

Differences in prevalence of allergic sensitization in urban and rural school children

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Background: Environmental factors are important causes of sensitization, even though the effect of specific pollutants and the interaction between pollution and aeroallergens are not completely known.

Purpose: To evaluate whether the exposure to pollutants or to allergens is a more important contributing factor in causing sensitization.

Methods: A group of 312 children living in the city and a group of 225 children living in a rural area, ages 11 to 14, were studied. All subjects underwent a skin prick test. The pollen counts were performed in the two different areas during the peak of the pollen season. At the same time the levels of ozone and suspended particulates were measured.

Results: The students living in the rural area showed a significantly higher percentage of sensitization than those in the city ($P = .046$). Sensitization to pollen was more frequent in the rural area ($P < .001$) but pet sensitization was more frequent in the city. More rural area students were sensitive to multiple allergens ($P = .034$). Pollen levels were higher in the rural area ($P = .001$). Both ozone and suspended particulate levels were higher in the city ($P = .001$ and $P < .001$, respectively).

Conclusions: The degree of pollen exposure is a larger contributing pathogenic factor in inducing sensitization than air pollution.

Ann Allergy Asthma Immunol 1999;83:252–256.

INTRODUCTION

The role of environmental factors in causing sensitization has been investigated by many researchers.^{1–4} To date, the effect of a given pollutant and its interaction with aeroallergens has not been well established. It has been hypothesized that pollution promotes sensitization: a relationship between high traffic and allergic symptoms has been demonstrated in young Germans⁵ and in children with rhinitis.³ National Health and Nutrition Survey II (NHANES II) has shown an increased

risk for becoming allergic among city dwellers.⁶ The comparisons between city and rural children in Sweden and Poland⁷ found that city children in both countries had a higher prevalence of sensitization. Nevertheless, the Polish children living in cities had fewer allergies than Swedish children living in cities, although they were exposed to higher pollutant levels. It has also been reported that in the former West Germany there was a higher prevalence of allergy than in the former East Germany, in spite of the higher prevalence of chronic respiratory diseases in the latter.⁸ A significant relationship between the allergen exposure level, mainly to pollen, and the degree of sensitization in youthful populations^{9–11} has been shown. It has also been reported that pollution, mainly due to diesel exhaust, is a critical factor in developing sensitization to *Cedrum Japonicum*.¹

It remains controversial whether the exposure to pollutants is a more impor-

tant contributing factor in causing sensitization than exposure to allergens. To investigate this topic, two different groups of school children, one group living in the city and the other living in rural areas, were studied. The exposure to pollen and pollutant concentrations and also the degree of sensitization were compared in both groups. For the pollen count we hypothesized a different pattern in the two areas, as already observed during the period 1991/93 (personal observation). Ozone and total suspended particulate levels were chosen because they can be considered to be good markers of pollution due to vehicle traffic and of pollutants that cause chronic respiratory irritations.

MATERIALS AND METHODS

Two different areas in the Genoa Province have been evaluated: the city center of Genoa and Serra Riccò. Genoa is one of the most important Mediterranean ports with a population of around 650,000. In contrast, Serra Riccò is a small village with 8,000 inhabitants. There are light traffic conditions and no industry. It is situated 300 meters above sea level and 20 kilometers from Genoa. The study was carried out between June 1995 and July 1996.

Subjects

The city group consisted of 312 pupils chosen from the schools of the city center of Genoa and the rural group consisted of 225 students attending the Junior High School (all aged 11 to 14 years).

Two hundred and eighty-four students from Genoa (91%) and two hundred and two from Serra Riccò (90%) agreed to participate in this study. All students had lived in the same house for at least 10 months each year since their birth. All children underwent a

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Received for publication March 12, 1998.

Accepted for publication in revised form May 8, 1999.

skin prick test that was performed according to the methodology and criteria proposed by the European Academy of Allergology and Clinical Immunology (EAACI).¹² Prick tests were done on the volar surface of the forearm, using 1-mm prick lancets. The needle was introduced through a drop of the test solution at a 45° angle to the skin.

