

## The Association between Diet and Symptoms of Allergic Diseases in Children Aged from 8 to 12 in Public Schools in Beirut and Mount Lebanon

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### Abstract

**Background:** The prevalence of allergic diseases including asthma, rhinoconjunctivitis and eczema, has increased in the Western world in recent decades, particularly in children, becoming a major public health problem in the whole world. Therefore, the objective of this 12 months study is to evaluate the relationship between eating habits and the symptoms of allergic diseases in children.

**Methods:** This cross-sectional epidemiological observational study was conducted among children (n=3104) in various public schools in Beirut and Mount Lebanon. A self-administered questionnaire, based on the "International Study of Asthma and Allergies in Childhood (ISAAC) and a Food Frequency Questionnaire (FFQ)" was used to evaluate the children's eating habits. The study took place between February and April 2016. The data collected were coded, entered and then analyzed using the Statistical Package for Social Sciences (SPSS).

**Results:** The prevalence of symptoms of asthma, rhino conjunctivitis, and eczema during the past 12 months reported 7.8%, 11.4% and 4.1%, respectively. The onset of allergic diseases symptoms, especially asthma, seems to be reduced by the consumption of certain food products, such as raw and cooked vegetables, grains, fish, dairy products, and fresh fruit juices. On the other hand, "salt" was associated with an increased risk for all studied allergic diseases. Bivariate and multivariate analyses were performed to identify the relationship between a certain diet and the symptoms of allergic diseases during 12 months.

**Conclusion:** This study explicates the association between eating habits and allergic diseases. Indeed, some foods belonging to the Western diet can be considered as risk factors, while others belonging to the Mediterranean diet proved to be protective. This leaves the door open to further studies from a different perspective.

**Keywords:** Allergic diseases; Asthma; Rhino conjunctivitis; Eczema; Eating habits

### Introduction

In the 21<sup>st</sup> century, allergic diseases, including asthma, allergic rhinitis, and atopic dermatitis, represents a major global challenge. Over the past three decades, allergy has been identified as a significant public health burden throughout the world, particularly in developed countries, due to the continuous growth in its prevalence, potential severity and its impact on quality of life [1-3]. Allergy is ranked as the fourth most common chronic condition in the world by the World Health Organization (WHO) [4].

An increased spread of allergic diseases has been reported at different rates [5-8], affecting about 20% of the world population [9]. Initially, pediatric asthma has increased rapidly over the past 20 years,

especially in developed countries [10]. According to Phase III of the international ISAAC study, approximately 14% of children aged 6-7 years and 13-14 years in 97 countries of the world are at risk of having symptoms of asthma [11]. Allergic rhinitis is recognized as the most frequent allergic disease in children [12], with an average of 22% [13] and expanding even more across regions and countries [14]. As for atopic dermatitis, its prevalence has increased considerably in recent decades, especially among children in Western countries, affecting up to 30% of pre-school children and 15% to 20% of school-aged children [15].

The etiology of this increase is not very clear; it can be explained by a combination of several factors, including genetic predisposition [16,17], the age of children, socioeconomic and environmental factors, and changes in lifestyle, including diet [18-23].

Diet has gained attention as a potential factor in increasing the prevalence of symptoms [24-26]. Diet is not a single exposure, but

rather a complex of several types of intercorrelated foods, some of which are protective factors from asthma, rhinoconjunctivitis, and eczema, while others are risk factors leading to an increase in the prevalence of allergic diseases [27]. The Mediterranean diet appears to be protective against allergic diseases [28-30] as it provides antioxidant-rich food sources such as vegetables, fruits, cereals, fish, high monounsaturated fats, Olive oil, low-fat dairy products and low consumption of meat and poultry [31].

As for Lebanon, no studies identified the association between dietary factors and allergic diseases in children and particularly public schools students. However, there are published studies on the prevalence and severity of atopic conditions in Lebanon among students of private schools and their risk factors, such as the studies by Waked et al. [32-35]. This study attempts to evaluate the association between dietary factors and the symptoms of allergic diseases in children aged 8 to 12 in public schools in Beirut and Mount Lebanon.

## Materials and Methods

### Type of study

This cross-sectional epidemiological observational study was conducted between February and April 2016 in various public schools in Grand Beirut and Mount Lebanon.

### Sampling

A cluster sampling was carried out to distribute public schools between the two governorates of Lebanon, Beirut, and Mount Lebanon. The sampling frame used to select the sample of schools comes from the book "General Education Guidebook" published by the Center for Educational Research and Development (CRDP) for the year 2013/2014 [36].

In each of the two governorates, a random sample of schools comprising the two primary and complementary cycles was established.

