

# Dog keeping at home before and during pregnancy decreased the risk of food allergy in 1-year-old children

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## Abstract

**Introduction:** The relationship between allergen exposure to animals in pregnancy and the development of allergic symptoms is not clear.

**Aim:** To evaluate the association between prenatal and postnatal exposure to pet ownership and development of atopic dermatitis, food allergy and wheezing in children at the age of 1 and 2.

**Material and methods:** The mother-child pairs included in this study were part of the Polish Mother and Child Cohort. Mothers in each trimester of pregnancy and 1 year after childbirth have completed a questionnaire on animal exposure. Children's health status was assessed at around one year and two years of age.

**Results:** Keeping a dog at home before and during pregnancy (every trimester) decreased the risk of food allergy in the first year of life. On the other hand, keeping any animal other than a dog (cat, hamster, guinea pig, rabbit) before pregnancy and during each trimester separately increased the risk of food allergy in the first year of life of children. Keeping a guinea pig in the first trimester of pregnancy increased the risk of wheezing in the first year of life. The analysis did not show any significant associations between keeping animals at home before and during pregnancy and the occurrence of atopic dermatitis in the second year of life.

**Conclusions:** Keeping a dog at home before and during pregnancy decreased the risk of food allergy in 1-year-old children. This effect was eliminated in case of having a cat, hamster, guinea pig, or rabbit.

**Key words:** children, pet, allergic diseases.

## Introduction

Exposure to animal allergens is a major risk factor for the development of sensitization and allergic diseases [1–4]. Cats, dogs, guinea pigs, hamsters, and rabbits are very popular pets in industrialized countries, where the percentage of pet ownership continues to increase [5]. Cats and dogs are the most common pets living in indoor environments and the frequency of their ownership is highly variable in Europe ranging from 7.2% to 35% for the cats and from 5.4 to 35% for the dogs [6]. In Poland these numbers are even higher; a survey from 2014 shows that 83% of Poles have a dog in their home and 44% own a cat, 4% – birds, 3% – rodents (mice, rats, hamsters) and 1% – reptiles [7].

The percentage of pet allergens carried on small particles (about 0.5–2  $\mu\text{m}$ ) become easily airborne under normal domestic ventilation and are able to trigger respiratory symptoms in sensitized patients. These allergens in the lower airways can cause prolonged bronchial inflammation [8], leading to the potential for acute airway tightening/obstruction [9, 10]. Cat and dog allergens should be considered as ubiquitous because they are found not only at homes, but also in other indoor private or public places where cats/dogs have been never kept [11]. Accumulation of pet allergens in indoor environments without animals correlate with the number of visitors owning a pet or with those who are in regular contact with these animals [11]. Several authors have shown that clothing and other items, such as human hair, con-

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stitute a means for transferring pet allergens in pet-free indoor environments [12–14]. Therefore, the higher the pet ownership in a given community, the higher the presence of pet allergens in apparently pet-free spaces [15].

According to some authors, children with asthma tend to become sensitized to the allergens prominent in their living environments. Sheikh *et al.* suggest a positive association between life style choices/environmental exposures and family history of asthma [16].

## Aim

The aim of the present study was to evaluate the association between prenatal and postnatal exposure to pet ownership and development of atopic dermatitis, food allergy and wheezing in children aged 1 and 2.

## Material and methods

### Study design and population

The mother-child pairs included in this study were part of the Polish Mother and Child Cohort (REPRO\_PL) – a multicentre prospective cohort established in 2007 with the aim to evaluate environmental factors contributing to the pregnancy outcomes and children's health [17–19]. All data were prospectively collected. Women were recruited if they fulfilled the following inclusion criteria: single pregnancy up to 12 weeks of gestation, no assisted conception, no pregnancy complications, and no chronic diseases as specified in the study protocol [17, 19]. The whole cohort comprises 1700 mother-child pairs followed-up from the pregnancy period [20]. The present assessment is restricted to subpopulation from the Lodz district (central Poland).

The participants were interviewed once in each trimester of pregnancy to collect and update socio-demographic data, medical and reproductive history, information about environmental, occupational and lifestyle factors. Children were assessed for their exposure and health status at 1 year of age [18, 21–24].

