

Diet and asthma in Lebanese schoolchildren: A cross-sectional study

Diana Malaeb PharmD, Msc, BCPS^{1,2} | Souheil Hallit PharmD, Msc, MPH, PhD^{3,4} |
Hala Sacre PharmD^{4,5} | Bassem Malaeb MD⁶ | Rabih Hallit MD³ |
Pascale Salameh PharmD, MPH, PhD^{2,7,8}

¹ School of Pharmacy, Lebanese International University, Beirut, Lebanon

² Life Sciences and Health Department, Paris-Est University, Paris, France

³ Faculty of Medicine and Medical Sciences, Holy Spirit University of Kaslik (USEK), Jounieh, Lebanon

⁴ INSPECT-LB: Institut National de Sante Publique, Epidemiologie Clinique et Toxicologie, Beirut, Lebanon

⁵ Drug Information Center, Order of Pharmacists in Lebanon, Beirut, Lebanon

⁶ Ain w Zein Medical Center, Shouf, Lebanon

⁷ Faculty of Pharmacy, Lebanese University, Hadath, Lebanon

⁸ Faculty of Medicine, Lebanese University, Hadath, Lebanon

Correspondence

Diana Malaeb, School of Pharmacy, Lebanese International University, Beirut, Lebanon.
Email: diana.malaeb@liu.edu.lb
Souheil Hallit, Building 560, Street 8, Biakout, Lebanon.
Email: souheilhallit@hotmail.com

Abstract

Objectives: The causes of the global increase in asthma in children are unknown. It has been hypothesized that diet is an important factor that may play a role in the pathogenesis of the disease. The objective was to evaluate the association between diet and current asthma among Lebanese children.

Methods: A cross-sectional study was conducted on 1000 children recruited from public and private schools in Lebanon. Of the total enrolled participants, 107 children were diagnosed with current asthma and were analyzed. The food frequency questionnaire was used to assess participants' dietary habits.

Results: The consumption of sweets ≥ 3 times weekly (ORa = 5.42), white bread ≥ 3 times weekly (ORa = 26.38), and olive oil daily (ORa = 9.80) were associated with higher odds of current asthma. Drinking carbonated beverages occasionally (ORa = 0.25) and ≥ 3 times per week (ORa = 0.03) was significantly associated with lower odds of current asthma. Adhering to Mediterranean diet (occasional, >3 times weekly and daily) was significantly associated with lower odds of current asthma compared to never consuming Mediterranean diet (ORa = 0.23 and ORa = 0.22, respectively). The occasional consumption of bread was significantly associated with higher odds of current asthma (ORa = 8.2), whereas daily consumption was significantly associated with lower odds (ORa = 0.336). Moreover, the occasional, ≥ 3 times weekly and daily consumption of meat were significantly associated with higher odds of current asthma (ORa = 9.6; ORa = 5.1 and ORa = 4.5), respectively. An occasional consumption of junk food was significantly associated with lower odds of current asthma (ORa = 0.044), whereas a daily consumption was associated with higher odds.

Conclusion: Adhering to certain diets might be associated with higher odds of current asthma.

KEYWORDS

asthma, children, food, Lebanon

1 | INTRODUCTION

Asthma, a chronic inflammatory airway disease characterized by bronchial hyperresponsiveness, is currently one of the most common childhood diseases mandating chronic drug therapy.¹ Asthma and other allergy-related diseases, such as rhinitis or atopic eczema, have increased dramatically throughout the population, especially among children in the Western world. In April 2017, the World Health Organization (WHO) showed that about 235 million people worldwide have asthma and this tremendous increase in asthma prevalence has become a serious public health issue.² However, the true etiology of asthma is still not well understood.^{3,4} This rapid increase is most likely the result of changes in environmental factors, although the etiology of asthma is strongly linked to genetics.⁵

Asthma in children has been rapidly increasing and is more common in developed countries than in developing countries.⁶ It is a complex disease that has a broad spectrum of potential determinants linked to both protective and exacerbating factors. Diet is one of the factors that affect the development and progression of asthma. Explicitly, in Western countries it is hypothesized that adopting fast food diets (poor in antioxidants such as vitamin A, C, and E, and β -carotene) instead of healthy diets, play a key role in asthma spread.⁷ Effect of diet on asthma pathogenesis could be explained through both immunomodulatory and antioxidant mechanisms. A high fatty diet increases the production of IgE through the formation of arachidonic acid-derived eicosanoids that favor the development of asthma.⁸ High intake of meat and poultry, and excessive consumption of polyunsaturated fatty acids mainly margarine and vegetable oil may also contribute to the tremendous increase in asthma prevalence.⁷ On the other hand, diets rich in vegetables, fruits, nuts, cereals, selenium, and low-fat dairy products inhibit the inflammatory response and increase individuals ability to restrain the inflammatory response and allergic diseases.⁹ Thus, these types of food have a protective effect and would prevent the development of asthma.^{10,11} In fact, several studies established that fish-enriched food has a protective effect and prevent the development of asthma in children.^{12,13} The mechanism by which fish prevent the progression of asthma is through their anti-inflammatory and immunomodulatory properties.¹⁴

Some studies show that adherence to the Mediterranean diet and the consumption of citrus fruits, apples and tomatoes have a protective effect on asthma-like symptoms and atopy.^{15,16} Several studies conducted in France,¹⁴ England,¹⁷ Spain,¹⁸ Lebanon,¹⁹ and Peru^{17,20} evaluated the effect of diet on the diagnosis of asthma. Findings^{14,17} concluded that the Mediterranean diet rich in fruits, vegetables, and fish has an inverse relationship with asthma. To date, there is rare data from studies conducted on Lebanese school children that assessed the impact of diet on asthma development. Hence, the primary objective of this study was to investigate the association of diet and current asthma in a representative sample of Lebanese schoolchildren.

2 | METHODS

2.1 | General study design

A cross-sectional study was conducted between January and June 2017 on Lebanese students from public and private schools.