### Study tool

A self-administered questionnaire containing questions on socio-demographic characteristics, asthma, allergic rhinitis, atopic dermatitis, dietary factors, and risk factors was used.

### Data were collected using

- A standardized questionnaire for young people from the ISAAC survey in several countries of the world to study the prevalence of asthma and Allergic diseases in children, their symptoms and management [37]
- A Food Frequency Questionnaire (FFQ) [38], to study the most common food evaluation tool used in major epidemiological studies of diet and health

The questionnaire was adjusted and adapted to meet the requirements of the Lebanese population. Then it was translated into Arabic to let the respondents understand the questions with ease. A confirmatory factor analysis took place and defined that the FFQ is a questionnaire adapted for food behavior assessment in children aged 8 to 12 Lebanese. (10 factors explained 70.47% of the concept, KMO 0.855, P value=<0.001). The questionnaires were completed by the parents.

## Variables of Interest

### Asthma

- The cumulative prevalence of asthma (lifetime asthma) was defined by the affirmative answer to the question: "Has your child ever had asthma at any time in his/her life?" If yes, has the diagnosis of asthma been confirmed by a doctor?
- Participants were categorized as having symptoms suggestive of asthma in the last 12 months (12-month asthma symptoms) if they answered yes they got a second question: "Has your child ever had wheezing in Chest in the past 12 months?"
- The severity of the evocative symptoms of asthma was evaluated by the presence of wheezing during the last 12 months  $\geq 4$  attacks of wheezing and/or  $\geq$  one night per week of sleeping disturbance related to breathing wheezing and/or whistling that limits the speech

### Allergic rhinitis

- The cumulative prevalence of rhinitis (Rhinitis Life) was defined by the positive response to the question: "Has your child ever had sneezing, runny nose or stuffy nose while (He/She) had no respiratory infection (neither cold nor rhino-pharyngitis, nor flu)?" If yes, has allergic rhinitis been confirmed by a doctor?
- Participants were classified as having rhinoconjunctivitis (12-month rhinoconjunctivitis symptoms) if they answered yes to the question "During the past 12 months, did your child have sneezing, a runny nose or a stuffy nose when he (she) had no respiratory infection (neither cold nor rhino-pharyngitis, nor influenza ...)?" If the answer was positive, they should answer the following question "During the last 12 months, these nose problems were they accompanied by tears or itching (scratching) of the eyes?"
- Children were considered to have severe rhinoconjunctivitis symptoms if they answered yes to the two previous questions and by many to the following question: "During the past 12 months, did these nose problems interfere with their everyday activities?"

### Atopic dermatitis

- The cumulative prevalence of eczema (Eczema life) was defined by the positive answer to the question: "Has your child ever had eczema?" If yes, has the diagnosis of eczema been confirmed by a doctor?
- The prevalence of symptoms suggestive of eczema (Eczema Symptoms 12 months) was defined by the positive answer to the questions: "Has your child had an itchy rash on the skin that appears and disappears intermittently at any time during the last 12 months? If so, "Did this itchy rash touch any of these areas at one time: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, around the neck, around the eyes or ears?"
- Participants were classified as having severe eczema symptoms if they answered "yes" to the two previous questions and "one or more nights per week" to the following question: "In the past 12 months, how many times did this rash that itch has prevented him from sleeping?"

### Dietary factors

Particular attention was paid to dietary factors, which were the major independent variables of this study. The food mentioned in the questionnaire were: vegetables, fruit, nuts, starches, meats, chicken, fish, eggs, dairy products, sugar and sweet products, spices, fats, beverage, fast food, canteen meals, and vitamins. The children's frequency of food consumption was measured per week (never/occasionally, 1-2 times,  $\geq 3$  times). In addition, two additional questions were added to the FFQ concerning the source of water (mineral water or tap water), and the amount of table salt consumed (not at all, in small quantities, in moderate amounts and very much).

### Statistical Analysis

The data collected were coded, registered and then analyzed using the Statistical Package for Social Sciences (SPSS) version 22 software (SPSS™ Inc., Chicago, IL USA).

Firstly, descriptive analyzes were performed using the mean and standard deviation to present the continuous variables while the percentages were used for the qualitative variables.