All allergen extracts were provided by Neo Abellò (Milan, Italy) and included the following: mites (*Dermatophagoides farinae* and *pteronyssinus*), cat, dog, grass mix, *Absinthium*, *Parietaria judaica*, birch, hazel, olive tree, *Alternaria tenuis*, *Cladosporium*, and *Aspergillum*. They are the most common allergens in the study areas. Skin reactions were recorded after 15 minutes by comparing the skin response to allergens with the response to negative control. A relationship between history and positive skin prick test (ie, wheal diameter $\geq$ to 4 mm as compared with control) has been considered a specific sensitization. Subjects were considered monosensitized when the skin prick test was positive for one group of allergens (ie, pollens, mites, pets, or molds), and polysensitized when the skin prick test was positive for two or more groups of allergens. All skin tests were performed by the same medical staff.

All subjects were required to fill in a questionnaire about their personal history, their parents' allergies, their home conditions and the keeping of pets (cats and/or dogs) in their houses.

Pollen Count

A "Seven-day Recording Volumetric Spore Trap" by Burkard Manufacturing Co Ltd (Belgium) was used to count the pollen. A helix dropped 10 liters of air per minute; the pollens and the spores were captured for seven consecutive days. The particles attached to an adhesive strip on a roll turning 2 minutes per hour. The strips were stained with fuchsin and the pollens were identified and counted (units/m³/24 h) by means of an optical microscope.^{13,14} One device was placed

near each school from June 1995 to July 1996.

Air Pollution

Ozone and suspended particulate levels were chosen to estimate air pollution, using two observing stations: the first at the Serra Riccò school and the other about 1 km from the Genoa schools.

The ozone concentration was calculated by measuring the quantity of UV radiation absorbed by the sample. The background of UV radiation was calculated without ozone by comparison to a standard curve. Thereafter, UV radiation was calculated with ozone to determine light intensity after absorbance. The ozone concentration was then determined by the Lambert-Beer equation. Because the ozone levels in Genoa were below the dangerous threshold throughout the entire year, except in summer (data on file), we chose only the period from July to August 1996 to collect ozone data.

The total suspended particulates survey was performed with the ponderal method, using a sequential analyzer. This device has a constant flow using an electronic pump; particulates are collected upon a filtering membrane from a given volume of aspirated air. The total suspended particulates were measured in the period from 23 April to 25 September 1996.

Statistical Analysis

The frequencies of allergic sensitization and the total pollen counts in Serra Riccò and Genoa were evaluated by chi square test (χ^2); the ozone concentrations and the total suspended partic-

ulates in the two zones were compared with the Student's *t* test (t-test).

RESULTS

Allergic Sensitization

Table 1 shows the frequencies of sensitizations and the distributions of monosensitized and polysensitized subjects. Among monosensitized students, those from Serra Riccò showed a significantly higher percentage of sensitization than those from Genoa ($\chi^2 = 3.963$; $P = .046$). Among polysensitized students, those from Serra Riccò showed a significantly higher percentage of sensitization than those from Genoa ($\chi^2 = 4.479$; $P = .034$).

Seventy-nine children (27.8%) from the city group and forty-six (22.8%) from the rural group had at least one parent suffering from allergies, but there was not a significant difference in genetic risk between the two groups ($\chi^2 = 1.32$; $P = .25$).

One hundred and forty-five (51.1%) urban families and eighty-four rural families (41.6%) kept pets in their houses ($\chi^2 = 3.88$; $P = .049$).

Table 2 shows the skin prick test results; the percentages of the single sensitizations are referenced to the allergic populations. Sensitizations to grass, *Absinthium*, and *Cladosporium* were significantly higher in the Serra Riccò students ($\chi^2 = 9.758$; $P = .002$; $\chi^2 = 8.857$; $P = .003$ and $\chi^2 = 4.938$; $P = .026$, respectively), whereas that to pets was higher in Genoa students ($\chi^2 = 4.050$; $P = .044$). Mite allergy was the most frequent sensitization in both Genoa and Serra Riccò students (69.2% and 63.4%, respectively) fol-

Table 1. Frequency of Allergic Sensitization and Distribution of Mono and Polysensitized Subjects

	Serra Riccò (202 students) n	Genoa (284 students) %	n	%	χ^2	P
Sensitized	93	46.0	104	36.6	3.963	.046
	Sensitized Subjects (n = 93) n	Sensitized Subjects (n = 104) %	n	%	χ^2	P
Monosensitized	21	22.6	39	37.5	4.479	0.034
Polysensitized	72	77.4	65	62.5		

lowed by grass in Serra Riccò (53.8%) and *Parietaria* in Genoa (42.3%).

