Urban environment adherence to the Mediterranean diet and prevalence of asthma symptoms among 10- to 12-year-old children: The Physical Activity, Nutrition, and Allergies in Children Examined in Athens study

Dimitra Grigoropoulou, M.Sc.,[1] Kostas N. Priftis, M.D., Ph.D.,[2,3] Mary Yannakoulia, Ph.D.,[1] Anastasios Papadimitriou, M.D., Ph.D.,[3] Michael B. Anthracopoulos, M.D., Ph.D.,[4] Konstantina Yfanti, M.Sc.,[1] and Demosthenes B. Panagiotakos, Ph.D.[1]

ABSTRACT

Epidemiological studies have revealed several associations between asthma symptoms and environmental and dietary factors, but the potential environment- diet interactions on asthma incidence have rarely been investigated. The aim of this work was to evaluate the interrelationships between urban/rural environment, adherence to a healthy dietary pattern, the Mediterranean diet, and childhood asthma. A cross-sectional survey was performed and 1125 (529 boys), 10- to 12-year-old children were selected from 18 schools located in urban Athens area (n = 700) and from 10 schools located in rural areas of Ilia and Viotia (n = 425), Greece. Children and their parents completed standardized questionnaires, which evaluated, among others, environmental factors and dietary habits. Asthma was defined according to Phase II of the International Study on Allergies and Asthma in Childhood criteria. Adherence to the Mediterranean diet was assessed using the Mediterranean and Diet Quality Index for children and adolescents (KIDMED) score. Living in urban areas was associated with higher odds of ever had asthma symptoms by 1.78 times (95% confidence interval [CI], 1.25–2.54) when compared with rural areas. In contrast, 1-unit increase in the KIDMED score was associated with 16% lower likelihood of having asthma symptoms (95% CI, 0.77–0.91), after adjusting for various confounders. When stratifying the analysis by area of living it was observed that adherence to the Mediterranean diet was associated with lower likelihood of asthma in both urban and rural areas (urban, odds ratio [OR] = 0.81, 95% CI, 0.73–0.91; rural, OR = 0.87, 95% CI, 0.75–1.00). Urban environment seems to increase the likelihood of childhood asthma, whereas adherence to the healthy Mediterranean dietary pattern could mediate the aforementioned association and confers significant protection.

(Allergy Asthma Proc 32:351–358, 2011; doi: 10.2500/aap.2011.32.3463)

Various environmental risk factors alone or in interaction with lifestyle patterns and genetic predisposition seem to play a dominant role in the development of childhood asthma.[1] Current evidence recognizes that residential areas may promote the development of childhood asthma. Specific features of both urban and rural environments, such as exposure to indoor allergens, close contact with large animals, and early exposure to microbes,[2,3] air pollutants[4–7], and climatic conditions,[8–10] have been associated with asthma prevalence and morbidity.

Regarding dietary habits, during the past few years there has been a substantial body of evidence discussing the role of diet in the development of asthma. Much of this research that has focused on fish,[11] fruits, and vegetables[12,13] and antioxidant nutrients[14,15] has shown that all of these dietary compounds may improve lung function and, consequently, protect against childhood asthma. Recent studies support that healthy dietary patterns, such as the Mediterranean diet, may be protective against the development of asthma and atopy or beneficial for controlling the symptoms.[16–24]

Despite the already evaluated environment–asthma and diet–asthma associations, there is lack of information about the degree of interaction of environmental factors and dietary habits and their potential implication for development of childhood asthma. Thus, in this comparative work we sought to evaluate the interaction of living environment and adherence to the traditional Mediterranean diet on asthma symptoms in children aged 10–12 years old from an urban area (*i.e.*, the metropolitan Athens area) and two rural areas (*i.e.*, Ilia, southern to Athens, and Viotia, northern to Athens) in Greece.

From the [1]Department of Nutrition and Dietetics, Harokopio University, Athens, Greece, [2]Department of Allergy–Pneumonology, Penteli Children's Hospital, Penteli, Greece, [3]Third Department of Pediatrics, Attikon Hospital, University of Athens Medical School, Athens, Greece, and [4]Respiratory Unit, Department of Pediatrics, University of Patras Medical School, Patras, Greece

The authors have no conflicts to declare pertaining to this article

Address correspondence and reprint requests to Demosthenes B. Panagiotakos, Ph.D., Department of Nutrition and Dietetics, Harokopio University, Athens, Greece, 46, Paleon Polemiston Street, 16674 Glyfada, Greece

E-mail address: d.b.panagiotakos@usa.net

Copyright © 2011, OceanSide Publications, Inc., U.S.A.

