

Diet, interleukin-17, and childhood asthma in Puerto Ricans

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ABSTRACT

Background: Dietary patterns might influence the pathogenesis of asthma in Puerto Ricans, the ethnic group most affected by this disease in the United States.

Objective: To examine the association among diet, T-helper cell type 17 cytokines, and asthma in Puerto Rican children.

Methods: As part of a case–control study of 678 Puerto Rican children 6 to 14 years old in San Juan, participants completed a 75-item questionnaire on the child's food consumption in the prior week. Foods were aggregated into 7 groups: fruits, vegetables, grains, protein foods, dairy, fats, and sweets. Logistic regression was used to evaluate consumption frequency of each group, plasma T-helper cell type 17 cytokine levels, and asthma. Based on this analysis, a food score (range –2 [unhealthy diet: high consumption of dairy products and sweets, low consumption of vegetables and grains] to +2 [healthy diet: high consumption of grains and vegetables, low consumption of dairy and sweets]) was created to identify dietary patterns.

Results: High consumption of grains was associated with lower odds of asthma (adjusted odds ratio [aOR] 0.52, 95% confidence interval [CI] 0.33–0.82), whereas frequent consumption of dairy products (aOR 1.93, 95% CI 1.32–2.84) or sweets (aOR 1.82, 95% CI 1.08–2.72) was associated with higher odds of asthma. A healthier diet (each 1-point increment in food score) was associated with lower levels of interleukin-17F ($\beta = -1.48$ pg/mL, 95% CI –1.78 to –1.20) and with 36% decreased odds of asthma (aOR 0.64, 95% CI 0.53–0.77).

Conclusion: A healthy diet, with frequent consumption of vegetables and grains and low consumption of dairy products and sweets, was associated with lower levels of interleukin-17F and decreased odds of childhood asthma in Puerto Ricans.

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Introduction

Childhood asthma continues to be a major public health problem worldwide.¹ Changes in dietary patterns might partly explain the “asthma epidemic” in industrialized nations such as the United States.²

Because of the complexity of human dietary behavior, intake of certain food groups or overall dietary patterns can have greater influence on health than a single food item or nutrient.³ A “Mediterranean diet” (characterized by low intake of saturated fats but high intake of fruits, vegetables, grains, and monounsaturated and

ω -3 polyunsaturated fatty acids, eg, in olive oil) has been associated with decreased risk of asthma or asthma symptoms,^{4,5} whereas a “Westernized” diet (low in fruits, vegetables, grains, and mono-unsaturated and ω -3 polyunsaturated fats but high in refined grains, red meats, sweets, and saturated fats) has been associated with asthma symptoms.⁶ Recent findings have suggested that an unhealthy diet and obesity worsen airway inflammation and asthma severity through pathways mediated by T-helper type 17 (T_H17) cells, including production of cytokines such as interleukin-17 (IL-17).^{7,8}

In the United States, Puerto Rican children have a disproportionate burden of asthma.^{9,10} Although a recent study of 633 Puerto Rican adolescents has reported a high frequency of unhealthy dietary patterns (eg, low in fruits or vegetables but high in soda or fried foods¹¹), no study has examined diet and asthma in Puerto Ricans.

The authors hypothesized that the frequent intake of healthier foods would lower the risk of childhood asthma, and that this beneficial effect would be mediated by downregulation of T_H17 cytokines.

Methods

Study Population

From March 2009 through June 2010, children were recruited from randomly selected households in the metropolitan area of San Juan, as previously described.^{12,13} Households were selected by a multistage probability sampling design. Primary sampling units were randomly selected neighborhood clusters based on the 2000 US census, and secondary units were randomly selected households within each primary sampling unit. A household was eligible if at least 1 resident was a child 6 to 14 years old. Of the 7,073 selected households, 6,401 (~91%) were contacted. Of these, 1,111 had at least 1 child within the study age range who met the other inclusion criteria (4 Puerto Rican grandparents, residence in the same household for ≥ 1 year). Of these 1,111 households, 438 (39.4%) had at least 1 eligible child with asthma (a case, defined as having physician-diagnosed asthma and ≥ 1 episode of wheeze in the previous year). From these 438 households, 1 child with asthma was selected (at random if there was >1 such child). Similarly, only 1 child without asthma (a control, defined as having neither physician-diagnosed asthma nor wheeze in the previous year) was randomly selected from the remaining 673 households. To reach a target sample of approximately 700 children, the authors attempted to enroll a random sample ($n = 783$) of these 1,111 children. Parents of 105 of these 783 households refused to participate or could not be reached. There were no significant differences in age, sex, or area of residence between eligible children who did ($n = 678$ [86.6%]) and did not ($n = 105$ [13.4%]) participate.

