

Role of the Home Environment in Rhinoconjunctivitis and Eczema in Schoolchildren in Pamplona, Spain

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■ Abstract

Background and Objective: Indoor air quality has become an important factor for sensitization and development of allergic diseases because of increased time spent in homes. We aimed to analyze the possible home-condition risk factors for allergic rhinoconjunctivitis, atopic eczema, and severe disease in schoolchildren aged 5 through 8 years.

Material and Methods: The parents of 3360 school children in Pamplona, Spain in the 5–8-year-old age bracket answered questions about rhinitis and eczema symptoms from the protocol of the International Study of Asthma and Allergies in Childhood (ISAAC). The instrument contained additional questions about current home conditions related to mold and dust exposure and about conditions in the first year of life. Associations between the allergic diseases and early and current exposure were studied with χ^2 tests and bivariate and multivariate logistic regression.

Results: Exposure to certain home conditions related to molds and dust in the first year of life increased the risk of allergic disease, but having good isolating windows in the first year of life protected against allergic rhinoconjunctivitis and severe atopic eczema. Some current home conditions were also related to an increased risk of current allergic disease; severe atopic eczema was more common among children with single glazing over the bedroom window.

Conclusion: Current and first-year-of-life home conditions related to dust and mold exposure should be controlled because they influence the prevalence of allergic rhinoconjunctivitis and atopic eczema diseases. Moreover, having a double-glazed window currently and in the first year of life seems to protect against these diseases.

Key words: Allergic conjunctivitis. Atopic conjunctivitis. Allergic rhinitis, perennial. Allergic rhinitis, seasonal. Atopic dermatitis. Air pollution, indoor. Risk factors. Child health.

■ Resumen

Antecedentes y objetivo: La calidad del aire interior se ha convertido en un factor importante en la aparición de sensibilizaciones y en el desarrollo de enfermedades alérgicas debido a las crecientes horas que se pasan en las viviendas. El objetivo de esta investigación es estudiar el papel de las condiciones ambientales del hogar en la aparición de rinitis y eczema en niños de 5 a 8 años de edad.

Material y métodos: Los padres de 3360 niños de Pamplona con edades comprendidas entre los 5 y los 8 años contestaron el cuestionario sobre rinitis y eczema del estudio ISAAC, junto con preguntas adicionales sobre la situación de la vivienda en el primer año de vida. Se estudió

la asociación entre enfermedades alérgicas y las exposiciones precoces mediante la prueba de la Ji cuadrado y regresión logística.

Resultados: La exposición durante el primer año de vida a ciertas condiciones de la vivienda relacionadas con el polvo y los mohos aumenta el riesgo de enfermedades alérgicas, el tener buenas ventanas aislantes durante el primer año de vida protege frente a la rinoconjuntivitis alérgica, y el eczema atópico grave. El riesgo de tener en la actualidad una enfermedad alérgica y eczema atópico es más frecuente en los niños en cuyo dormitorio hay en la actualidad ventanas con un sólo cristal.

Conclusión: Las condiciones el primera año de vida y actuales de la vivienda relacionadas con la exposición a polvo y humedad influyen en la prevalencia de rinoconjuntivitis y eczema atópico y deberían controlarse para evitar su desarrollo. Tener una ventana con doble cristal en el primer año de vida y en la actualidad parece tener un efecto protector.

Palabras clave: Conjuntivitis alérgica. Conjuntivitis atópica. Rinitis alérgica. Dermatitis atópica. Contaminación del aire interior. Factores de riesgo. Salud infantil.

Introduction

The prevalence of allergy has been on the rise in many countries, and there is an ongoing search for causal associations to identify strategies to reverse this trend [1]. A family history of atopic disease is a known major risk factor [2]. Environmental factors remain important in the expression of the disease, yet studies at an individual level have rather limited value in identifying what those factors are. In 1991, the need to standardize the methodology for determining the prevalence and risk factors for allergic diseases throughout the world led to the International Study of Asthma and Allergies in Childhood (ISAAC) [3].

