Indoor exposure associated risk for eczema in early childhood

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Abstract

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

Within an epidemiological study involving 2536 children the effect of indoor exposure on allergic symptoms and physician-confirmed eczema has been investigated. The exposure situation has been characterised on hand of the redecoration activities before birth and in the first years of life.

Highly exposed children showed a significant effect on allergic disorders. The lifetime prevalences without any vs. of all three redecoration activities (painting, floor covering and new furniture) 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.

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.

Keywords: indoor exposure, allergic disorders, children.

1 Introduction

Besides a genetic predisposition and the controversially-discussed hygiene hypothesis (Strachan [1, 2]), other factors influence the development of allergies

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in early childhood: food, pollens, etc. and as lately described also indoor chemical pollutants, particularly volatile organic compounds (VOC) (Herbarth and Rehwagen [3], Wolkoff and Nielsen [4]). Important VOC sources are, e.g., smoking and emissions from building materials and furnishings (Samet et al. [5, 6], Cooke [7]). During and following home renovation activities, e.g., painting and/or floor 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. [8], Koren et al. [9], Ware et al. [10], Norback et al. [11], Wieslander et al. [12] Diez et al. [13]). 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 [14] Warner et al. [15, 16]). 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 were given by Diez et al. [13] 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.

2 Material and methods

2.1 Study population

The presented investigation is based on the data of an epidemiologic cross-sectional study (LISS study - **L**eipzig **i**nfection, allergy and airway diseases study among **s**chool **s**tarters). 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 completed a detailed self-administered questionnaire on indoor exposure as well as their family medical history (e.g., physician-diagnosed diseases and symptoms of allergic disease). 2950 parents agreed to fill out this questionnaire. For this investigation, 2536 complete data sets were available (86% of self administered questionnaires).

The study design and methodology have been described in detail elsewhere (Krumbiegel et al. [17], Herbarth et al. [18]).

2.2 Disorders (target variables)

The target variables were lifetime prevalences of physician-diagnosed eczema and physician-diagnosed 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 occur at the first time.

2.3 Predisposition

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

2.4 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 investigated area is traffic. Considering earlier experience from epidemiological studies in the same city (Herbarth et al. [19], Fritz and Herbarth [20]) the traffic related 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 renovations, time of redecoration, i.e., prenatal (during pregnancy) as well as postnatal (during the first six years of the child's life), with special emphasis on the timing 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 volatile organic compounds (VOCs). To assess the exposure maximum, three main types of renovations [painting, new floor covering, new furniture] were summed up in a variable called "reno_max". This means that all 3 activities have to be carried out at the same time, then the "reno_max" variable get "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.

2.5 Statistical analysis

The data analysis was performed using Statistica (Statsoft, Inc. 2004, STATISTICA for Windows Vers. 6 [26]). 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 (characterised by traffic density in the area of residence) (Fritz and Herbarth [20, 21]).

3 Results

At time of investigation (mean age of children 6.3 ± 0.6 years) (Table 1), the lifetime prevalences were 16.9% for eczema and 12.7% for allergic symptoms manifestations 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 the birth nor afterwards in the 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, divided in painting, floor covering and new furniture. The reno_max group comprises 936 study participants (36.9% of the study population).

Table 1: Study parameter description.

	N	%
study area		
population	656,878	
total no of 6 to 7 years old children in the area (one birth year)	3,919	
number of involved schools	119	
response		
(A) questionnaire	2,950	75.3 related to 3,919
(B) complete data set concerning all questions relevant for analysis	2,536	85.9 related to (A)
study participants		
mean age [a] 6.3		
female / male	1,257 / 1,279	49.6 / 50.4
participants with older siblings	1,051	41.4

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

Table 2: Lifetime prevalences of allergic disorders and frequencies of some covariates (data referred to the age of 6.3 years).

ALLERGIC SYMPTOMS and DISEASES		prevalence [%]	n/2536
allergic symptoms (physician diagnosed)		12.7	321
eczema		16.9	428
EXPOSURE		frequency [%]	
OUTDOOR	traffic influenced area	35.7	903
INDOOR	renovation activities		
	painting	49.4	1252
	floor covering	68.8	1775
	new furniture	60.1	1524
no renovation activity of any sort		21.2	537
"reno-max" only: just before birth		22.0	557
during the 1st year of life		6.5	164
during the 2nd and 3rd year of life		5.2	131
from the 4th year of life		3.3	84
PREDISPOSITION	family atopy history	33.8	857

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); % refer to the total number of participants (N=2536).

As far as 'timing' of renovations was concerned, the data suggest that the strongest effect was observed when renovations took place just around birth (Figure 1). Only "reno_max" data have been considered in these logistic models adjusted for those variables called in Table 5. Included were 1473 cases (see Table 3, 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 4 variables were included to characterize the redecoration time (before birth, in the first, in the second / third year, 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 takes place before first health effects were seen. In fact, timing showed a definite trend, the earlier in a child's life the renovations were carried out, the greater is the risk to develop allergic disorders later on (Figure 1).