Secondly, bivariate analyzes were performed to investigate the relationship between two sets of variables: the symptoms of asthma, rhinoconjunctivitis and eczema during 12 months, and the external and internal factors: socio-demographic and socio-economic factors of children and their parents, BMI, physical activity, history of personal and family atopy, prematurity, postnatal respiratory problem, breastfeeding and length of stay, exposure to maternal smoking during breastfeeding, vaccination, age at introduction of solid foods and medical history (recurrent otitis media, Repetition and Gastroesophageal reflux disease (GERD)). A value of  $p < 0.05$  was considered statistically significant. The chi-square test  $\chi^2$  was used for the comparison between categorical variables in addition to the Fisher test in case of expected value  $n < 5$ . Unadjusted Odds ratio (OR) values were calculated to study the relationship between diet and symptoms of allergic diseases.

Finally, multivariate descending stepwise models were carried out using logistic regressions to find independent factors related to the symptoms of allergic diseases while adjusting to the various confounding factors. The independent variables introduced in the initial model were those with a  $p < 0.20$  value in the bivariate analyzes, as well as other variables that could be treated from a theoretical point of view, such as predictor variables such as sex and body mass index (BMI). This allowed us to examine the relative weight of each of the indicators included in the model. In the final model, variables with a  $p < 0.05$  value were only selected. The final results were expressed as adjusted Odds Ratio (ORa) with 95% confidence intervals (CI) to measure the effect of disease onset compared with unexposed.

## Results and Discussion

### Description of the population

In this study, 3104 schoolchildren aged 8-12 years were included in the analysis (Figure 1).

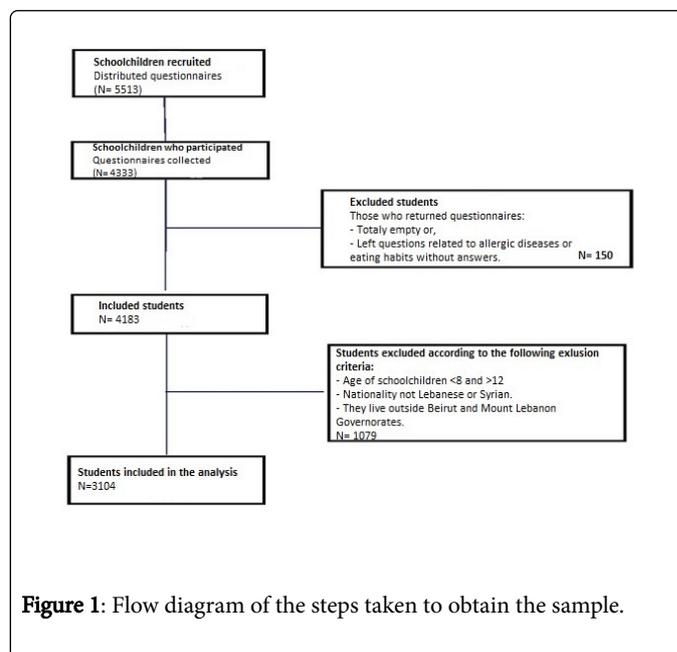


Figure 1: Flow diagram of the steps taken to obtain the sample.

The socio-demographic and socio-economic characteristic of the children is shown in Table 1. A total of 66% of the children were Lebanese. 48.6% (n=1510) of the children were boys and 50.8% (n=1576) were girls. 71.4% lived in Mount Lebanon and 28.6% lived in Beirut. As for familial atopy, 3.4%, 6.7% and 1.6% of mothers, as well as 1.7%, 3.9% and 1.1% of fathers had a history of asthma, allergic rhinitis, and eczema, respectively.

Variables	Number	Percentage (%)
Sex of the Child (N=3086)		
Boy	1510	48.6
Girl	1576	50.8
Age of the Child		
8 years	137	4.4
9 years	551	17.8
10 years	804	25.9
11 years	833	26.8
12 years	779	25.1
Siblings		
Only child	66	2.1
1 à 2 brothers or sisters	1236	39.8
$\geq 3$ brothers or sisters	1802	58.1
Type of region (N=2916)		
Urban environment	1640	52.8
Rural environment	629	20.3
Intermediate environment	647	20.8

Monthly family income a (N=2927)		
Low income	2138	73
Intermediate income	710	24.3
High Income	79	2.7

<sup>a</sup>Low income: <500,000L.L. And 500,000-1,000,000 L.L.; Intermediate income: 1,000,000-2,000,000 L.L. and 2,001,000-4,000,000 L.L.; High income:> 4,000,000 L.L.

symptoms of asthma and 4.1% had symptoms of eczema. In addition, 4%, 0.9%, and 2% reported severe symptoms of asthma, rhinoconjunctivitis and eczema respectively. Statistical analysis confirmed that sex, nationality, place of residence, and a number of siblings were not significantly associated with any symptoms of asthma, rhino conjunctivitis, and eczema during these 12 months. However, the history of familial allergy and recurrent angina were significantly associated with symptoms. On the other hand, no association was found with symptoms of eczema. The association of dietary habits with the symptoms of allergic diseases in children during the same 12 months is shown in Table 2.