Pollen Count

Pollen count shows the daily means of total pollen counts in four consecutive blossoming. Each Serra Riccò pollen count was compared with the corresponding count in Genoa. The pollen counts were higher in Serra Riccò during the observed periods ($\chi^2 = 83.208$; $P < .001$), with a mean ratio 2.8:1. The highest ratio was observed in September (4.4:1) and the lowest in February–March (1.4:1). Representative grass, *Parietaria* and *Absinthium* pollen trends are reported in Tables 3, 3a, 3b and 3c, respectively. Pollen counts in

Table 2. Distribution of Allergen Sensitization Among Sensitized Children in Serra Riccò and Genoa

Allergens	Serra Riccò (93 sensitized students)		Genoa (104 sensitized students)		χ^2	P
	Sensitized	%	Sensitized	%		
Mites	59	63.4	72	69.2	0.502	0.479
Grass	50	53.8	32	30.8	9.758	0.002
<i>Parietaria</i>	39	41.9	44	42.3	0.008	0.927
Olive tree	21	22.5	25	24.0	0.005	0.942
<i>Absinthium</i>	21	22.6	7	6.7	8.857	0.003
Birch-hazel	19	20.4	19	18.3	0.041	0.839
<i>Aspergillum</i>	11	11.8	6	5.8	1.582	0.208
<i>Alternaria</i>	10	10.7	5	4.8	1.694	0.193
<i>Cladosporium</i>	8	8.6	1	1.0	4.938	0.026
Dog-cat dander	9	9.7	22	21.1	4.050	0.044

Table 3. Total Pollen Counts: Daily Means of Pollens Counts are Reported for Four Blossom Periods

	Jun–Jul 95	Sep 95	Feb–Mar 96	May–Jun 96	χ^2	P
Serra Riccò	1070.8	181.3	368.8	1017	83.208	.001
Genoa	343.5	40.7	269.1	466.7		

Table 3a. Grass Monthly Mean Pollen Counts*

	Jul 95	Sep 95	Feb 96	Mar 96	Apr 96	May 96	Jun 96	Jul 96	χ^2	P
Serra Riccò	43	2.1	0.4	1.0	10.8	239.5	66.6	24.2	29.8	<.001
Genoa	16.6	2.3	0.1	0.1	2.0	33.5	29.7	14.6		

* The lines in bold represent the periods of main blossoming in the two study areas. The χ^2 values are referred to all the periods.

Table 3b. *Parietaria* Monthly Mean Pollen Counts*

	Jul 95	Sep 95	Feb 96	Mar 96	Apr 96	May 96	Jun 96	Jul 96	χ^2	P
Serra Riccò	419.1	118.5	0.2	4.2	343.6	478.2	388.5	471.6	18.46	.010
Genoa	105.9	35.4	0.4	3.9	94.1	179.5	133.4	116.7		

* The lines in bold represent the periods of main blossoming in the two study areas. The χ^2 values are referred to all the periods.

Table 3c. *Absinthium* Monthly Mean Pollen Counts*

	Jul 95	Sep 95	χ^2	P
Serra Riccò	0.3	45	19.93	<.001
Genoa	0.1	0.9		

* The lines in bold represent the periods of main blossoming in the two study areas. The χ^2 values are referred to all the periods.

Serra Riccò were significantly higher than in Genoa (grass $\chi^2 = 29.8$; $P < .001$; *Parietaria* $\chi^2 = 18.46$; $P = .010$; *Absinthium* $\chi^2 = 19.93$; $P = .001$).

Air Pollution

Figure 1 shows the ozone concentrations; they were significantly higher in Genoa both in July ($t = 4.700$; $P = .001$) and August ($t = 9.543$; $P = .001$). The daily means of total suspended particulates from April 23 to September 25, 1996 in Serra Riccò were $60.9 \mu\text{g}/\text{m}^3$ (standard deviation, ± 28.3) whereas it was $72.5 \mu\text{g}/\text{m}^3$ (SD ± 29.8) in Genoa. Overall, the mean particulate levels were significantly higher in Genoa ($t = 9.323$; $P < .001$).

DISCUSSION

Allergen exposure and air pollution are the major contributing environmental factors that worsen allergic respiratory symptoms both at the nasal and bronchial levels. On the other hand, it is not clear whether these two factors play a pathogenic role in the development of sensitization. The present study was designed to evaluate the percentages of sensitized children in different areas, considering their different exposure to pollen and pollutants. We chose the model of schoolchildren as a sufficient life-period of environmental exposure with no other interfering factors such as smoking.