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

	prevalence [%]		
	never redecorated[1]	reno_max	p (χ^2)
allergic symptoms	9.3	16.8	<0.0001
eczema	11.5	20.3	<0.0001

[1]never redecorated means not any activity, neither painting nor floor covering nor new furniture; this group of participants is used to be the control group

Table 5: Adjusted Odds Ratios (OR) for allergic disorders depending on at most renovation activities (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).

	allergic symptoms		Eczema	
	OR	p	OR	p
parental predisposition	**2.53**	<0.0001	***1.30***	0.0705
sex	**0.71**	0.0251	**0.74**	0.0360
older siblings	1.13	0.4218	***0.76***	0.0594
smoking during pregnancy	0.93	0.7861	1.28	0.2501
ETS	1.23	0.2050	**1.49**	0.0073
pets (cat)	***1.33***	0.0590	1.21	0.1784
outdoor exposure (traffic)	1.15	0.3915	0.92	0.9169
indoor exposure (reno_max)	**1.85**	0.0004	**1.95**	<0.0001

Rem: ETS – environmental tobacco smoking (passive smoking); smoking in presence of the child, sex: 0 = male; 1 = female, both models high significant: $p_{model}<0.0001$, trend in italics.

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), 1 or 2 activities and 3 activities (reno_max group). The risk increases per additional activity about 1.27 (95%CI: 1.14 … 1.41; p<0.0001) in the case of allergic symptoms and about 1.21 (95%CI: 1.10 … 1.33; p<0.0001) in the 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 and colleagues [22] 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 siblings (n=875) is 0.59 and within the group with older siblings (n=598) 0.55.

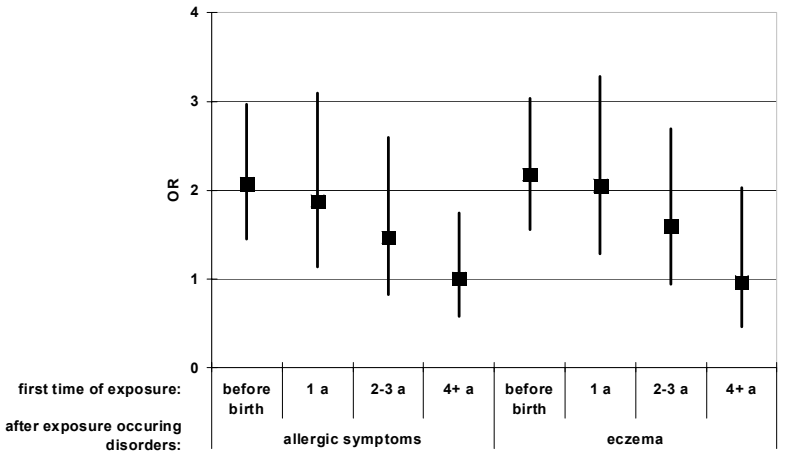

Figure 1: Odds Ratios (OR +/- 95%CI) for allergic disorders depending on the timing of the renovations – reno_max - (in years) and subsequent occurring disorders and symptoms (adjusted for parental predisposition, sex, older siblings, smoking in presence of the child in the first years of life (ETS), smoking during pregnancy, pets (cat), outdoor exposure characterised by traffic). (Rem: redecoration activities in the 1st, 2nd and 3rd, 4th year and later - 1a, 2-3a, 4+a; in both models ($p<0.0001$) considered only reno_max and control group, not considered cases with one or two redecoration activities (see Table 2, $N_{total}=1473$)).

4 Conclusion

This study suggests an influence of residential renovations 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. 78.8% of all parents in this study redecorate their apartment before birth and in early life of the children, 36.9% carry 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 (e.g., ETS - environmental tobacco smoking), renovation activities associated indoor exposure leads to the same or to a higher risk in terms of the increase of the odds ratio (Table 5).

The early manifestation of eczema and its role as predictor of respiratory allergic disorders later in life (Bergmann et al. [25]) allocates a special importance on this disorder in defining the timing 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 (Figure 1 and Table 5).

The results of this study confirm the results of the LARS study (Diez et al. [13]). 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 [1, 2]) a strong sibling effect was not observed. A birth order effect on the frequency of the renovation activity was not observed as well.

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. Secondly, regarding the symptoms and/or diseases the parents were asked to put down on the questionnaire physician diagnosed symptoms and/or diseases only. Results of newborn cohort studies which are carried out in the same area come to similar results concerning the frequency of redecoration activities and prevalence's (Herbarth et al. [23], Diez et al [13], Zutavern et al [24]). In these studies the information of redecoration activities and of health effects has been collected immediately.

However, the study has several notable strengths. First, the study 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.

It can be concluded that extensive renovations 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 in- and outdoor will lead to elevated concentrations of noxious substances and an increasing indoor air problem.

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