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RELATIONSHIP BETWEEN SPECIFIC SERUM IGE TO *ASCARIS LUMBRICOIDES* AND ONSET OF RESPIRATORY SYMPTOMS IN BANGLADESH IMMIGRANTS

G. DI LORENZO, M.L. PACOR[1], P. MANSUETO, M. ESPOSITO-PELLITTERI, N. SCICHILONE[2], V. DITTA, C. LO BIANCO, M.S. LETO-BARONE, G. DI FEDE[3], R. CORROCHER[1], S. MANSUETO and G.B. RINI

Dipartimento di Medicina Clinica e delle Patologie Emergenti, Università degli Studi di Palermo; [1]Dipartimento di Medicina Clinica e Sperimentale, Università degli Studi di Verona; [2]Istituto di Medicina Generale e Pneumologia, Cattedra di Malattie dell'Apparato Respiratorio, Università degli Studi di Palermo; [3]Dipartimento di Discipline Chirurgiche ed Oncologiche, Università degli Studi di Palermo, Italy

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The role of helminths in asthma and/or rhinitis and in allergic sensitization is still unclear. We assessed the relationship between *Ascaris*-specific IgE, respiratory symptoms and allergic sensitization in Bangladesh immigrants. 246 individuals were examined from 1996 to 2001. Serum total IgE, *Ascaris* IgE, specific IgE to inhalant allergens, skin prick tests (SPT) and parasitological evaluation of the stool were performed. Total serum IgE were significantly higher in *Ascaris*-IgE positive (> 0.35 kU/L) individuals (806.5 [409.0-1436.0] kU/L *vs.* 207.0 [127.0-332.5] kU/L; $P < 0.0001$) and in subjects with respiratory symptoms (413.0 [239.0-1096.0] kU/L *vs.* 259.5 [147.0-387.0] kU/L), ($P < 0.0001$), but not in SPT positive subjects (413.0 [179.0-894.0] kU/L *vs.* 404.6 [305.0-1201.0] kU/L ($P = 0.5$). *Ascaris*-specific IgE were detected in 48 subjects with respiratory symptoms (40.0%) and in 46 subjects without respiratory symptoms (36.5%) ($P = 0.5$). The SPT positivity was similar between *Ascaris*-IgE seropositive (38.2%) and *Ascaris*-IgE seronegative (38.1%) subjects ($P = 0.9$). Total IgE and length of stay in Italy correlated with SPT positivity (OR 5.6 [CI 95% 1.5-19.8], $P = 0.007$, and OR 1.5 [CI 95% 1.3-1.7], $P < 0.0001$), and with respiratory symptoms (OR 13.7 [CI 95% 3.0-62.4], $P = 0.0007$, and OR 2.4 [CI 95% 1.9-3.0], $P < 0.0001$). *Ascaris*-IgE were negatively associated with SPT positivity (OR 0.3 [CI 95% 0.1-0.8], $P = 0.02$) and with respiratory symptoms (OR 0.1 [CI 95% 0.04-0.7], $P = 0.01$). Our findings favour the role of environmental factors in the development of respiratory symptoms in immigrants, irrespective of *Ascaris*-IgE.

Asthma is highly prevalent in populations that become urbanised. Although the explanation for this phenomenon is not known, one reason that could be advocated is represented by the lower prevalence of infection with intestinal parasites in more affluent populations, since parasite infection has been postulated to prevent IgE-mediated allergic disease by blocking effector-cell IgE receptors with parasite-induced specific and polyclonal IgE, or by the production of anti-inflammatory interleukins (1-2) Other potential explanations include increased exposure to house dust-mite allergens due to the

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Mailing address: Dr Gabriele Di Lorenzo, MD,
Dipartimento di Medicina Clinica
e delle Patologie Emergenti,
Via del Vespro 141,
90127 Palermo, Italy
Tel: + 39 091 6552987 - Fax: +39 091 6552936
e-mail: dilo601@unipa.it

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adoption of housing and bedding styles that favour dust-mite replication. Indeed, a recent study has shown a rising trend of asthma and allergy in the population of the Eastern regions in Germany, probably related to changes in lifestyle (3).