The standardized ISAAC questionnaire was used, after translation into Arabic and back translation into English to ensure the accuracy of questions.²¹ The list of schools, provided by the Lebanese Ministry of Higher education, was used to randomly select the centers.

Seventeen public schools were contacted from all Lebanese geographic areas: 5 in Beirut; 3 in South Lebanon; 1 in Nabatieh; 2 in Mount Lebanon; 5 in North Lebanon; and 1 in Bekaa. For recruitment in private institutions, 17 schools were contacted: 6 in Beirut, 6 in Mount Lebanon; 2 in North Lebanon; 1 in Nabatieh; 2 in Bekaa. Eight schools (1 public and 7 private) refused to participate, while 26 out of 34 (73.3%) agreed to distribute the questionnaires to their students between the first and the ninth grade. Eligible participants were randomly selected from each school using an online randomization program. Students had to take the questionnaires home in a sealed envelope to be filled out by their parents, who were also asked to sign the written informed consent and return it along with the questionnaire to be collected by the enquirer. Participants with a chronic respiratory condition other than asthma such as cystic fibrosis were excluded from the study.

2.2 | Ethical aspect

The Institutional Review Board of the Lebanese International University Faculty of Pharmacy waived the need for an approval based on the fact that it was an observational study that respected participants' autonomy and confidentiality and induced minimal harm to them.

2.3 | Questionnaires

Standardized questionnaires were distributed to the participants meeting the inclusion criteria to document current asthma status and assess respiratory symptoms using validated questions from the ISAAC questionnaire.²¹ In addition to dietary and medical history information, the questionnaire encompassed a section on demographics, including age, gender, current height, and weight, the number of younger and older siblings, and caregiver education. The questionnaires were collected anonymously from all age groups.

The respiratory health status of the child was assessed using the ISAAC questionnaire.²¹ A current asthma status was defined by asthma previously diagnosed by a physician, in addition to wheezing/whistling in the chest over the past 12 months. A chronic respiratory symptom was considered if any of the following was positive: wheezing, cough, difficulty breathing, or chest congestion. The presence of cough was defined by a positive answer to the question: "In the last 12 months, have you ever noticed your child having a dry cough at night, apart from cough but associated with a cold or chest infection?" while the presence of wheezing was defined by a positive answer to the question "Has your child ever had wheezing or whistling in the chest at any time in the past?" To know if the child had respiratory problems, the question used was "Have you ever found your child having difficulty breathing?" A positive answer to the following question revealed the presence of bronchial congestion:

"Have you found your child complaining from nasal congestion?" and "Do you currently see your child having chest congestion?" Healthy individuals have been defined by the absence of any of the symptoms mentioned above that support current asthma, and the absence of any bronchial symptoms. Additional information about the questionnaire can be found in previous papers.^{19,22–28}

2.4 | Dietary assessment

Participants' dietary habits were assessed using a food frequency questionnaire (FFQ) previously adapted and used among Lebanese children, consisting of 16 semi-quantitative questions covering different food categories (including the five basic food categories typically consumed by the Lebanese population).^{29,30}

The FFQ included the following food and dietary items commonly consumed by children: vegetables (cooked and raw), fruits, olive oil, fish and sea food, meats (including cooked meats, poultry, ham, and hotdog), pasta, sweets (cake, ice cream, chocolate), dairy products, carbonated beverages, fruit juice, fast food (hamburger, pizza), Lebanese pizza (known as Mankouche with thyme or cheese or yogurt-based kechek), fried potatoes and chips.^{29,30} All subjects were asked about the usual frequency of intake of different food items during the last 12 months and were asked to report the frequency of these intakes per week (never, occasional, more than three times per week, daily). In addition, a question was added, independently from the FFQ, to assess the fatty acids most consumed by children (butter, margarine, and vegetable oil).

2.5 | Statistical analysis

The questionnaires were coded and the collected data were introduced using Statistical Package for Social Sciences (SPSS) software, version 23.0 by an independent person who was unaware of the objectives of the study. All continuous variables were presented as mean (M) and standard deviation (SD), and the categorical variables were presented as frequencies. Correlations between dietary factors and health outcomes were determined by the Pearson chi-square test; if the cell count was below 5, the Fisher's exact test was applied. The Student t-test was used to compare the means between the groups. Multiple logistic regressions models were used to assess the association between dietary factors and the presence/absence of current asthma (taken as the dependent variable) that showed a $P < 0.2$ in the bivariate analysis. Potential confounders may be eliminated only if $P > 0.2$, in order to protect against residual confounding. We ensured model adequacy to the data by the use of the Hosmer Lemeshow test. Adjusted odds ratios (ORa) were then calculated. A $P < 0.05$ was considered statistically significant.

2.6 | Identifying dietary patterns among school students

In nutritional epidemiology, various statistical methods are used to derive common eating patterns among specific populations.

The most common one is factor analysis which derives patterns based on inter-correlations between food items/groups. In this study, factor analysis was used to identify food group patterns based on inter-correlations between these food components. An exploratory factor analysis was performed to identify patterns of food categories consumed by school children from our sample, that is, to look at food items that were consumed at the same frequency by individuals. After ensuring sample adequacy with the Kaiser–Meyer–Olkin (KMO) index and Bartlett's Chi square test of sphericity, factors of food categories consumption were extracted using the principal component analysis and using a promax rotation. Factors with Eigenvalues higher than one were retained; confirmation of adequacy with a Scree plot was performed and interpretability of the results was taken into account. Items with factor loading ≥ 0.4 were considered as belonging to a factor. Reliability analysis was performed by Cronbach's alpha values for factors and the total scale. Each factor was then divided into categories to represent the frequency of intake (never, occasional, ≥ 3 times weekly and daily).

3 | RESULTS

Out of 1200 questionnaires distributed in schools, 1000 (83.33%) were collected back. There were 807 healthy children, 86 children with probable asthma (chronic respiratory symptoms) and 107 with current asthma. Patients with probable asthma were excluded from the analysis. There were missing values in our results since not all questions were answered by all parents.

