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Redecoration of apartments promotes obstructive bronchitis in atopy risk infants – Results of the LARS study

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Abstract

Findings by other authors indicate that exposure to chemical emissions from indoor paint is related to asthma symptoms in adults. In their first years of life children are receptive to obstructive airway diseases. The aim of this study was to investigate the influence of redecoration of the apartment on airway symptoms in infants during the first two years of life. The Leipzig Allergy Risk Children Study (LARS) is a birth cohort study with the following inclusion criteria: double positive family atopy anamnesis, cord blood IgE > 0.9 kU/l, or low birth weight between 1500–2500 g. Within the context of LARS, 186 parents of risk children completed a questionnaire on the respiratory symptoms of their children and the redecoration of their apartment at the end of the first and second year of life. A total 22% of the children suffered from obstructive bronchitis once or more during their first year, and 11% experienced this condition during their second year of life. Redecoration of the apartment had a significant influence on the appearance of obstructive bronchitis in the first (OR 4.1 95%CI 1.4–11.9) and in the second year of life (OR 4.2 95%CI 1.4–12.9). (The OR are adjusted for cord blood-IgE >0.9 kU/l, birth weight ≤ 2500 g, male sex and double positive parental atopy anamnesis, dampness, smoking or pet in the apartment). Simultaneous contamination from redecoration activities and additional exposures such as smoking, a pet or dampness in the apartment increased the risk for obstructive bronchitis in the first year (OR 9.1; 95% CI 2.3–34.8) as well as in the second year (OR 5.1; 95%CI 1.6–15.6). Our data suggest that redecoration of the apartment is associated with the development of acute inflammations, but not with a chronic influence on the airways in atopy risk infants. At an exposure to more than one environmental factor, pronounced effects were seen.

Key words: Redecoration – obstructive bronchitis – atopy risk infants – combined effects

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Introduction

Findings by Wieslander et al. (1997) indicate that exposure to chemical emissions from indoor paint is related to asthma, and that some volatile organic compounds (VOCs) cause inflammatory reactions in the airways of adults. Indoor air quality is partly characterized by a variety of VOCs in relatively low concentrations (Seifert et al. 1986). Human activities such as home decoration (Wolkoff 1999, Wieslander et al. 1997) or smoking (Wallace et al. 1987) typically increase the concentration of VOCs in indoor air. Wieslander et al. (1997) found that in apartments redecorated during the previous year total VOCs had been elevated by an average amount of 100 $\mu g/m^3$. Increased VOC concentrations in indoor air could lead to inflammatory reactions in the mucous membranes of the airways (Molhave et al. 1986).

In early childhood infants are receptive to obstructive airway diseases. The first year of life is a particularly vulnerable period since the airways are very small. The lung volume doubles during the first six months of life and triples by the end of the first year (Dezateux and Stocks 1997). At the end of the first year the lung has reached only 40% of the adult size (Schwartze 1990).

Inflammations of the airways are accompanied by swellings of the mucous membranes and increased mucous production. Moreover, the development of the immune system has not yet reached the state of a TH1 immunological response within the first two years of life (Koning et al. 1996), and a higher sensitivity to viral infections exists. Hence, infants during the first years of life may react even more sensitively with airway symptoms than adults to redecoration of the apartment.

The Leipzig Allergy Risk Children Study (LARS) is a cohort study on the influence of chemical exposure within apartments on the health outcome of atopy risk children during the first years of life (Diez et al. 1996, 2000). Children with double positiv atopy family anamneses, elevated cord blood IgE, or a low birth weight were included in the study since it is assumed that these children are particularly sensitive to the development of environmentally influenced airway diseases and possibly later asthma. The results may supply hypotheses about risks for airway diseases in primarily healthy infants. In this paper the influence of redecoration on the occurrence of obstructive bronchitis in one- and two-year-old risk children is studied.

Methods

LARS was approved by the ethics commission of the University of Leipzig. Informed consent by parents was obtained. A total of 475 children with allergic risk factors and/or with lower birth weight were selected from the entire number of newborns ($n = 3540$) within the area of Leipzig between March, 1995 and March, 1996. All of the 186 children for whom cord-blood-IgE measurements had been recorded and for whom questionnaires had been filled out at each of the three time periods – birth, twelve months and 24 months – were selected for this longitudinal study (Tab. 1).

