

Exposure to pets and allergies in children

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Currently, there is ongoing discussion regarding potential protective effects of exposure to pets during early childhood on the development of atopic disorders in children later in life. We used data from three consecutive cross-sectional surveys to study the relationship between contact with dogs, cats and other pets, and allergic diseases in schoolchildren 5–14 years of age. In three study areas of the former East Germany, 7,611 questionnaires were received from 5,360 different children who were examined between 1992 and 1999 as school entrants, or third- or sixth-graders. Allergic sensitization to common aeroallergens (birch, grass, mite, cat) was assessed by specific serum immunoglobulin E (IgE) concentrations [using radioallergosorbent testing (RAST)] for 85% of the children. After adjustment for possible confounders, inverse associations were found between contact with dogs in the first year of life and lifetime prevalences of asthma [odds ratio (OR) = 0.68; 95% confidence interval (CI): 0.43–1.08], hay fever (OR = 0.61; 95% CI: 0.39–0.95), eczema (OR = 0.76; 95% CI: 0.61–0.94), itchy rash (OR = 0.76; 95% CI: 0.61–0.94), and pollen sensitization (RAST $\geq$ 4: OR = 0.56; 95% CI: 0.38–0.82). These effects were more pronounced for children with atopic parents. Similar associations were observed for current contact with dogs. We identified no clear relationships for the other pets (cats, rodents, birds), with the exception that children currently exposed to cats were more likely to be sensitized against cats. In conclusion, this study supports the hypothesis of a potential protective mechanism related to dog exposure in early life, especially for children of atopic parents. However, this association was found only for dogs and not for cats.

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The role of environmental and lifestyle-related factors in childhood in the development of asthma and atopic diseases is an important topic of current research (1–6). In particular, exposure to furred pets is a subject of controversy.

Some studies considered pet exposure to be a risk factor for asthma and allergic diseases (7). It was argued that the observed inverse associations could be explained by selective avoidance and removal of pets (8).

On the other hand, in more recent studies there is increasing evidence that early contact with pets, particularly cats or dogs, might be a protective factor for sensitization and allergies (9–12). Studies from Norway and Sweden reported that children exposed to dogs or cats during early life had a lower frequency of allergic diseases in the first 4 years of life and at school age (9,10). A

further study examining Swedish schoolchildren reported a negative association of hay fever with cat ownership but not with exposure to dogs (11). Finally, data from the European Community Respiratory Health Survey (ECRHS) showed a strong protective effect between the presence of a dog in the home during childhood and atopy in adulthood (12).

These findings might be indirectly supported by a variety of studies which found that children living in rural areas (with a higher probability of contact with furry animals), have a lower prevalence of atopic diseases and atopic sensitization than urban children (5,13–15).

In this study we investigated the association between contact with pets and atopic diseases in three cross-sectional surveys of German children 5–14 years of age.

Subjects and methods

Study design

Three consecutive cross-sectional surveys on the long-term effects of air pollution on the respiratory health of schoolchildren were conducted in three regions of the former East Germany during 1992–93, 1995–96, and 1998–99. The study areas of Bitterfeld and Hettstedt were characterized by high levels of air pollution and the county of Zerbst served as a control area. A detailed description of the study regions has been provided previously (16,17).

Subjects

We invited all school entrants, and third- and sixth-grade schoolchildren, who were residents of Zerbst and Hettstedt counties, and a subgroup of children from selected schools in Bitterfeld county, to participate in our study. All day-care centers and schools in the Zerbst and Hettstedt areas were contacted. Because of the larger area of Bitterfeld county, schools and day-care centers in this county were randomly selected to represent all resident school-age children. School entrants and third-graders of the first and second survey were partially re-examined as third- and sixth-graders in the following survey. In total we received 7,611 questionnaires from 5,360 different children. The response rates in the three surveys were 89%, 75%, and 76%. All participants were white Caucasians. The study protocol was approved by the University of Rostock Ethics Committee. Informed consent was obtained from the parents of all participating children.

Questionnaire

Data on socio-economic factors, living conditions, children's health, and parental atopy were obtained from the parents by a self-administered questionnaire. In particular we asked about regular contacts of the child to pets (dogs, cats, rodents, birds) at the time of the examination and (only in surveys 2 and 3) retrospectively in the first year of life. We considered the following health outcomes from the questionnaire: ever physician-diagnosed allergic diseases (asthma or asthma-like bronchitis, hay fever, eczema), infectious diseases (ever physician-diagnosed bronchitis, ≥ 2 febrile infections in the past 12 months), and allergic symptoms (ever wheezing, rhinitis symptoms in the past 12 months, ever itchy rash). We combined children with at least one of the following symptoms – frequent sneezing, runny

or blocked nose without concurrent infection, or itchy eyes – in the group of rhinitis symptoms.

