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Association between indoor renovation activities and eczema in early childhood

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Abstract

Background: Other factors besides a genetic disposition seem to play a role in the development of allergic disorders. Exposure to risk factors such as indoor air pollution is becoming increasingly interesting, especially during early childhood.

Methods: Within an epidemiological study (LISS: Leipzig infection, allergy and airway diseases study among school starters, involving 2536 children, birth cohort 1991/92, carried out in 1997/98) the effect of indoor exposure on physician-confirmed eczema and allergic symptoms has been investigated. The exposure situation has been characterized on hand of the redecoration activities (painting, floor covering and new furniture) before birth and in the first years of life.

Results: Highly exposed children showed a significant effect on allergic disorders. The lifetime prevalences without any vs. all three redecoration activities were for allergic symptoms 9.3% vs. 17.2% and for eczema 11.5% vs. 20.4%. Adjusted for confounders, the redecoration associated burden led to odds ratios of 1.8 (95% CI: 1.3–2.6) for allergic symptoms and 1.9 (95% CI: 1.4–2.7) for eczema.

Conclusion: Exposure emissions due to redecoration activities seem to be associated with the risk of eczema and allergic symptoms. Thus, prevention of allergic disorders should include the avoidance of such activities around birth and in the first year of life.

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Keywords: Indoor exposure; Allergic disorders; Children

Introduction

Besides a genetic predisposition and the controversially discussed hygiene hypothesis (Strachan, 1989,

2000), other factors influence the development of allergies in early childhood: food, pollens, etc., and as lately described also indoor chemical pollutants, particularly volatile organic compounds (VOCs) (Herbarth and Rehwagen, 1998; Wolkoff and Nielsen, 2001). Important VOC sources are, e.g., smoking and emissions from building materials and furnishings (Samet et al., 1987, 1988; Cooke 1991). During and following home renovation activities, e.g., painting and/or floor

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covering, indoor exposure levels can be high. These exposure situations have been found to affect inflammatory processes as well as allergic disorders (Harving et al., 1991; Koren et al., 1992; Ware et al., 1993; Norback et al., 1995; Wieslander et al., 1997; Diez et al., 2000). Moreover, it remains largely unclear whether a time window exists within which the organism may be especially sensitive to these specific environmental influences. Several studies have investigated the existence of a time period and whether varying factors of influence early in a child's life does lead to an increased incidence of sensitization later in life, including whether prenatal exposure via the mother may have an impact on the offspring. Until now these investigations have been restricted to environmental factors which are able to cause allergies directly above all to allergen exposure (Warner, 1999; Warner and Warner, 2000; Warner et al., 2000). The effect of possibly indirectly affecting factors—trigger factors—is to a great extent unknown except for smoking. First attempts to clear up the role of indoor chemicals is given by Diez et al. (2000) but restricted to risk groups.

The present study is intended not only to contribute to the debate of the extent of chemical noxes being involved in triggering allergen-induced processes but also address the question of timing by examining the influences of pre- and postnatal exposure due to renovation activities.

Materials and methods

Study population

The presented investigation is based on the data of an epidemiologic cross-sectional study (LISS study—Leipzig infection, allergy and airway diseases study among school starters). The LISS study was carried out during the fall and winter 1997–1998 (birth cohort 1991/92) and included all children of the City of Leipzig and its surrounding county ($n = 3919$) eligible to enter first grade in the fall of 1998 (Table 1). Participation was on a voluntary basis, requiring an informed written consent by both parents/guardian of the children. The study was approved by the ethics committee of the University of Leipzig.

The parents were asked to complete a detailed self-administered questionnaire on indoor exposure with special emphasis on possible exposures to chemical substances in their immediate environment as well as their family medical history (e.g., physician-diagnosed diseases and symptoms of allergic disease). Two thousand nine hundred and fifty parents agreed to fill in this questionnaire. For this investigation, 2536 complete data sets were available (86% of self-administered questionnaires).

Table 1. Study parameter description

	<i>n</i>	%
<i>Study area</i>		
Population	656,878	
Total number of the population of 6 to 7 years old children in the area (one birth year)	3919	
Number of involved schools	119	
<i>Response</i>		
(A) Questionnaire	2950	75.3 related to 3919
(B) Complete data set concerning all questions relevant for the analysis	2536	85.9 related to (A)
<i>Study participants</i>		
Mean age (years)	6.3	
Female/male	1257/1279	49.6/50.4
Participants with older siblings	1051	41.4

All medical examinations as well as encouragements to the parents to return the questionnaires were carried out by the medical personnel of the respective local Departments of Public Health. The study design and methodology have been described in detail elsewhere (Krumbiegel et al., 2000; Herbarth et al., 2001).