At birth, cord blood IgE level was measured with the Pharmacia CAP system (Upjohn GmbH, Freiburg, Germany). Children with cord-blood-IgE > 0.9 kU/l are probably at risk for atopy (Croner et al. 1982). Each mother answered a questionnaire developed by the MAS (Multicenter Atopy Study) study group (Bergmann et al. 1993) regarding atopic diseases of the parents and siblings of the newborn. Newborns with two atopic family members (both parents or one parent and a sibling with hay fever, asthma or atopic dermatitis) were selected to participate in the study. Children with low birth weight (1500 – 2500 g) were also integrated in the study because they are risk children concerning airway diseases like asthma or obstructive bronchitis.

The parents of the 186 study participants completed a more detailed questionnaire at birth in interview and further self-administrated questionnaires at the time of first and second birthday of their children. The questionnaires contained items on respiratory symptoms (wheezing, breathlessness, diagnosis of croup by physician) of the children during the first and second year of life.

In this study obstructive bronchitis was defined to be characterized by the symptoms "one or more wheezing incidents" or "one or more attacks of breathlessness" during the first or second year of the infant's life. This definition of obstructive bronchitis based on results of the LARS-working-group, published by Meusel (2002). A high correlation had been calculated between clinical diagnosed obstructive bronchitis and these items from questionnaires (96.6% sensitivity and 100% specificity). Children with the medical diagnosis of croup as an illness of the upper airways were excluded and not evaluated to be cases of obstructive bronchitis. Furthermore, the questionnaires included a question about redecoration of the apartment during pregnancy, the first, and the second year of the infant's life, such as: "Have you redecorated your apartment during the last year (including painting, new wall-to-wall carpeting or new furniture)?" Accordingly, information about overall redecoration exists for three time periods. All the separate redecoration events were requested from the mothers only about pregnancy. Information about laying out new wall-to-wall carpets was available for the 1st and 2nd year of life, too. Some other influencing factors were also recorded, including: "Is there smoking in your apartment?"; "Do you currently have a pet?"; "Is there any water damage in your apartment?" The corresponding yes/no answers were

also taken as parameters in the model of logistic regression.

Statistical analysis

The statistical calculations were performed using the software Statistica for Windows (version 5.5e, 1994–2000 by Statsoft Inc., Tusla, OK, USA). A chi-square test (with one degree of freedom) was used in order to differentiate between binary dependent and independent variables. The relations between redecoration of the apartment and obstructive bronchitis were calculated by logistic regression, adjusted for cord-blood-IgE > 0.9 kU/l, birth weight ≤ 2500 g, male sex and double positive parental atopy anamnesis. Further confounders were smoking, keeping a pet and dampness in the apartment since other authors have shown that these factors could have an influence on the occurrence of obstructive airway illnesses (Li et al. 1999, Peat et al. 1998).

The calculation of the odds ratios (OR) was carried out according to the Maximum Likelihood method.

In further models of logistic regression the influences of redecoration plus an additional risk (redecoration plus keeping a pet, or redecoration plus smoking in the apartment, or redecoration plus dampness) on obstructive bronchitis were calculated. For these models new influencing variables were encoded, in which the redecoration of the apartment was added to one further risk factor.

Table 1. Characteristics of the 186 study participants at birth: frequency and prevalence.

Characteristics of study population	n/N (%)
Male sex	99/186 (53)
Cord blood IgE > 0.9 kU/l	113/186 (61)
Positive parental atopy anamnesis[1]	24/186 (13)
Double positive atopy anamnesis[2]	70/186 (37)
Birth weight 1500–2500 g	33/186 (18)

Percentages are referred to the total cohort of 186 children. A single character can contain several others. [1] Both parents with asthma, hay fever or atopic dermatitis. [2] One parent and one sibling or both parents with asthma, hay fever or atopic dermatitis.

Table 2. Percentage of frequency of children with obstructive bronchitis, wheezing, croup, and breathlessness during 1st and 2nd year of life.

Symptoms/diagnosis	1st Year of life n/N (%)	2nd Year of life n/N (%)
Only wheezing	38/186 (20)	14/184 (8)
Only attacks of breathlessness	1/186 (0.5)	5/184 (3)
Wheezing and breathlessness	4/186 (2)	8/184 (4)
Wheezing or breathlessness	43/186 (23)	27/184 (15)
Excluded children with croup	3/186 (2)	7/184 (4)
Children with obstructive bronchitis	40/186 (22)	20/184 (11)

Results

The characteristics of the study group regarding sex, birth weight and atopic risks are shown in Table 1.