Table 1 summarizes the sociodemographic and socioeconomic factors. The results showed that our sample included 49.6% boys and 50.4% girls. The mean age of the children was 10.34 ± 3.96 years, with almost similar distribution among governorates. Eighty-four percent of these children received all their vaccinations, while 47% were delivered by C-section. Half of the fathers and 35.7% of the mothers smoked, with the highest proportion of both parents having a secondary level of education.

3.1 | Factor analysis

Six factors were created where each factor represented a group of food items with similar frequency of consumption among interviewed subjects. Factor one included chocolate, chips, beverages, sweets, pastry, French fries, and fast food and was named carbohydrate and fried/junk food diet. Factor two included vegetables, fruits, and named vegetables and fruits Diet. Factor three included brown and white bread and was simply named "bread." Factor four included fish and olive oil and was called Mediterranean Diet. Factor five included red meat, and factor six included milk and dairy products and was named dairy products diet.

Out of all the food items, one item (nuts) was removed. All remaining items could be extracted from the list, since no items

TABLE 1 Characteristics of the children who underwent study enrollment and their parents who completed the questionnaire

Variable	Children	Mother	Father
Age, years (m ± SD)	10.34 ± 3.96		
Gender – no (%)			
Male	496 (49.6)		
Female	504 (50.4)		
Place of baby residence – no (%)			
Beirut	143 (14.3)		
Mount Lebanon	139 (13.9)		
South	149 (14.9)		
North	138 (13.8)		
Bekaa	121 (12.1)		
Nabatieh	150 (15.0)		
Akkar	160 (16.0)		
School type – no (%)			
Private	80 (8.0)		
Public	920 (92.0)		
Child vaccinations – no (%)			
No	153 (15.3)		
Yes	847 (84.7)		
Method of baby delivery – no (%)			
Normal	530 (53.0)		
C-section	470 (47.0)		
Asthmatic diagnosis – no (%)	107 (10.7)		
Child still suffering from asthma – no (%)			
No	44 (4.4)		
Yes	63 (6.3)		
Smoke regularly – no (%)		357 (35.7)	503 (50.3)
Level of education			
Illiterate		25 (2.5)	28 (2.8)
Primary school		43 (4.3)	194 (19.4)
Complementary		187 (18.7)	325 (32.5)
Secondary school		482 (48.2)	345 (34.5)
University		263 (26.3)	108 (10.8)
Smoking			
Cigarettes		215 (21.5)	369 (36.9)
Waterpipe		135 (13.5)	108 (10.8)
Others		7 (0.7)	7 (0.7)
Family history of asthma			
Sister	2 (0.2)	9 (9.0)	57 (5.7)
Brother	25 (2.5)		
Others	26 (2.6)		
Family history of eczema			
Sister	8 (0.8)	11 (1.1)	7 (0.7)
Family history of allergic rhinitis			
Sister	11 (1.1)	15 (1.5)	7 (0.7)

(Continues)

TABLE 1 (Continued)

Variable	Children	Mother	Father
Brother	26 (2.6)		
Others	23 (2.3)		
Kindergarten child attendance	180 (18.0)		
Number of siblings older than child			
No	199 (19.9)		
1-2 siblings	533 (53.3)		
>3 siblings	268 (26.8)		
Number of siblings younger than child			
No	381 (38.1)		
1-2 siblings	511 (51.1)		
>3 siblings	108 (10.8)		

over-correlated to each other ($r > 0.9$), had a low loading on factors (< 0.3) or because of a low communality (< 0.3). The factor analysis for the items was run over the whole sample (Total $n = 1000$). The items converged over a solution of six factors that had an Eigenvalue over 1, explaining a total of 72.86% of the variance. A Kaiser-Meyer-Olkin measure of sampling adequacy of 0.690 was found, with a significant Bartlett's test of sphericity ($P < 0.001$). According to the promax rotated matrix, the components are summarized in Table 2. Moreover, an acceptable Cronbach's alpha was found for the full scale (0.743).

3.2 | Bivariate analysis

When comparing healthy children to those with current asthma, the bivariate analysis showed that a higher proportion of asthmatic children significantly consumed sweets ≥ 3 times per week (27.1 vs 12.9%), chocolate ≥ 3 times per week (28.0 vs 14.3 %), those never eating brown bread (83.2 vs 58.7%), white bread ≥ 3 times per week (22.4 vs 7.4 %), milk ≥ 3 times per week (33.0 vs 16.6%), never drinking carbonated beverages (20.8 vs 7.2 %), pastry on a daily basis (28.0 vs

TABLE 2 Promax rotated matrix of the dietary items

Factor	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	h ² communalities
Chocolate	0.833						0.708
Chips	0.832						0.689
Carbonated beverages	0.797						0.638
Fast food	0.779						0.632
Sweets	0.734						0.629
Pastry	0.637						0.752
Fried food (French fries, nuggets)	0.570						0.639
Vegetables		0.901					0.840
Fruits		0.845					0.762
Brown bread			-0.922				0.862
White bread			0.827				0.834
Fish				0.828			0.650
Olive oil				0.774			0.684
Red meat					0.807		0.766
Milk						0.881	0.787
Dairy products						0.723	0.647
Percentage of variances explained	25.10%	13.49%	0.85%	8.77%	8.32%	7.32%	

Factor 1: Carbohydrate and fried/junk food Diet; Factor 2: Vegetables and fruits Diet; factor 3: Bread Diet; Factor 4: Mediterranean Diet; factor 5: Meat Diet; Factor 6: Dairy Products.

Cronbach alpha for all items = 0.743

5.8%), French Fries/nuggets ≥ 3 times per week (32.4 vs 21.0 %), olive oil on a daily basis (70.5 vs 44.9%), dairy products ≥ 3 times per week (31.8 vs 18.2 %), occasional vegetables intake (25.5 vs 8.0%), ≥ 3 times per week of red meat (45.8 vs 25.1%), ≥ 3 times per week of fast food (18.1 vs 4.5 %) and ≥ 3 times per week of fish (20.6 vs 8.5%) more than healthy children respectively. Furthermore, a higher percentage of current asthmatic children came from private schools ($P < 0.001$) and had a positive family history of asthma, eczema, allergy or allergic rhinitis ($P < 0.001$) (supplementary Table S1).

