

Short communication

Symptoms suggestive of atopic rhinitis in children aged 6–9 years and the indoor environment

Background: We aimed to investigate the influence of indoor factors on the prevalence of symptoms suggestive of atopic rhinitis in children aged 6–9 years in Upper Austria.

Methods: We analyzed the results from an extended ISAAC (International Study of Asthma and Allergies in Childhood) questionnaire, answered by the parents, about indoor environment and symptoms strongly suggesting atopic rhinitis. This was defined as having reported a running, obstructed, or itchy nose apart from having a cold in the last year. The overall response rate was 93.4%. After excluding 6016 children (17.1%) with changed indoor environment (due to allergies in the family), we analyzed the remaining subsample of 18 606 questionnaires.

Results: The following factors were associated with an increased risk: mother's smoking during pregnancy and/or during time of breast-feeding (OR 1.28; CI 1.07–1.52), synthetic bedding (OR 1.21; CI 1.09–1.36), dampness/mold at home (OR 1.51; CI 1.31–1.74), central heating with gas (OR 1.75; CI 1.06–2.87), and space heating (OR 1.66; CI 1.01–2.98). Cooking with wood (OR 0.62; CI 0.46–0.84) was negatively associated with symptoms.

Conclusions: The indoor environment plays a role in the symptoms of atopic rhinitis in children. However, the population-attributable risks were not particularly high; they were between –2.7% and 9% for the various exposures considered in this study.

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Key words: children; indoor factors; ISAAC; logistic
regression; rhinitis.

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Accepted for publication 5 June 2000

The prevalence of atopic diseases is increasing in children worldwide (1, 2), as people in Westernized countries spend upward of 90% of their time indoors (3). It is therefore important to investigate the impact of the indoor environment on the prevalence of nasal symptoms suggesting atopic rhinitis. In particular, atopy and allergic sensitization to indoor and outdoor allergens have been found to be important risk factors for the development of allergic rhinitis, and it has been suggested that children become sensitized to their immediate surroundings.

This report is based on a previously reported ISAAC questionnaire survey conducted in Upper Austria (4) which was answered by the parents of children aged 6–9 years (5). The sample used for this report contained only data from children whose parents reported no changes to the indoor environment, such as the removal of a pet or carpeting, because of allergic disease in the

family. We excluded children with reported avoidance behavior, since this could produce a negative bias in association with indoor exposures and rhinitis symptoms. In particular, a high number of pets at home and the presence of carpeting have been thought to be partly responsible for the increased allergy prevalence in the West (6–8). The potentially harmful effect of cats and dogs indoors is known, and their removal is often recommended in the event of allergic disease in a family member. Similarly, parents are often told to avoid carpeting to reduce exposure.

Material and methods

We conducted a population-based study (1995–7) in Upper Austria (area ~12 000 km², ~1 377 900 inhabitants). The findings have been reported previously (5), and the overall response rate in the study was 93.4%

($n = 35\,238$). In the analyses performed here, we used a subset of 29 222 (82.9% of the applicable questionnaires) children aged 6–9 years collected in the population-based study, whose parents had answered a validated questionnaire about asthma and allergies, and who had not removed a pet or a carpet due to allergic disease in the family. Furthermore, we included only those children whose parents had answered all relevant questions in the multiple logistic regression analysis, thus leaving 18 606 questionnaires (63.7% of the applicable questionnaires without avoidance behavior). This subsample did not differ from the original population with respect to sociodemographic factors.

For the analysis of the prevalence of nasal symptoms suggesting atopic rhinitis, which is also called hay fever, we used the question, “Has your child ever sneezed or had a running, obstructed, or itchy nose apart from a cold in the last 12 months?”, and not “Has your child ever had hay fever (diagnosed by a doctor)?” This question was used for two reasons:

- 1) “Hay fever” is a term often used only for seasonal symptoms of rhinitis (9); therefore, children suffering from perennial symptoms of rhinitis might not be diagnosed as having hay fever.
- 2) Many children have symptoms suggestive of atopic rhinitis such as a running nose without a cold, but they often do not undergo diagnosis (10).