DO NOT COPY

METHODS

Study's Sample

The sampling procedure of the extended Physical Activity, Nutrition, and Allergies in Children Examined in Athens (PANACEA) study took place during 2005–2009.[25] Overall, 1125 students (boys and premenstrual girls) aged from 10 to 12 years old were voluntarily enrolled into the study; of these students 700 were selected from 18 schools located in the greater Athens area, 300 students were selected from 7 schools located in Ilia county, and 125 students were selected from 3 schools located in Viotia county. The schools were randomly selected from a list provided by the regional education offices. The sampling was equally distributed between September and May for all areas and the overall participation rate was 83.5%. All participants completed all of the questionnaires.

The total number of enrolled children ($n = 1125$) was deemed adequate to evaluate odds ratios (ORs) between various groups of study equal to 1.20, at probability level <0.05, and achieving statistical power equal to 77% (G-Power free software; Kiel University, Kiel, Germany).

Measurements

Evaluation of Asthma Symptoms. To evaluate asthma symptoms, the translated International Study on Allergies and Asthma in Childhood standardized and validated self-administered questionnaire was used.[26] The questionnaire consisted of questions about the severity and the frequency of asthma symptoms. More specifically, the presence of (current or ever had) asthma was based on four questions: (1) "Did the child ever wheeze?" (2) "Did he/she ever have disturbed sleep due to wheezing?" (3) "Was he/she ever diagnosed with asthma?" and (4) "Did he/she ever have dry cough at night, apart from cases of cold or chest infection?" In the present work ever had asthma symptoms were used in the analysis.

Dietary Evaluation and Adherence to the Mediterranean Diet. Dietary evaluation was based on a validated semiquantitative Food Frequency Questionnaire, designed for the study and completed by the children, with the assistance of their parents when needed.[27] Information about the frequency of consumption of 63 foods and beverages usually consumed in Greece, as well as other dietary habits and behaviors (*i.e.*, eating breakfast, meals' frequency, *etc.*), was recorded. Typical serving sizes of the aforementioned food and beverages were standard units for measurements. Adherence to the Mediterranean diet was evaluated using the Mediterranean Diet Quality Index for children and adolescents index (KIDMED).[28] The total score ranges from −4 to 12 and it was divided into three categories: ≥8, optimal diet; 4–7, improvement needed to adjust intake to Mediterranean patterns; and ≤3, very low diet quality.

Evaluation of Sociodemographic, Lifestyle, and Anthropometric Characteristics. Information about the parental educational level, smoking habits, number of cars within the family, and history of atopic symptoms was collected. Moreover, the availability of child's own room, the number of siblings, breast-feeding history, and kindergarten or nursery attendance were also recorded.

Physical activity status of children was evaluated using a relevant questionnaire that has been shown to be a reliable and valid instrument of physical activity in children.[29] Standing height to the nearest 0.1 cm after children had removed their shoes and body weight to the nearest 0.1 kg on calibrated digital scales were also measured. Children's body mass index (BMI) was calculated to classify them as overweight and obese using the international cutoff points for BMI for overweight and obesity by sex between 2 and 18 years.[30]

Geoclimatic Information of the Studied Areas

Because macroenvironment was one of the target factors to be evaluated in this work, some geoclimatic data of the sampled urban and rural areas are presented.[31] Athens is the capital and largest city of Greece and it is characterized as an urban area, with high population density (7366.98/km^2). Because of its location, the climate is much drier compared with most Greek cities with relative humidity ranging from 46.7 to 70.1%, temperature range from −3.2 to 42.0°C, average rainfall from 5.2 to 64.1 mm, and air pollution, which is characterized by high concentrations of particles and photochemical smog. Ilia is a county of western Greece (and south to Athens) with mostly plain, agricultural areas, with low population density 73.84/km.^{2} Ilia experiences a relative humidity range from 62.9 to 79.4%, temperature range from −5.8 to 42.4°C, and average rainfall of 4.5–194 mm. Viotia, settled in central Greece (and northern to Athens), has plain and mountainous areas with agricultural and industrial development and its population density is also low, 44.41/km.^{2} The climate is characterized by cold winters and hot summers with average temperature range from −2.6 to 41.1°C, average relative humidity range from 47.6 to 74.6%, and average rainfall of 7.0 to 99.3 mm. The surveyed areas (Ilia and Viotia) were mainly rural, large areas of open country with low population density.