3.3 | Dietary patterns of school children

The bivariate analysis of food factors with current asthma compared to healthy patients showed that a significantly higher proportion of asthmatic children consumed the Mediterranean diet daily (39.3% vs 21.9%), occasional intake of bread diet (43.0% vs 21.8%), daily intake of meat (37.4% vs 22.6%), daily intake of junk food (57.9% vs 22.3%) and daily intake of dairy products (35.5% vs 25.1%), respectively (Table 3).

3.4 | Multivariable analysis

A first logistic regression, taking each food item as an independent variable, showed that eating sweets occasionally (ORa = 12.34) and ≥ 3 times per week (ORa = 5.417), white bread ≥ 3 times per week (ORa = 26.38) and consuming olive oil daily (ORa = 9.8) were significantly associated with higher odds of current asthma. Drinking carbonated beverages occasionally (ORa = 0.246) and ≥ 3 times per week (ORa = 0.033) was significantly associated with lower odds of current asthma, respectively. Furthermore, males had significantly more current asthma than females (ORa = 0.611) and being in a private school was significantly associated with higher odds of current asthma (ORa = 2.49); same as for a positive family history of current asthma (ORa = 10.36) and allergy (ORa = 6.64) (supplementary Table S2).

A second logistic regression, taking the factors obtained in the factor analysis as independent variables, showed that occasional and daily consumption of the Mediterranean diet were significantly associated with lower odds of current asthma (OR = 0.23 and OR = 0.22) respectively. Consuming "Bread diet" occasionally was significantly associated with higher odds of current asthma (OR = 8.2), whereas its daily consumption was significantly associated with lower odds (OR = 0.336). Moreover, the occasional, ≥ 3 times per week and daily consumption of Meat diet were significantly associated with higher odds of current asthma (OR = 9.6; OR = 5.1 and OR = 4.5) respectively. An occasional consumption of junk food diet was significantly associated with lower odds of current asthma (OR = 0.044), whereas a daily consumption was associated with higher odds of current asthma by 14 times. Finally, the consumption of dairy products occasionally, ≥ 3 times per week and daily were significantly associated with higher odds of current asthma by 19 times, 11.8 times, and 9.5 times, respectively (Table 4).

4 | DISCUSSION

In this cross-sectional study, we present findings on the major food categories and dietary patterns adopted by a large sample of Lebanese schoolchildren. We highlighted some factors related to higher odds of current asthma (occasional consumption of bread diet, consumption of meat diet occasionally, ≥ 3 times per week and daily, daily consumption of junk food and the consumption of dairy products occasionally, ≥ 3 times per week and daily). On another hand, the adherence to the Mediterranean diet was significantly associated with lower odds of current asthma.

Our results showed that daily intake of fast food was significantly associated with higher odds of current asthma. Our findings are consistent with the results of other conducted studies, which found positive associations between fast food consumption and the prevalence of wheeze.^{31,32} The underlying plausible mechanism for this positive relationship is that fast food consumption is rich in hydrogenated fats, known to be sources of trans-fatty acids, which are strongly linked to allergic diseases and asthma.¹¹ Moreover, the addition of fat in the diet might be involved in the pathophysiology of atopic diseases since consumed fat modulate immune reactions.⁷ Reduction in saturated fat increased the prevalence of allergic diseases and asthma.³³ Dairy products and milk is a source of saturated fat and is associated with a lower risk of allergic diseases and asthma. Some studies reported that excessive milk intake can protect against allergic diseases.³⁴ Our study showed that less frequent milk consumption lowered the current asthma risk.

The study results also demonstrated that daily fish intake protects against current asthma, which is consistent with the results of an epidemiological study.³⁵ Scientific evidence suggests that ω -3 fatty acids, highly present in fish, would protect against developing asthma. However, other studies showed contradictory results and demonstrated that the intake of fish increases the risk of asthma and wheeze.³⁵⁻³⁷

We found that daily intake of fruits exerted a protective effect on current asthma, which was expected since antioxidants and the biological active factors in fruits have a favorable effect. The possible mechanism is that reactive oxygen species, released from eosinophils, and neutrophils might play a key role in asthma development. They contract airways smooth muscle, stimulate both histamine release from mast cells and mucus secretion.³⁸ Therefore, the inverse relation between dietary antioxidant intake and wheezing episodes is that vitamin C in fruits, the major antioxidant present in the airway surface liquid of the lung, protects against endogenous oxidants. This finding is in agreement with the previous studies conducted on children.^{16,17}

In this study, carbonated beverages were shown to be associated with lower odds of asthma. However, soft drinks contain large amounts of sugar and its consumption increases susceptibility to allergic airway inflammation and activates the innate immune system in the lung.³⁹ The mechanisms linking soft drink consumption to asthma are unclear. Foods that may promote oxidative stress and inflammation could theoretically have effects on the pathogenesis of asthma since asthma is highly associated with inflammation.³⁹

TABLE 3 Bivariate analysis of the food factors with current asthma

Factor	Absence of current asthma	Presence of current asthma	P-value
Carbohydrate and fried/junk food diet			0.089
Never	218 (24.4%)	35 (32.7%)	
Occasional	242 (27.1%)	19 (17.8%)	
>3 times/week	214 (24%)	23 (21.5%)	
Daily	219 (24.5%)	30 (28%)	
Vegetables and fruits diet			<0.001
Never	221 (24.7%)	29 (27.1%)	
Occasional	221 (24.7%)	28 (26.2%)	
>3 times/week	196 (21.9%)	42 (39.3%)	
Daily	255 (28.6%)	8 (7.5%)	
Bread diet			<0.001
Never	(26.1%)	17 (15.9%)	
Occasional	(21.8%)	46 (43%)	
>3 times/week	(25.1%)	34 (31.8%)	
Daily	241 (27%)	10 (9.3%)	
Mediterranean diet			<0.001
Never	221 (24.7%)	29 (27.1%)	
Occasional	221 (24.7%)	28 (26.2%)	
>3 times/week	196 (21.9%)	42 (39.3%)	
Daily	255 (28.6%)	8 (7.5%)	
Red meat diet			<0.001
Never	227 (25.4%)	(12.1%)	
Occasional	255 (28.6%)	(4.7%)	
>3 times/week	212 (23.7%)	(25.2%)	
Daily	199 (22.3%)	62 (57.9%)	
Dairy products diet			0.01
Never	239 (26.8%)	(15.9%)	
Occasional	220 (24.6%)	(18.7%)	
>3 times/week	210 (23.5%)	(29.9%)	
Daily	224 (25.1%)	38 (35.5%)	