The evaluation of asthma and allergy in individuals that migrate from developing to industrialized countries provides a unique opportunity to investigate the contribution of environmental factors to the development of such conditions. In the last 10 years, a large number of people from developing countries have emigrated to industrialized countries. Many immigrants in Sicily (Italy) are from Asian countries, such as Bangladesh. Some of these individuals have experienced respiratory symptoms suggestive of rhinitis and/or asthma only after their arrival in Italy (4).

According to the hygiene hypothesis, the presence of *Ascaris*-specific IgE may protect from the development of allergic diseases. In South America the presence of antibodies to *Ascaris* has been associated with a lower prevalence of allergic diseases. Prolonged exposure to *Ascaris* during the very first period of life has been considered sufficient to provide lifetime protection from the development of allergic diseases (5). However, it has also been speculated that the 'removal of protection' during adulthood (e.g. by a reduced exposure to helminths), might favour the appearance of allergy in genetically predisposed subjects (3). *Ascaris*-specific IgE is not specific for an ongoing infection but is more likely a general marker of previous contact with helminthic antigen. To investigate the role of intestinal helminth infections on allergy-related immune response, it is useful to measure *Ascaris* IgE as a marker of previous helminth contact. The analysis of this data offers the opportunity to examine the influence of *Ascaris* seroreactivity on allergic sensitization. In this scenario, immigrants from developing countries to countries with a westernized lifestyle offer a useful model to evaluate this hypothesis (4, 6-8).

MATERIALS AND METHODS

Subjects

Two hundred and forty-six adult subjects from Bangladesh living in Palermo (Italy) were studied, using a case-control design. We selected 120 subjects treated at the Outpatients Clinic of the Dipartimento di Medicina Clinica e delle Patologie Emergenti, University of Palermo (Italy) for respiratory symptoms and 126 subjects of Bangladesh without respiratory symptoms, matched for sex and age. The demographic characteristics of the patients are reported in Table I. All data concerning the length of stay in Palermo, working conditions, exposure to pets at home, size of family and personal history were recorded on the clinical report during their first visit to the clinic, both in subjects with and without respiratory symptoms. All patients were able to speak Italian or were accompanied by an Italian-speaking relative. Allergy was defined on the basis of allergic symptoms (rhinitis, conjunctivitis, asthma) and positive skin prick testing for at least one allergen, confirmed by specific IgE determination. Each individual was considered asthmatic if he/she reported at least two episodes of wheezing, coughing and dyspnea in the previous 12 months and was currently taking medications for asthma. Each individual was considered rhinitic if he/she reported at least two episodes of sneezing, rhinorrhea and nasal congestion without flu in the previous 24 months and was currently taking medications for rhinitis. However, in each examined subject, asthma/and or rhinitis was physician-diagnosed.

Informed consent according to the declaration of Helsinki of 1975 was obtained from each subject before the clinical evaluation. Each subject that entered the study was adequately informed on the aims, methods, anticipated benefits and potential hazards of the study and the discomfort it may entail. Because this study was a non-therapeutic biomedical research, they were informed that they were at liberty to abstain from participation in the study and that they were free to withdraw their consent to participate at any time. However, the study was approved by the Ethical Committee of the Dipartimento di Medicina Clinica e delle Patologie Emergenti, University of Palermo.

Skin Prick Test (SPT)

SPT was performed in all patients (9). The allergenic extracts used (Alk Abellò, Milan, Italy) were grass pollens (*Lolium perenne, Cynodon, Phleum pratense*), mugwort (*Compositae*), wall pellitory (*Parietaria judaica*), trees (*Olea europea* and *Cupressus*), house dust mites (*Dermatophagoides pteronyssinus* and *farinae*), cat and dog dander, moulds (*Alternaria alternata, Aspergillus, Cladosporium herbarum, Candida, Penicillium*) and *Blatella germanica*. Histamine (10 mg/mL) and glycerine were used as positive and negative controls, respectively.

