

Airways Inflammation, Atopy, and (1→3)- β -D-Glucan Exposures in Two Schools

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This study investigated two schools, one of which had previous mold problems. Pupils aged 6 to 13 yr were investigated using a questionnaire on symptoms and a skin prick test. The amount of airborne (1→3)- β -D-glucan was measured in the classrooms. The levels were significantly higher in the problem school than in the control school (15.3 versus 2.9 ng/m³). The extent of respiratory as well as general symptoms was higher among the pupils in the problem school. Among the atopics, the extent of symptoms of dry cough, cough with phlegm, and hoarseness was similar to the nonatopics in the control school, but significantly higher in the problem school. The results suggest that (1→3)- β -D-glucan, either by itself or as an indicator of molds, is a risk indicator of airways inflammation. Rylander R, Norrhall M, Engdahl U, Tunsäter A, Holt PG. Airways inflammation, atopy, and (1→3)- β -D-glucan exposures in two schools.

AM J RESPIR CRIT CARE MED 1998;158:1685-1687.

Symptoms such as irritation in the eyes, nose, and throat, dry cough, and skin problems have been reported from many different indoor environments. A number of reports relate the presence of such symptoms to humidity or mold growth (1-4). The symptom profile reported suggests that the underlying pathology is an airways inflammation.

In several investigations, it has been demonstrated that a component of the mold cell wall—(1→3)- β -D-glucan—induces inflammation and is a powerful immunostimulator (5). Field studies have demonstrated a relation between the extent of symptoms in buildings and the amount of airborne (1→3)- β -D-glucan (6) as well as the incidence of atopy and decrease in FEV₁ over the number of years living in the buildings (7).

Recent studies from several laboratories (reviewed in refs. 8 and 9) suggest that susceptibility to the allergy-promoting effects of environmental irritants may be considerably more marked in childhood than in adulthood. In view of this, a study was undertaken in one school where mold problems had been reported for several years. A school without mold problems served as control. Measurements were made of the amount of airborne (1→3)- β -D-glucan in the classrooms in the two schools, and the parents answered a questionnaire on symptoms from the airways and general symptoms. A skin prick test was used to determine the extent of atopy.

METHODS

The study population comprised all pupils in the first to fifth grades (6 to 13 yr old); a total of 244 pupils in the problem school and 103 pupils

in the control school. The pupils were evenly distributed among the different grades. A questionnaire consisting of 28 questions was distributed to the parents of all pupils in the study. The questions related to background factors such as atopic heredity, the size of the dwelling, the presence of pets, parents' smoking habits, and the presence of humidity or mold problems in the house. Questions were asked on different symptoms, which had been present during the last 3 mo, and how often they were present. A positive answer was defined as those who answered "sometimes per month" up to "daily or almost daily."

Atopy was assessed on the basis of skin test reactivity to a panel of indoor and outdoor allergens, including mite species, fungal spores, animal danders, and pollens. The participation rate in the skin prick test was 58% from the control school and 63% from the problem school.

Measurements of airborne (1→3)- β -D-glucan were made in six classrooms in the problem school and 11 classrooms in the control school according to a method previously described in detail (7).

The numerical analyses were made with the aid of the statistical program SPSS. Differences between the groups were analyzed by comparing the proportion of positive answers using a chi-square test, Fisher exact test, and Wilcoxon rank test. The level of significance was defined as $p < 0.05$.

RESULTS

The amount of airborne (1→3)- β -D-glucan in the control school varied between 0 and 6.9 ng/m³ with an average of 2.9. In the problem school, the concentrations varied between 9.2 and 27.4 with an average of 15.3. The average levels were significantly different between the two schools ($p < 0.001$). The measurements of these levels agreed with data obtained during earlier measurements in the two schools.