However, the results obtained in this study might not be totally reliable since we did not account for other factors, such as obesity and smoking that would increase the odds of current asthma along with the consumption of carbonated beverages. More studies are needed to evaluate this association in depth.

Additionally, olive oil used in cooking and salads dressing exhibit an anti-oxidant effect, where the main active components of olive oil are oleic acid, phenolic derivatives (hydroxytyrosol, tyrosol, oleuropein, and liguostroside), and squalene, all of which are responsible to exert the protective effects on asthma and allergic diseases.⁴⁰ However, in this study olive oil consumption was associated with higher risk of current asthma probably due to the fact that in this study group mainly children salads consumption is low compared to other age categories and olive oil is not mainly used in cooking in the Lebanese population.

4.1 | Sociodemographic factors

Our study findings showed that males are at a higher risk for current asthma than females, which is similar to what is described in the literature,^{26,41} although the exact mechanisms for sex-related differences in asthma have not been fully determined.

We also found a significant association between the positive family history for allergies and current asthma in children, which is consistent with the results of other studies.^{41,42} Study results examining asthma family risk have been inconclusive with some pointing to a maternal link, others to a paternal link, and others have not found an association between asthma and family history.^{43,44} Nevertheless, our results reinforce previous findings that show an association between father history of asthma and childhood current asthma, that may be genetically or both genetically and

TABLE 4 Multivariable analysis. Logistic regression taking the presence vs absence of current asthma as the dependent variable and the food factors as independent variables

Variable	P-value	ORa	95% Confidence Interval	
Sex (females ^a vs males)	0.006	2.174	1.157	3.773
School type (private ^a vs public school)	0.019	.349	0.145	0.752
Mediterranean diet ^b	<0.001			
Occasional	.002	0.230	0.090	0.956
>3 times/week	0.123	1.817	0.850	2.983
Daily	0.005	0.222	0.079	0.667
Bread diet ^b	<0.001			
Occasional	<0.001	8.268	3.356	14.563
>3 times/week	0.219	.535	0.198	1.063
Daily	0.036	.336	0.121	0.978
Meat diet ^b	0.001			
Occasional	<0.001	9.673	3.170	20.386
>3 times/week	0.001	5.133	1.982	12.322
Daily	0.004	4.530	1.617	9.611
Junk food diet ^b	<0.001			
Occasional	<0.001	.044	0.012	1.051
>3 times/week	0.887	1.065	0.451	2.854
Daily	<0.001	14.685	5.837	
Dairy products ^b	<0.001			
Occasional	<0.001	19.038	6.310	30.354
>3 times/week	<0.001	11.866	4.403	18.713
Daily	<0.001	9.565	3.806	18.622

^aReference group.^bFood factors compared to low consumption category.

environmentally mediated.^{43,45} Clinicians, specifically pediatricians, may be able to use parent and grandparent family history as an indicator for identification of asthma in early childhood and determine the need for diagnostic assessments.⁴⁶

The study also showed that breastfeeding is a protective factor against current asthma. Previous findings concluded that breastfeeding reduces childhood asthma and other allergic diseases.⁴⁷ The underlying reason for the inverse relation between breastfeeding and asthma is that breast milk and the avoidance of cow's milk protein prevent the development of wheezing and asthma in children.⁴⁸

4.2 | Limitations and strengths

The present study has some potential limitations. The lack of accountability for multiple testing should be acknowledged, with a reasonable chance of false discovery. Participants' recall about food intake might be a source of bias. The FFQ was adapted to Lebanese children but not validated in Lebanon. It is a cross-sectional study where the findings cannot establish a causal relationship. However, we have no reason to think that current asthmatic children are changing eating behaviors due to asthma diagnosis, since the

association between asthma and food is still unclear; this reinforces the associations that were found. Nevertheless, prospective studies are needed to consolidate the relationship between asthma and diet to better understand the effect that different food categories may have. Finally, residual confounding is possible since it is likely that we did not take all confounders of the association into account, particularly the ones related to pollution; studies that include the effect of pollution into account are suggested to further refine the associations we found.

The strengths of this study are the large number of subjects recruited from all Lebanese geographic areas and the utilization of the validated version of the FFQ that covers nearly all the specific information on the frequency of the different food items. The diagnosis of probable and diagnosed asthma was established in accordance with international criteria.

5 | CONCLUSION

In addition to the known risk factors of asthma, diet seems to be a potential risk factor too. Although additional studies are needed to

confirm these findings, this study provides evidence that adopting a healthy diet rich in fruits, fish, and natural antioxidants is inversely related to current asthma. Accordingly, a healthy lifestyle and parent awareness are essential to the prevention of asthma.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