Total serum and specific IgE assays

Serum samples were drawn from each subject and were immediately frozen and stored at -80° C until they were

analyzed. Total and specific serum IgE were determined using Unicap® with fluroimmunoassay technique (Pharmacia and Upjohn Diagnostics AB, Uppsala, Sweden), according to the manufacturer's instructions. The following antigens were tested: *Ascaris lumbricoides* (p1), grass (g6), mugwort (w6), *Parietaria judaica* (w21), *Olea europea* (t9), *Cupressus* (t23), *Dermatophagoides pteronyssinus* (d1), *Dermatophagoides farine* (d2), cat (e1), dog (e2), *Alternaria* (m3) *Aspergillus* (m6) and *Blatella germanica* (i6). Levels greater than or equal to 0.35 kU/L (level 1 on the specific IgE scale) were considered positive. Total IgE was also determined by the same method with a detection limit of 2 kU/L and an upper limit of 5000 kU/L (9).

Spirometry

FEV was measured with a Gould 2400 automated system (Sensormedics BV, Bilthoven, Netherlans), taking into account the highest of 3 successive measurements, provided that the difference between measurements was within 100 mL (9).

Stool test

Stool samples were examined for helminths. Subjects were positive for the stool test if any helminth ova parasites were identified during microscopic examination. Parasitological observations were validated by a physician in regular quality control checks.

Statistical analysis

Data were analysed with SYSTAT 10 software package (Systat Software Inc., California, USA). Data of serum total, *Ascaris*-specific IgE and allergens-specific-IgE were not normally distributed, so log-transformed data were used in all calculations. Where *Ascaris*-specific IgE were < 0.35 kU/L, we assigned a value of 0.34 kU/L. In the text we present these data as median and 25^{th}-75^{th} percentiles. Levels of serum total IgE and *Ascaris*- and allergens-specific IgE were examined with t student test, analysis of variance, χ^2 tests and Sperman's rank correlation as appropriate. Two logistic regression analyses were performed to determine the relationship between skin test responses or respiratory symptoms and serum total IgE, *Ascaris*-specific IgE and the time elapsed since arrival in Italy. An odds ratio less than 1 indicated a negative association between the variable and the outcome, whereas an odds ratio greater 1 indicates a positive association. For all statistical analyses a value of $P < 0.05$ was considered statistically significant.

RESULTS

We studied 246 subjects, 157 males (30.7 ± 6.9 yrs) and 89 females (30.5 ± 6.0 yrs) ($P = 0.8$). The Bangladesh immigrants evaluated at the Outpatient Clinic were affected by respiratory symptoms: asthma (n = 18), rhinitis and asthma (n = 44) and rhinitis alone (n = 58). One hundred and twenty-six subjects did not report respiratory symptoms consistent with a diagnosis of asthma and/or rhinitis, and this has been confirmed with a complete clinical and functional (i.e. anterior rhinoscopy and spirometry) evaluation.

Stool test

None of the 246 subjects examined presented a positive stool sample for *Ascaris* or other helminth.

Serum total IgE and Ascaris-specific IgE

Immigrants who were *Ascaris*-IgE seropositive (> 0.35 kU/L) (n = 94, 38.2%) showed higher levels of total serum IgE (806.5 [409.0-1436.0] kU/L) than the *Ascaris*-IgE seronegative (< 0.35 kU/L) subjects (n = 152, 61.8%) (207.0 [127.0-332.5] kU/L, $P < 0.0001$). However, the levels of total serum IgE were higher in subjects with respiratory symptoms (413.0 [239.0-1096.0] kU/L) compared with subjects without respiratory symptoms (259.5 [147.0-387.0] kU/L) ($P < 0.0001$).

No significant difference in total serum IgE was found irrespective of the presence (413.0 [179.0-894.0] kU/L) or not (404.6 [305.0-1201.0] kU/L) of SPT positivity ($P = 0.5$) for the entire study group as well as for the asthmatics, the rhinitics and the asthma plus rhinitis group (Table II).

Ascaris-specific IgE were detected in 48 subjects with respiratory symptoms (40.0%) and in 46 subjects without respiratory symptoms (36.5%) ($P = 0.5$). However, the levels of *Ascaris*-specific IgE were significantly different between the subjects with and without respiratory symptoms (0.35 [0.30-3.0] kU/L *vs.* 0.30 [0.30-0.90] kU/L, respectively ($P = 0.03$).