Written parental consent and assent were obtained for participating children. The study was approved by the institutional review boards of the University of Puerto Rico (San Juan, Puerto Rico), Brigham and Women's Hospital (Boston, Massachusetts), and the University of Pittsburgh (Pittsburgh, Pennsylvania).

Study Procedures

One of the child's caretakers (usually the mother) completed a questionnaire slightly modified from one used in the Collaborative Study of the Genetics of Asthma¹⁴ containing questions about demographics, the child's general and respiratory health, family history of asthma, breastfeeding, environmental tobacco smoke, and outdoor physical activity. Height and weight were measured to the nearest centimeter and kilogram, respectively. Dietary data were collected using a semiquantitative food-frequency questionnaire

adapted from one developed and validated to measure intake of 75 food items in Costa Ricans.¹⁵

Fifteen circulating T_H17 pathway-related cytokines (IL-1b, IL-4, IL-6, IL-10, IL-17A, IL-17F, IL-21, IL-22, IL-23, IL-25, IL-31, IL-33, interferon- γ , soluble CD40 ligand, and tumor necrosis factor- α) were measured in plasma samples using the Bio-Plex Pro Human T_H17 cytokine panel on the BioPlex HTF system (Bio-Rad Laboratories Inc, Hercules, California). Assays were designed on magnetic beads in a capture-sandwich immunoassay format. Levels are presented as picograms per milliliter. Undetectable cytokine levels were assigned a constant (half the lowest limit of detection). All cytokine levels were logarithmically transformed for data analysis.

Statistical Analysis

Asthma was defined as physician-diagnosed asthma and at least 1 episode of wheeze in the previous year. The frequency of consumption of each food item was measured using 8 categories: never or less than once a month, occasionally or 1 to 3 times/month, 1 to 2 times/week, 3 to 4 times/week, once daily, 2 to 3 times/day, 4 to 5 times/day, or at least 6 times/day. Based on a food guidance system developed by the US Department of Agriculture Center for Nutrition Policy and Promotion,¹⁶ each food-frequency questionnaire item was assigned to 1 of 6 food groups: fruits, vegetables, grains, protein foods, dairy, and fats. A seventh group (sweets, soda, and snacks) was added for completion. To avoid misclassification, Pearson correlation analysis was used to assign complex foods (such as tacos, burritos, pizza, and soup) to 1 of the 7 food groups (eg, ham-and-cheese sandwich intake was most highly correlated with intake of grains and thus was assigned to that group). This food grouping is presented in detail in eTable 1. To avoid bias from an individual's tendency to respond at the lower or higher end of the scale, the reported “average frequency” was calculated for the 75 items for each individual, and each item was scored as a deviation from the mean.

Two-sample *t* tests (for continuous variables) or χ^2 tests (for categorical variables) were used to compare characteristics between cases and controls. Logistic regression was used for analysis of quartiles of food group consumption and asthma. Logistic models were adjusted for age, sex, annual household income ($< \$15,000$ or $\geq \$15,000$ [near the median household income for Puerto Rico in 2008–2009]¹⁷), health insurance (private or employer-based vs others), parental history of asthma, early-life (in utero or before 2 years of age) environmental tobacco smoke exposure, body mass index *z*-score (based on 2000 Centers for Disease Control and Prevention growth charts¹⁸), moderate to intense outdoor physical activity vs none to minimal, and breastfeeding (never, ≤ 6 months, or > 6 months). Based on the results of this analysis, cutoff points were chosen to evaluate dichotomized intake (high vs low) of each food group (quartiles were grouped by odds ratios [ORs] < 1.0 vs > 1.0 ; eg, quartiles 2–4 vs 1 for grains and quartiles 3–4 vs 1–2 for dairy).