Consistent with other studies on Swedish schoolchildren, the highest frequencies of positive responses were observed with seasonal pollens (notably birch and timothy grass; 12.1 and 11.3%), followed by cat (7.6%) and *Dermatophagoides pteronyssinus* (6.4%). There were no significant differences between the two school populations in frequency of responses to any of the test panel allergens. A positive reaction against mold was unusual, with only one of 206 tested children having

(Received in original form December 30, 1997 and in revised form June 11, 1998)

Supported by Vårdalstiftelsen (Contract 95/52/A95020), the Swedish Council for Building Research (Contract 940544-8), the Center for Indoor Air Research (Contract 96-09), and the Asthma and Allergy Society in Gothenburg, Sweden.

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Am J Respir Crit Care Med Vol 158, pp 1685-1687, 1998
Internet address: www.atsjournals.org

TABLE 1
THE EXTENT OF DIFFERENT SYMPTOMS AMONG NONATOPIC AND ATOPIC PUPILS

	Nonatopic			Atopic		
	Control School	Problem School	p	Control School	Problem School	p
n	110	53		31	12	
% Reporting						
Eye irritation	4.6	18.0	0.006	30.0	45.5	NS
Nose irritation	6.5	14.9	NS	31.0	36.4	NS
Congested nose	18.5	32.7	NS	44.4	50.0	NS
Throat irritation	11.2	25.5	0.031	14.3	22.2	NS
Dry cough	10.3	26.1	0.024	7.1	54.5	0.003
Dry cough at night						
without cold	8.2	23.1	0.012	6.5	58.3	< 0.001
Cough with phlegm	7.5	17.0	NS	7.1	40.0	0.031
Hoarseness	5.8	21.3	0.008	7.1	30.0	0.006
Wheezing	2.8	13.5	0.014	13.3	36.4	NS
Tiredness	10.4	37.5	< 0.001	21.4	50.0	NS
Headache	20.2	56.0	< 0.001	24.1	54.5	NS
Skin eruptions, start > 5 yr	15.5	26.4	NS	9.7	25.0	NS

NS = nonsignificant.

a positive reaction. There was no significant difference in the reaction pattern between the two schools.

The extent of symptoms among atopic and nonatopic pupils in the two schools is summarized in Table 1. Among children without as well as with atopy, the extent of symptoms was generally higher in the problem school. A comparison between pupils with atopy or no atopy in the control school demonstrated that eye and nose irritation, nose congestion, and wheezing were significantly more common among atopic children. The same pattern was found in the problem school.

Regarding the extent of dry cough, cough with phlegm, dry cough at night without cold, and hoarseness, pupils with atopy did not have an increased incidence of these symptoms as compared with nonatopics in the control school. In the problem school, however, the incidence of these symptoms in atop-

ics was markedly larger, both compared with atopics in the control school and nonatopics in the problem school.

The extent of nasal irritation over the year in the two schools is reported in Figure 1. In both schools, the proportion of pupils with nasal irritation increased toward the months of April and May. The extent of symptoms was, however, larger in the problem school. During the summer months, the extent of symptoms decreased and was similar among pupils in the two schools during the months of June, July, and August. After the start of the school year, the extent of nasal symptoms increased rapidly in the problem school, but remained relatively constant in the control school.

No significant differences were demonstrated between pupils in the two schools regarding heredity for allergy, the size of their dwellings, parents' smoking habits, or the presence of