Fig. 1 shows the levels of *Ascaris*-specific IgE related to the respiratory symptoms. We found significant difference between asthmatics with SPT positivity and rhinitics with SPT positivity ($P = 0.0009$), between asthmatics with SPT positivity and rhinitics without SPT positivity ($P = 0.002$), between asthmatics without SPT positivity and rhinitics with SPT positivity ($P = 0.006$), between asthmatics without SPT positivity and rhinitics without SPT

Table I. *Demographic characteristic of the subjects.*

	Subjects with respiratory symptoms (n = 120)	Healthy subjects (n = 126)	*P*
Males/Females (n)	80/40	77/49	0.3
Age (yrs, mean ± SD)	30.8 ± 7.5	30.5 ± 5.6	0.7
Residence in Italy (yrs, mean ± SD)	6.4 ± 2.3	3.1 ± 1.4	< 0.0001
Onset of respiratory symptoms (yrs, mean ± SD)	2.8 ± 1.3	NA	NA
Size of the family (mean ± SD)	4.7 ± 0.9	4.5 ± 1.0	0.08
Current smokers (n)	0	0	NA
Ex-smokers (n)	0	0	NA
Non-smokers (n)	120	126	NA
FEV_1 (% pred. mean ± SD)	99.1 ± 5.5	99.4 ± 5.2	0.6
Asthma (n)	18	0	NA
Asthma plus rhinitis (n)	44	0	NA
Rhinitis (n)	58	0	NA
Serum total IgE kU/L (median and 25^{th}-75^{th} percentiles)	413.0 [239.0-1096.0]	259.5 [147.0-387.0]	< 0.0001
Serum specific *Ascaris*-IgE (> 0.35 kU/L) (yes/no)	48/72	46/80	0.5
Serum specific *Ascaris*-IgE kU/L (median and 25^{th}-75^{th} percentiles)	0.35 [0.30-3.0]	0.30 [0.30-0.90]	0.03
Skin Prick Test positive/negative	94/26	0/126	< 0.0001
Presence of Ascaris in the stool	0	0	NA

NA = not applicable
SD = Standard Deviation

Table II. *Comparison of serum total IgE among the study groups. Data are presented as median and 25^{th}-75^{th} percentiles.*

	Without SPT positivity Subjects (n = 26)	With SPT positivity Subjects (n = 94)	*P*
Asthmatics (n = 18)	933.0 [413.0-1401.0]	1501.0 [837.0-2738.0]	0.4
Asthma plus rhinitis (n = 44)	1096.0 [305.0-1436.0]	678.0 [160.0-1910.0]	0.6
Rhinitics (n = 58)	314.0 [279.0-396.2]	290.5 [160.0-494.5]	0.9

Table IIIa. *Odds Ratios (95% CI) for skin test responses.*

	OR (95% CI)	*P*
Serum total IgE levels	5.6 (1.5-19.8)	0.007
Ascaris-specific IgE levels	0.3 (0.1-0.8)	0.02
Length of stay in Palermo	1.5 (1.3-1.7)	< 0.0001

Table IIIb. *Odds Ratios (95% CI) for respiratory symptoms.*

	OR (95% CI)	*P*
Serum total IgE levels	13.7 (3.0-62.4)	0.0007
Ascaris-specific IgE levels	0.1 (0.04-0.7)	0.01
Length of stay in Palermo	2.4 (1.9-3.0)	< 0.0001

positivity ($P = 0.005$), between subjects with asthma plus rhinitis and SPT positivity and rhinitics with SPT positivity ($P < 0.0001$) and, finally, between subjects with asthma plus rhinitis and SPT positivity and rhinitics without SPT positivity ($P = 0.001$). No other differences were observed between the study groups.

Skin Prick Test

Skin prick testing showed a positivity for at least one inhalant allergen in 94 out of 120 subjects (78.3%) with respiratory symptoms. Patients were most commonly sensitized to *Parietaria judaica* (46.6%), house dust mites (41.6%), *Olea europea* (35.0%), and grass pollens (20.0%). The percentages of the response to other allergen tests were lower: mugwort (11.6%), dander of cat (10.0%) and *Cupressus* (6.6%). The spectrum of allergic sensitization in immigrants to Palermo overlapped that of the general population living in the South of Italy (27-28).