A total of 22% of 186 infants suffered from obstructive bronchitis in the first year, and 11% of 184 (minus 2 incomplete questionnaires) experienced this condition in the second year of live. The frequency of occurrence of various airway symptoms is catalogued in Table 2. As is shown attacks of breathlessness occurred very seldom. The frequency of obstructive bronchitis decreased for the whole cohort between the first and second year of life ($\chi^2 = 5.6$; $p = 0.02$).

About two thirds (66%) of the parents reported the redecoration of their apartment during pregnancy. Only 19% redecorated their apartment during the first or second year of the child's life ($\chi^2 = 34.3$; $p < 0.01$) The numbers of smoking, pet keeping, and/or dampness are also given (Tab. 3).

Influences of redecoration of the apartment during the different periods of time on the occurrence of obstructive bronchitis and wheezing are shown in Table 4. No association existed between overall redecoration or the various redecoration events during maternal pregnancy and infantile obstructive bronchitis or wheezing during the first or second year of life.

Redecoration during the first year of the infant's life had a significant influence on obstructive bronchitis up to the first birthday (OR 3.6) but not in the second year. However, the influence on wheezing was not significant.

Furthermore there was a significant relation between overall redecoration of the apartment during the children's second year of life and obstructive bronchitis (OR 4.3) and wheezing (OR 3.7). No significant influence from laying new wall-to-wall carpets in children's rooms on airway diseases in the 1st and 2nd year of life could be proven.

The next calculation should answer the question whether additional confounders such as smoking, dampness or house pets in the apartment influence the significant association between the redecoration of the apartment and the occurrence of obstructive bronchitis.

All indoor contamination during pregnancy which was recorded on the questionnaires had no effect on the frequency of obstructive bronchitis appearing during the first and second year of life.

Table 3. Incidence of redecoration events, smoking, dampness, and pets in the apartments during three periods of time.

In the apartment	During pregnancy n/N (%)	During 1st year n/N (%)	During 2nd year n/N (%)
Redecoration*	121/186 (66)	36/186 (19)	35/186 (19)
Painting of walls	82/184 (44)	No information	No information
New furniture	93/184 (50)	No information	No information
Adhesive new carpeting in children's room	26/183 (14)	22/185 (26)	18/126 (14)
Smoking	47/184 (26)	43/186 (23)	55/186 (30)
Pet keeping	75/186 (40)	66/186 (35)	65/186 (35)
Dampness	69/182 (38)	41/172 (24)	38/179 (21)

* Including painting or new furniture or new carpeting in the dwelling. The question relating to the floor covering was not answered by all parents.

Table 4. Associations between redecoration of the apartment during pregnancy, 1st and 2nd year of life and its effect on obstructive bronchitis or wheezing in atopy risk children during their 1st and 2nd year of life.

	During 1st year		During 2nd year	
	Obstructive bronchitis OR 95%CI	Wheezing OR 95%CI	Obstructive bronchitis OR 95%CI	Wheezing OR 95%CI
Redecoration*				
During pregnancy	0.6 (0.3–1.3)	0.7 (0.3–1.8)	1.5 (0.5–4.3)	0.9 (0.3–2.6)
During 1st year	3.6 (1.4–9.1)**	2.5 (0.9–7.3)	1.6 (0.5–5.1)	1.5 (0.5–5.1)
During 2nd year			4.3 (1.6–12.2)**	3.7 (1.3–10.1)**
Never redecoration	0.7 (0.3–1.5)	0.6 (0.2–1.4)	2.2 (0.7–6.4)	0.9 (0.3–2.5)

The OR are adjusted for cord-blood-IgE $>$ 0.9 kU/l, birth weight $\leq$ 2500 g, male sex, and double positive parental atopy anamnesis. Male sex had a significant influence on obstructive bronchitis in the first year (OR 5.1; CI 2.1–12.5) but not in the 2nd year. Significant OR are indicated by ** ($p < 0.01$). * Including painting or new furniture or new carpeting in the dwelling.

Table 5. Model of logistic regression: factors influencing obstructive bronchitis and wheezing during the first year of life.