**Table 1:** Sociodemographic characteristics of children in the sample.

### Prevalence of symptoms of asthma, rhino conjunctivitis, and eczema

In the past 12 months, the symptoms of allergic diseases were as follows: 11.4% had symptoms of rhinoconjunctivitis, 7.8% reported

Alimentation	Asthma Symptoms 12 month		Rhino-conjunctivitis Symptoms 12 month		Eczema Symptoms 12 month	
	OR [95% IC]	P-value	OR [95% IC]	P-value	OR [95% IC]	P-value
Fruits and vegetables						
Raw Vegetables	0.66 [0.50-0.87]	0.003	0.92 [0.73-1.17]	0.529	1.45 [0.85-2.47]	0.163
Baked Vegetables	0.83 [0.63-1.10]	0.209	0.84 [0.66-1.05]	0.136	1.64 [0.98-2.73]	0.057
Thyme	0.84 [0.63-1.10]	0.216	1.15 [0.91-1.45]	0.229	0.88 [0.53-1.46]	0.621
Pickles	0.72 [0.50-1.02]	0.045	0.95 [0.72-1.25]	0.74	0.76 [0.41-1.40]	0.38
Citrus	0.81 [0.61-1.07]	0.145	1.20 [0.95-1.52]	0.12	0.87 [0.52-1.45]	0.606
Other fruits	0.72 [0.54-0.96]	0.063	0.81 [0.63-1.03]	0.092	0.93 [0.55-1.57]	0.801
Starches						
Cereals	0.80 [0.59-1.10]	0.18	0.95 [0.73-1.25]	0.758	1.24 [0.69-2.21]	0.459
Rice and pasta	0.96 [0.72-1.29]	0.821	0.96 [0.75-1.21]	0.737	0.88 [0.53-1.47]	0.645
Potatoes	0.85 [0.64-1.14]	0.291	1.01 [0.80-1.28]	0.882	0.75 [0.45-1.25]	0.282
Grains	0.62 [0.47-0.83]	0.001	0.97 [0.77-1.22]	0.82	1.12 [0.68-1.85]	0.651
Meat and Eggs						
Chicken	0.71 [0.53-0.94]	0.018	0.84 [0.67-1.07]	0.173	1.00 [0.60-1.67]	0.973
Pisces	0.69 [0.49-0.97]	0.036	0.97 [0.74-1.26]	0.831	0.53 [0.29-0.98]	0.042
Red meat	0.78 [0.55-1.11]	0.182	0.92 [0.70-1.21]	0.592	0.69 [0.38-1.26]	0.231
Processed Meat	1.10 [0.79-1.53]	0.558	1.02 [0.77-1.34]	0.885	0.91 [0.60-1.39]	0.666
Eggs	0.70 [0.53-0.94]	0.017	1.08 [0.84-1.37]	0.524	0.96 [0.57-1.63]	0.893
Milk and derivatives						
Milk	0.76 [0.57-1.02]	0.04	0.87 [0.68-1.10]	0.249	0.94 [0.55-1.60]	0.833
Other dairy products	0.57 [0.41-0.77]	0.001	1.02 [0.73-1.43]	0.87	1.17 [0.57-2.41]	0.653
Nuts	1.03 [0.77-1.38]	0.811	0.93 [0.72-1.18]	0.565	0.91 [0.53-1.56]	0.748
Table salt	1.31 [0.98-1.74]	0.041	1.37 [1.08-1.74]	0.008	1.39 [0.81-2.37]	0.223
Spices	0.96 [0.71-1.30]	0.813	1.02 [0.80-1.30]	0.87	0.90 [0.52-1.55]	0.711