An SPT positivity for at least one inhalant allergen was found in 36 (38.2%) subjects with *Ascaris*-IgE seropositivity and in 58 (38.1%) subjects without *Ascaris*-IgE seropositivity ($P = 0.9$). Thirty-eight subjects (40.4%) presented one positivity, 20 subjects (21.2%) presented two positivities, 22 subjects (23.4%) presented three positivities, 8 subjects (8.5%) presented four positivities and 6 subjects (6.3%) were positive to five inhalant allergens. We were unable to find any difference between subjects with and without *Ascaris*-IgE seropositivity with respect to the number of positivities to SPT ($P = 0.3$). Also, no difference was found among the concentrations of *Ascaris*-IgE in SPT-positive subjects (0.35 [0.30-3.0] kU/L) and in SPT-negative subjects (0.35 [0.30-1.1] kU/L) ($P = 0.2$). Finally, in SPT-positive subjects with respiratory symptoms (n = 94) the levels of serum specific IgE, expressed by the sum of the serum specific IgE > 0.35 kU/L, were higher in subjects with *Ascaris*-IgE seropositivity (115.8 [45.6-188.5]) than in those without *Ascaris*-IgE seropositivity (48.3 [15.1-89.7]) ($P = 0.002$).

Period of residence in Palermo and respiratory symptoms and SPT

The time elapsed between the arrival in Italy and the appearance of respiratory symptoms was known in all subjects. All declared that respiratory symptoms had appeared after their arrival in Italy. The mean period of residence in Italy was 6.4 ± 2.3 years for the patients with respiratory symptoms and 3.1 ± 1.4 years for the subjects without respiratory symptoms

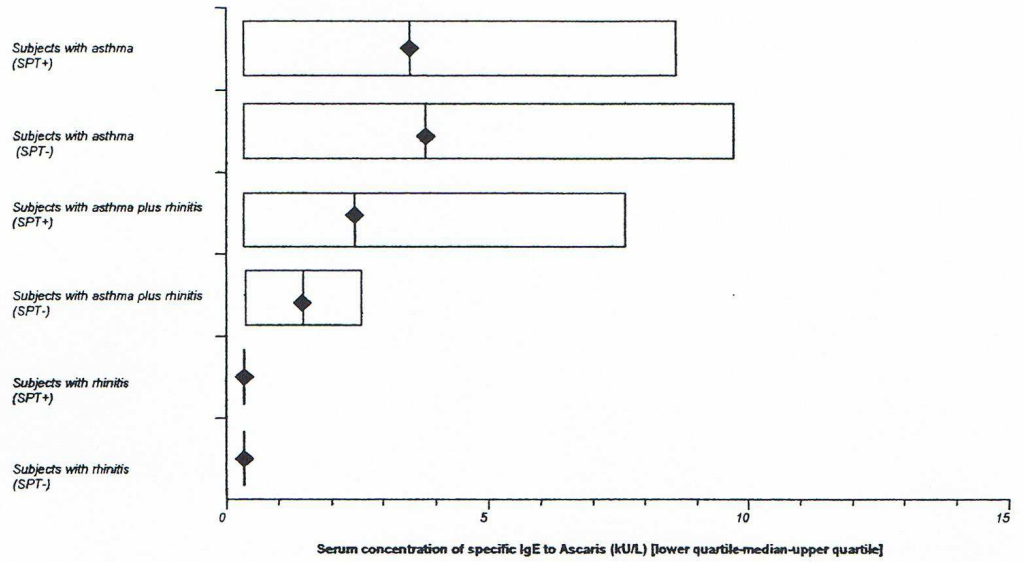

Fig. 1. *Serum Ascaris-IgE concentration in relation to clinical phenotypes (asthma, rhinitis and asthma plus rhinitis). Significant differences were found between asthmatics with SPT positivity and rhinitics with and without SPT positivity (P = 0.0009 and P = 0.002), between asthmatics without SPT positivity and rhinitics with and without SPT positivity (P = 0.006 and P = 0.005), between subjects with asthma plus rhinitis and SPT positivity and rhinitics with and without SPT positivity (P < 0.0001 and P = 0.001). Data are presented as median and 25th-75th percentiles.*