Influences during 1st year n = 172	On obstructive bronchitis during 1st year of life OR 95%CI	On wheezing during 1st year of life OR 95%CI
Male sex	4.8 (1.9–12.5)***	4.8 (1.7–13.7)**
Cord-blood-IgE $>$ 0.9 kU/l	0.6 (0.2–1.8)	0.6 (0.2–2.0)
Birth weight $\leq$ 2500 g	1.0 (0.3–3.7)	1.2 (0.3–4.9)
Double positive parental atopy family anamnesis	0.3 (0.1–1.3)	0.3 (0.1–1.9)
Redecoration during 1st year	4.1 (1.4–11.9)***	2.4 (0.7–8.6)
Smoking in the apartment	2.4 (1.0–6.0)**	2.7 (1.0–7.2)*
Dampness in the apartment	2.0 (0.8–5.0)	1.9 (0.7–5.0)
Pet in the apartment	1.7 (0.7–3.9)	1.8 (0.7–4.5)

Each factor was adjusted against each other. Statistical significance was only obtained for smoking, redecoration and male sex. Significant OR are indicated by * ($p < 0.05$), ** ($p < 0.005$), *** ($p < 0.001$).

During the first year of life redecoration of the apartment led to an increase in the risk of obstructive bronchitis up to the first birthday, even after consideration of confounders, the strongest being male sex. In addition, smoking in the apartment also had an effect, although it was a smaller one (Tab. 5).

Redecoration of the apartment during the second year of life was also an influential factor for obstructive bronchitis and wheezing during the children's second year of life even after the above mentioned confounders were considered (Tab. 6).

In further models the effect of more than one simultaneous exposure was calculated. A simultaneous contamination from redecoration activities and an additional exposure such as smoking, a pet or dampness in the apartment increased the risk for obstructive bronchitis in the first year (OR 9.1; 95% CI 2.3–34.8; n = 172) as well as in the second year (OR 5.1; 95%CI 1.6–15.6; n = 178; Odds Ratios adjusted for cord-blood-IgE $>$ 0.9 kU/l, birth weight $\leq$ 2500 g, male sex and double positive parental atopy anamnesis).

Table 6. Model of logistic regression: factors influencing obstructive bronchitis and wheezing during the second year of life.

Influences during 2nd year n = 178	On obstructive bronchitis during 2nd year of life OR 95%CI	On wheezing during 2nd year of life OR 95%CI
Male sex	2.3 (0.7–7.5)	4.3 (1.3–14.6)**
Cord-blood-IgE > 0.9 kU/l	2.5 (0.6–11.3)	2.4 (0.6–10.2)
Birth weight < MK = > 2500 g	0.6 (0.1–7.3)	1.2 (0.2–10.2)
Double positive parental atopy family anamnesis	1.1 (0.2–5.6)	1.0 (0.2–5.1)
Redecoration during 2nd year	4.1 (1.4–12.9)*	3.0 (1.0–9.1)*
Smoking in the apartment	0.7 (0.2–2.4)	1.0 (0.3–2.8)
Dampness in the apartment	1.0 (0.3–3.7)	1.3 (0.4–4.2)
Pet in the apartment	1.0 (0.3–3.1)	1.5 (0.5–4.4)

Each factor is adjusted against each other. Significant OR are indicted by * ($p < 0.05$), ** ($p < 0.01$).

Discussion

Some studies (Steffensen et al. 2000, von Mutius et al. 1993) describe that infants with low birth weight < 2500 g also exhibit a higher risk for allergies and obstructive airway diseases. These infants have an immature immune system at birth (Borte et al. 1993a, b; Lehmann et al. 1998) which probably can be the cause of a subsequent development of atopy. This is the reason why this population was included in our study. Children with a double positive family anamneses for allergies represent a special risk group for asthma (von Mutius 1999). Former results of the MAS study indicated that elevated cord-blood IgE level is more often linked with early sensitization against food allergens, but not systematically with atopic symptoms. In a multiple logistic model recurrent wheezing in the first two years was neither influenced by atopy anamneses of the parents nor by elevated cord-blood IgE (Bergmann et al. 1997). Only male sex was found to be a significant risk factor for wheezing as it was found in our study. Young et al. (2000) reported a 1.5–2 times higher incidence of obstructive airway illnesses for boys which can be explained by the smaller size of their airways at birth compared with girls (Stocks 1999).

The frequency of obstructive bronchitis in our study group decreased from the first (22%) to the second (11%) year of life. This finding can be caused by the growth of the airways and/or by the increasing outdoor stays of two-year-old children. It is somewhat difficult to compare the prevalence of bronchitis symptoms of our infants with findings of other studies, because the results depend on the selection criteria of the investigated collective and the respective definitions of bronchitis and asthma which both may be different. According to the German Multicenter Atopy Study (Bergmann et al. 1994), 15% of two-year-old atopy-risk children suffer from recurrent wheezing.