Immunoglobulin E measurements

Allergic sensitization to common aeroallergens (mixed grasses, birch, cat, and house dust mite *Dermatophagoides pteronyssinus*) was assessed by measurements of specific serum immunoglobulin E (IgE) concentrations for 85% of the children, using the radioallergosorbent test (RAST)-FEIA-CAP system (Pharmacia, Freiburg, Germany). Children with a specific IgE concentration of ≥ 0.35 kU/l (RAST ≥ 1) were considered to be sensitized and those with an IgE concentration of ≥ 17.5 kU/l (RAST ≥ 4) to be strongly sensitized.

Statistical methods

Logistic regression was used to analyze the association between pet contacts and allergic symptoms and diseases. As covariates we included gender, age-group, region, survey, parental education (highest education of father or mother for a duration of at least 12 years), parental atopy (paternal- or maternal-experienced asthma, hay fever, eczema or other allergies), breast-feeding (full breast-feeding for at least 4 weeks), day-care attendance in the first year of life, current bedroom sharing, and current environmental tobacco smoke (ETS) exposure at home. Contacts with dogs, cats, rodents, and birds were mutually adjusted for each other.

Because $\approx 33\%$ of the children participated in at least two surveys, we used the generalized estimating equations (GEE) approach (18) to account for the correlations between repeated observations of the same children. Results are presented as odds ratios (OR) together with 95% confidence intervals (CI). The computations were performed by using the GENMOD procedure of SAS 6.12 (SAS Institute, Cary, NC, USA).

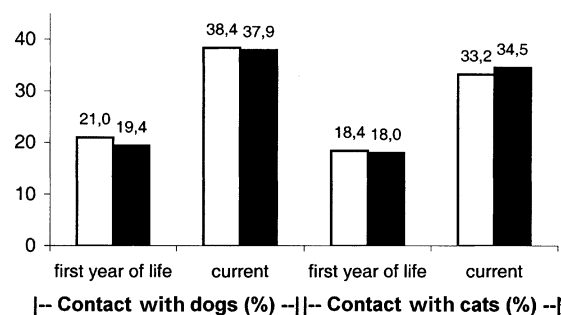


Fig. 1. Contact with pets for children with and without atopic parents. (□), No parental atopy; (■), parental atopy.

Results

Information on current contact with pets was available for 7,448 of 7,611 questionnaires. Additionally, 4,992 participants provided data on contact with pets in the first year of life (only in the second and third survey). Current regular contacts with dogs, cats, rodents, and birds were reported for 38%, 34%, 26%, and 21% of the children, whereas 21%, 18%, 7%, and 8% had already experienced exposure to these pets in their first year of life.

Contact with dogs was more frequent in older children, in the later surveys, in Zerbst compared to Bitterfeld, with lower parental education, and in families with smokers (Table 1). Similar results were observed for cats (not shown), but girls had a higher probability of having contact with cats and no association was seen with parental education or ETS. About 50% of the students who had contact with dogs were also exposed to cats. Figure 1 illustrates that the prevalences of pet exposure differed only marginally between children with non-atopic and atopic parents.

Table 2 shows crude prevalences for children with and without contact with dogs and cats, whereas Table 3 presents mutually adjusted ORs. Complete information on potential confounders was available for 6,935 questionnaires concerning current contacts and 4,667 questionnaires concerning contacts in the first year of life, respectively.

Current contact with dogs was significantly negatively associated with asthma, hay fever, bronchitis, rhinitis symptoms, sensitization to pollen, and cat allergens. For contact with dogs in

the first year of life, significant negative associations were observed with hay fever, eczema, bronchitis, itchy rash and pollen sensitization (RAST class ≥ 4), but not with wheezing and rhinitis symptoms. The OR for asthma was similar in both analyses (current: 0.71, first year of life: 0.68), but not significant in the second case. For sensitization to any of the four measured allergens (judged as at least one RAST value ≥ 1) an OR of 1.08 (CI: 0.90–1.29) was obtained with dog exposure in the first year of life and an OR of 0.79 (CI: 0.70–0.90) with current exposure (data not shown). The corresponding numbers for strong sensitization (at least one RAST ≥ 4) were 0.80 (CI: 0.59–1.07) and 0.87 (CI: 0.72–1.04). A significant positive association with dog contact was observed only for febrile infections (current: OR=1.15; first year of life: OR=1.16).