Among the environmental factors implicated, those related to indoor air quality have been gaining attention. Allergic patients were once advised to avoid going outside to prevent exposure to wind, molds, and pollens. Today, however, there has been a large increase in the time spent indoors, where mean temperatures are higher, there is reduced ventilation, and use of carpeting is widespread, possibly increasing the levels of allergens in homes in developed countries [4]. Indoor air pollution is generally less well understood than outside air pollution [5], however. Dust is the principal supplier of indoor allergens in the form of dust mites and pet dander among other allergens [6]. Outdoor fungal spores and pollens transported indoors may be components of house dust, although fungal spores can also come from indoor plants [7], paper and other sources. Early exposure to these allergens may be critical for primary sensitization, and reducing exposure may offer a chance for primary prevention of sensitization and atopic diseases [8]. It seems that the pattern of allergen exposure and sensitization is different depending on the allergen. For example, early exposure to cat or dog allergens seems to protect against later allergy, whereas with dust mites early allergen exposure offers no such protection [9].

Our hypothesis was that the first year of life and current home conditions influence the risk of developing allergic rhinoconjunctivitis and atopic eczema. Our aim was to analyze the possible home-condition risk factors for allergic rhinoconjunctivitis, atopic eczema, and severe disease in schoolchildren aged 5 through 8 years.

Material and Methods

Sample

The ISAAC methods of 1992 are available from <http://isaac.auckland.ac.nz>. The present study was carried out by the ISAAC center in Pamplona, Spain, in school children in the 5–8-year-old age bracket.

All schools of the area were invited to participate and 52 agreed to take part. Questionnaires in Basque and Spanish were distributed in 12 schools so that the children's parents could answer questions related to symptoms of rhinitis and eczema (the ISAAC core questionnaire) and to current and first-year-of-life home conditions. These questionnaires had been previously approved by the research ethics committee of the Department of Health Sciences of the Public University of Navarre. A total of 3360 questionnaires were collected for analysis from December 2000 through April 2001.

Definition of Allergic Rhinitis and Atopic Eczema

To define allergic rhinoconjunctivitis, the parents were asked to respond to the following questions: a) "In the past 12 months, has your child had a problem with sneezing, or a runny, or blocked nose when your child did not have a cold or the flu?" b) "In the past 12 months, has this nose problem been accompanied by itchy, watery eyes?" and c) "In the past 12 months, how much did this nose problem interfere with your child's daily activities? A little, a moderate amount, or a lot?" The first question detected children who had rhinitis problems in the past 12 months, and the second one detected allergy among them. Allergic rhinoconjunctivitis was defined by a positive answer to both questions. The third question, used to detect children who had severe symptoms, was analyzed only in children with allergic rhinoconjunctivitis. Because it was answered for few children, we had to reduce the number of categories; thus, children who had any problems with daily activities, no matter the frequency, were grouped in a single category called "having problems with daily activities at least a little."

To define atopic eczema, the following questions from the ISAAC study were used: a) "Has your child had an itchy rash at any time in the last 12 months?" b) "Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks or around the neck, ears or eyes?" and c) "In the last 12 months, how often, on average, has your child been kept awake by this itchy rash? Never, less than 1 night per week, or 1 or more nights per week?" The first question detected children who had eczema in the past 12 months, and the second one detected flexural eczema at the common sites at this age. Atopic eczema was defined by a positive answer to both questions. The third question was used to study children with severe symptoms, and it was only analyzed in children who had atopic eczema in the past 12 months. Because it was answered for few children, we had to group affirmative answers in 1 category called "waking up at least once in the last 12 months."

Exposure to Home Risk Factors

Different home risk factors were studied with an environmental questionnaire partially proposed by the ISAAC center of Pamplona. All the questions analyzed were related to home factors that contribute to current indoor air quality and quality in the first year of life: exposure to dust, molds, animal dander, outdoor allergen exposure indoors, and indoors air pollutant exposure.

Statistical Analyses

Frequencies for each disease-related question were calculated using the SPSS software, version 12; χ^2 tests were used to analyze the relationships between allergic rhinoconjunctivitis, atopic eczema or their severity and each risk factor. Comparisons of quantitative variables were made

with Student *t* tests. For all the significant qualitative risk factors, the EpiCalc 2000 program was used to calculate the odds ratios (OR) and their 95% confidence intervals (CI).