Next, a logistic model including all food groups was built using a stepwise approach, and then a food score was created to identify dietary patterns including food groups that were significantly associated with lower (vegetables and grains, healthy food groups) or higher (dairy and sweets, unhealthy food groups) odds of asthma. Participants were assigned a score of +1 for high consumption of healthy food groups or a score of –1 for high consumption of unhealthy food groups. Thus, the score ranged from –2 (most “unhealthy diet”) to +2 (most “healthy diet”). In addition, logistic regression was used to evaluate the relation between cytokine levels and asthma (as a binary outcome); linear regression was used to evaluate the association among food groups, dietary patterns, and cytokine levels (as a continuous

Table 1
Characteristics of study participants^a

Covariate	Control (n = 327)	Cases (n = 351)
Age (y)	10.5 ± 2.7	10.0 ± 2.6 ^c
Boys	159 (48.6)	201 (57.3) ^c
Breastfed		
Never	142 (47.2)	159 (52.8)
≤6 mo	152 (51.4)	144 (48.7)
>6 mo	26 (8.0)	46 (13.1)
Annual household income <\$15,000	196 (62.8)	225 (65.4)
No private or employer-based health insurance	205 (62.7)	239 (68.1)
Parental asthma	103 (31.7)	232 (66.3) ^c
Early-life exposure to ETS	131 (40.2)	174 (49.6) ^c
BMI z-score	0.5 ± 1.1	0.7 ± 1.2
Outdoor activity ^b	240 (73.4)	268 (76.4)

Abbreviations: BMI, body mass index; ETS, environmental tobacco smoke.

^aData are presented as number (percentage) for categorical variables or mean ± SD for continuous variables. Percentages were calculated for children with complete data.^bAt least a moderate amount of outdoor activity, including playing, practicing sports, and walking.^c*P* < .05 for comparison between groups (conducted using 2-sample *t* tests or χ^2 tests, as appropriate).

outcome). SAS 9.3 (SAS Institute, Cary, North Carolina) was used for all analyses.

Results

Compared with children without asthma (*n* = 327), those with asthma (*n* = 351) were slightly younger and more likely to be male and have a history of parental asthma and early-life environmental tobacco smoke exposure (Table 1).

Table 2 presents the prevalence of asthma according to consumption frequency quartile for each food group: a higher intake frequency of dairy products and a lower intake frequency of vegetables or grains were significantly associated with higher prevalence of asthma. In the logistic regression analysis (Table 3), increased consumption of vegetables or grains was significantly and linearly associated with lower odds of asthma, and there was evidence of potential thresholds for the relation between fruits, dairy products, and sweets and asthma.

Cutoff points were chosen to dichotomize the consumption of each group as high or low (Table 4, model 1) based on quartile analyses (quartiles with adjusted ORs [aORs] <1.0 vs >1.0): high intake of dairy products or sweets was associated with higher odds of asthma (aOR 1.72, 95% confidence interval [CI] 1.19–2.49; aOR 1.71, 95% CI 1.12–2.62, respectively), whereas high consumption of grains or vegetables was associated with lower odds of asthma (aOR 0.58, 95% CI 0.38–0.89; aOR 0.46, 95% CI 0.30–0.71, respectively). When simultaneously accounting for other food groups (Table 4, model 2), frequent consumption of grains was associated with decreased odds of asthma (aOR 0.52, 95% CI 0.33, 0.82), whereas frequent intake of dairy products and sweets was associated with higher odds of asthma (aOR 1.93, 95% CI 1.32–2.84; aOR 1.72, 95% CI 1.08–2.72, respectively). The association between dietary patterns and asthma was evaluated. A healthier diet (each 1-point increment in food score) was associated with 36% lower odds of asthma (aOR 0.64, 95% CI 0.53–0.77). The proportion of children with asthma decreased from 75% in the group with the most unhealthy diet (lowest food score) to 34% in the group with the most healthy diet (highest food score; Fig 1; *P* for linear trend <.01). These results remained the same after also adjusting for atopic status (aOR 0.60, 95% CI 0.49–0.73). Confirmatory analysis was conducted using quartiles based only on data from children

Table 2Proportion of children with asthma per quartile^a of food group consumption in study participants (*N* = 678)

Food group	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Fruits	55.6%	48.2%	50.6%	52.7%
Vegetables	60.6%	52.4%	47.0%	47.1% ^b
Grains	63.5%	41.2%	56.9%	45.6% ^b
Protein foods	54.4%	47.1%	49.7%	55.9%
Dairy	50.6%	42.9%	56.8%	56.8% ^b
Fats	56.8%	55.0%	47.7%	47.6%
Sweets, sodas, snacks	52.1%	47.3%	48.5%	59.2%

^aQuartile 1 represents the least consumption and quartile 4 represents the most consumption.^b*P* for linear trend <.05.

without asthma (“healthy” quartiles), which yielded similar results; exploratory analyses stratifying by breastfeeding history also yielded similar results (data not shown).