($P < 0.0001$). In particular, the length of residence in Italy before the onset of respiratory symptoms was 4.6 ± 1.5 years (2-8 years) for the rhinitic group, 7.9 ± 1.7 years (5-11 years) for the asthma plus rhinitis group and 8.3 ± 1.9 years (5-11 years) for the asthmatic group. In subjects with asthma plus rhinitis, the rhinitis preceded the onset of asthma or they occurred contemporarily. Finally, no difference was found among SPT-positive (6.3 ± 2.4 years) or -negative (7.0 ± 2.2 years) subjects ($P = 0.1$) as regards the onset of respiratory symptoms and length of residence in Palermo. However, when all subjects were considered, the number of SPT positivities was associated with the years of residence in Palermo (rho = 0.46, CI 95% 0.38 to 0.57). Whereas, we did not find any relationship between the years of residence in Palermo and the serum levels of specific IgE to *Ascaris* (rho = -0.10 CI 95% -22 to 0.01).

Logistic regression analysis for skin test responses and total serum IgE, *Ascaris*-specific IgE levels and the time of residence in Palermo showed that subjects with higher total serum IgE levels and longer residence in Palermo were more likely to have skin test positive responses (Table IIIa). Similar results were obtained when respiratory symptoms were employed as the dependent variable (Table IIIb). The presence of *Ascaris*-specific IgE was negatively associated both with skin test positive responses and with respiratory symptoms. These data confirm that the environmental factor plays a more crucial role in subjects with an atopic predisposition.

DISCUSSION

The prevalence of allergic respiratory diseases, such as asthma and rhinoconjunctivitis, has increased dramatically since the advent of industrialization. Many hypotheses have been advocated to explain this phenomenon: better hygiene, fewer severe infections early in life due to treatment with antibiotics and vaccinations, the loss of some protective effects that occur in rural lifestyles, environmental pollution and changes in dietary habits (1-2). Each hypothesis is supported by several observations; however, environmental changes represent the common factor that contributes to promote allergic diseases and respiratory symptoms (10-11). In rural countries of Africa and Asia, the prevalence of atopic diseases and respiratory symptoms (i.e. rhinitis and/or asthma) is lower than that detected in Europe and in

the United States (12).

An ecologic relationship between the prevalence of atopic disease and parasitism has been reported (13). The role of gastrointestinal helminth infections as environmental determinant of atopy/allergy is gaining increasing interest. *Ascaris lumbricoides* is responsible for the most prevalent infection (14). This is likely to be an important determinant of the host immune response to the parasite (14), in that the helminth infections are the most efficient inducers of the Th2 immune response. A central hypothesis to explain the reduced allergic manifestations in helminth-infected subjects has been expounded by Linch (15-16). Because high levels of polyclonal (i.e. nonantigen-specific) IgE occur in most worm infections, the investigator has suggested that few FcεRIs receptors on mast cells are occupied by IgE molecules to allergen(s). However, more recent studies cast doubt on the explanation involving non-specific IgE. In the study by Dold et al., children who were *Ascaris*-IgE seropositive had 10-fold higher levels of total IgE and higher prevalence rates of allergen-specific IgE seropositivity. However, the same children had higher prevalence of allergic rhinitis and asthma (3).

As a cross-reactivity is reported between *Ascaris* and other intestinal parasites, such as *Anisakis simplex* (17), in all subjects with a RAST > 0.35 kU/L for *Ascaris,* we performed the RAST for *Anisakis simplex*, but no subjects showed positive results for this parasite (data not shown).

The findings of our study indicate that many Bangladesh immigrants in Palermo were symptom-free before leaving the country of origin and that respiratory symptoms appeared after their arrival in Italy.