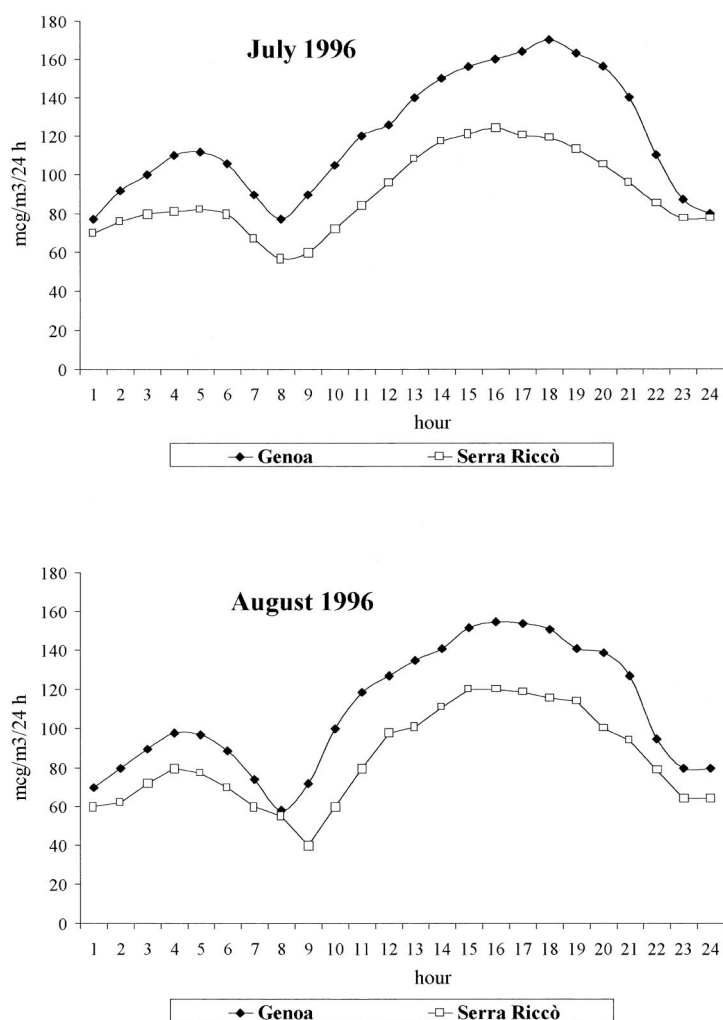


Figure 1. O₃ hourly mean concentrations of July and August 1996 in Genoa and Serra Riccò.

In Serra Riccò there was only one school, while in Genoa we chose the school closest to the monitoring station.

In regard to air pollution, both ozone and total suspended particulates are more concentrated in the city area, because of the high amounts of traffic and the numerous industries there. The high levels of ozone and of the total suspended particulates during the summer underlines the prevalence of pollution caused by traffic. We considered as total suspended particulates the contents of heavy metals, lead and polycyclic aromatic hydrocarbons, because the presence of die-

sel vehicles in the surrounding areas of Genoa is very low.

Serra Riccò is a rural village, with no industry, low traffic density, and with large green open spaces. This latter factor explains why the large amounts of pollens significantly exceed those of Genoa, both as total pollen counts and as specific pollen counts (grass, *Parietaria*, *Absinthium*).

Overall, rural students showed higher percentages of sensitization than the city students. These results contrasts with those reported by Ishizaki et al¹, but they are consistent with those reported by Priftis et al.¹⁵ It has

been hypothesized that the individual degree of sensitization was related to the allergen exposure level, since there were not any statistical differences in genetic predisposition to allergic sensitization between the two areas.¹⁶ On the other hand, consistent with the Eggleston et al results, there was a more sensitization to pets in the city area, where animals are kept in houses rather than in the rural area where they are mostly outdoor pets.¹⁶

A new finding is the occurrence of more monosensitized children in the city than in the country areas: a possible explanation may be that mite allergy, which is prevalent in monosensitized, occurs early in childhood, whereas pollen allergy, which is prevalent in polysensitization, occurs later as previously demonstrated.¹⁷ Further, the polysensitization in Serra Riccò was mainly due to house dust mite and pollens.

Pollen allergy is due to a higher level of allergen exposure than mite allergy: since the pollen season is of shorter duration than the mite exposure. Sensitization to mites was similar in the rural area and in the city, whereas the pollen count was higher in the rural area than in the city. This could explain the finding of more children with both sensitizations in the rural areas.