We observed no clear relationships for the other pets (cats, rodents or birds), with the exception that children who currently lived close to cats had a higher probability of being sensitized against cats.

To explore possible effect modifications, we tested interactions of contact with dogs with survey, region, gender, age-groups and parental atopy, by inclusion of the appropriate product terms into the models. Systematic differences with statistically significant interaction terms were only found for contacts in the first year of life and parental atopy. The effects of early contact with dogs were more pronounced for children with atopic parents (Fig. 2).

Adjusting additionally for type of building and community size showed similar results for dog contact in the first year of life and slightly

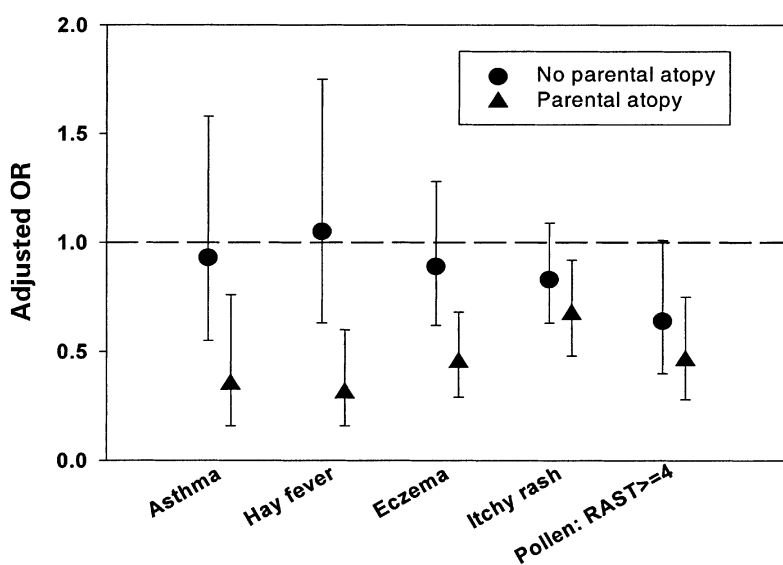


Fig. 2. Adjusted odds ratios (adj. OR) and 95% confidence intervals (CI) of allergic disorders associated with contact with dogs during the first year of life for children with and without atopic parents. RAST, radioallergosorbent test.

Table 1. Description of children with and without regular contact with dogs

	Regular contact with dogs			
	First year of life		Current	
	No (n=3,968)	Yes (n=1,024)	No (n=4,600)	Yes (n=2,848)
Boys	53.2%	53.2%	52.7%	51.9%
Age 5–7 years	21.7%	21.5%	27.4%	20.4%
Age 8–10 years	34.6%	36.8%	34.6%	33.3%
Age 11–14 years	43.7%	41.7%	38.0%	46.3%
Region				
Zerbst	25.8%	34.3%	25.5%	36.7%
Bitterfeld	45.1%	35.6%	43.7%	33.1%
Hettstedt	29.2%	30.1%	30.8%	30.2%
Survey				
1 (1992/93)	—	—	36.3%	26.8%
2 (1995/96)	57.3%	49.9%	37.7%	36.9%
3 (1998/99)	42.7%	50.1%	26.0%	36.3%
Higher parental education*	43.1%	35.6%	44.3%	38.3%
Parental atopy† (current)	31.9%	29.7%	30.2%	29.8%
Full breast-feeding (≥ 4 weeks)	45.9%	47.3%	44.6%	45.4%
Day care (first year of life)	13.1%	13.2%	14.4%	15.6%
Bedroom sharing (current)	37.4%	37.7%	44.6%	35.6%
ETS exposure (current)	42.0%	51.6%	41.5%	50.3%
House made of concrete	37.5%	28.5%	45.3%	23.5%
Community size				
<2,500 inhabitants	16.2%	26.5%	9.1%	29.9%
2,500–4,000 inhabitants	14.2%	17.6%	12.1%	17.9%
>16,000 inhabitants	69.6%	55.9%	78.8%	52.2%
Contact with dogs (first year of life)	—	—	8.7%	37.1%
Contact with dogs (current)	32.9%	75.2%	—	—
Contact with cats (first year of life)	10.1%	49.8%	12.9%	25.9%
Contact with cats (current)	30.5%	48.6%	24.5%	48.5%

*Education of father or mother of at least 12 years' duration.