DO NOT COPY

Table 1 **Sociodemographic and lifestyle characteristics of 10- to 12-yr-old children living in urban areas (Athens) and rural (Ilia southern to Athens; Voitoia, northern to Athens) areas**

	Urban Areas, Athens	Rural Areas, Ilia and Viotia	*p*
n	700	425	
Age (yr)	11.2 ± 0.75	11.3 ± 0.69	0.25
Boys (%)	46	48	0.44
Physically active (%)	52	67	<0.001
Obesity (%)	9	2.4	<0.001
Overweight (%)	27.6	27.9	<0.001
KIDMED score (0–12)	4.7 ± 1.9	5.3 ± 2.0	<0.001
KIDMED score >8 (%)	2.4	4.8	<0.001
Has fruit or fruit juice (fresh/commercial) every day (%)	67.1	91.5	<0.001
Has a second fruit every day (%)	20.9	64.2	<0.001
Has fresh or cooked vegetables daily (%)	64.3	77.2	<0.001
Has fresh or cooked vegetables >1/day (%)	38.0	42.1	0.171
Fish consumption (>2–3/wk) (%)	6.9	12.1	0.004
Likes pulses and eats them >1/wk (%)	68.9	72.0	0.27
Consumes pasta or rice almost every day (%)	18.3	22.8	0.06
Cereals for breakfast (%)	16.1	29.5	<0.001
Uses olive oil at home (%)	93.0	87.9	0.04
Skip breakfast (%)	26.9	27.7	0.77
Has dairy products for breakfast (%)	76.1	63.0	<0.001
Has commercially baked goods for breakfast (%)	1.7	2.4	0.46
Has two yogurts and/or some cheese daily (%)	48.7	38.4	0.001
Has sweets and candy several times/day (%)	9.9	10.8	0.60

Results are presented as means ± SD or relative frequencies. The p *values were retrieved from* t*-test or* Z *test. KIDMED = Mediterranean Diet Quality Index for children and adolescents.*

DO NOT COPY

Bioethics

The study has been designed according to the principles of the declaration of Helsinki (1989). The protocol of the study has been approved by the Education Institute of the Hellenic Ministry of Education (approval 29712/G7/2006). To enroll a child in the study, their parents or guardians were informed about the objectives and methods of the study and signed an informed consent; participating children provided their verbal assent.

Statistical Analysis

All continuous variables presented as mean ± SD, and the categorical variables were presented as frequencies. Associations between categorical variables were tested using the chi-square test, and comparisons between proportions were evaluated using the *Z* test. Comparisons between mean values were evaluated using the *t*-test, after checking for the normality of the distributions. To assess the relationship between asthma symptoms and adherence to the Mediterranean diet, multiple logistic regression analysis was applied, after adjusting for various factors that were considered as potential confounders or effect mediators (*i.e.*, environmental factors). To test for the potential mediating effect of urban/rural environment on Mediterranean diet in asthma, we stratified the analyses by county of residence. Results are presented as ORs and their corresponding 95% confidence intervals (CIs). Hosmer-Lemeshow statistic was calculated to evaluate model's goodness of fit. Wald test was used to evaluate the effect size of the estimated ORs (the higher the Wald test, the better). All reported probability values (*p* values) were based on two-sided hypotheses and compared with a significant level of 5%. SPSS 18 software was used for all the calculations (SPSS Inc., Chicago, IL).