Symptoms present between March and September were considered seasonal rhinitis; symptoms throughout the year, perennial rhinitis.

The independent variables considered in the present report on the influence of indoor factors were the following: mother’s smoking during pregnancy and/or during the time of breast-feeding, passive smoke exposure (fewer than 10, 10–19, 20–29, 30–39, 40–49, or 50 or more cigarettes smoked at home per day), material used for the child’s bedding (synthetic [foam mattresses, synthetic fiber used for pillows and blankets] or natural bedding [feathers, eiderdown, cotton, or animal hair]), dampness or mold at home, type of energy or fuel used for cooking (electric, gas, coal, wood), type of heating used at home (electric; central heating with gas, coal, wood, or oil; space heating; single stove with gas, coal, wood, or oil), and presence of pets indoors.

Other variables which were adjusted for, as potential confounders, included age, sex, parent or sibling history of hay fever, and highest level of parental education (primary school, high school, college, university).

The odds ratios (OR) and the respective 95% confidence intervals (CI) for symptoms of rhinitis in the last 12 months were calculated by multiple logistic regression. A P value of <0.05 was considered statistically significant. All calculations were performed by the Statistical Analysis System (SAS) for Windows. The

Table 1. Demographic factors, family history, parental smoking, and risk of atopic rhinitis

	%	<i>n</i>	OR	CI	
Sex female	49.00	9118	0.66	0.59	0.73
Age groups					
6 years	21.20	3947	1.00	—	—
7 years	45.53	8471	1.09	0.94	1.26
8 years	30.10	5598	1.14	0.98	1.34
9 years	3.17	590	1.20	1.01	1.42
Educational level of father					
Primary school	11.46	2131	1.00	—	—
High school	65.12	12117	1.18	0.95	1.45
College	14.62	2720	1.31	1.02	1.69
University	8.80	1638	1.53	1.15	2.04
Educational level of mother					
Primary school	26.41	4914	1.00	—	—
High school	48.20	8969	1.24	1.07	1.44
College	19.60	3646	1.32	1.09	1.58
University	5.79	1077	1.31	0.99	1.72
Hay fever in family					
Father hay fever	5.37	1000	0.91	0.75	1.10
Mother hay fever	5.57	1036	1.94	1.62	2.33
Sibling hay fever	3.41	634	0.95	0.74	1.20
Number of cigarettes smoked at home per day					
<10	17.84	3320	1.09	0.93	1.28
10–19	8.34	1551	0.94	0.75	1.18
20–29	3.70	687	1.00	0.73	1.36
30–39	0.86	160	0.75	0.40	1.43
40–49	0.42	78	1.00	0.45	2.24
>49	0.18	34	2.90	1.21	6.95
Mother’s smoking during pregnancy and/or time of breast-feeding	14.30	2326	1.28	1.07	1.52

This table is adjusted for age, sex, family history of hay fever, highest level of education of parents, and all other indoor factors analyzed in model.

Table 2. Indoor factors (heating, cooking, pets, mold, and bedding) and risk of atopic rhinitis