Sugar and sweet products						
Confectionery and desserts	0.71 [0.53-0.95]	0.023	1.01 [0.49-2.07]	0.976	0.92 [0.68-1.26]	0.633
Oriental Pastries	0.78 [0.57-1.06]	0.12	0.89 [0.69-1.14]	0.369	0.87 [0.51-1.50]	0.627
White table sugar	0.94 [0.64-1.38]	0.772	1.00 [0.73-1.39]	0.955	1.77 [1.05-2.97]	0.03
Honey	0.78 [0.51-1.19]	0.25	1.22 [0.90-1.66]	0.187	0.62 [0.30-1.28]	0.203
Jam	0.91 [0.65-1.28]	0.61	0.82 [0.62-1.09]	0.184	1.17 [0.64-2.14]	0.601
Fat						
Olive oil	0.83 [0.62-1.10]	0.201	0.81 [0.64-1.02]	0.079	1.31 [0.79-2.18]	0.291
Vegetable oil	0.93 [0.70-1.24]	0.653	0.98 [0.77-1.23]	0.872	1.15 [0.69-1.92]	0.58
Mayonnaise	0.67 [0.48-0.93]	0.018	0.91 [0.70-1.17]	0.461	1.16 [0.67-1.99]	0.581
Butter	0.82 [0.59-1.14]	0.256	1.01 [0.78-1.31]	0.917	0.81 [0.45-1.46]	0.5
Margarine	1.07 [0.77-1.48]	0.661	1.02 [0.78-1.33]	0.875	0.87 [0.44-1.57]	0.656
Chips	0.80 [0.58-1.11]	0.18	0.87 [0.66-1.13]	0.286	0.84 [0.57-1.26]	0.407
Drinks						
Fruit juices (not fresh)	0.72 [0.54-0.97]	0.03	0.96 [0.76-1.22]	0.787	1.63 [0.97-2.73]	0.052
Vegetable juice	1.22 [0.75-1.97]	0.42	1.54 [1.06-2.23]	0.022	1.83 [0.80-4.15]	0.142
Hot chocolate	1.16 [0.81-1.65]	0.415	1.44 [1.08-1.90]	0.01	1.02 [0.54-1.93]	0.945
Caffeine	0.75 [0.45-1.26]	0.288	1.34 [0.94-1.91]	0.097	1.05 [0.46-2.41]	0.902
Tea	0.84 [0.63-1.12]	0.254	0.93 [0.73-1.17]	0.552	0.99 [0.595-1.65]	0.971
Fresh fruit juice	0.69 [0.52-0.93]	0.014	0.72 [0.57-0.92]	0.008	0.79 [0.46-1.33]	0.383
Soft drinks	0.86 [0.63-1.18]	0.37	0.98 [0.76-1.26]	0.907	1.18 [0.69-2.02]	0.523
Rapid Restauration "Fast food"	0.98 [0.76-1.26]	0.902	1.44 [0.81-2.57]	0.206	0.86 [0.63-1.18]	0.37
Vitamins						
Vitamin D	0.78 [0.50-1.21]	0.002	1.11 [0.80-1.54]	0.533	1.14 [0.56-2.30]	0.71
Other vitamins	0.67 [0.40-1.13]	0.134	0.97 [0.67-1.41]	0.897	1.07 [0.52-2.18]	0.843

**Table 2:** The association of food products with symptoms of asthma, rhino conjunctivitis and eczema during the past 12 months in the sampled children.

### Results presented as odds ratio

The chi-square test was used to check the association between food products and the symptoms of allergic diseases.

The content of variable: Raw Vegetables: raw vegetable, green pepper, salad. Eggs: Boiled White Egg, Boiled Whole Egg, Fried Egg. Other fruits: cherry, fig, pineapple, strawberry, other fresh fruit, canned fruit, died fruit. Fresh fruit juice: Fruit cocktail, fresh fruit juice. Nuts: fresh nut, grilled nuts, raw nuts, fried nuts. Cereals: bagel and corns, brown bread, pastry. Rice and pasta: stuffed pasta, Chinese rice. Chicken: grilled boiled chicken, Fried chicken. Pisces: Shushi raw fish, grilled smoked fish, fried fish.

Red meat: raw red meat, pork, fried red meat. Processed meat: mortadella, sausage. Other dairy product: dairy product, white cheese, low fat dairy product, fresh cream, kachta, kechek, shanklish, yellow

cheese. Confectionery and desserts: sweet, sweet Arabic, ice cream, marshmallow, halawe, pudding, Turkish delight and biscuit, cotton candy. Spices : pepper, cumin. Fruit juice : fruit juice, fruit juice diet. Rapid Restauration "Fast food": fast food, fast food canteen. Soft drinks: soft drink, soft drink diet.

### Association between dietary factors and symptoms of allergic diseases

Each of the dependent variables (12-month asthma symptoms, 12-month rhinoconjunctivitis symptoms and 12-month eczema symptoms) was subjected to a logistic regression model including all statistically significant indicators that were notable in bivariate analyzes, under control of sex and body mass index (BMI).

Consumption of grains (ORa=0.78 [0.27-0.75]), cooked vegetables (ORa=0.44 [0.74-0.98]), fruit juice (ORa=0.49 [0.36-0.75]) and vitamin supplements with the exception of vitamin D (ORa=0.07 [0.01-0.74]) were all inversely associated significantly with 12-month asthma symptoms. In contrast, vitamin D supplementation was strongly associated with an increase in 12-month asthma symptoms (ORa=8.96 [1.54-51.96]).