RESULTS

Diet and Asthma Symptoms

In Table 1 various characteristics of the children are presented by area of residence. Children living in urban areas were less physically active ($p < 0.001$), more likely to be obese ($p = 0.002$), and less likely to adhere to a Mediterranean dietary pattern, because they had ~10% lower total KIDMED scores ($p < 0.001$), compared with children living in rural areas. Moreover, the proportion of children with high adherence to the

Mediterranean diet was double in children living in rural areas when compared with urban areas (4.8% versus 2.4%; $p < 0.001$). Age–sex–adjusted analysis showed that children that were very close to the Mediterranean diet had lower likelihood of having asthma symptoms compared with those who were away from this dietary pattern (OR/1 unit in the KIDMED score = 0.84; 95% CI, 0.77, 0.91). Regarding the specific components of the KIDMED index, children living in rural areas were more likely to eat fruit or fruit juice every day ($p < 0.001$), to have a second fruit every day ($p < 0.001$), and to have fresh or cooked vegetables daily ($p < 0.001$) or more than once per day ($p < 0.001$) compared with the children living in urban areas. These rural children also consumed fish more often ($p = 0.004$) and were more likely to have cereal for breakfast ($p < 0.001$) than children living in urban areas. Children in urban areas were more likely to consume dairy products for breakfast ($p < 0.001$) or have two yogurts and/or some cheese daily ($p = 0.001$; Table 1). The vast majority of the participants (*i.e.*, 98.5%) consumed pasteurized milk. The aforementioned associations were similar in both urban and rural areas. Moreover, there were no significant associations between the level of adherence to the Mediterranean diet and the level of physical activity as well as the obesity status of children ($p > 0.10$; Table 1).

Urban/Rural Environment and Asthma Symptoms

The prevalence of ever had asthma symptoms was 23.7% (27.6% among boys and 20.4% among girls; $p = 0.03$) in the urban Athens area, 16.7% (21.6% among boys and 11.8% among girls; $p = 0.023$) in rural areas of Ilia, and 9.6% (10.3% among boys and 9.0% among girls; $p = 0.79$) in rural Viotia areas (Table 2). The overall prevalence of asthma in rural areas was 14.6 (18.4% among boys and 11.0% among girls; $p = 0.01$). The prevalence of asthma symptoms was higher in urban areas when compared with rural areas ($p < 0.001$); whereas no difference regarding asthma symptoms prevalence was observed between the two rural areas ($p = 0.29$). Moreover, children living in the urban area of Athens had 1.78 times higher likelihood of having asthma symptoms when compared with children living in rural areas (OR = 1.78 95% CI, 1.25–2.54), after adjusting for age and sex (Table 2).

Some environmental factors in relation to asthma symptoms were then studied (Table 3). No differences were observed between children living in rural and urban areas regarding the frequency of parental smoking at home or the use of own bedroom or presence of other children within the family; however, children living in rural areas spent more time in outdoor activities, were taking care of pets more often, and were less likely to have attended nursery school when compared with children living in urban areas. Outdoor activities such as playing with friends outdoors during leisure time or visiting parks seem to confer further protection against asthma prevalence in the children studied (OR = 0.85; 95% CI, 0.77, 0.93), whereas taking care of pets (another characteristic of rural environment in the present study) was not associated with asthma symptoms prevalence (OR = 1.02; 95% CI, 0.95, 1.10). Moreover, children living in Viotia spent more hours in outdoor activities when compared with children living in Ilia ($p < 0.001$) or in Athens areas ($p < 0.001$; Table 3).

Table 2 **Prevalence of asthma symptoms among 10- to 12-yr-old children living in urban areas (Athens; $n = 700$) and 10- to 12-yr-old children living in rural areas (Ilia southern to Athens, Viotia, northern to Athens; $n = 425$)**

	Urban areas, Athens	Rural Areas, Ilia and Viotia	*p*
n	700	425	
Any asthma symptoms (ever) (%)	23.7	14.6	<0.001
Night cough (ever) (%)	12.8	13.2	0.84
Exercise wheeze (ever) (%)	4.5	4.1	0.71
Wheeze limiting speech (ever) (%)	5.1	1.8	0.15
Wheeze disturb sleep (ever) (%)			<0.001
<1 time/wk	19.6	3.3	
>1 time/wk	6.6	7.3	

Adjusted for age, sex, and body mass index.
Results are presented as relative frequencies. The p *values retrieved from Z test.*