†Asthma, hay fever, eczema or other allergy in at least one parent.

decreased the effects of current contact with dogs for some health outcomes (results not shown).

As information on contact with pets in the first year of life was available only from the second and third survey, but information on current contacts from all surveys, our analyses were based on different populations. Alternatively, we restricted the computations for current pet contact also to the last two surveys. For dogs we found similar significant effects for hay fever (OR=0.74), bronchitis (OR=0.87), and sensitization against cats (OR=0.64). The effects of asthma (OR=0.78), rhinitis symptoms (OR=0.93), and pollen sensitization (OR=0.88) decreased and were no longer statistically significant, but instead the OR for mite sensitization changed to 0.84 (CI: 0.70–1.00). The association between current cat contact and cat sensitization remained significant (OR=1.37).

Finally, we considered again the association between current cat contact and sensitization against cats, separating additionally by cat contact in the first year of life. Only those with current cat contact, but without early contact with cats, had significantly higher sensitization

rates against cats when compared to those with neither early nor current cat contact (OR=1.49, CI: 1.12–1.99). Children exposed to cats both in early life and at the time of examination showed only a minor increase in the prevalence of sensitization (OR=1.13).

Discussion

We investigated the association between contact with pets and allergic diseases. Current contact with dogs was a protective factor with regard to asthma, hay fever, bronchitis, rhinitis symptoms, and sensitization to pollen and cat. Contact with dogs in the first year of life was inversely associated with hay fever, eczema, itchy rash, bronchitis, and sensitization to pollen. No clear relationships were found for the other pets.

Other literature

Our results for contact with dogs agree well with reports from other studies that analyzed pet-keeping and atopic diseases. In addition, the stronger effect of early life exposure in children of

Table 2. Crude prevalences of allergic symptoms and diseases and contact with pets

	Contact with dogs				Contact with cats			
	First year of life		Current		First year of life		Current	
	No (n=3968)	Yes (n=1024)	No (n=4600)	Yes (n=2848)	No (n=4080)	Yes (n=912)	No (n=4940)	Yes (n=2508)
Allergic diseases*								
Asthma†	4.3%	2.8%	4.1%	2.7%	4.4%	2.5%	4.1%	2.5%
Hay fever	6.1%	3.1%	5.6%	4.1%	5.9%	3.7%	5.5%	4.2%
Eczema	11.4%	7.6%	11.1%	9.5%	10.7%	10.2%	10.5%	10.4%
Infectious diseases								
Bronchitis*	41.4%	33.8%	47.0%	40.4%	40.6%	36.5%	45.7%	42.1%
≥ 2 febrile infections‡	25.3%	28.5%	27.8%	28.6%	25.6%	27.8%	27.9%	28.6%
Allergic symptoms								
Wheezing§	22.8%	20.6%	24.5%	22.0%	22.8%	20.4%	24.6%	21.4%
Rhinitis symptoms‡¶	17.8%	18.1%	18.9%	16.3%	17.5%	19.2%	18.2%	17.2%
Itchy rash§	19.3%	15.8%	17.7%	16.5%	18.7%	18.2%	17.7%	16.4%
RAST sensitization (>0.35 kU/l)								
Pollen**: RAST ≥ 1	21.1%	19.5%	23.2%	19.4%	21.0%	19.7%	22.5%	20.2%
Pollen**: RAST ≥ 4	7.0%	4.1%	6.6%	5.6%	6.6%	5.9%	6.7%	5.3%
Mite: RAST ≥ 1	16.1%	18.0%	16.2%	15.6%	16.4%	16.8%	16.0%	15.9%
Mite: RAST ≥ 4	4.0%	4.1%	3.5%	3.4%	4.2%	3.2%	3.8%	2.8%
Cat: RAST ≥ 1	8.2%	6.5%	8.2%	6.5%	8.1%	6.9%	7.1%	8.4%
Cat: RAST ≥ 4	1.0%	1.4%	1.0%	1.0%	1.1%	0.9%	0.9%	1.1%

*Ever physician-diagnosed.

†Asthma or asthma-like bronchitis.

‡In the last 12 months.

§Ever.

¶Frequent sneezing, runny or blocked nose without concurrent infection, or itchy eyes.