The different percentages of sensitization in the two areas may be due to different pollen exposure levels. This is supported by an earlier study, showing pollen allergy to be more frequent in the areas with higher pollen counts.¹¹ The studies concerning the relationship between pollution and sensitization are inconsistent. Some reports suggest a positive relationship between the degree of pollution and the number of sensitized patients,^{1,3,5} but other studies show no differences in the numbers of sensitized patients between rural and city areas.^{6,18}

In conclusion, the present data confirm the importance of the pollen exposure levels as a pathogenic factor able to induce sensitization. Further studies should explore the role played

by pollutants as risk factors for worsening respiratory symptoms.

REFERENCES

1. Ishizaki T, Kazuhiro K, Ikemori R, et al. Studies of prevalence of Japanese cedar pollinosis among the residents in a densely cultivated area. *Ann Allergy* 1987;58:265–270.
2. Hirota I, Shunkichi B, Kazunori M. The relationship between Japanese cedar pollinosis and air pollutants deposited on the pollen. *Aerobiologia* 1996;12:37–42.
3. Keil U, Weiland SK, Duhme H, Chambless L. The International Study of Asthma and Allergies in childhood: objectives and methods; results from German ISAAC centers concerning traffic density and wheezing and allergic rhinitis. *Toxicol Lett* 1996;86(2–3):99–103.
4. Rusznak C, Devalia JL, Davies RJ. Airway response of asthmatic subjects to inhaled allergen after exposure to pollutants. *Thorax* 1996;51(11):1105–1108.
5. Weiland SK, Mundt KA, Ruckmann A, Keil U. Self-reported wheezing and allergic rhinitis in children and traffic density on street of residence. *Ann Epidemiol* 1994;4(3):243–247.
6. Carrozzi L, Baldacci S, Viegi G, et al. Inquinamento atmosferico e malattie allergiche respiratorie: aspetti epidemiologici. Dal Congresso “Ambiente ed Allergopatie,” Napoli 1995.
7. Braback L, Breborowicz A, Dreborg S, et al. Atopic sensitization and respiratory symptoms among Polish and Swedish school children. *Clin Exp Allergy* 1994;24(9):826–835.
8. Von Mutius E, Martinez FD, Fritzsch C, et al. Difference in the prevalence of asthma and atopy in two areas of West and East Germany. *Am J Respir Crit Care Med* 1994;149:358–364.
9. Van Strien RT, Verhoeff AP, Van Wijnen JH, et al. Der p I concentrations in mattress surface and floor dust collected from infants’ bedrooms. *Clin Exp Allergy* 1995;25(12):1184–1189.
10. Ingram JM, Sporik R, Rose G, et al. Quantitative assessment of exposure to dog (Can f I) and cat (Fel d I) allergens: relation to sensitization and asthma among children living in Los Alamos, New Mexico. *J Allergy Clin Immunol* 1995;96(4):449–456.
11. Frei T, Torricelli R, Peeters AG, Wüthrich B. The relationship between airborne pollen distribution and the frequency of specific pollen sensitization at two climatically different locations in Switzerland. *Aerobiologia* 1995;11:269–273.
12. Expert Panel Report 2. Guidelines for the diagnosis and management of asthma 2nd edition. NIH Publication 97-4051, April 1997.
13. Ong EK, Singh MB, Knox RB. Seasonal distribution of pollen in the atmosphere of Melbourne: an airborne pollen calendar. *Int J Aerobiol* 1995;11:51–55.
14. Tarragò IB. An annual study of airborne pollen in northern Mexico City. *Int J Aerobiol* 1996;12:191–195.
15. Priftis K, Ziva M, Mathioudakis G, et al. Sensitization of asthmatic children to common environmental allergens according to their residence. *J Asthma* 1993;30(6):445–450.
16. Eggleston PA, Ansari AA, Adkinson NF Jr, Wood RA. Environmental challenge studies in laboratory animal allergy. Effect on different airborne allergen concentrations. *Am J Respir Crit Care Med* 1995;151(3 Pt 1):640–646.
17. Silvestri M, Oddera S, Rossi GA, Crimi P. Sensitization to airborne allergens in children with respiratory symptoms. *Ann Allergy, Asthma Immunol* 1996;76(3):239–244.
18. Wilkie AT, Ford RP, Pattemore P, et al. Prevalence of childhood asthma symptoms in an industrial suburb of Christchurch. *N Z Med J* 1995;108(1000):188–190.

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