Urban/Rural Environment, Dietary Habits, and Asthma Symptoms

Despite the aforementioned associations, residual confounding may still exist. Thus, multiple logistic regression analysis, stratified by area of living, was applied (Table 4). The analysis showed that 1-unit increase in the KIDMED score was associated with 16% lower likelihood of having asthma symptoms, adjusted for age, sex, BMI, physical activity status, and energy intake (Table 4). Moreover, a greater adherence to the Mediterranean diet was inversely associated with ever had wheeze (OR = 0.88; 95% CI, 0.78, 0.98) and exercise wheeze (OR = 0.79; 95% CI, 0.67, 0.93). The results pertaining to the living area showed that living in urban Athens increased the likelihood of having asthma symptoms by 1.78 times more than living in the

DO NOT COPY

Table 3 **Environmental characteristics among 10- to 12-yr-old children living in urban areas (Athens; n = 700) and 10- to 12-yr-old children living in rural areas (Ilia southern to Athens, Viotia, northern to Athens; n = 415) areas**

	Urban Areas, Athens	Rural Areas, Ilia and Viotia	p
n	700	425	
Living in own bedroom (%)	74	77	0.17
Parent currently smoking in house (%)	52	53	0.89
Other brother/sisters (%)	85	88	0.27
Playing outdoors (%)	68	74	0.03
Hours/day playing outside home	0.9 ± 0.5	3.7 ± 2.2	<0.001
Attended nursery school (%)	16.7	3.4	<0.001
Taking care of pets (%)	52.5	76.6	<0.001
Visits parks (%)	57.2	71.5	<0.001

Adjusted for age, sex, and body mass index. Results are presented as mean ± SD or frequencies.

Table 4 **Results from multiple logistic regression analysis that evaluated the role of environment and diet on the prevalence of asthma symptoms in (n = 1125) 10- to 12-yr-old children living in urban (Athens) and rural (Ilia southern to Athens, Viotia, northern to Athens) areas**

	OR	95% CI	Wald Test
All children (n = 1125)			
Age (per 1 yr)	0.82	0.67–1.01	3.42
Boys vs girls	1.52	1.11–2.07	6.98
County (urban vs rural)	1.78	1.25–2.54	10.25
KIDMED score (per 1/12 unit)	0.84	0.77–0.91	18.35
Active versus inactive children	1.04	0.76–1.42	0.05
BMI (per 1 kg/m^2)	1.05	1.01–1.09	5.19
Children living in urban areas (n = 700)			
Age (per 1 yr)	0.10	0.77–1.29	0.13
Boys vs girls	2.29	1.54–3.41	4.83
KIDMED score (per 1/12 unit)	0.81	0.73–0.91	14.31
Active vs inactive children	1.04	0.70–1.54	0.28
BMI (per 1 kg/m^2)	1.03	0.98–1.08	1.43
Children living in rural areas (n = 425)			
Age (per 1 yr)	0.50	0.33–0.78	9.63
Boys vs girls	1.61	0.87–2.96	2.29
KIDMED score (per 1/12 unit)	0.87	0.75–1.00	3.71
Active vs inactive children	0.81	0.43–1.55	0.40
BMI (per 1 kg/m^2)	1.14	1.04–1.26	7.94

BMI = body mass index; KIDMED = Mediterranean Diet Quality Index for children and adolescents.

rural areas of the study. It is of interest that the effect size measures (ORs) of both areas of living and dietary habits variables were similar to the ones observed in the previously presented age- and sex-adjusted analysis (*i.e.*, the influence of the additional factors on the aforementioned associations was very low). Then, the analysis was repeated in urban and rural areas separately. It was observed that greater adherence to the Mediterranean diet (*i.e.*, higher KIDMED score) was associated with lower odds of having asthma symptoms in children living in rural areas, as well as in children living in urban areas. Moreover, the effect size measure of the diet variable on the studied outcome was higher in the urban than the rural areas of the study (*i.e.*, higher Wald test score; Table 4). No difference regarding the association between KIDMED score and asthma prevalence was observed between the two rural areas of Ilia and Viotia studied here.

Moreover, boys had higher likelihood of having asthma symptoms when compared with girls in both

DO NOT COPY

rural and urban areas; BMI was positively associated with prevalence of asthma symptoms in rural areas only. No association was observed regarding asthma symptoms and physical activity status (Table 4).