In the logistic regression analysis, several cytokines were associated with asthma (data not shown): IL-1b (OR 0.64, 95% CI 0.44–0.94) and IL-22 (OR 0.70, 95% CI 0.56–0.88) were associated with lower odds of asthma, and IL-17F (OR 1.34, 95% CI 1.11–1.62) and IL-23 (OR 1.65, 95% CI 1.14–2.38) were associated with higher odds. When the relation between food groups and those 4 cytokines was analyzed, IL-17F was consistently associated with all 4 significant food groups: consumption of vegetables or grains was associated with lower levels of IL-17F, whereas consumption of dairy or sweets was associated with higher levels of IL-17F (eTable 2). The association between IL-17F and dietary patterns was tested: IL-17F decreased from a geometric mean of 22.9 pg/mL in the group with most unhealthy diet to 4.8 pg/mL in the group with the most healthy diet (Fig 1). In addition to lower odds of asthma, a healthier diet was associated with lower IL-17F levels (adjusted β = −1.48 pg/mL, 95% CI −1.78 to −1.20, *P* < .001 after Bonferroni correction for multiple comparisons; eTable 3). This association remained significant after also adjusting for atopic status (data not shown).

Discussion

Frequent consumption of vegetables and grains, but low consumption of dairy products and sweets, was associated with lower plasma levels of IL-17F and decreased risk of childhood asthma. To the authors’ knowledge, this is the first report of an association among dietary intake patterns, IL-17F, and asthma.

Although vegetable and fruit intake has been associated with lower levels of serum C-reactive protein (a marker of systemic inflammation) in Puerto Rican adults,¹⁹ only 14.5% meet recommendations for daily fruit and vegetable intake (and ~91% were not even aware of such recommendations).²⁰ A recent study reported that, on average, Puerto Rican children in New York City consume less fruits and vegetables but more sweetened beverages than children from other ethnic minority groups.²¹ Consistent with this finding, the mean daily fruit and vegetable intakes in the present study were only 1.9 and 1.3 servings per day, respectively. Moreover, only 18.6% of children met the recommended 5 servings of fruits and vegetables per day (data not shown).

The present findings for vegetable consumption are supported by previous studies of children in Canada,²² Greece,²³ and those participating in phase III of the International Study of Asthma and Allergies in Childhood (ISAAC), which did not include the United States or Puerto Rico.²⁴ The present study provides further evidence that more frequent vegetable consumption, a proxy for antioxidant intake, can protect against asthma.

Table 3Logistic regression analysis of quartiles of food group consumption and asthma^a

Food group	Odds ratio (95% confidence interval)			
	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Fruits	1.0	0.56 (0.34–0.95) ^b	0.79 (0.48–1.32)	0.80 (0.48–1.34)
Vegetables	1.0	0.73 (0.43–1.22)	0.48 (0.28–0.81) ^b	0.56 (0.34–0.95) ^{b,c}
Grains	1.0	0.36 (0.21–0.61) ^b	0.69 (0.41–1.18)	0.40 (0.23–0.67) ^{b,c}
Protein foods	1.0	0.76 (0.46–1.26)	0.73 (0.44–1.22)	0.76 (0.45–1.26)
Dairy	1.0	0.64 (0.39–1.06)	1.42 (0.84–2.39)	1.31 (0.78–2.22)
Fats	1.0	0.93 (0.55–1.57)	0.67 (0.40–1.12)	0.82 (0.48–1.37)
Sweets, sodas, snacks	1.0	0.82 (0.49–1.36)	0.80 (0.48–1.35)	1.49 (0.89–2.50)

^aAll models were adjusted for age, sex, household income, parental asthma, body mass index, outdoor physical activity, early-life environmental tobacco smoke, and breastfeeding. Quartile 1 represents the least consumption and quartile 4 represents the most consumption.