**Mixed grass, birch.

atopic parents was found in other investigations (9,10). However, the differentiation between cats and dogs yields conflicting results. Bråbäck et al. (11) observed an inverse association with allergic rhinitis for cats at home, but not for dogs, in 10–11-year-old Swedish schoolchildren. A Norwegian cohort study (9) found less allergic rhinitis at 4 years of age and less atopic eczema at 0–6 months of life if pets (a cat or a dog) were kept at home when the child was born. Both effects were stronger for cats than for dogs. On the other hand, data from the ECRHS study (12) showed that the presence of a dog in the home during childhood was negatively associated with adult sensitization (one or more allergens) both for children with atopic parents (OR=0.82) and without parental allergy (OR=0.85). The corresponding effect for cats in childhood was seen only for atopic parents (OR=0.86), but not without parental allergy (OR=1.00).

Other studies did not differentiate between pets. A Swedish research team found that children exposed to cats or dogs during the first year of life had a lower frequency of allergic rhinitis at 7–9 years of age and of asthma at 12–13 years (10). Rönmark et al. (19) investigated a cohort of 3,525 children (7 and 8 years of age) in northern Sweden. Having or having had pets at

home was inversely associated with prevalences of asthma and wheezing at age 7, but was associated with an increased 1-year incidence of wheezing (age 7–8 years).

Avoidance

Brunekreef et al. (8) presumed that the protective effect is a bias caused by selective avoidance of keeping pets. It is argued that removing pets from the home for health reasons causes the flawed conclusion that pets are protective with regard to allergies. However, there are several arguments that the observed effects hold true.

First, we observed similar inverse associations both for current contacts and contacts during the first year of life. If the ORs for current contacts were biased through avoidance after the development of an allergic disease, one would expect stronger effects for current exposure compared to early exposure. Nevertheless, for our data the associations with asthma were similar, while hay fever and eczema or itchy rash showed stronger associations with early exposure.

Second, if avoidance was the reason for the protective effects, children from families with parental hay fever or asthma would have substantially less contact with dogs. However, in our study the prevalences of contact with dogs

Table 3. Adjusted odds ratios (OR) and 95% confidence intervals (CI) of allergic symptoms and diseases associated with contact with pets†

	Contact with dogs				Contact with cats			
	First year of life		Current		First year of life		Current	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Allergic diseases‡								
Asthma§	0.68	(0.43–1.08)	0.71*	(0.53–0.96)	0.80	(0.47–1.37)	0.82	(0.60–1.12)
Hay fever	0.61*	(0.39–0.95)	0.72**	(0.57–0.91)	0.85	(0.55–1.29)	0.85	(0.67–1.09)
Eczema	0.65**	(0.48–0.87)	0.92	(0.78–1.09)	1.08	(0.81–1.45)	0.93	(0.78–1.10)
Infectious diseases								
Bronchitis‡	0.75**	(0.64–0.89)	0.87*	(0.79–0.97)	0.94	(0.79–1.12)	0.89*	(0.81–0.99)
≥ 2 febrile infections¶	1.16	(0.96–1.40)	1.15*	(1.02–1.30)	1.18(*)	(0.97–1.42)	1.07	(0.95–1.21)
Allergic symptoms								
Wheezing††	0.90	(0.73–1.09)	0.95	(0.84–1.08)	0.94	(0.76–1.15)	0.91	(0.80–1.03)
Rhinitis symptoms¶	1.05	(0.85–1.30)	0.86*	(0.75–0.98)	1.11	(0.89–1.38)	0.96	(0.83–1.10)
Itchy rash††	0.76*	(0.61–0.94)	0.90	(0.79–1.04)	1.06	(0.85–1.31)	0.88(*)	(0.77–1.02)
RAST sensitization (>0.35 kU/l)								
Pollen‡‡: RAST ≥ 1	1.00	(0.80–1.24)	0.83**	(0.72–0.95)	1.00	(0.80–1.25)	0.92	(0.80–1.05)
Pollen‡‡: RAST ≥ 4	0.56**	(0.38–0.82)	0.87	(0.70–1.07)	1.26	(0.85–1.87)	0.84	(0.65–1.07)
Mite: RAST ≥ 1	1.23(*)	(0.99–1.54)	0.92	(0.79–1.07)	0.88	(0.69–1.13)	1.05	(0.91–1.22)
Mite: RAST ≥ 4	1.21	(0.79–1.87)	0.96	(0.71–1.31)	0.71	(0.43–1.15)	0.78	(0.57–1.08)
Cat§§: RAST ≥ 1	0.82	(0.59–1.15)	0.66***	(0.52–0.83)	0.95	(0.68–1.33)	1.46***	(1.17–1.81)

†ORs were adjusted for gender, age-group, region, survey, parental education, parental atopy, breast-feeding, day care attendance, bedroom sharing, current ETS exposure at home, contact with rodents and birds, and mutually for contact with dogs and cats.