REFERENCES

- Gupta R, Sheikh A, Strachan DP, Anderson HR. Burden of allergic disease in the UK: secondary analyses of national databases. *Clin Exp Allergy*. 2004;34:520–526.
- Global Initiative for Asthma website. 2017 GINA Report. Global Strategy for Asthma Management and Prevention. Available from: https://www.researchgate.net/publication/324814416_Wheezing_phenotypes_and_risk_factors_in_early_life_The_ELFE_cohort.
- Penard-Morand C, Raherison C, Charpin D, et al. Long-term exposure to close-proximity air pollution and asthma and allergies in urban children. *Eur Respir J* 2010;36:33–40.
- Saadeh D, Salameh P, Baldi I, Raherison C. Diet and allergic diseases among population aged 0 to 18 years: myth or reality? *Nutrients*. 2013;5:3399–3423.
- Beasley R. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. *The Lancet*. 1998;351:1225–1232.
- Pin I, Pilenko-McGuigan C, Cans C, Gousset M, Pison C. Epidemiology of respiratory allergy in children. *Archives de pediatrie: organe officiel de la Societe francaise de pediatrie*. 1999;6:6S–13S.
- Devereux G, Seaton A. Diet as a risk factor for atopy and asthma. *J Allergy Clin Immunol*. 2005;115:1109–1117. quiz 1118.
- Calder PC. Polyunsaturated fatty acids and cytokine profiles: a clue to the changing prevalence of atopy? *Clin Exp Allergy*. 2003;33:412–415.
- Hughes DA. Dietary carotenoids and human immune function. *Nutrition* 2001;17:823–827.
- Arvaniti F, Priftis KN, Papadimitriou A, et al. Adherence to the Mediterranean type of diet is associated with lower prevalence of asthma symptoms, among 10–12 years old children: the PANACEA study. *Pediatr Allergy Immunol*. 2011;22:283–289.
- Nagel G, Weinmayr G, Kleiner A, Garcia-Marcos L, Strachan DP, Group IPTS. Effect of diet on asthma and allergic sensitisation in the International Study on Allergies and Asthma in Childhood (ISAAC) Phase Two. *Thorax*. 2010;65:516–522.
- Chatzi L, Torrent M, Romieu I, et al. Diet, wheeze, and atopy in school children in Menorca, Spain. *Pediatric allergy and immunology* 2007;18:480–485.
- Tabak C, Wijga AH, de Meer G, Janssen NA, Brunekreef B, Smit HA. Diet and asthma in Dutch school children (ISAAC-2). *Thorax* 2006;61:1048–1053.
- Saadeh D, Salameh P, Caillaud D, et al. Prevalence and association of asthma and allergic sensitization with dietary factors in schoolchildren: data from the french six cities study. *BMC Public Health*. 2015;15:993.
- Chatzi L, Apostolaki G, Bibakis I, et al. Protective effect of fruits, vegetables and the Mediterranean diet on asthma and allergies among children in Crete. *Thorax*. 2007;62:677–683.
- Farchi S, Forastiere F, Agabiti N, et al. Dietary factors associated with wheezing and allergic rhinitis in children. *Eur Respir J*. 2003;22:772–780.
- Bakolis I, Hooper R, Thompson RL, Shaheen SO. Dietary patterns and adult asthma: population-based case-control study. *Allergy*. 2010;65:606–615.
- Castro-Rodriguez JA, Garcia-Marcos L, Rojas JDA, Valverde-Molina J, Sanchez-Solis M. Mediterranean diet as a protective factor for wheezing in preschool children. *J Pediatr*. 2008;152:823–828. e822.
- Hallit S, Raherison C, Abou Abdallah R, Hallit R, P Salameh. Correlation of types of food and asthma diagnosis in childhood: a case-control study. *J Asthma* 2018;55:1–9.
- Rice JL, Romero KM, Galvez Davila RM, et al. Association between adherence to the Mediterranean diet and asthma in peruvian children. *Lung* 2015;193:893–899.
- Asher MI, Keil U, Anderson HR, et al. International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods. *Eur Respir J*. 1995;8:483–491.
- Hallit S, Assi TB, Hallit R, Salameh P. Allergic diseases, smoking, and environmental exposure among university students in Lebanon. *J Asthma*. 2018;55:35–42.
- Hallit S, Raherison C, Waked M, Hallit R, Layoun N, Salameh P. Validation of the mini pediatric asthma quality of life questionnaire and identification of risk factors affecting quality of life among Lebanese children. *J Asthma*. 2018;1–11.
- Hallit S, Raherison C, Waked M, Salameh P. Association between caregiver exposure to toxics during pregnancy and childhood-onset asthma: a case-control study. *Iran J Allergy Asthma Immunol*. 2017;16:488–500.
- Hallit S, Raherison C, Waked M, Salameh P. Validation of asthma control questionnaire and risk factors affecting uncontrolled asthma among the Lebanese children's population. *Respir Med*. 2017;122:51–57.
- Hallit S, Salameh P. Exposure to toxics during pregnancy and childhood and asthma in children: a pilot study. *J Epidemiol Glob Health*. 2017;7:147–154.
- Hallit S, Raherison C, Malaeb D, Hallit R, Kheir N, Salameh P. The AAA risk factors scale: a new model to screen for the risk of asthma, allergic rhinitis and atopic dermatitis in children. *Med Princ Pract*. 2018;27:472–480.
- Hallit S, Raherison C, Malaeb D, et al. Development of an asthma risk factors scale (ARFS) for risk assessment asthma screening in children. *Pediatr Neonatol*. 2018. <https://doi.org/10.1016/j.pedneo.2018.05.009>
- Salameh P, Jomaa L, Issa C, et al. Assessment of dietary intake patterns and their correlates among university students in Lebanon. *Front Public Health*. 2014;2:185.
- Issa C, Darmon N, Salameh P, Maillot M, Batal M, Lairon D. A Mediterranean diet pattern with low consumption of liquid sweets and refined cereals is negatively associated with adiposity in adults from rural Lebanon. *Int J Obes*. 2011;35: 251.
- Robertson C. The association between fast food outlets and the prevalence of symptoms of asthma from the International Study of Asthma and Allergies in Childhood (ISAAC). *Eur Respir J*. 1998;12:244s.
- Wickens K, Barry D, Friezeema A, et al. Fast foods – are they a risk factor for asthma?. *Allergy*. 2005;60:1537–1541.
- Black PN, Sharpe S. Dietary fat and asthma: is there a connection? *Eur Respir J*. 1997;10:6–12.
- Woods RK, Walters EH, Raven JM, et al. Food and nutrient intakes and asthma risk in young adults. *Am J Clin Nutr*. 2003;78:414–421.
- Nafstad P, Nystad W, Magnus P, Jaakkola JJ. Asthma and allergic rhinitis at 4 years of age in relation to fish consumption in infancy. *J Asthma*. 2003;40:343–348.
- Miyake Y, Sasaki S, Arakawa M, Tanaka K, Murakami K, Ohya Y. Fatty acid intake and asthma symptoms in Japanese children: the Ryukyus Child Health Study. *Clin Exp Allergy*. 2008;38:1644–1650.
- Miyake Y, Tanaka K, Sasaki S, Arakawa M. Polyunsaturated fatty acid intake and prevalence of eczema and rhinoconjunctivitis in Japanese children: the Ryukyus Child Health Study. *BMC Public Health*. 2011;11:358.
- Kita H. Eosinophils: multifaceted biological properties and roles in health and disease. *Immunol Res*. 2011;242:161–177.