DISCUSSION

An inverse relationship between the level of adherence to the Mediterranean diet and the prevalence of asthma symptoms was observed in both urban and rural areas, irrespective of potential confounders. Our findings have important public health implications because they suggest a strong, nonpharmacologic means for preventing childhood asthma, irrespective of living area. The presented results are consistent with previous studies, including PANACEA study in urban Athens only,[16] that have evaluated the association between the Mediterranean diet and asthma.[16–24] However, there is also a small number of recent studies that do not support this hypothesis.[32,33] It should be emphasized that the Mediterranean-like dietary pattern is a pattern providing good amount of monounsaturated fatty acids, a balanced ratio of $(n-6)/(n-3)$, essential fatty acids, high amounts of fiber, and antioxidants. These nutrients have been proposed to be important against oxidative stress and inflammatory diseases such asthma.[11–15] Moreover, this approach takes into consideration the complicated interactions, intercorrelations among nutrients and foods, and the potential cumulative effects, as well as the lifestyle/eating behavior confounding.[34,35] The participating children had a moderate-to-low level of adherence to a Mediterranean dietary pattern, a finding that supports previous evidence for low adherence to traditional dietary patterns among children in Greece[36] and that should raise concerns among public health policy makers.

Another important finding of the present study was the association of urban environment with increased asthma prevalence. Many studies[5–7] have found associations between several urban air pollutants and adverse health effects in children. Climatic conditions, such as changes in the weather,[8] the relative humidity,[9] or the temperature, and the number of sunny hours,[10] have also been related to asthma prevalence. In the present study, the majority of rural areas of Ilia and Viotia experience greater humidity, lower temperature, and greater average rainfall when compared with urban Athens areas. As per the existing literature, these climatic conditions could probably cause adverse effects asthma symptoms. The small difference in the prevalence of asthma symptoms between the two rural areas, Ilia and Viotia, could be attributed to the variations in climatic conditions, such as humidity and rainfall. The lower prevalence observed in these areas when compared with Athens could probably be attributed to the greater adherence to the Mediterranean diet (*i.e.*, the proportion of children with high adherence to the Mediterranean diet was double in children living in rural areas when compared with urban areas). Thus, dietary habits could play a key role in asthma expression, mediating the adverse effect of environmental factors such as climatologic conditions.

In Athens more children attended nursery school and fewer children were taking care of pets than in rural areas of Ilia and Viotia. Nursery school attendance is a potential risk factor for asthma symptoms.[37] In contrast, taking care of pets has been reported as protective, depending on the type of pet.[38,39] After adjustments for these factors our results did not change.

There are also studies suggesting that psychosocial factors may contribute to asthma symptoms.[40] Area of living is an important determinant of the way of life and stressful events. This could be also a factor influencing our results, explaining some of the difference found in asthma symptom prevalence between rural and urban environments.

Moreover, the present study revealed that outdoor activities (such as outdoor playing with friends), a key element of behaviors within rural environment, seems to confer further protection against asthma prevalence in children. Lower vitamin D levels have been recently associated with a higher risk for asthma symptoms.[41] Vitamin D deficiency may be prevalent even in sunny areas. In our study children living in rural areas seems to spend more time outdoors, limiting the probability of vitamin D deficiency.

In Phase III of the International Study on Allergies and Asthma in Childhood study,[42] large international differences were observed with higher rates in regions where prevalence was previously low. As the authors stated this may reflect greater awareness of this condition and/or changes in the diagnostic procedures in the clinical practice, but another explanation could be the changes that have occurred in the traditional diets of developing countries because of the nutritional transition to more westernized lifestyle and eating habits.

Limitations

This cross-sectional study has limitations, such as recall bias and inability to document causal relationships. Another limitation is that there is lack of objective measurements, such as lung function and laboratory analysis of allergens. Moreover, the information retrieved on dietary habits and asthma symptoms were complimentarily provided by the children's parents who could be subject to recall bias; this is a potential reason for the strength of the results observed.

CONCLUSION

The presented data reveal the protective role of the Mediterranean diet on asthma symptoms in school-

DO NOT COPY

aged children, irrespective of area of living. However, rural environment seems to be associated with lower prevalence of asthma among 10- to 12-year old children. Greater adherence to this healthy dietary pattern and outdoor activities constitute the way of living of many children living in rural areas; this may partially explain the aforementioned findings. Public health policy makers should pay close attention to the exploration of the role of the urban/rural environment, the dietary habits of children and their interrelationships on asthma development.