In a second step, risk factors significantly associated with each disease condition were analyzed by bivariate logistic regression using the SPSS software, version 12, adjusting for age, sex, and language of answering. In some cases, when it was possible and necessary, exact statistics tests were used (Cytel LogXact software, version 5).

In the last step, multivariate logistic regression analyses were carried out for some related risk factors to determine whether they had independent effects.

Results

We found that 6.4% (95% CI, 5.6%-7.3%) of children between 5 and 8 years old had current rhinoconjunctivitis and 19.5% of them had some degree of problems with activities of daily living because of symptoms. Atopic eczema in the past 12 months was reported by 7.0% (95% CI, 6.2%-7.9%), and 20% of such children had woken up at least once because of itching.

Bivariate analysis showed that having moisture and mold on the walls and either a single layer or a double layer of glazing on the bedroom window in the first year of life were found to be risk factors for current allergic rhinoconjunctivitis (Table 1). Having pets in the first year of life was a risk factor for more severe disease (Table 2). There were no changes after adjusting by age, sex, and language. The bivariate analysis for eczema showed that not cleaning with a mop in the first year of life was the only significant risk factor for current atopic eczema (Table 1). Children who had atopic eczema in the past 12 months had a higher risk for severe eczema if the family did not use a vacuum cleaner, did not have plants indoors, and had only a single layer of glass over the bedroom window in the first year of life (Table 2). There were no changes after adjusting by age, sex, and language.

Table 1. Home Environmental Risk Factors for Rhinoconjunctivitis and Atopic Eczema in the First Year of Life*

	Response	Allergic Rhinoconjunctivitis				Atopic Eczema			
		OR	95% CI	OR†	95% CI†	OR	95% CI	OR†	95% CI†
Moisture on walls	Yes	2.44	1.62 – 3.68	2.47	1.63 – 3.73	–	–	–	–
	No	1	–	1	–	–	–	–	–
Molds on walls	Yes	2.46	1.52 – 3.99	2.46	1.52 – 4.00	–	–	–	–
	No	1	–	1	–	–	–	–	–
Use mop to clean	Yes	–	–	–	–	1	–	1	–
	No	–	–	–	–	1.54	1.16 – 2.05	1.56	1.17 – 2.08
Type of window	SGW	–	–	1.57	1.07 – 2.30	–	–	–	–
	DW-SG	–	–	1.82	1.25 – 2.64	–	–	–	–
	SFW-DG	1	–	1	–	–	–	–	–

*OR indicates odds ratio; CI, confidence interval; SGW, a single glass covering the bedroom window; DGW-SG, a double-glazed bedroom window with simple glass (2 glass-holding frames in a "storm window" configuration); SFW-DG, a single-frame bedroom window, but with double glazing in the frame.
† Adjusted for age, sex, and language.

Table 2. Home Risk Factors for Severe Rhinoconjunctivitis and Atopic Eczema in the First Year of Life*

	Response	Severe Rhinoconjunctivitis				Severe Atopic Eczema			
		OR	95% CI	OR†	95% CI†	OR	95% CI	OR†	95% CI†
Pets	Yes	2.80	1.10 – 7.11	3.01	1.16 – 7.79	–	–	–	–
	No	1	–	1	–	–	–	–	–
Vacuum cleaner	Yes	–	–	–	–	1	–	1	–
	No	–	–	–	–	2.57	1.34 – 4.94	2.65	1.35 – 5.15
Plants indoors	Yes	–	–	–	–	1	–	1	–
	No	–	–	–	–	2.04	1.12 – 4.50	2.14	1.06 – 4.33
Type of window	SGW	–	–	–	–	2.60	1.17 – 5.81	2.94	1.27 – 6.77
	DW-SG	–	–	–	–	1.09	0.52 – 2.27	1.14	0.54 – 2.41
	SFW-DG	–	–	–	–	1	–	1	–

*OR indicates odds ratio; CI, confidence interval; SGW, a single glass covering the bedroom window; DGW-SG, a double-glazed bedroom window with simple glass (2 glass-holding frames in a "storm window" configuration); SFW-DG, a single-frame bedroom window, but with double glazing in the frame.