	%	n/All numbers analyzed	OR	CI	
Heating					
Electric heating	1.77	330	1.00	—	—
Central heating not otherwise specified	8.13	1513	1.61	0.96	2.69
Central heating with gas	16.3	3033	1.75	1.06	2.87
Central heating with coal	2.15	400	1.38	0.73	2.59
Central heating with wood	18.72	3483	1.32	0.80	2.19
Central heating with oil	19.1	3551	1.45	0.88	2.38
Single stove not otherwise specified	1.2	224	1.63	0.82	3.23
Single stove with gas	0.25	46	1.96	0.67	5.70
Single stove with coal	0.15	27	0.74	0.09	5.86
Single stove with wood	3.1	575	1.48	0.82	2.66
Single stove with oil	1.13	210	1.45	0.97	2.17
Space heating	5.95	1106	1.77	1.05	2.98
Not otherwise specified	22.08	4108	1.66	1.01	2.73
Cooking					
Electric	63.18	11 755	1.00;	—	—
Gas	4.75	884	1.22	0.96	1.56
Coal	0.19	35	0.40	0.05	3.04
Wood	7.23	1345	0.62	0.46	0.84
More than one option	24.65	4587	0.88	0.76	1.02
Pet at home					
No pet	43.3	8061	1.00	—	—
Dog	4.32	804	1.06	0.81	1.39
Cat	31.7	5899	0.99	0.86	1.13
Hamster	5.58	1039	1.25	1.00	1.57
Mouse	0.68	126	1.42	0.82	2.48
Rabbit	6.57	1223	1.05	0.84	1.32
Bird	7.78	1448	1.17	1.43	0.95
Dampness at home	15.31	2849	1.51	1.31	1.74
Natural bedding	62.40	11 611	1.00	—	—
Synthetic bedding	37.60	6995	1.21	1.09	1.36

This table is adjusted for age, sex, family history of hay fever, parental education, and all other factors in model.

population-attributable risk for the significant indoor factors was calculated by the formula of Pearce et al. (11): $P(R - 1)/R$, where P is the proportion of all cases that are exposed and R is the odds ratio of the factors being considered.

Results

The mean age of the analyzed subsample of 18 606 children was 7.15 years (SD: 0.79), and 9488 (51%) children were boys. We analyzed the population for the presence of rhinitis in spring, summer, and autumn (March–September) compared to symptoms present throughout the year. Of the investigated population, 5.1% had seasonal symptoms, and 4.1% had perennial symptoms. We found no difference in the influence of indoor factors on the presence of rhinitis symptoms between children suffering from symptoms only during the pollen season and those having symptoms of rhinitis during the whole year. The ORs and confidence intervals for the risks pertaining to the analyzed indoor factors are given in Tables 1 and 2. Children whose mothers smoked during pregnancy and/or during the time of breast-feeding had a significantly increased risk (OR 1.28; CI 1.07–1.52)

for symptoms of rhinitis in the last 12 months. There was a significant increase of nasal symptoms in the last 12 months if the number of cigarettes smoked at home was more than 50 per day (OR 2.9; CI 1.21–6.95). The use of synthetic bedding – foam mattresses, synthetic fiber used for pillows and blankets – was associated with a significantly higher risk of nasal symptoms than bedding made of feathers, eiderdown, cotton, or animal hair (OR 1.21; CI 1.09–1.36). Dampness and mold at home reported by the parents was significantly associated with an increase in nasal symptoms (OR 1.51; CI 1.31–1.74). Central heating with gas (OR 1.75; CI 1.06–2.87) and space heating (OR 1.77; CI 1.05–2.98) showed statistically significant results (Table 1). Cooking with wood stoves (OR 0.62; CI 0.46–0.84) decreased the risk of nasal symptoms in the last 12 months significantly. Table 3 shows the population-attributable risks for the different significant indoor risk factors.

Discussion

This study aimed to investigate the influence of the indoor environment on the risk of nasal symptoms suggesting atopic rhinitis. Although the influence of