The study was approved by the Ethical Committee of the Nofer Institute of Occupational Medicine, Lodz, Poland; written consent was obtained from all the subjects before the study.

### Assessment of maternal exposure to animals during pregnancy

Mothers in each trimester of pregnancy have completed a questionnaire on animal exposure (having a pet at home), including exposure to pets for 3 months before becoming pregnant. In addition, a questionnaire with mothers was conducted one year after childbirth. The questions concerned: a) having pets in the house where the baby was, and b) the species of the pet possessed (cat, dog, rabbit, hamster, guinea pig).

## Child health assessment

Children's health status was assessed at around 1 year and 2 years of age. For the appropriate recognition of the children's health status, an interview was performed with mothers and supplemented (verified) with information from the medical chart of each child [18, 21–25]. In addition, the current child health status assessment was performed by a paediatrician/allergist. Finally, based on availability of the data on exposure and physical examination at the age of 24 months, the analysis was performed for 529 children.

The first part of the questionnaire covers certain sociodemographic information (i.e., family size, financial status of the family, and parental educational level). The occurrence of allergy among family members was noted. The second part of the questionnaire (developed by an allergist, based on recommendations from the International Study of Asthma and Allergies in Childhood) investigated the child's health and condition. The allergy outcomes were analysed for the following symptoms: wheezing, cough, bronchitis, eczema, food allergy; the childhood outcomes were confirmed by an allergist/physician. The duration of each infection and disease, medications taken, and hospitalizations, if any, were identified.

## Statistical analysis

The associations between presence of: i) atopic dermatitis, ii) food allergy, iii) at least one episode of wheezing (defined as dependent variables) and animal exposure (defined as independent variable) were assessed by logistic regression. The effect of animals exposure was corrected for the effects of other independent risk factors of dependent variable, defined previously in this cohort. First, logistic regression was used to assess the relationship between dependent variables and each of the independent variables (presented in Tables 1 and 2). A stepwise forward procedure was then used to select variables. Predictors with  $p$  levels of at least 0.1 estimated in univariate models were included into multivariate regression analyses. All of the statistical analyses were performed using SPSS 11.5. The null hypothesis was rejected if  $p < 0.05$ .

## Results

Five hundred and thirty nine participants were included in the current analysis. Baseline characteristics of these population are given in Table 3. The lifetime prevalence of the selected outcomes is given. Almost 40% of children had a positive parental history of atopy.

The results of the univariate logistic regression are presented in Tables 1 and 2. Associations between keeping a pet at home before pregnancy and every trimester and doctor-diagnosed food allergy was found. Keeping

**Table 1.** Associations between presence of atopic dermatitis, food allergy, wheezing (at least one episode) during the first year of life and animal exposure at home during pregnancy in univariate model of logistic regression analysis

Animal exposure	Atopic dermatitis			Food allergy			Wheezing		
	OR	95% CI for OR		OR	95% CI for OR		OR	95% CI for OR	
Prenatal:									
Cat	1.06	0.59	1.92	0.79	0.48	1.28	0.96	0.49	1.89
Dog	0.63	0.36	1.13	0.48	0.30	0.76	1.70	0.83	3.49
Hamster	0.95	0.11	8.14	0.53	0.06	4.72	3.94	0.68	22.72
Guinea pig	–	–	–	1.23	0.23	6.42	4.56	0.71	29.12
Any animal	1.30	0.69	2.46	1.93	1.18	3.16	0.71	0.22	2.26
First trimester:									
Cat	0.84	0.45	1.58	0.88	0.54	1.45	0.97	0.48	1.95
Dog	0.74	0.42	1.31	0.48	0.31	0.76	1.48	0.76	2.91
Hamster	1.80	0.36	8.96	1.22	0.23	6.56	2.99	0.56	16.06
Guinea pig	–	–	–	1.82	0.32	10.34	10.32	1.65	64.47
Any animal	1.24	0.68	2.27	1.97	1.24	3.13	0.83	0.30	2.29
Second trimester:									
Cat	1.00	0.52	1.90	1.10	0.66	1.83	0.67	0.30	1.47
Dog	0.60	0.33	1.07	0.59	0.37	0.93	1.41	0.72	2.75
Hamster	–	–	–	0.62	0.07	5.48	3.54	0.62	20.24
Guinea pig	0.85	0.10	7.13	2.33	0.60	8.98	3.20	0.59	17.34
Any animal	1.48	0.82	2.65	1.64	1.04	2.60	0.78	0.38	1.59
Third trimester:									
Cat	0.98	0.52	1.85	1.22	0.73	2.03	0.66	0.30	1.49
Dog	0.56	0.32	1.00	0.53	0.33	0.84	1.79	0.89	3.60
Hamster	–	–	–	1.61	0.14	18.33	3.68	0.32	42.45
Guinea pig	–	–	–	1.25	0.23	6.65	3.52	0.61	20.49
Any animal	1.62	0.92	2.86	1.74	1.09	2.78	0.66	0.32	1.38