† Adjusted for age, sex, and language.

Table 3. Multivariate Logistic Regression: Risk for Current Rhinoconjunctivitis in Relation to First-Year-of-Life Home Conditions, Adjusted For Age, Sex and Language*

Allergic Rhinoconjunctivitis				Allergic Rhinoconjunctivitis			
	Response	OR	95% CI		Response	OR	95% CI
Moisture on walls	Yes	2.08	1.13 – 3.82	Moisture on walls	Yes	1.90	1.01 – 3.56
	No	1	–		No	1	–
Mold on walls	Yes	1.33	0.65 – 2.71	Mold on walls	Yes	1.34	0.64 – 2.79
	No	1	–		No	1	–
Type of window				Type of window	SGW	1.52	1.03 – 2.23
					DW-SG	1.83	1.26 – 2.66
					SFW-DG	1	–

*OR indicates odds ratio; CI, confidence interval; SGW, a single glass covering the bedroom window; DGW-SG, a double-glazed bedroom window with simple glass (2 glass-holding frames in a "storm window" configuration); SFW-DG, a single-frame bedroom window, but with double glazing in the frame.

Multivariate logistic regression showed that having mold on the wall in the first year of life was not independent of having moisture on the walls. When type of window was added to the model, having a single-glazed window or a second layer of single glazing (a "storm window") continued to exercise a significant influence, in addition to moisture on the walls (Table 3).

Current home conditions were also studied. Bivariate analysis indicated that not having pets, having moisture on the walls, not cleaning the bedroom with a broom or a mop, having between 0 to 5 soft toys and a single layer of glazing over the bedroom window were risk factors for allergic rhinoconjunctivitis (Table 4). Among children with allergic rhinoconjunctivitis, those whose families did not use a vacuum-cleaner had higher risk for severe disease (Table 5).

In relation to atopic eczema, having pets forbidden by a physician was found to be the only factor associated with

atopic eczema, because after bivariate exact logistic regression adjusted for age, sex, and language, not cleaning the bedroom with a mop was no longer significantly related (Table 4). Those children who had atopic eczema in the past 12 months and a single layer of glazing over the bedroom window (no additional "storm window") had a higher risk for severe disease (Table 5).

Discussion

Early allergen exposure plays a very important role in the development of atopy and allergy [10]. For example, early exposure to ingested or inhaled allergen triggers can accelerate the development of allergic asthma in children [11] and primary sensitization to antigens such as dust mites may occur prenatally [12]; a fetus is even able to mount a proliferative

Table 4. Current Home Risk Factors and Allergic Rhinoconjunctivitis and Atopic Eczema*

Response		Allergic Rhinoconjunctivitis				Atopic Eczema			
		OR	95% CI	OR†	95% CI†	OR	95% CI	OR†	95% CI†
Pets forbidden	Yes	7.20	5.22 – 9.93	7.16	5.18 – 9.88	2.46	1.70 – 3.57	2.53	1.74 – 3.68
	No	1	–	1	–	1	–	1	–
Moisture on walls	Yes	1.68	1.01 – 2.79	1.69**	0.95 – 2.80**	–	–	–	–
	No	1	–	1	–	–	–	–	–
Broom use	Yes	1	–	1	–	–	–	–	–
	No	1.39	1.03 – 1.86	1.39**	1.03 – 1.88**	–	–	–	–
Mop use	Yes	1	–	1	–	1	–	1	–
	No	1.35	1.10 – 1.66	1.35	1.10 – 1.66	1.32	1.01 – 1.72	1.32‡	0.99 – 1.72‡
Type of window	SGW	1.59	1.12 – 2.26	1.60	1.12 – 2.28	–	–	–	–
	DW-SG	1.36	0.98 – 1.88	1.36	0.98 – 1.88	–	–	–	–
	SFW-DG	1	–	1	–	–	–	–	–
No. of soft toys	0-5	2.88	1.39 – 5.97	3.01	1.44 – 6.29	–	–	–	–
	6-10	1.40	0.65 – 3.01	1.42	0.66 – 3.07	–	–	–	–
	11-15	1.60	0.67 – 3.36	1.51	0.67 – 3.39	–	–	–	–
	16-20	1	–	1	–	–	–	–	–
	21-25	1.16	0.34 – 5.93	1.12	0.33 – 3.80	–	–	–	–
	26-30	2.14	0.55 – 8.40	2.15	0.55 – 8.47	–	–	–	–
	≥ 30	1.75	0.51 – 5.98	1.70	0.49 – 5.85	–	–	–	–