The consumption of fresh fruit juice (fruit cocktail, fresh fruit juice) (ORa=0.54 [0.37-0.89]), as well as the consumption of olive oil (ORa=0.63 [0.34-0.82]) during the last 12 months, have been shown to be protective against rhinoconjunctivitis symptoms 12 months. On the other hand, the consumption of honey (ORa=1.71 [1.22-3.39]) and table salt (ORa=1.44 [1.02-2.36]) have been shown to be risk factors for rhinoconjunctivitis symptoms.

Factors significantly associated with eczema symptoms in the last 12 months, which were protective, we noted "fish" (Shushi raw fish, grilled smoked fish, fried fish) (ORa=0.14 [0.10-0.99]) and "meat" (raw red meat, pork, fried red meat) (ORa=0.18 [0.48-0.73]) (Table 3).

	ORa [95% IC]	p-value
Factors associated with asthma symptoms 12 months <sup>a</sup>		
Gender Female	0.16 [0.06-0.42]	<0.001
History of family allergy	1.31 [2.23-6.09]	<0.001
Repeated Angina	1.19 [1.45-7.70]	0.005
Postnatal respiratory complications	2.09 [6.25-55.76]	<0.001
Grains	0.78 [0.27-0.75]	0.002
Baked Vegetables	0.44 [0.74-0.98]	0.008
Fruit juice	0.49 [0.36-0.75]	0.004
Vitamin Supplements	0.07 [0.01-0.74]	0.027
Vitamin D Supplements	8.96 [1.54-51.96]	0.014
Factors associated with rhino conjunctivitis 12 months <sup>b</sup>		
Vaccination	0.47[0.36-0.83]	0.002
History of family allergy	1.816 [1.51-3.36]	<0.001
Postnatal respiratory complications	1.22 [1.94-5.92]	<0.001
Overweight (overweight and obese)	1.47 [1.37-2.08]	0.018
Exposure to external pollution	1.47 [1.05-2.44]	0.027
Fresh fruit juices	0.54 [0.37-0.89]	0.015
Olive oil	0.63 [0.34-0.82]	0.005
Honey	1.71 [1.22-3.39]	0.006
Table Salt	1.44 [1.02-2.36]	0.038
Factors associated with eczema symptoms 12 months <sup>c</sup>		
Exposure to pesticide first year	1.99 [1.99-17.01]	0.002
Exposure to external pollution	1.22 [1.04-1.43]	0.014
Meat	0.18[0.48-0.73]	0.017
Fish	0.14 [0.10-0.99]	0.018

ORa: Odds Adjusted ratio; IC: Confidence Interval

**Table 3:** Multivariate analyzes of factors associated with the symptoms of allergic diseases in children aged 8 to 12 years in public schools in Beirut and Mount Lebanon.

All of these multivariate analyzes included all dietary-related variables and confounding factors that have  $p \leq 0.20$  in bivariate analysis, also adjusting for sex and BMI.

The method of selecting the variables that has been favoured here is the backward step-by-step method (Backward).

The reference category is the absence of the factor studied. The confounding factors used in the analysis of diet and allergic diseases: socio-demographic and socio-economic characteristics, age of introduction of solid food, house quality, children born at term.

<sup>a</sup>Classification table: Overall percentage 93%, Model specification test <0.001, Nagelkerke R-2 0.202, Hosmer-Lemeshow test 0.974.

Variable entered originally in the model of asthma symptoms 12 months: gender- history of family allergy - family smoker- repeated Angina-term baby- postnatal respiratory complications -breast feeding-smoke-vaccination- solid food-throat infections-ear infections- exposure to external pollution - house quality-exposure to pesticides now- exposure to pesticides first year-raw vegetable-thyme-baked vegetables-pickles-citrus fruit-grains- milk-sweets-arabic sweets-mayonnaise-fresh fruit juice-caffeine-tea- vitamin supplements-vitamin D supplements cereals-fried potatoes-fruit juices- soft drinks-chicken-fish-meat-all Dairy products-eggs-overweight -table salt-all other fruits-induced allergen major-NSAI Duse.

<sup>b</sup>Classification table: Overall percentage 90.4%, Model specification test <0.001, Nagelkerke R-two 0.195, Hosmer-Lemeshow test 0.793

Variable entered originally in the model of Current Rhino conjunctivitis 12 months: mom age-mom education- history of family allergy- income- gender-city rural-term baby-postnatal respiratory complications-breast feeding-smoking-solid food-vaccination- ear infections- throat infections- NSAI Duse- exposure to external pollution-family smoker-exposure topesticides now-exposure to pesticides first year-house quality- cooked vegetable-honey-jam-fresh fruit juice-vegetable juice-hot chocolate-all other fruits- overweight-sport index-major indoor allergens-olive oils- table salt.