– Not enough observation to calculate OR (95% CI).

a dog at home before and during pregnancy (every trimester) decreased the risk of food allergy in the first year of life (OR; 95% CI) (Table 1). On the other hand, keeping any animal other than a dog (cat, hamster, guinea pig, rabbit) before pregnancy and during each trimester separately increased the risk of food allergy in the first year of life (OR; 95% CI) (Table 1).

We found an association between keeping a guinea pig in the first trimester of pregnancy and increasing the risk of wheezing in the first year of life (OR; 95% CI) (Table 1).

The analysis did not show any significant associations between keeping animals at home before and during pregnancy and the occurrence of atopic dermatitis in the second year of life (OR; 95% CI) (Table 2).

All the above associations were still significant after adjustment in the multivariate model. Independent statistical predictors of study outcomes determined previously in this cohort were used. The adjustment variables for

atopic dermatitis were: atopy in the family, father's education, frequency of cleaning, and breastfeeding. Associations with food allergy are corrected for breastfeeding. The number of infections and paternal/maternal smoking were used as adjustment variables for wheezing.

## Discussion

Exposure to animal allergens constitutes a relevant risk factor for the development of allergic sensitization. We showed that keeping a dog at home before and during pregnancy decreased the risk of food allergy in the first year of life. On the other hand, keeping any animal other than a dog (cat, hamster, guinea pig, rabbit) before and during pregnancy separately increased the risk of food allergy in the first year of life; having a guinea pig in the first trimester of pregnancy increased the risk of wheezing in the first year of life. Our analysis did not show any significant associations between keeping ani-

**Table 2.** Associations between presence of atopic dermatitis, food allergy, wheezing (at least one episode) during the second year of life and animal exposure at home during pregnancy in univariate model of logistic regression analysis

Animal exposure	Atopic dermatitis			Food allergy			Wheezing		
	OR	95% CI for OR		OR	95% CI for OR		OR	95% CI for OR	
Prenatal:									
Cat	0.75	0.39	1.44	0.55	0.28	1.08	0.90	0.45	1.82
Dog	1.05	0.57	1.96	0.92	0.49	1.71	1.20	0.60	2.41
Hamster	2.04	0.18	23.04	1.99	0.17	22.96	2.79	0.25	31.66
Guinea pig	1.15	0.12	10.82	–	–	–	1.43	0.15	13.45
Any animal	1.11	0.57	2.15	1.51	0.79	2.90	1.00	0.48	2.09
First trimester:									
Cat	0.99	0.52	1.91	0.88	0.45	1.73	0.96	0.47	1.96
Dog	0.92	0.50	1.70	0.84	0.45	1.58	1.30	0.65	2.59
Hamster	4.17	0.57	30.37	4.35	0.60	31.78	1.96	0.20	19.44
Guinea pig	–	–	–	–	–	–	2.56	0.22	29.87
Any animal	1.04	0.55	1.93	1.27	0.68	2.39	0.81	0.39	1.65
Second trimester:									
Cat	0.85	0.42	1.73	0.83	0.40	1.72	0.79	0.36	1.73
Dog	0.91	0.50	1.66	0.88	0.48	1.64	1.14	0.59	2.22
Hamster	–	–	–	2.03	0.18	23.10	2.64	0.23	30.19
Guinea pig	4.04	0.55	29.45	1.38	0.14	13.66	–	–	–
Any animal	0.83	0.45	1.55	1.00	0.53	1.86	1.15	0.60	2.24
Third trimester:									
Cat	0.91	0.46	1.80	0.98	0.48	2.01	1.03	0.47	2.25
Dog	0.80	0.43	1.47	0.83	0.44	1.58	0.88	0.44	1.77
Hamster	–	–	–	4.30	0.26	70.73	5.89	0.36	97.36
Guinea pig	–	–	–	–	–	–	–	–	–
Any animal	1.05	0.57	1.95	1.01	0.53	1.93	1.66	0.84	3.30