Table 3. Population-attributable risks for different significant indoor factors

	% Cases exposed	% Cases not exposed	OR	PAR
Mother's smoking during pregnancy and/or time of breast-feeding	17.4	12.5	1.28	3.8
> 50 cigarettes smoked at home per day			2.90	
Central heating with gas	21.5	16.3	1.75	9.2
Space heating	8.1	6.4	1.66	3.2
Cooking with wood	4.4	7.4	0.62	−2.7
Synthetic bedding	42.2	36.1	1.21	7.3
Dampness or mold at home			1.51	

indoor factors on the prevalence and severity of allergic diseases in general has been widely acknowledged (12, 13), only a few papers have examined their importance for nasal symptoms (14, 15). These can be present without a positive result in the widely used skin prick tests, as shown in a Swiss ISAAC study, where only about half the children reporting rhinitis symptoms throughout the year in the last 12 months had a positive result in the skin prick test (10). Therefore, it is appropriate to evaluate the importance of indoor factors on nasal symptoms themselves rather than on related measures such as skin prick test positivity. Bias in recall of exposures and symptoms is possible, although unlikely, as parents were reporting current indoor exposures and symptoms within the last year. However, the main limitation of this prevalence study is that factors associated with symptoms in 6–9-year-old children may not be the same as those found in other age groups later in life. Unfortunately, measurements of outdoor air pollution could not be included in the study, but, in any case, the indoor environment has been found to be more important for allergic sensitization than the outdoor (16).

Many studies have found that passive smoke exposure increases the prevalence of allergic disease and asthma (16–18), although the findings are still controversial (16, 19). In our study, as also described by other authors (20), a mother's smoking during pregnancy and/or the time of breast-feeding is associated with an increased risk. Regarding passive smoke exposure, we found a significant relationship between 50 or more cigarettes smoked per day in the child's home and symptoms of rhinitis. We also found a significant relationship between nasal symptoms in the last 12 months and use of synthetic bedding. Parents with children suffering from an allergic disease are often advised to use only synthetic bedding for their children, although there is no evidence to support this recommendation (21, 22). Recent studies have found larger allergen loads in synthetic bedding than feather bedding (23). Further studies are needed to confirm the findings that synthetic bedding might entail a risk factor for allergic disorder that has not yet been found. We found a significant association between dampness or mold at home and symptoms of rhinitis in children in

the last 12 months. The improved insulation of buildings in recent years and the increased use of humidifiers in combination with reduced ventilation may result in an increase of dampness or mold at home. Dampness and mold alone and good living conditions for house-dust mites are both found to be important risk factors for respiratory symptoms (13, 24).

We assumed that a higher indoor temperature might be found in homes where space heating is used, and this could be the reason for the higher risk of symptoms of rhinitis in children living in homes where space heating is used. Nevertheless, the underlying mechanism is not known. Central heating with gas – a very common type of heating in our study population – was associated with an increased risk of symptoms during the last 12 months in our study. Parents may have reported various forms of heating with gas, where gas combustion takes place within the home, as having central heating with gas. In view of the detrimental effect of gas combustion found by other authors, this reporting practice seems to be a plausible explanation of the finding. Studies in adults (25) and in children (26) have found gas combustion at home to be a risk factor for the development of respiratory symptoms (27). In comparison, heating with coal or wood seemed to have a protective effect in Bavarian children (28). We found similar results for the use of wood for cooking, a method which decreased the risk of symptoms of rhinitis significantly when compared to electric cooking (for which we presumed no causative relation with allergic disease). We found no significant association in our data with cooking with gas.

In our study, a higher living standard, which we defined by a higher level of parental education, is clearly associated with an increased report of atopic disease manifestation. This has also been found by other authors (29, 30). Many reasons for the increasing prevalence of allergies in childhood are still to be identified. Western lifestyle (2) and indoor environment are held to be at least partly responsible. We were able to demonstrate that the indoor environment is an important source of potentially harmful components that might lead to nasal symptoms without a cold, thus strongly suggesting an allergic or otherwise irritated nasal mucosa (31). Research should continue to focus

on the differences in indoor environment between populations in order to find strategies to help decrease the prevalence of symptoms.

Acknowledgments

We thank all school headmasters and the participating parents and children. The Non-Communicable Diseases Research Centre at the Wellington School of Medicine is supported by the Health Research Council of New Zealand.

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