<sup>c</sup>Classification Table: Overall Percentage 51.3%, Model Specification Test <0.001, Nagelkerke R-2 0.284, Hosmer-Lemeshow Test 0.667.

Variable entered originally in the model of Current Eczema Symptoms 12 months: family allergy- income-- postnatal respiratory complications -breast feeding smoke - solid food- vaccination- ear infections- throat infections- NSAI Duse- heartburn-reflux- all other fruits- exposure to external pollution - family smoker-exposure to pesticides now- exposure to pesticide first year-house quality- fresh fruit juice- vegetable juice-sport -table salt- raw vegetable- baked vegetables-white sugar- chicken- meat-fish.

This study is the first of its kind in Lebanon to assess the relationship between dietary factors and allergic diseases in children aged from 8 to 12 years old. First of all, this study showed that the prevalence of symptoms of asthma (7.8%), rhino-conjunctivitis (11.4%) and eczema (4.1%) during the past 12 months are very similar to the results of the ISAAC III study published in 2013. Showing that

the Eastern Mediterranean, of which Lebanon belongs, was among the regions with the lowest prevalence of symptoms of asthma (<10%), rhino-conjunctivitis (10%-13%) and eczema (<5%) [11]. These results, compared with data from a study done in Lebanon, reveal that this prevalence in Lebanon is declining [39]. Concerning personal atopy, our results are consistent with the study by Pols et al. which demonstrates a very significant positive association in the history of personal allergy and the risk of having other allergic diseases [40].

This study showed that male sex, a well-known risk factor in the literature [32], might be associated with an increase in asthma symptoms during the last 12 months (multivariate analysis). Unlike our results, which showed no association, some epidemiological studies suggest that low monthly family income and area of residence were positively associated with rhinoconjunctivitis symptoms [33,34,41]. In addition, our findings are in line with some epidemiological studies on risk factors for allergic diseases, which noted that the history of familial allergy [32] and postnatal respiratory complications [42] might be positively associated with the onset of symptoms of asthma and rhinoconjunctivitis during the past 12 months.

The consumption of raw vegetables, pickles, and cooked vegetables showed insignificant association with asthma symptoms. In addition, vegetable juice has a significantly high-risk factor in the area of rhinoconjunctivitis symptoms. These controversial results are well consistent with some studies. In short, studies suggest the existence of a beneficial association between the increased intake of antioxidants and allergic diseases [43-45]. On the other hand, other studies show that the increase in allergic diseases is a result of the increased intake of antioxidants [46]. The consumption of fresh fruit juice can play a protective role against the symptoms of asthma and rhinoconjunctivitis as shown in our 12 months' study, which agrees with many previous studies [47,48]. In fact, according to the Phase III of the major ISAAC international epidemiological study, consuming 3 fruits per week plays a protective role in the development of asthma in children and adolescents. At the same time, no significant relation was found with the symptoms of eczema, which does not go well with other studies that have demonstrated the protective effect of fruits on atopic dermatitis [47,48].

A study performed in children in Puerto Rico [49] reveals an inverse association between grain consumption and asthma. Indeed, these results are in agreement with those of our study.

Subsequently, during this same 12-month study in Lebanon, fish consumption in children was inversely associated with asthma and eczema symptoms, which agrees with several studies suggesting the reverse association of omega 3 of fish and seafood with asthma in children while showing the beneficial effect of fish consumption [20,50].

Similarly, our study has shown a low association between moderate chicken consumption and the development of asthma symptoms in the past 12 months [51,52].

The insignificant association between consumption of eggs, milk and dairy products with asthma symptoms is consistent with other studies that have provided evidence for their negative association with saturated fatty acids in milk and dairy products [53,54].

A study conducted in 2016, linked sugar consumption to an increase in the spread of allergic rhinitis [55]. Similarly, other studies have shown that a diet rich in polyunsaturated fatty acids ((PUFA)-

Omega 6) present in sugar and sugary products increases the risk of atopic dermatitis in children [56,57] because they destroy the immune response and consequently contribute to the development of atopic diseases [55]. In this regard, these data are consistent with our findings that honey and hot chocolate can be positively associated with rhinoconjunctivitis symptoms.