Disorders (target variables)

The target variables were lifetime prevalences of physician-diagnosed eczema and allergy-associated symptoms. Eczema was selected separately from the allergic symptoms since this manifestation is the earliest sign of an allergic disorder in children's life. The following questions were entered into the analyses: “Has a physician ever diagnosed eczema/endogenous eczema/atopic dermatitis/neurodermatitis in your child?” and “At what age was this diagnosis made for the first time?” In addition to these eczema questions, a question pertaining to physician-diagnosed allergic diseases was included: “Has a physician ever diagnosed an allergy in your child?” This question corresponds with questions about the kind of allergy and allergic symptoms and the age at what these symptoms occurred the first time.

Predisposition

A predisposition was positive when either mother or father suffered from at least one of the following disorders: hayfever, eczema or asthma.

Exposure

To avoid a misclassification of the total exposure the outdoor pollution had been included in the statistical analysis. The main source of outdoor pollution in the area under investigation is traffic. Considering earlier experience from epidemiological studies in the same city (Herbarth et al., 1999; Fritz and Herbarth, 2001), traffic census and detailed description given in the questionnaires the traffic-related outdoor exposure in the area of residence was estimated for each participant.

Indoor exposure was assessed based on questionnaire-based information focusing on type of home renovation, time of redecoration, i.e., prenatal (during pregnancy) as well as postnatal (during the first 6 years of the child's life), with special emphasis on the date of renovations and the onset of the first overt of allergic symptoms. Exposure maxima are of special interest. Such maximum of indoor exposure is marked by a high emission of potential sources. Temporary sources originate from renovating activities. These activities are associated with high emissions of VOCs. To assess the exposure maximum, three main types of renovation (painting, new floor covering, new furniture) were summed up in a variable called “reno_max”. This means that if all three activities have been carried out at the same time, the “reno_max” variable gets “yes”, otherwise “no”.

The time of renovation was given by the parents in the questionnaire. With all this information it was possible to realize whether the activities took place before or after the first onset of the described diseases or symptoms.

Statistical analysis

Data analysis was performed using Statistica (StatSoft, Inc., 2001, STATISTICA for Windows Version 6.1). The χ^2 -test was used to determine the statistical significance of the exposure-associated differences in prevalences.

Logistic regression analyses were applied to calculate the odds ratios (OR) for the association between target variables and indoor exposure linked activities. Odds ratios were adjusted for the following confounders: family history of atopy (FHA defined above), gender, contact to cats, number of older siblings, mother's smoking during pregnancy, smoking in the presence of the child, outdoor exposure (characterized by traffic density in the area of residence) (Fritz and Herbarth, 2001, 2004).

Results

At time of investigation (mean age of children 6.3 ± 0.6 years) (Table 1), lifetime prevalences were

16.9% for eczema and 12.7% for allergic symptom manifestation. They are shown in Table 2 together with the frequencies of pertinent study parameters.

The control group has been selected considering all families who have not carried out any redecoration activities neither around birth nor afterwards in later life time. This concerns 537 study participants (21.2% of the study population). Table 3 shows the frequencies of redecoration activities and the link between different activities like painting, floor covering and new furniture. The reno_max group comprises 936 study participants (36.9% of the study population).

Table 4 shows significantly higher prevalences of both allergic symptoms and diagnosed eczema within the first 6 years of life associated with reno_max activities at any time. The association between reno_max and allergic symptoms after adjustment for other possible allergy risk factors are shown in Table 5.

As far as date of renovation was concerned, the data suggest that the strongest effect was observed when renovation took place just around birth (Fig. 1). Only

Table 2. Lifetime prevalences of allergic disorders and frequencies of covariates entered into the logistic regression model (data referred to 6.3 years)

Allergic symptoms and diseases	Prevalence (%)	n/total
Allergic symptoms (physician diagnosed)	12.7	321/2536
Eczema	16.9	428/2536
Exposure	Frequency (%)	
<i>Outdoor</i>		
Traffic influenced area	35.7	903/2536
<i>Indoor</i>		
Smoking during pregnancy	11.4	289/2536
Smoking in presence of the child within the first 3 years of life	40.3	1025/2536
Pets (cat)	38.6	971/2536
Renovation activities		
Painting	49.4	1252/2536
Floor covering	68.8	1775/2536
New furniture	60.1	1524/2536
No renovation activity of any sort	21.2	537/2536
reno_max only		
Just before birth	22.0	557/2536
During the 1st year of life	6.5	164/2536
During the 2nd and 3rd year of life	5.2	131/2536
From the 4th year of life	3.3	84/2536
Predisposition		
Family atopy history	33.8	857/2536

reno_max data have been considered in these logistic models adjusted for those variables named in Table 5. Included were 1473 cases (see Table 3, control group

Table 3. Frequencies of redecoration activities

Painting	Floor covering	New furniture	
		No	Yes
No	No	21.2 (537) control group	4.7 (119)
No	Yes	10.2 (258)	14.6 (370)
Yes	No	3.4 (86)	3.2 (82)
Yes	Yes	5.8 (148)	36.9 (936) reno_max group

% (n)—% referring to the total number of participants (n = 2536).