In the first two years of life obstructive bronchitis is mainly caused by viruses. Respiratory syncytial virus (RSV), rhinovirus, corona virus, parainfluenza virus 1–3 and adenovirus A and B have been identified in infants with airway infections (von Mutius 1998). Parainfluenza and RSV viruses are thought to be primarily responsible for infections of the lower airways (Martinez 1999).

Other factors like smoking or redecoration of the children's apartment have an additional significant influence on the appearance of obstructive bronchitis in risk children. This was clearly provable despite the small number of cases. The number of cases varied within the individual models because of the fact that not all parents answered the questionnaires completely.

Compared with a former evaluation of LARS cross sectional data of the first year of life including 310 cases (Diez et al. 2000), the OR are in part higher in this longitudinal study of 186 cases. This could be caused by the fact that in our present study all the models of logistic regression were adjusted for male sex, parental double positive atopy family anamneses, elevated cord blood IgE and low birth weight whereas in our first paper this had not been done. Unfortunately, due to the small number of cases here, no other confounders such as social status (Bergmann et al. 2000), the protective effect of breastfeeding (Diez et al. 2000), the effect of cooking with gas (Chauhan et al. 1998) or heating with coal (Herbarth et al. 2001) and the child's enrolling in a child care center with the consequence of increased contact to germs could be taken into account. This should be considered in further investigations.

Our main result that redecoration of apartments contributes to the appearance of obstructive bronchitis in early childhood, is supported by data of the

Swedish study BAMSE. This birth cohort study of 4089 children of a normal population established an increased risk of asthma in two-year-old children, if the children's bedrooms had been redecorated (OR 1.5; 95%CI 1.0 – 2.2) (Emenius et al. 2001).

In an early investigation with children from LARS a correlation was found between symptoms of an airway infection identified by clinical examination of the children at the age of six weeks and the redecoration of the apartment during the time of pregnancy, particularly with regard to the use of paints (Diez et al. 2000). Redecoration during pregnancy, however, had no influence on subsequent obstructive airway infections during the course of the following time of the first or second year of life. On the other hand, redecoration of the apartment was of influence on symptoms within the corresponding year. Apparently redecoration activities have a short to middle term effect on the airways of children in their first years of life. The use of paints on large walls as well as installing floor coverings and new furniture produce an increased concentration of various volatile organic compounds in the indoor air, such as alkanes, styrene, toluene, or pinene (Wieslander et al. 1997, Hoffmann et al. 2000, Diez et al. 2000). Increased VOC concentrations in the indoor air can have an irritating effect on the epithelium of the airways (Molhave 1991). They can also increase the inflammatory reaction of the airway epithelium or create an environment favorable for infections by inhibiting the mucociliary clearance. This effect is known in the case of exposure to tobacco smoke (Li et al. 1999).

Children who suffered repeatedly from obstructive airway diseases in their first year often develop asthma or chronic obstructive bronchitis later on (Martinez 1999, von Mutius 1998). VOCs released during redecoration work could still have an unfavorable long-term effect on the development of obstructive airway illnesses via another pathophysiological mechanism. VOCs enter the body through the lungs and are absorbed by the blood (Ashley et al. 1996). They may influence the immune regulation of TH-cells. A trend toward a reduction in TH1-cells which produce INF-γ as well as an increase of the share of TH2-cells which produce IL4 was observed in 3-year-old children in association with raised VOC concentrations (C6 – C12-alkanes, benzene, ethyl benzene, xylene, ethyl toluene, chlorobenzene) in indoor air (Lehmann et al. 2001).

The combined air contamination, which arises due to the redecoration of the apartment and an additional risk factor for airway illness (smoking, pets or dampness) increases the risk for obstructive bronchitis by a factor of 2.2 in the first year of life and by a factor of 1.2 in the second year of life. Emenius et al. (2001) achieved a similar result in the BAMSE study, where the combined contamination of indoor air due to painting work in the children's bedroom, a family member who smokes, and increased dampness in the apartment raised the risk for asthma in two-year-old children to OR 3.5 (CI 1.38 – 8.95).

The results of our study lead to the conclusion that redecorating the apartment, especially in connection with further exposures such as smoking, house pets and increased dampness, can have a short-term effect of promoting airway diseases in infants and small children. It should be recommended for small children not to stay in recently redecorated rooms for many hours, e.g. over night. The question of whether this has a long-term negative influence, insofar as it might promote the appearance of asthma or chronic obstructive airway illnesses in later years, should be clarified by further studies.

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