^b $P < .05$ compared with lowest (first) quartile.

^c $P < .05$ for linear trend.

Although whole grains might lower the risk of chronic diseases such as coronary heart disease, diabetes, and cancer and might contribute to body weight management and digestive health,²⁵ few studies have examined whether intake of whole grains is associated with respiratory health. Similarly, a higher intake of whole grain products was associated with 54% lower odds of asthma in a study of Dutch school-age children.²⁶ Whole grains might protect against asthma through the antioxidant and anti-inflammatory effects of their contents (vitamins, minerals, and phytonutrients).²⁷ In support of this hypothesis, consumption of whole grains was inversely associated with C-reactive protein serum levels in a study of 13,811 adults in the United States.²⁸

Few studies have reported on dairy product consumption and asthma. In the present study, consumption of dairy products (including pasteurized milk and cheese) was associated with increased odds of asthma. A community-based cross-sectional study of Australian young adults found that cheese intake was inversely associated with asthma but that intake of whole milk was positively associated with increased odds of asthma.²⁹ The present study did not distinguish types of dairy products (whole, low fat, or fat free); whether each type of dairy product affects asthma differently requires further investigation. In a study of Central European children living in farm environments, consumption of raw

Table 4Logistic regression analysis of high vs low food group consumption and asthma^a

Food group	Low	High ^b	
		Model 1	Model 2 ^c
Fruits	1.0	0.71 (0.47–1.08)	—
Vegetables	1.0	0.58 (0.38–0.89) ^d	—
Grains	1.0	0.46 (0.30–0.71) ^e	0.52 (0.33–0.82) ^e
Protein foods	1.0	0.75 (0.50–1.13)	—
Dairy	1.0	1.72 (1.19–2.49) ^e	1.93 (1.32–2.84) ^e
Fats	1.0	0.79 (0.52–1.22)	—
Sweets, sodas, and snacks	1.0	1.71 (1.12–2.62) ^d	1.72 (1.08–2.72) ^d

^aAll models were adjusted for age, sex, household income, parental asthma, body mass index, outdoor physical activity, early-life environmental tobacco smoke, and breastfeeding.

^bHigh vs low: quartiles 2, 3, and 4 vs 1, except for dairy (quartiles 3–4 vs 1–2) and sweets (quartiles 4 vs 1–3).

^cModel 2 was built using all food groups (from model 1) in a stepwise selection approach; thus, each group also is adjusted for the other food groups listed (eg, grains are adjusted for all covariates and for consumption of dairy and sweets).

^d $P < .05$.

^e $P < .01$.

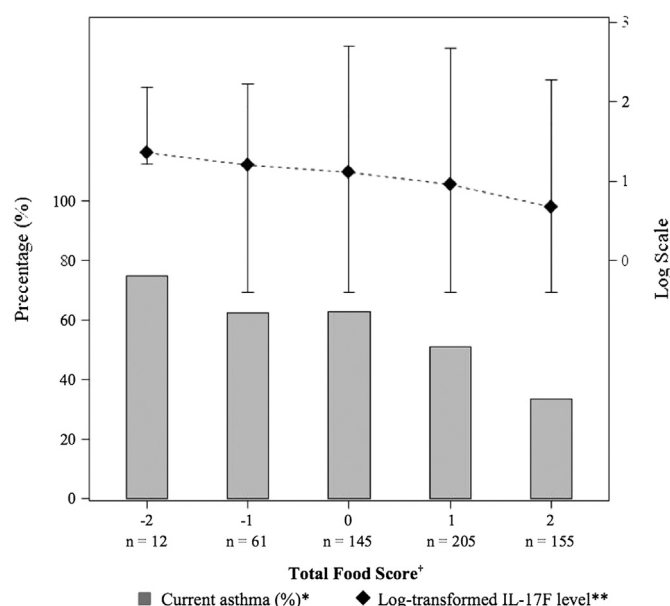


Figure 1. Dietary pattern, interleukin-17F plasma levels, and proportion of children with current asthma ($n = 578$). [†]Participants who had high consumption of vegetables or grains were assigned a score of +1 for each. Those who had higher consumption of dairy products or sweets were assigned a score of -1 for each. The overall dietary pattern is represented by the sum of the 4 individual scores (range -2 for the most “unhealthy diet” to +2 for the most “healthy diet”). ^{*} P for trend $< .01$; ^{**} P for trend = .01.