‡Ever physician-diagnosed.

§Asthma or asthma-like bronchitis.

¶In the last 12 months.

††Ever.

‡‡Mixed grass, birch.

§§Not computed for a radioallergosorbent test (RAST) value of ≥ 4, because of too small prevalences.

(*)p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001.

differed only slightly in families with a history of atopic disease and those without (Fig. 1). Similar results were found in other investigations. The Norwegian cohort study (9) saw strong protective effects in a birth cohort followed-up to the age of 4 years. In this study dogs tended to be kept a little less commonly in atopic families, but the difference was small. Keeping of dogs was reported by 8.1% (70/868) of the families with one member who was atopic and by 9.6% (157/1,640) of families with no asthma or hay fever. Lau et al. (3) reported no difference in mite and cat allergen concentrations at 6 and 18 months between families with and without a history for asthma or atopy.

Third, no protective effects of cats were observed. Cat allergen is much more frequent and a very potent allergen. Therefore, it would be more likely for allergic persons to remove the cat, thereby faking protective effects in our analyses.

Finally, Hesselmar et al. (10) observed similar protective results when children, whose parents had actively decided against pet keeping during infancy because of allergy in the family, were excluded.

Therefore, we believe that avoidance, at the most, can modulate the protective effects but not be the reason for it.

Possible explanation

What might be the reason for the protective effects of dogs? A Western lifestyle is thought to be associated with a higher prevalence of atopic diseases (20). Thus, keeping dogs might be an indicator of a more traditional lifestyle. We assessed a number of socio-economic and environmental factors and controlled for them in the analyses, but it cannot be excluded that uncontrolled confounding may still influence the result of this study.

Several epidemiological studies showed a lower prevalence of hay asthma and hay fever in children living on a farm or in rural areas (5,13–15). The reasons for this are not understood, but a factor seems to exist that is directly or indirectly related to farming and reduces the risk of developing allergic sensitization or hay fever. Possibly it is the same factor that is responsible for the observed protective effects of dogs. If, on the other hand, the protective effects of dogs are caused by a different factor, the farming effect might be partly explained by dog keeping.

Early childhood exposure to infectious diseases are speculated to play a protective role for the development of atopic sensitization and hay fever (21). Dogs might provide additional exposure to

microbial antigens and thus stimulate the immune response of children towards T helper 1 (Th1) immunity.

Data published recently found increased concentrations of house dust endotoxin in the homes of families who live on farms and in homes where animals were kept indoors (6,22–24). At present, little is known about the association of the measured exposure to endotoxin in house dust and allergies in children. However, it is speculated that the level of environmental endotoxin and other bacterial wall components are protective determinants for the development of allergic diseases in childhood (6,25,26).

Limitations

Some inconsistencies of our findings should be mentioned. The inverse association between dog exposure in the first year of life and hay fever was not found for rhinitis symptoms. No effects were observed for wheezing. For current dog exposure an inverse relationship was seen with pollen sensitization of ≥ 0.35 kU/l, but for contact in the first year of life an association was found only with stronger pollen sensitization (≥ 17.5 kU/l), and no such effects were observed for mite and cat. Therefore, the results on sensitization should be interpreted with caution.

Several aspects of possible bias have to be addressed. In the questionnaire we only asked for contact with pets. The range of contact with pets is large. It could mean that the child sees a pet once in a while at a friend's house, or that the pet sleeps on child's bed every night. Furthermore, information on contact with pets in the first year of life was gained retrospectively, as well as data on lifetime prevalences of several allergic disorders, but the latter were supported by objective measurements of specific IgE concentrations.

Conclusions

In conclusion, our data provide further evidence that exposure to furred pets or other factors related to pet exposure might be protective with regard to allergic diseases. As the effects were restricted to dogs in our study, but have been more pronounced for cats in other investigations, further research is necessary to explore the underlying mechanisms that might be responsible for the observed results.

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