1.96 (0.96, 4.00)	0.07
Grains				
High intake at both visits (n=235)	reference		reference	
Low intake at first visit (n=74)	1.80 (1.05, 3.09)	0.03	1.92 (1.04, 3.54)	0.04
Low intake at second visit (n=66)	1.10 (0.64, 1.90)	0.73	1.15 (0.62, 2.12)	0.67
Low intake at both visits (n=31)	2.80 (1.21, 6.52)	0.02	2.49 (0.97, 6.41)	0.06
Dairy products				
High intake at both visits (n=123)	reference		reference	
Low intake at first visit (n=81)	0.69 (0.39, 1.21)	0.20	0.60 (0.31, 1.16)	0.13
Low intake at second visit (n=77)	0.73 (0.41, 1.30)	0.29	0.70 (0.35, 1.35)	0.29
Low intake at both visits (n=125)	0.53 (0.32, 0.89)	0.02	0.65 (0.93, 1.11)	0.15
Sweets/soda/snacks				
High intake at both visits (n=43)	reference		reference	
Low intake at first visit (n=67)	0.83 (0.38, 1.81)	0.63	0.63 (0.26, 1.54)	0.31
Low intake at second visit (n=65)	0.78 (0.36, 1.73)	0.54	0.54 (0.23, 1.30)	0.17
Low intake at both visits (n=231)	0.66 (0.34, 1.30)	0.23	0.52 (0.25, 1.09)	0.08

OR=odds ratio, CI=confidence interval

*All models were adjusted for age, sex, change in body mass index z-score, parental education, use of inhaled corticosteroids in the six months prior to the second visit, time spent outdoors at both visits, and the time interval between study visits.