(but not boiled) milk was associated with lower odds of asthma and atopy, a finding attributed to whey protein in raw milk, which would be rarely consumed by children in urban San Juan.³⁰

A handful of studies have shown an association between sugar intake and asthma. A recent analysis of ecologic data from 53 countries participating in phase III of ISAAC found a positive relation between per-capita sugar consumption and severe asthma symptoms in children.³¹ Daily consumption of soda or soft drinks has been associated with increased risk of asthma in high school students in the United States³² and adults in Australia.³³ Intake of soft drinks and salty snacks might lead to asthma through sensitivity to food preservatives such as sulfites³⁴ or increased sodium content (which has been linked to airway hyperresponsiveness in children with asthma).³⁵ A recent study indicated that non-caloric artificial sweeteners alter microbial metabolic pathways linked to host susceptibility to dysbiosis and glucose intolerance³⁶; dysregulation of these pathways through diet has been linked to airway hyperresponsiveness and allergic airway inflammation.^{7,37} In the present study, children with a healthy diet would have, on average, approximately 83% lower odds of asthma than children with an unhealthy diet. These findings underscore the importance of assessing overall dietary patterns and not only specific nutrients.

The present study is the first to associate a healthier diet with lower IL-17F levels in children with and without asthma. TH17 cells, IL-17A, and IL-17F (which might regulate adipogenesis and glucose homeostasis³⁸) correlate with asthma severity,^{39,40} eosinophilic inflammation,⁴¹ and airway smooth muscle contraction.⁴² Kim et al⁷ recently reported that diet-induced obesity leads to airway hyperresponsiveness in mice, and that this is mediated by IL-17. A handful of studies have suggested that foods rich in energy and lipids produce metabolic stress, leading to higher IL-17 levels, whereas ω -3 polyunsaturated fatty acids and fruit juice inhibit IL-17 production.^{43–46} Thus, the authors postulate that the healthier diet measured by their food score

could lead to lower IL-17 levels, thus decreasing the risk of asthma. The present findings were significant for IL-17F but not for IL-17A, which is consistent with some prior reports.^{47,48} In the present cohort and in other studies of asthma⁴⁸ and other inflammatory conditions,⁴⁹ IL-17A serum levels were markedly lower than those of IL-17F, and thus differences might be more difficult to detect.

The present study has considerable strengths, including a study sample representative of children living in the largest city in Puerto Rico, detailed phenotyping, and the ability to account for different potential confounders. This study also has some limitations. A cross-sectional design does not allow the determination of a temporal relation among dietary intake, cytokine levels, and asthma. However, dietary patterns at school age are likely to be correlated with those in early life. Some complex foods such as pizza, hamburgers, or burritos are difficult to categorize. However, the authors performed a sensitivity analysis removing complex foods (each one separately and all at once) from their assigned groups, without significant changes in the results. In the present cohort, the frequency of food allergy is approximately 10% of participants; the analyses remained unchanged after additional adjustment for the presence of food allergies. Further studies are needed to identify food allergies in relation to dietary patterns in Puerto Rico. Data for food consumption were reported by parents, and thus recall bias, social desirability bias, and inaccurate reporting are possible but unlikely, because food-frequency questionnaires completed by parents of young children have been shown to be accurate.⁵⁰ These findings might not be generalizable to non-Puerto Rican children. However, recent studies have found that unhealthy dietary patterns are common in underserved populations and ethnic minorities on the US mainland.¹⁰

In summary, the present findings suggest that a dietary pattern including frequent consumption of dairy products and sweets, sodas, and snacks but infrequent grain or vegetable intake leads to increased odds of asthma in Puerto Rican children. This might be mediated through an IL-17F-dependent inflammatory pathway. These results further emphasize ongoing public health efforts to foster positive dietary habits (eg, through education and access to food sources) in poor and ethnic minorities in the United States.¹⁰

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Supplementary Data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.janai.2015.07.020>.