– Not enough observation to calculate OR (95% CI).

mals at home before and during pregnancy and the occurrence of atopic dermatitis.

Although food allergy is the most common in infants and young children, risk factors remain largely unknown. Koplin *et al.* demonstrated that children with a dog at home were less likely to develop egg allergy by one year of age [26]. In our present study, we observed that having a dog before and during pregnancy reduced the risk of food allergy in the first year of life. Numerous studies suggested that dog ownership is associated with a distinct house dust microbial exposure [27–34]. Pets can affect the home microbiome [35]. Household dust samples collected from homes where outward-living animals were richer in bacteria and more diverse, contained more taxa in significantly higher abundance, representing the phyla *Acidobacteria*, *Actinobacteria*, *Bacteroidetes*, *Firmicutes*, *Proteobacteria*, *Spirochaetes* and *Verrucomicrobia* [29]. Tun *et al.* observed that exposure to pets increased the

abundance of two bacteria, *Ruminococcus* and *Oscillospira*, which have been negatively associated with childhood atopy [36]. In particular, research suggests that pregnant mothers who live in houses with dogs are less likely to give birth to children who go on to develop allergies [32–34] or atopic dermatitis [29]. After exposure to the dust associated with the dog, home dust is added to the *Lactobacillus johnsonii* strains, which are associated with significant reductions in the total number and proportion of activated CD11c(+)/CD11b(+) and CD11c(+)/CD8(+) cells [30].

Nagao *et al.* showed that sensitization to a dog was common at an early age despite dog ownership. Sensitization to secretoglobins and lipocalins and less to serum albumins explained the pet sensitization. Asthmatic children had a higher proportion of sensitization to dog, cat and horse allergens at entry compared with non-asthmatic children. Component resolved diagnosis

for dog and cat allergens showed that IgE antibodies to Can f 1 and Fel d 1 was common even at a very young age [37]. Pyrhönen *et al.* stated that early exposure to dog and cat at home is associated with a higher incidence of respective pet allergy (sIgE and skin prick tests) during the first four years of life [38]. Pohlabeln *et al.* showed that in families without a history of atopic disease, the prevalence of asthma and eczema among 2-year-old children was significantly lower in those families that owned a dog at the time the children were born. In contrast, in families with a history of atopic disease, early dog exposure was associated with a higher prevalence of asthma and eczema in 2-year-old children [39].

On the other hand, we have shown that having any animal (cat, hamster, guinea pig, rabbit, etc.) before and during pregnancy separately increases the risk of food allergy in the first year of life. In the case of “any animal”, it is most likely the effect of summing up various factors related to the presence of animals at home. However, all individual exposures are associated with ORs below or close to 1 and then these significant associations with “any animal” and food allergy seem uncertain. Disturbance of the balance between the beneficial effect of the microbe and the adverse effect of enzymes such as proteases may increase the risk of allergy. The cat exposure in the first year of life was significantly and independently associated with current wheezing and current asthma and current rhinoconjunctivitis at the age of 7 [40]. However, Lodge *et al.* concluded that exposure to cats or dogs at birth showed a moderate reduction in risk of wheeze and hay fever after 7 years of age [41]. Brunekreef *et al.* proved among children (6–7 years of age) that cat exposure in the first year of life was associated with current symptoms of asthma, wheeze, rhinoconjunctivitis, and eczema, especially in less affluent countries [42]. Collin *et al.* determined that pet ownership during pregnancy and childhood in the birth cohort was consistently associated with a reduced risk of aeroallergen sensitization and atopic asthma at the age of 7, but tended to be associated (particularly for rabbits and rodents) with an increased risk of non-atopic asthma [31].