It has been reported that the prevalence of asthma in the Bangladesh population is higher in children aged 5-14 years (7.3%) than in adults of 15-44 years (5.3%) (18). The prevalence of geohelminths in school children (age 5-14 years) in Bangladesh, by stool microscopy, showed *Ascaris lumbricoides* in 69% (19). Thus, the high rates of helminths infections in Bangladeshi children might contribute to the lower prevalence of allergy. Finally, in Bangladesh, asthma is equally prevalent in metropolitan as in rural areas. The hygiene hypothesis could explain the lower prevalence of asthma observed in Bangladesh as compared to more developed countries (18-19).

Little is known about the effects of sudden and massive exposure of the immigrants to airborne allergens that are not present in the country of origin (i.e. *Parietaria judaica* and *Olea europea*). One reasonable hypothesis is that the polluted atmosphere, in combination with an exposure to new allergens, favours the sensitization and/or appearance of respiratory symptoms in predisposed subjects. Palermo can be considered a slightly polluted city, the main source of air pollutants being from vehicle exhaust. A dramatic increase in automobile use has occurred in the past 30 years; furthermore, the number of diesel vehicles has increased. Several studies have shown that exposure to diesel exhaust particles enhances allergen-specific IgE synthesis in mice (20-23). Therefore, allergen exposure in the presence of diesel exhaust particles could have contributed to allergen sensitization in Bangladesh immigrants in the city of Palermo. The association between traffic density and the development of respiratory symptoms reinforces the possible role of environmental pollution (24-25). In this regard, it has been observed that traffic limitations during the summer Olympic Games held in 1996 in Atlanta (GA, USA) resulted in air quality improvement and in a significant decrease in childhood respiratory diseases (26).

Another hypothesis lies in the improved hygienic life conditions that might have contributed to the appearance of respiratory symptoms in extra-European immigrants in Palermo. In 1989, Strachan et al. observed an inverse relation between allergic rhinitis and the number of children in the household (27). The authors proposed that the declining family size led to a reduced rate of infection among children, thus inducing allergic sensitization. This hypothesis, which is part of the hygiene hypothesis, has been recently supported by several studies (28-31) and has been advocated to explain the rising trend of allergies in the new generations of populations living in industrialized countries. This explanation could be also valid for immigrants to a Western industrialized city. However, in our study the family size was not different between subjects with respiratory symptoms and healthy subjects.

Although the immigrants of our study were generally young adults, the reduced exposure to *Ascaris* might have facilitated the Th2-mediated immune responses towards allergens (32). The

prevalence of *Ascaris* in Sicily is much lower than that of most developing countries, and this might have contributed to the development of allergic disorders in Bangladesh immigrants.

Our results demonstrate that the concentration of total serum IgE did not influence skin test reactivity to allergen *in vivo* and the levels of specific IgE *in vitro*. However, the subjects with incident *Ascaris*-IgE seropositivity and respiratory symptoms showed higher total serum IgE as opposed to those with *Ascaris*-IgE seronegativity, whereas the concentration of specific IgE to allergens were not different, suggesting that they were predisposed and had only a basal higher synthesis of total IgE. The spectrum of allergic sensitization in Bangladesh immigrants living in the city of Palermo was similar to the one noted in the Italian population living in the South of Italy (33) and is in line with the observations of Kalioncu et al. and Tedeschi et al. on extra-European immigrants to Sweden and to Milan, respectively (4, 34). In our study, *Parietaria* pollen was the most important allergen followed, in ranking order, by house dust mites, *Olea Europea* and grass pollens. However, the higher presence of SPT positive to dust house mites in females than in males confirms the role of the environment on the development of allergic diseases. Indeed, all the female immigrants are housemaids, whereas the men are gardeners or porters, thus spending most of their time outside.

In conclusion, our study conducted on Bangladesh immigrants suggests that hygienic lifestyle and environmental factors in a western industrialized city favour the development of respiratory symptoms, irrespective of the presence of specific serum IgE to *Ascaris* (35). The relationship between worms and allergies is worth exploring since conflicting theories have been proposed. The main reason for the need of clarification is that the physiologic function of the IgE system is still not well understood even if nematode infection has been extensively used as an approach to understanding IgE regulation. For this reason, the prevalence of chronic respiratory symptoms in immigrants can represent an important public health problem in the host country.

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Competing interests

The Authors declare that they have no competing interests.

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