ACKNOWLEDGMENTS

The authors thank the field investigators of the "PANACEA" study: Adina Tsoutsou, Marios Papadopoulos, Martha Harisi (pediatricians), Yannis Lentzas (physician), Maria Konstantinidou (dietician), Dionysia Kounadi (visiting nurse), Nika Priftis (sports science specialist), and George Antonogiorgos (physician/biostatistician). The authors also thank the schoolteachers, the children, and their parents who participated in the study for their support.

REFERENCES

1. Long A. Aeroallergen sensitization in asthma: Genetics, environment, and pathophysiology. Allergy Asthma Proc 31:89–95, 2010.
2. Maier RM, Palmer MW, Andersen GL, et al. Environmental determinants of and impact on childhood asthma by the bacterial community in household dust. Appl Environ Microbiol 76:2663–2667, 2010.
3. Strachan DP. Hay fever, hygiene and household size. BMJ 299: 1259–1260, 1989.
4. Priftis KN, Anthracopoulos MB, Nikolaou-Papanagiotou A, et al. Increased sensitization in urban vs. rural environment—Rural protection or an urban living effect? Pediatr Allergy Immunol 18:209–216, 2007.
5. McConnell R, Islam T, Shankardass K, et al. Childhood incident asthma and traffic-related air pollution at home and school. Environ Health Perspect 118:1021–1026, 2010.
6. Moore K, Neugebauer R, Lurmann F, et al. Ambient ozone concentrations cause Increased hospitalizations for asthma in children: An 18-year study in Southern California. Environ Health Perspect 2008:116, 1063–1070.
7. Barnett AG, Clark NA, Demers PA, et al. Effect of early life exposure to air pollution on development of childhood asthma. Environ Health Perspect 118:284–290, 2010.
8. Mireku N, Wang Y, Ager J, et al. Changes in weather and the effects on pediatric asthma exacerbations. Ann Allergy Asthma Immunol 103:220–224, 2009.
9. García-Marcos L, Batllés-Garrido J, Blanco-Quirós A, et al. Influence of two different geo-climatic zones on the prevalence and time trends of asthma symptoms among Spanish adolescents and schoolchildren. Int J Biometeorol 53:53–60, 2009.
10. Priftis KN, Paliatsos AG, Panagiotopoulou-Gartagani P, et al. Association of weather conditions with childhood admissions for wheezy bronchitis or asthma in Athens. Respiration 73:783–790, 2006.
11. Takemura Y, Sakurai Y, Honjo S, et al. The relationship between fish intake and the prevalence of asthma: Tokorozawa Childhood and Pollonosis Study. Prev Med 34:221–225, 2002.
12. Sharma SK, and Banga A. Prevalence and risk factors for wheezing in children from rural areas of north India. Allergy Asthma Proc 28:647–653, 2007.
13. Okoko BJ, Burney RG, Newson RB, et al. Childhood asthma and fruit consumption. Eur Respir J 29:1161–1168, 2007.
14. Seaton A, Godden DJ, and Brown K. Increase in asthma: A more toxic environment or a more susceptible population? Thorax 49:171–174, 1994.
15. Gilliland FD, Behrane KT, Li YF, et al. Children's lung function and antioxidant vitamin, fruit, juice, and vegetable intake. Am J Epidemiol 158:576–584, 2003.
16. 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 22:283–289, 2011.
17. Nagel G, Weinmayr G, Kleiner A, et al. Effect of diet on asthma and allergic sensitisation in the International Study on Allergies and Asthma in Childhood (ISAAC) Phase Two. Thorax 65:516–522, 2010.
18. Simopoulos AP. The Mediterranean diet: What is so special about the diet of Greece? The scientific evidence. J Nutr 131: 3065–3073, 2001.
19. 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 62:677–683, 2007.
20. Chatzi L, and Kogevinas M. Prenatal and childhood Mediterranean diet and the development of asthma and allergies in children. Public Health Nutr 12:1629–1634, 2009.
21. Garcia Marcos L, Canflanca I, Garrido JB, et al. Relationship of asthma and rhinoconjunctivitis with obesity, exercise and Mediterranean diet in Spanish schoolchildren. Thorax 62:503–508, 2007.
22. De Batlle J, Garcia-Aymerich J, Barraza-Villarreal A, et al. Mediterranean diet is associated with reduced asthma and rhinitis in Mexican children. Allergy 63:1310–1316, 2008.
23. Castro-Rodriguez JA, Garcia-Marcos L, Alfonseda Rojas JD, et al. Mediterranean diet as a protective factor for wheezing in preschool children. J Pediatr 152:823–828, 2008.
24. Barros R, Moreira A, Fonseca J, et al. Adherence to the Mediterranean diet and fresh fruit intake are associated with improved asthma control. Allergy 63:917–923, 2008.
25. Priftis KN, Panagiotakos DB, Anthracopoulos MB, et al. Aims, methods and preliminary findings of the Physical Activity, Nutrition and Allergies in Children Examined in Athens (PANACEA) epidemiological study. BMC Public Health 7:140, 2007.
26. Weiland SK, Bjorksten B, Brunekreef B, et al. Phase II of the International Study of Asthma and Allergies in Childhood (ISAAC II): Rationale and methods. Eur Respir J 24:406–412, 2004.
27. Antonogeorgos G, Grigoropoulou D, Papadimitriou A, et al. Validation of a semi-quantitative Food Frequency Questionnaire designed for children aged 10–12 years: The PANACEA-FFQ. Proc Hellenic Pediatric Conf Suppl 50, 2011.
28. Serra-Majem L, Ribas L, Ngo J, et al. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. Public Health Nutr 7:931–935, 2010.
29. Argiropoulou E, Michalopoulou M, Aggeloussis N, et al. Validity and reliability of physical activity measure in Greek high school age children. J Sports Sci Med 3:147–159, 2004.
30. Cole TJ, Bellizi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ 320:1–6, 2000.
31. Hellenic National Meteorological Service. Available online at www.emy.gov.gr; last accessed November 20, 2010.
32. Lange NE, Rifas-Shiman SL, Camargo CA Jr, et al. Maternal dietary pattern during pregnancy is not associated with recurrent wheeze in children. J Allergy Clin Immunol 126:250–255, 2010.