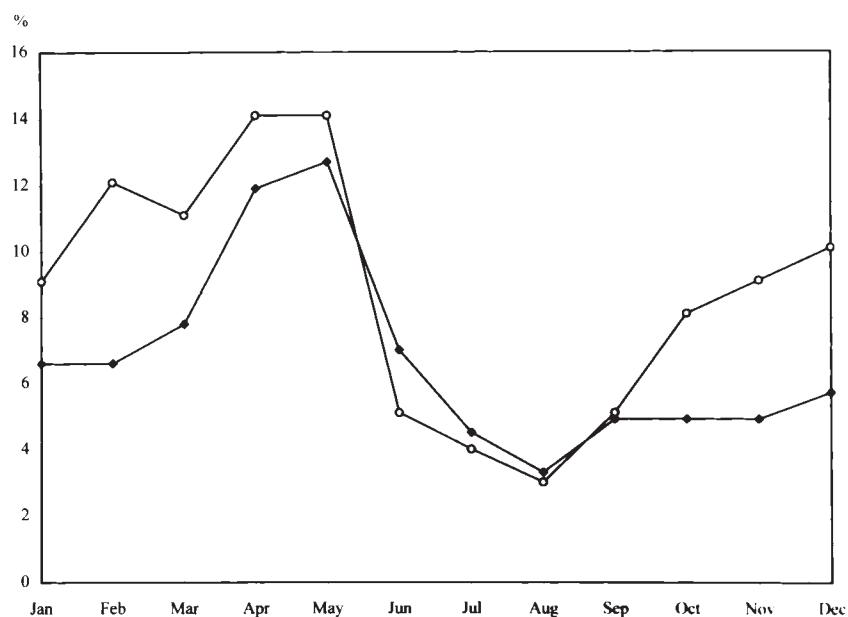


Figure 1. The proportion of pupils in the control school (closed squares) and the problem school (open circles) reporting nasal irritation during different months of the year.

pets, nor were there any significant differences regarding the presence of humidity or molds in the homes or the presence of severe disease among the pupils. The population in the areas for the two schools was homogenous from a socioeconomic point of view.

DISCUSSION

In a study of this kind, there are several potential errors. Measurement of the amount of airborne (1→3)-β-D-glucan in the schools relies on a generation of airborne dust using a standardized method (6, 7) and it is not certain that this corresponds to the exposure that takes place when pupils move normally in the room. The increase in particles as well as their size suggests, however, that a reasonably realistic exposure condition was present.

The dropout from the skin prick test in the two schools was very similar and in the analysis of the dropouts that were made, no systematic difference between the schools in terms of the characteristics of the families could be demonstrated.

The presence of mold in the problem school was known when the investigation was performed, and thus one cannot exclude that there was a certain overreporting of symptoms. There were, however, distinct patterns in that the symptoms of dry cough, cough with phlegm, and hoarseness were not increased when comparing atopic and nonatopic pupils in the control school, whereas more pupils in the problem school reported these symptoms. Such differences related to a specific symptom profile speak against the hypothesis that overreporting could be a major reason for the higher incidence of symptoms in the problem school.

The proportion of atopics was similar in the two schools, which suggests that exposure to (1→3)-β-D-glucan or mold has not caused atopy during the exposure time and with the exposure levels that were present. Results from another investigation demonstrated a higher proportion of atopics in flats with higher levels of (1→3)-β-D-glucan, but only among those who had lived several years in their dwelling (7).

Regarding symptoms from the lower airways, namely dry cough, cough with phlegm, dry cough nightly, and hoarseness, the atopics in the problem school had more symptoms than the atopics in the control school, whereas they did not differ from the nonatopics in the latter school. This suggests that atopic children are a risk group for upper airways symptoms related to exposure to mold or (1→3)-β-D-glucan.

The investigation focused on a relation between different symptoms, atopy, and the amount of airborne (1→3)-β-D-glucan indicative of mold exposure. Other agents, which have been suggested as causative for symptoms in indoor air, are solvents, volatile organic compounds (VOC), such compounds from microorganisms (MVOC) and environmental tobacco smoke (ETS). It is unlikely that the symptoms could be due to ETS as no smoking was present in the schools investigated

and no difference in smoking habits among parents was found between the schools. There were no sources of VOC.

The question of whether (1→3)-β-D-glucan per se is the principal causative agent for the effects related to the exposure in mold, or whether it is a marker for the presence of other mold components, cannot be answered on the basis of this investigation. (1→3)-β-D-glucan is, however, a biologically potent agent in low doses and should be a suspect agent for the time being (10).

The finding that symptoms of airways inflammation are more prevalent in atopic children is consistent with a growing body of literature suggesting that environmental agents that cause airways inflammation appear to differentially affect subjects with preexisting atopic disease. The best studied example of this phenomenon is the role of respiratory virus infections in triggering exacerbation of asthma in previously asymptomatic atopic children (11). It appears possible from this study that (1→3)-β-D-glucan and other mold products may act in a similar fashion. However, given that, unlike intercurrent infections, these agents are persistent in the environment, their overall potency in relation to the pathogenesis of airway disease may be greater than expected.

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