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eTable 1

Food groupings from the frequency of consumption questionnaire

Food group	Food item
Fruits (natural fruits or 100% natural juices)	Grape, cranberry or apple juice (100% natural), tropical fruits (orange, pineapple, grapefruit), papaya, cantaloupe, mango, apples, pears, grapes, peaches, plums, ripe bananas, strawberries, kiwis, canned fruit (mandarins, pineapple, fruit cocktail, peaches, pears)
Vegetables	Broccoli, spinach, carrots, squash, iceberg (American), Romaine lettuce, cabbage, Brussels sprouts, coleslaw, sweet corn, cucumber, celery, radishes, onions, green peppers, mixed vegetables or green beans or peas (frozen or canned), starchy vegetables or viands (potatoes, sweet potatoes, yam, taro root), green bananas, green or ripe plantains
Grains (whole grains and refined grains)	Rice, oats, cream of wheat, cornmeal, rice flour, white or wheat bread (sandwich or loaf), ready-to-eat cereals (refined or wheat), popcorn, granola bars, oatmeal cookies, noodle or rice soups (commercial or homemade) ^a , pastas ^a , ham-and-cheese sandwich ^a
Protein foods (meats and meat substitutes)	Chicken, turkey, pork chops, boiled ham sandwich (pork or turkey), seafood (shrimp or lobster), fish (tuna, salmon, codfish, fowl), sausages or hot dog (without bread), boiled egg, bean (white, pink or red), chickpeas, pigeon peas, lentils, nuts (almonds, pecans, walnuts, pistachios, peanuts, sunflower seeds)
Dairy	Plain milk (whole, low fat, 2%, or fat free), chocolate milk (Quick), cheese (any type), white cheese Latin style (eg, Indulac), yogurt (low fat or regular), PediaSure, tacos or burritos ^a
Fats	Mayonnaise, butter, margarine, cream cheese, Mayo-ketchup, salad dressing, tomatoes/spaghetti sauce, ketchup, potato chips, fried green plantains, vegetable oils, olive oil, avocado, pizza ^a , hamburger ^a , hotdog ^a , fritters ^a
Sweets, sodas, and snacks	Chocolates (Snickers, Kit-Kat, M&M), ice cream, ice cream bars or sandwiches (any flavor), lollipops (hard candies), candies or chewy sweets (starbursts), doughnuts, cakes, pastry shop confectionary (eg, Bimbo), sweetened breads (cinnamon bread or Mayorcas), pancakes or French toast, soda crackers or Ritz crackers, Pop Tarts, sugar cookies (Oreo, chocolate chip, macadamia, vanilla), malt drink, colas (regular or diet), Hi-C, Space Gang, Hawaiian Punch, Capri Sun, orange or pineapple juice, West Indian cherry (Acerola) juice, Freezes, Eskimos, Limbers, frozen fruit bars

^aComplex foods were assigned using correlation analysis and added to the group with the highest correlation (eg, pizza correlated best with fats, pasta with grains, etc). Sensitivity analyses removing these items did not alter the main results.

eTable 2T-helper cell type 17 cytokine levels and food groups^a

Cytokine	Vegetable	Grains	Dairy	Sweets
IL-1b	−0.03	−0.02	0.02	0.01
IL-17F	−0.04 ^b	−0.04 ^b	0.04 ^b	0.03 ^b
IL-22	−0.02	−0.01	−0.01	0.004
IL-23	−0.05	−0.01	0.06	−0.05

Abbreviation: IL, interleukin.

NOTE: Cytokine levels were logarithmically transformed for data analysis.

^aData are presented as β values. All models were adjusted for age, sex, household income, parental asthma, body mass index, outdoor physical activity, early-life environmental tobacco smoke, and breastfeeding.

^b $P < .05$.**eTable 3**T-helper cell type 17 cytokine levels and dietary patterns^a

Cytokine	β (95% CI)	P value
IL-1b	−0.02 (−0.07 to 0.02)	.336
IL-17F	−0.17 (−0.25 to −0.08)	<.001
IL-22	−0.01 (−0.08 to 0.07)	.899
IL-23	0.01 (−0.04 to 0.05)	.716

Abbreviations: CI, confidence interval; IL, interleukin.

NOTE: Cytokine levels were logarithmically transformed for data analysis.

^aAll models were adjusted for age, sex, household income, parental asthma, body mass index, outdoor physical activity, early-life environmental tobacco smoke, and breastfeeding.