*OR indicates odds ratio; CI, confidence interval; SGW, a single glass covering the bedroom window; DGW-SG, a double-glazed bedroom window with simple glass (2 glass-holding frames in a "storm window" configuration); SFW-DG, a single-frame bedroom window, but with double glazing in the frame.

† Adjusted for age, sex, and language.

‡ Exact test

Table 5. Current Home Risk Factors for Severe Allergic Rhinoconjunctivitis and Atopic Eczema*

Response		Severe Current Rhinoconjunctivitis				Severe Current Atopic Eczema			
		OR	95% CI	OR†	95% CI†	OR	95% CI	OR†	95% CI†
Vacuum cleaner	Yes	1	–	1	–	–	–	–	–
	No	2.07	1.11 – 3.86	2.17	1.15 – 4.10	–	–	–	–
Type of window	SGW	3.08	1.30 – 7.30	3.58	1.47 – 8.71	–	–	–	–
	DW-SG	1.89	0.78 – 4.60	2.01	0.81 – 5.01	–	–	–	–
	SFW-DG	1	–	1	–	–	–	–	–

*OR indicates odds ratio; CI, confidence interval; SGW, a single glass covering the bedroom window; DGW-SG, a double-glazed bedroom window with simple glass (2 glass-holding frames in a "storm window" configuration); SFW-DG, a single-frame bedroom window, but with double glazing in the frame.

response to a common allergic trigger at as early an age as 22 weeks [13]. We studied home conditions in the first year of life as a reflection of early exposure to indoor allergens, finding that exposure to moisture and molds was a risk factor for current allergic rhinoconjunctivitis. This finding is consistent with the idea that elevated moisture facilitates the growth of molds and dust mites, favoring higher allergen concentrations [14]. Fungal spores have been recognized as potential causes of respiratory

allergies and other respiratory complaints [15], and it is known that contact with fungal components may cause eczema or trigger inflammatory skin eruptions in a subgroup of patients with atopic eczema [16]. Even though molds are found both indoors and outdoors, they are considered to participate in the induction of allergic disease indoors much less often than house dust mites and animal dander [17]. We found no relationship between moisture or mold exposure and atopic eczema.

Children who did not have indoor plants in their homes had a higher risk for severe eczema, meaning that parents of atopic children might have been advised not to have plants indoors because dust and molds can accumulate on them. The manner of cleaning the bedroom or having carpets or wall-to-wall carpeting at home was unrelated to disease in our study. Carpets accumulate high concentrations of dust [18], as do mattresses, pillows, and upholstered furniture [19], and children having them in the home would be more likely to be exposed to dust mites, possibly leading to an increased risk for early sensitization and development of respiratory allergies [20]. Although dust mite sensitization is more related to asthma (50% of sensitized children had asthma in a cohort study in the United Kingdom [21]), sensitization to dust mites was also related to atopic eczema in that study. In an Italian study, positive skin reactivity to house dust mite was associated with risk of atopic eczema persistence and possible development of allergy [22]. In Japan, patients with a positive reaction 48 hours after exposure in scratch tests were found to have elevated levels of specific immunoglobulin (Ig) E for house dust mite antigens and high rates of atopic eczema [23]. Exposure to dust could be a risk factor for atopic eczema, and we found that not cleaning the bedroom with a mop was initially a risk factor, although after adjusting for age, sex, and language it did not remain significant. In contrast, those children whose families did not use a vacuum cleaner in the first year of life, possibly indicating a higher exposure to dust, had higher risk for current severe eczema.