Nordlund *et al.* found that a specific IgE response to more than three animal-derived components – lipocalin (nMus m 1, rEqu c 1, Fel d 4, rCan f 1, 2), kallikrein (rCan f 5) and secretoglobulin (rFel d 1) – was more common among severe asthmatics compared to children with controlled asthma [43]. In another study by Eldeirawi *et al.*, exposure in utero to cats/dogs and birds jointly was associated with increased odds of asthma, ever wheezing and current exercise-induced wheezing compared to children not exposed to these pets *in utero* [44].

Freitas *et al.* observed that the high concentration of endotoxin from Gram-negative bacteria, found in the rooms where guinea pigs were staying, was associated with increased wheezing in workers [45]. Collin *et al.* also confirmed that rabbit and rodent ownership in this birth

**Table 3.** Description of the study cohort (n =539)

Variable	N (%) or mean ± SD
Clinical profile:	
Atopic dermatitis	57 (11)
Food allergy	56 (10)
Wheezing	46 (9)
Family status:	
Mother's age [year]	28.9 ±4.4
Maternal education:	
< 9 years of education	21 (4)
10–12 years of education	178 (33)
> 12 years of education	339 (63)
Father's age [year]	30.9 ±5.5
Paternal education:	
< 9 years of education	24 (4)
10–12 years of education	292 (54)
> 12 years of education	213 (40)
Marital status (unmarried)	134 (25)
ETS at the first trimester	267 (49)
ETS at the second trimester	393 (73)
ETS at the third trimester	388 (72)
Parental self-reported allergy	208 (38)
Frequent cleaning (more than 2/week)	30 (8.1)

ETS – environmental tobacco smoke.

cohort was associated with an increased risk of episodes of wheezing during early childhood [31]. In our study, having a guinea pig in the first trimester of pregnancy increased the risk of wheezing in the first year of life.

Wegienka *et al.* proved that living with a dog was associated with decreased odds of having ≥ 1 positive SPT and having eczema [46]. Also according to Thorsteinsdottir *et al.*, the risk of atopic dermatitis was significantly lower in children with domestic dog exposure. The risk of atopic dermatitis decreased in a dose-dependent manner with an increasing number of dogs. The protective effect was restricted to children born to mothers with atopic disorders as no effect was observed in children born to mothers without atopy. Paternal atopic status did not affect the risk of atopic dermatitis [47]. Meta-analysis developed by Pelucchi *et al.* reported a favourable effect of exposure to dogs and pets on the risk of AD in infants or children, whereas no association emerged with exposure to cats [48]. Our analysis did not show any significant associations between keeping animals at home before and during pregnancy and the occurrence of atopic dermatitis.

In the second year of life, we did not find a connection between the presence of animals at home before and during pregnancy and the occurrence of food allergies, atopic dermatitis or wheezing. Pregnancy and first months of baby's life are a period of very dynamic development of the baby's immune system and the influence of various factors during this period can condition the development of allergic diseases. Allergy in children is influenced by multiple factors including genetic, socio-economic, sociodemographic and environmental factors. The relationship between the environment and atopy, as well as between environmental exposure and genetic susceptibility has not been clarified so far. It is known that no single factor determines the development of an allergic disease, it is rather an accumulation of environmental factors.

Domestic animals are one of the most common allergens that children are sensitized to worldwide. The relationship between allergen exposure to animal allergens in pregnancy and the development of allergic symptoms has been investigated in a number of studies but the results are inconsistent. Our study has shown that a dog has a protective effect on the development of food allergy, which may be associated with the beneficial effects of the microbe of this animal. This effect is eliminated in case of having any animal. There is no connection between having animals during pregnancy and the occurrence of allergic symptoms in the second year of life, most probably due to other environmental and genetic factors.

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### Conflict of interest

The authors declare no conflict of interest.

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