Table 4. Prevalences of allergic disorders depending on extent of renovation (reno_max = wall painting + new floor covering + new furniture)

	Prevalence (%)		
	Never redecorated ^a	reno_max	p (χ^2)
Allergic symptoms	9.3	16.8	<0.0001
Eczema	11.5	20.3	<0.0001

^aNever redecorated means not any activity, neither painting nor floor covering nor new furniture; this group of participants is the control group.

and reno_max group). All cases with one or two redecoration activities have been excluded. Apart from the adjusting variables in each of both models four variables were included to characterize redecoration activity before birth, in the first year of life, in the second and third year of life, in the fourth year of life and later. Both models, for allergic symptoms as well as for eczema, are significant with $p < 0.0001$. It should be mentioned again that starting with birth only those cases have been considered for which the exposure took place before first health effects were seen. In fact, timing showed a definite trend, the earlier in a child's life renovations were carried out, the greater is the risk to develop allergic disorders later on (Fig. 1).

To derive a kind of dose-response relationship the number of activities has been included in the model. The variable “indoor exposure (reno_max)” (Table 5) has been replaced by the number of renovation activities: no activity (control group), one or two activities and three activities (reno_max group). The risk increases per additional activity about 1.27 (95% CI: 1.14–41; $p < 0.0001$) in case of allergic symptoms, and about 1.21 (95% CI: 1.10–1.33; $p < 0.0001$) in case of eczema. Both models are significant with $p < 0.0001$ and base on $n = 2536$ included cases.

A siblings and birth order effect as reported by Strachan et al. (1997) was not observed in association with renovation activity among these study participants. Only a trend is visible for eczema and the number of older siblings within the logistic model. It can be suspected that with increasing birth number the renovation activity goes down. This is not the case. The ratio “number of no renovation activities/number of reno_max activities” within the group without older

Table 5. Adjusted odds ratios (OR) for allergic disorders depending on highest renovation activities

	Allergic symptoms			Eczema		
	OR	95% CI	p	OR	95% CI	p
Parental predisposition	2.53	1.87;3.41	<0.0001	1.30	0.98;1.72	0.0705
Sex	0.71	0.52;0.96	0.0251	0.74	0.56;0.98	0.0360
Older siblings	1.13	0.84;1.53	0.4218	0.76	0.57;1.01	0.0594
Smoking during pregnancy	0.93	0.56;1.55	0.7861	1.28	0.84;1.97	0.2501
ETS	1.23	0.89;1.69	0.2050	1.49	1.11;2.00	0.0073
Pets (cat)	1.33	0.99;1.82	0.0590	1.21	0.91;1.61	0.1784
Outdoor exposure (traffic)	1.15	0.84;1.57	0.3915	0.92	0.69;1.23	0.9169
Indoor exposure (reno_max)	1.85	1.31;2.61	0.0004	1.95	1.43;2.67	< 0.0001

Only cases included without any redecoration activity—internal control group—and with “reno_max” activity, not included cases with one or two activities out of painting, floor covering and new furniture; total remaining cases $n = 1473$ included in the models.

Remarks

- ETS—environmental tobacco smoking (passive smoking); smoking in presence of the child.
- Sex: 0 = male; 1 = female.
- Both models highly significant: $p_{\text{model}} < 0.0001$.
- Trend in italics.