Good air conditioning systems and isolating windows in bedrooms can help to keep outdoor allergens such as molds and pollens from penetrating houses. Nevertheless, we found no relationship between disease development and having air conditioning in the first year of life, in contrast to what was observed in a study in Singapore, where patients without air conditioning were at increased risk of mold sensitization and polysensitization [24]. We found that children who had either a single-glazed window or a second level of glazing had a higher risk for current rhinoconjunctivitis, even though closed windows with double glazing would theoretically offer better prevention against outdoor pollens and molds; this observation contrasted with reports from a German review that insulating windows increased the prevalence of atopic diseases [25]. A single-glazed window was also found to be a risk factor for severe eczema in our study; it may be that the fit of the window frame rather than the thickness of the glass panes is the most important feature for keeping out allergens such as grass pollen [26].

Tobacco smoke is related to an increased incidence of asthma, and pre- and postnatal smoke exposure is also related to specific sensitization to food allergens during the first 3 years of life [27]. However, in our study, the exposure to tobacco smoke in pregnant mothers and in the first year of a child's life was not a risk factor for the development of allergic diseases.

There is controversy about the effect of the exposure to high levels of cat allergen in the first year of life. The exposure to high levels of cat allergen seems to protect children from having an allergic response to cat allergen, due to a modified T-helper type 2 response characterized by the presence of IgG4 antibody instead of IgE antibody [9]. However, we found no

such protective effect in children exposed to pets in their first year of life. Moreover, having pets seemed to be a risk factor for current severe rhinoconjunctivitis.

After multivariate logistic regression analyses for factors related to allergic rhinoconjunctivitis, we could see that exposure to molds was not independent from moisture on walls, probably because moisture provides the suitable environmental conditions for mold's growth [28].

Children exposed to current moisture had a higher risk for allergic rhinoconjunctivitis. Such exposure can be a risk factor for allergy symptoms in a previously allergic child [29, 30], but in Finland, it has also been shown that new allergic diseases can appear in normal children exposed to moisture and molds at school [31]. Children in houses where brooms and mops are not used have a higher risk for current allergic rhinoconjunctivitis, possibly because families with an allergic child have been advised to use vacuum cleaners instead to clean the child's bedroom because such vacuum cleaners help avoid severe symptoms because they are more effective in eliminating dust [32, 33]. It has also been found that children having 0 to 5 soft toys in their bedrooms have a higher rate of allergic rhinoconjunctivitis, possibly because such toys are avoided in the bedrooms of children allergic to indoor allergens so that dust does not accumulate. Finally, although passive smoking has been seen to increase the risk of wheezing and atopic eczema [34], we found no relationship between current passive smoking and allergic disease in the child.

A ban on having pets at home was related to current rhinoconjunctivitis and eczema, because this factor identified children with allergy to pets. On the other hand, we found no relationship between allergic diseases and the use of gas at home, even though indoor pollutants from gas combustion are thought to increase the likelihood of initial sensitization to house dust mites and play a role in the development of atopic asthma [35].

It is clear that current home conditions and those in the first year of life influence the exposure to indoor allergens and the development of rhinitis and eczema. Moisture, molds, and home conditions related to the accumulation of dust are important factors that should be controlled to avoid early sensitization and the development of these diseases, and good isolating windows in the first year of life would protect children from having current allergic rhinoconjunctivitis and severe eczema. Although we know the limits of retrospective epidemiological studies, the present one has been carried out in the setting of an important international study, and the results underline the importance of taking measures that would help to avoid early indoor allergen exposure and current symptoms. However, because of the limitations of home characteristics reporting as a predictor of the absence of allergens (as exposure can occur even when no cats or no carpets are present, for example [18]), research should be extended to include prospective studies with more objective measurements to corroborate these results.

Acknowledgments

We thank all children, parents, and schools who made this study possible. This work was partially supported by research

grant number 640/1999 from the Department of Health of the government of the Spanish autonomous community of Navarre.

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■ *Manuscript received September 5, 2006; accepted for publication November 8, 2006.*

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