39. Shi Z, Dal Grande E, Taylor AW, Gill TK, Adams R, Wittert GA. Association between soft drink consumption and asthma and chronic obstructive pulmonary disease among adults in Australia. *Respirology*. 2012;17:363–369.
40. Castro-Rodriguez JA, Garcia-Marcos L. What are the effects of a mediterranean diet on allergies and asthma in children? *Front Pediatr*. 2017;5:72.
41. Waked M, Salameh P. Maternal waterpipe smoke exposure and the risk of asthma and allergic diseases in childhood: a post hoc analysis. *Int J Occup Med Environ Health*. 2015;28:147–156.
42. Watson W, Kapur S. Atopic dermatitis. *Allergy Asthma Clin Immunol*. 2011;7:S4.
43. Kuiper S, Muris JW, Dompeling E, et al. Association between first-degree familial predisposition of asthma and atopy (total IgE) in newborns. *Clin Exp Allergy*. 2006;36:594–601.
44. Dik N, Tate RB, Manfreda J, Anthonisen NR. Risk of physician-diagnosed asthma in the first 6 years of life. *Chest*. 2004;126:1147–1153.
45. Mingomataj EC, Xhixha F, Gjata E, Hyso E, Qirko E. Prevalence of a family history of atopic disease among 3 generations of atopic respiratory patients in Tirana, Albania. *J Investig Allergol Clin Immunol*. 2008;18:190–193.
46. Valerio MA, Andreski PM, Schoeni RF, McGonagle KA. Examining the association between childhood asthma and parent and grandparent asthma status: implications for practice. *Clin Pediatr (Phila)*. 2010;49:535–541.
47. Kneepkens CM, Brand PL. Clinical practice: breastfeeding and the prevention of allergy. *Eur J Pediatr*. 2010;169:911–917.
48. Pali-Scholl I, Renz H, Jensen-Jarolim E. Update on allergies in pregnancy, lactation, and early childhood. *J Allergy Clin Immunol*. 2009;123:1012–1021.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Malaeb D, Hallit S, Sacre H, Malaeb B, Hallit R, Salameh P. Diet and asthma in Lebanese schoolchildren: A cross-sectional study. *Pediatric Pulmonology*. 2019;1–10.
<https://doi.org/10.1002/ppul.24280>

Supplementary tables

Supplementary Table 1: Bivariate analysis of factors associated with current asthma.				
Variable	Healthy	Diagnosed Asthma	Pearson Chi-Square	P-value
Sweets			27.397	<0.0001
Never	0 (0.0)	1 (0.9)		
Occasional	451 (50.6)	36 (33.6)		
>3 times per week	115 (12.9)	29 (27.1)		
Daily	325 (36.5)	41 (38.3)		
Chocolate			15.265	0.002
Never	27 (3)	1 (0.9)		
Occasional	274 (30.8)	32 (29.9)		
>3 times per week	127 (14.3)	30 (28.0)		
Daily	463 (52.0)	44 (41.1)		
Brown Bread			25.358	<0.0001
Never	523 (58.7)	89 (83.2)		
Occasional	218 (24.5)	12 (11.2)		
>3 times per week	47 (5.3)	0 (0.0)		
Daily	103 (11.6)	6 (5.6)		
White Bread			34.434	<0.0001
Never	65 (7.3)	2 (1.9)		
Occasional	149 (16.7)	7 (6.5)		
>3 times per week	66 (7.4)	24 (22.4)		
Daily	611 (68.6)	74 (69.2)		
Milk			67.587	<0.0001
Never	113 (12.7)	19 (17.9)		
Occasional	550 (61.7)	24 (22.6)		
>3 times per week	148 (16.6)	35 (33.0)		
Daily	80 (9.0)	28 (26.4)		
Beverages			31.997	<0.0001
Never	64 (7.2)	22 (20.8)		
Occasional	460 (51.6)	54 (50.9)		
>3 times per week	233 (26.2)	10 (9.4)		
Daily	134 (15.0)	20 (18.9)		
Pastry			65.021	<0.0001
Never	28 (3.1)	0 (0.0)		
Occasional	691 (77.6)	68 (63.6)		
>3 times per week	120 (13.5)	9 (8.4)		
Daily	52 (5.8)	30 (28.0)		
Chips			7.296	0.063
Never	53 (6.0)	0 (0.0)		