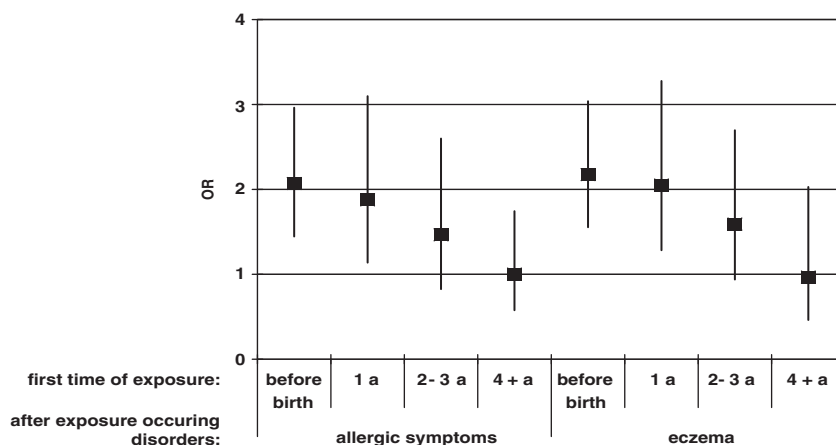


Fig. 1. OR (95% CI) for allergic disorders depending on the date of the renovation (in years) and subsequently occurring disorders and symptoms (adjusted for parental predisposition, sex, older siblings, smoking in presence of the child in the first years of life (ETS), smoking during pregnancy, pets (cat), outdoor exposure characterized by traffic).

siblings ($n = 875$) is 0.59 and within the group with older siblings ($n = 598$) 0.55.

Discussion

This study suggests an influence of residential renovation on allergic disorders. The chemical indoor exposure levels seem to play an important role because of the frequency of renovations which were carried out in the investigated households. Of all parents in this study 78.8% had redecorated their apartment before birth or in early life of the children, 36.9% had carried out all three activities (painting, floor covering and new furniture) (Table 3), 28.5% of them before birth and in the first year of life (Table 2). Compared to other lifestyle behaviours, such as smoking, renovation activities associated indoor exposure leads to the same or to a higher risk in terms of the increase of the OR (Table 5). Comparing OR only a child's odds to eczema was increased when the parents smoked in presence of the child during the child's first years of life (OR = 1.49, 95% CI: 1.11–2.00; Table 5) whereas indoor renovation (reno_max associated load) increased the risk for eczema (OR = 1.95, 95% CI: 1.43–2.67) as well as for allergic symptoms (OR = 1.85, 95% CI: 1.31–2.61) (Table 5).

The early manifestation of eczema and its role as predictor of respiratory allergic disorders later in life (Bergmann et al., 1998) allocates a special importance on this disorder in defining the date of any adverse exposure effects, one reason to avoid redecoration associated exposure as well as their level of concentration during pregnancy and the first year of life (Fig. 1 and Table 5).

The results of this study confirm the results of the LARS study (Diez et al., 2000). Whereas high risk children were involved in the LARS study, the LISS study is population based on 75.3% of all children of one birth year living in the area (Table 1).

Considering the “hygiene-hypothesis” (Strachan, 1989, 2000) a strong sibling effect was not observed. A birth order effect on the frequency of the renovation activity was not observed as well. The measured influence of the redecoration activity on the frequency of the considered disorders and symptoms can be ascribed to the activity alone.

Several limitations need to be considered. First, the presented results base on questionnaire data. The questions have been answered by the parents when the children were 6 years old. Some questions are related to events which took place around birth. Perhaps inaccuracies are possible both concerning the kind of effect or event/activity and concerning the time of their onset. Secondly, parents were asked to put down on the questionnaire physician diagnosed symptoms and/or diseases only. Since the call of a physician is a more impressive event than the observation of a symptom by the parents it can be assumed that the answers are correct. A further reason for this assumption is that the results of newborn cohort studies which were carried out in the same area came to similar results concerning the frequency of health effects and redecoration activities (Herbarth et al., 1998; Diez et al., 2000; Zutavern et al., 2006). In these studies the information of redecoration activities and or of health effects has been collected immediately.

However, the study has several notable strengths. First, the sample size is very large. No comparative study with respect to the population size is known which addressed the topic we deal with especially concerning

indoor air quality. Second, the study participants have been recruited from one birth year. In total 75% of all children of the total cohort participated.

It can be concluded that extensive renovation during pregnancy, especially around the time of birth, and during the first year of life seem to affect the development of allergic disorders. These findings should be considered like active and passive smoking by general practitioners or specialists when they advice prospective parents, especially expectant mothers, on the “dos and don’ts” during and after pregnancy. Avoidance of such activities particularly by parents themselves affected by atopy would be an effective measure of prevention. In fact, in contrast to smoking (active and passive smoking), this prevention measure may be more effective, since the risk is greater, it is easier to achieve and avoidance of such activities (renovation, floor covering or painting) involve no personal consequences (e.g., habit and withdrawal symptoms).

The complexity of the problem will gain in importance since legislative measures to conserve energy will continue which indirectly will affect the air indoors. The reduction in air exchange between indoor and outdoor will lead to elevated concentrations of noxious substances and an increasing indoor air problem.

The question of a threshold value for VOC concentrations resulting from renovation activities, i.e., levels which may prevail in an infant’s home without having an acute effect or one which manifests only later in life, will remain the subject of further studies.

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