DO NOT COPY

33. Gonzalez Barcala FJ, Pertega S, Bamonde L, et al. Mediterranean diet and asthma in Spanish schoolchildren. Pediatr Allergy Immunol 21:1021–1027, 2010.
34. Hu FB. Dietary pattern analysis: A new direction in nutritional epidemiology. Curr Opin Lipidol 13:3–9, 2002.
35. Panagiotakos DB, Pitsavos C, and Stefanadis C. A-priori and a-posterior dietary pattern analyses have similar estimating and discriminating ability in predicting 5-Y incidence of cardiovascular disease: Methodological issues in nutrition assessment. J Food Sci 74:218–224, 2009.
36. Kontogianni MD, Vidra N, Farmaki AE, et al. Adherence rates to the Mediterranean diet are low in a representative sample of Greek children and adolescents. J Nutr 138:1951–1956, 2008.
37. Garcia-Marcos L, Mallol J, Sole D, et al. International study of wheezing in infants: Risk factors in affluent and non-affluent countries during the first year of life. Pediatr Allergy Immunol 21:878–888, 2010.
38. Bufford JD, Reardon CL, Li Z, et al. Effects of dog ownership in early childhood on immune development and atopic diseases. Clin Exp Allergy 38:1635–1643, 2008.
39. Ownby DR, Johnson CC, and Peterson EL. Exposure to dogs and cats in the first year of life and risk of allergic sensitization at 6 to 7 years of age. JAMA 28:963–972, 2002.
40. Turyk ME, Hernandez E, Wright RJ, et al. Stressful life events and asthma in adolescents. Pediatr Allergy Immunol 19:255–263, 2008.
41. Brehm JM, Celedon JC, Soto-Quiros ME, et al. Serum vitamin D levels and markers of severity of childhood asthma in Costa Rica. Am J Respir Crit Care Med 179:765–771, 2009.
42. Pearce N, Aıt-Khaled N, Beasley R, et al. Worldwide trends in the prevalence of asthma symptoms: Phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax 62:758–766, 2007. □

DO NOT COPY

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.