Occasional >3 times per week Daily	389 (44.2) 266 (30.2) 173 (19.6)	51 (48.6) 30 (28.6) 24 (22.9)		
Frites, nuggets, escalope Never Occasional >3 times per week Daily	28 (3.1) 610 (68.5) 187 (21.0) 66 (7.4)	1 (1.0) 64 (61.0) 34 (32.4) 6 (5.7)	8.198	0.042
Olive oil Never Occasional >3 times per week Daily	70 (7.9) 241 (27.0) 180 (20.2) 400 (44.9)	1 (1.0) 11 (10.5) 19 (18.1) 74 (70.5)	29.603	<0.0001
Dairy products Never Occasional >3 times per week Daily	10 (1.1) 126 (14.1) 162 (18.2) 593 (66.6)	1 (0.9) 5 (4.7) 34 (31.8) 67 (62.6)	15.768	0.001
Vegetables Never Occasional >3 times per week Daily	5 (0.6) 71 (8.0) 169 (19.0) 646 (72.5)	0 (0.0) 27 (25.5) 6 (5.7) 73 (68.9)	39.850	<0.0001
Fruits Never Occasional >3 times per week Daily	5 (0.6) 109 (12.2) 129 (14.5) 648 (72.7)	0 (0.0) 29 (27.1) 1 (0.9) 77 (72.0)	29.334	<0.0001
Nuts Never Occasional >3 times per week Daily	58 (6.5) 590 (66.2) 110 (12.3) 133 (14.9)	0 (0.0) 96 (89.7) 6 (5.6) 5 (4.7)	25.637	<0.0001
Red meat Never Occasional >3 times per week Daily	68 (7.6) 558 (62.6) 224 (25.1) 41 (4.6)	3 (2.8) 54 (50.5) 49 (45.8) 1 (0.9)	23.383	<0.0001
Fast food Never Occasional >3 times per week	164 (18.4) 673 (75.5) 40 (4.5)	0 (0.0) 80 (76.2) 19 (18.1)	56.715	<0.0001

Daily	14 (1.6)	6 (5.7)		
Fish			16.218	0.001
Never	32 (3.6)	3 (2.8)		
Occasional	762 (85.5)	81 (75.7)		
>3 times per week	76 (8.5)	22 (20.6)		
Daily	21 (2.4)	1 (0.9)		
Gender			0.068	0.082
Male	434 (48.6)	459 (51.4)		
Female	62 (57.9)	45 (42.1)		
Place of baby residence –			2.095	0.911
Beirut	126 (14.1)	17 (15.9)		
Mount Lebanon	124 (13.9)	15 (14.0)		
South	132 (14.8)	17 (15.9)		
North	121 (13.5)	17 (15.9)		
Bekaa	112 (12.5)	9 (8.4)		
Nabatieh	135 (15.1)	15 (14.0)		
Akkar	143 (16.0)	17 (15.9)		
School type			15.498	<0.0001
Private	61 (6.8)	19 (17.8)		
Public	832 (93.2)	88 (82.2)		
Method of baby delivery			5.761	0.018
Normal	485 (54.3)	45 (42.1)		
C-section	408 (45.7)	62 (57.9)		
Breast-feeding	717 (80.2)	67 (62.6)	17.626	<0.0001
Father level of education			23.007	<0.0001
Illiterate	28 (3.1)	0 (0.0)		
Primary school	171 (19.1)	23 (21.5)		
Complementary	295 (33.0)	30 (28.0)		
Secondary school	292 (32.7)	53 (49.5)		
University	107 (12.0)	1 (0.9)		
Mother level of education			22.667	<0.0001
Illiterate	24 (2.7)	1 (0.9)		
Primary school	40 (4.5)	3 (2.8)		
Complementary	151 (16.9)	36 (33.6)		
Secondary school	447 (50.1)	35 (32.7)		
University	231 (25.9)	32 (29.9)		
Family history of asthma			544.798	<0.0001
None	842 (94.3)	32 (29.9)		

Any member	51 (5.7)	75 (70.1)		
Positive family history				
Eczema	4 (0.4)	22 (20.6)	170.114	<0.0001
Allergy	213 (23.9)	90 (84.1)	164.292	<0.0001
Allergic Rhinitis	69 (7.7)	15 (14.0)	133.868	<0.0001

Supplementary Table 2: Multivariate analysis.				
Logistic regression taking current asthma as the dependent variable and each food category as an independent variable.				
Factor	P-value	OR_a	95% Confidence Interval	
			Lower	Upper
Sweets	<0.0001			
Never	Ref	1		
Occasional	<0.0001	12.345	5.416	28.136
>3 times per week	<0.0001	5.417	2.597	11.299
Brown bread	0.792			
Never	Ref	1		
Occasional	0.309	0.677	0.320	1.434
>3 times per week	0.997	0	0	
Daily	0.980	1.022	0.179	5.824
White bread	<0.0001			
Never	Ref	1		
Occasional	0.985	0.976	0.081	11.726
>3 times per week	0.013	26.381	2.012	345.846
Daily	0.295	3.872	0.308	48.701
Carbonated beverages	<0.0001			
Never	Ref	1		
Occasional	0.002	0.246	0.099	0.608
>3 times per week	0.000	0.033	0.010	0.104
Daily	0.659	0.765	0.233	2.515
Olive oil	<0.0001			
Never	Ref	1		
Occasional	0.370	2.883	0.285	29.118
>3 times per week	0.561	1.984	0.197	19.970
Daily	0.048	9.803	1.023	93.961
Red meat	0.005			
Never	Ref	1		
Occasional	0.076	3.785	0.871	16.445
>3 times per week	0.062	4.129	0.932	18.299
Daily	0.108	0.118	0.009	1.594
Dairy products	0.006			
Never	Ref	1		
Occasional	0.705	0.640	0.064	6.450
>3 times per week	0.347	2.797	0.327	23.896
Daily	0.748	1.417	0.170	11.828
Fish	0.002			

Never	Ref	1		
Occasional	0.838	1.134	0.340	3.785
>3 times per week	0.083	3.088	0.863	11.050
Daily	0.569	0.508	0.049	5.216
Sex (Male vs Female)	0.046	0.611	0.377	0.991
School type (Public vs private)	0.006	2.494	1.306	4.760
Method of baby delivery (Normal vs C-section)	0.086	1.474	0.947	2.294
Breastfeeding	<0.0001	0.159	0.09	0.282
Mother's level of education				
Illiterate	Ref	1		
Primary school	0.055	0.055	0.002	1.069
Complementary	0.562	0.434	0.026	7.325
Secondary school	0.036	0.048	0.003	0.826
University	0.218	0.171	0.010	2.849
Positive family history of asthma	<0.0001	10.361	4.374	24.544
Positive family history of allergy	<0.0001	6.642	3.067	14.383