In addition, our study highlights a remarkable association of table sugar with eczema symptoms. On the contrary, an unexpected result was found in this study, which is the inconsiderable association between confectionery and desserts and symptoms of asthma, this result is consistent with the data (2014) which reported the protective effect of confectionery and chocolate on the current rhinoconjunctivitis, while explaining that "cocoa", is relatively rich in polyphenol, a strong antioxidant, thus influencing the immune system [58].

Olive oil is defined as an important component of the Mediterranean diet, an antioxidant, a source of vitamin E and a rich source of omega-3 fatty acids [58]. According to the study of Olive oil can be a protective factor for asthma and allergic rhinitis [53]; this is similar to our results, linking the consumption of olive oil with the symptoms of rhinoconjunctivitis.

Consumption of table salt can be considered as a risk factor for symptoms of asthma and rhinoconjunctivitis, which is comparable to the results of some other studies [54-59].

The present study suggests that vitamin D supplementation may increase the risk of asthma in children (multivariate analysis). In contrast, many studies have confirmed the efficacy of vitamin D in the prevention of allergic diseases, especially asthma [60-63]. These unexpected results seem to be contradictory, although they may be biased. From a scientific point of view, vitamin D acts on innate immunity, acquired immunity and more specifically increases interleukin-10 production, thereby reducing skin inflammation [64]. In addition, the inverse association of other vitamins (vitamins A, C, and E) with asthma symptoms was consistent with other studies [49,65].

To assess the association between dietary factors and allergic symptoms, all children who already reported allergic symptoms were excluded from analyzes. After this exclusion, the study showed a significant association between the consumption of eggs, preserved fruit, pasta, and walnuts. In addition, an insignificant association is present with the consumption of pepper and table sugar. It is the first study that discusses this relationship; however, this association may be present, as these foods are part of the Mediterranean diet [47,58] and especially the Lebanese cuisine.

### Strengths and limitations

Like any epidemiological investigation, our study has several limitations. This was a cross-sectional descriptive observational study, which posed a problem of the temporality of the association between cause and effect. Selection bias is still possible due to the refusal of some students to participate in the study, especially since it was not possible to assess the profile of non-respondents. In addition, classification bias may be present since the study is based on self-reported information due to lack of time and funding to use objective methods to measure exposure (e.g. biological markers) and the lack of an objective assessment of symptoms and diagnosis [66].

Also, the associations found between risk factors and symptoms of allergic diseases may result from differential information biases where symptomatic subjects may overestimate their exposure to these factors. Indeed, the information was obtained by the parents of the children who may be subjected to memory lapses [67]. Not forgetting to mention that the assessment of diet was based on isolated foods, which is irrelevant since people do not eat isolated foods but rather consistent meals of a variety of foods consisting of “A combination of nutrients at a time” [19].

In the context of asthma and allergic diseases which are multifactorial diseases, other factors were not taken into account in the study. We cite feeding during the pre-and post-natal period [60], factors related to the mother other than nutrition, such as prenatal smoking [68], Alcohol consumption [69]. In addition, severe allergic diseases are misclassified, due to lack of questions about the use of allergy medications (such as dosage of drugs taken).

Consequently, this may affect the internal validity of the results. Another factor influencing internal validity is the nonresponse on several questions, probably because of the length of the questionnaire. Hence, a sub-or overestimate of the effect of exposure on the disease can be highlighted.

As a result, this study took place in the public schools of Beirut and Mount-Lebanon only, and in a small age group (8 to 12), which does not allow us to generalize our results to the whole child population from Lebanon. As a result, this affects the external validity of our study.

However, this study's strengths are related to the high response rate, the remarkable sample size (3104 children included in the analysis among 5513 children recruited). Besides, this is the first study conducted in public schools in Lebanon, from which the information collected on the symptoms of the disease includes standardized elements from the validated questionnaire (ISAAC) that has been used in epidemiological studies carried out on the Lebanese population [32,33,39] and abroad [20,69]. Similarly, the evaluation of allergic diseases in this study was not performed according to the diseases reported subjectively by the parents, but rather according to the symptoms. ISAAC validated this method in order to reduce the risk of having a differential bias.

## Conclusion and Recommendation

In conclusion, foods that are rich in antioxidants can be a non-pharmacological mean to reduce the risk of symptoms of asthma, rhinoconjunctivitis and eczema. Indeed, the Mediterranean diet may be “a preventive and protective diet” in children during that same 12-months study. In opposition, some foods belonging to the Western diet may be considered as risk factors, such as table sugar and table salt, which are significantly associated with symptoms of asthma, rhinoconjunctivitis and eczema. Therefore, this study provides a critical starting point for further longitudinal and interventional studies needed to create appropriate dietary strategies for the primary prevention of harmful allergic diseases, thereby affecting individuals, their families and societies.

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