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Indoor Pet Exposure and the Outcomes of Total IgE and Sensitization at Age 18 Years

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Abstract

Background—Early-life exposure to household pets has been shown to be protective for allergic sensitization in childhood.

Objective—Evaluate the association between early life pet exposure and allergic sensitization at age 18 years.

Methods—Teens who had been enrolled in the Detroit Childhood Allergy Study birth cohort in 1987–1989 were contacted at age 18 years. Serum total IgE and allergen-specific IgE to 7 common allergens (dust mite, cat, dog, ragweed, Timothy grass, *Alternaria*, peanut; atopy defined as any specific IgE $\geq$ 0.35 kU/L) were measured at age 18 years. Annual interview data from childhood were used to determine indoor dog and cat ($\geq$ 50% of their time in the home) exposure during early life. Exposure was considered in various ways: first year, cumulative lifetime, and age groups, as well as multiple pets.

Results—Dog or cat exposure in the first year of life was not associated with atopy (relative risk=0.97, 95% confidence interval 0.83–1.12). Those living with pets in the first year and were atopic at 18 years had lower total IgE. Neither cumulative exposure nor exposure at a particular age was strongly and consistently associated with either outcome. While not statistically significant, there was a pattern of decreased odds of sensitization among those with two or more pets versus no pets in the first year of life.

Conclusions—Early life pet exposure may be associated with lower total IgE among atopic individuals, but is not strongly associated with decreased likelihood of sensitization to common allergens at age 18 years.

Keywords

Pets; Allergy; Epidemiology

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INTRODUCTION

Exposure to pets has received much attention as a potential risk or protective factor in allergic disease research.^{1–22} Various measures of exposure (timing, duration, type) and outcomes (IgE, skin prick testing, symptom reporting) have been investigated across studies and results have been mixed. No single study has examined all of these numerous components of pet exposure for associations with allergy risk. Additionally, few studies have been able to examine whether the effects seen in early life persist beyond childhood.

Meanwhile, parents frequently ask physicians whether they should allow their children to have pets – usually dogs and cats – in the home because they worry that cat and dog exposure increases the risk of allergies. There are no clear answers since evidence has been mixed over the years and research results have been as variable as the study approaches. The analyses presented here employ a systematic approach to study this important exposure. In a recent text, Strachan and Sheikh discussed the life course epidemiology of respiratory and allergic diseases.²³ They concluded that early life events affect the development of the immune system during poorly defined critical periods which in turn can affect the risk of allergic disease. In the life course epidemiology approach, there are various models of how a factor may be considered to cause subsequent disease.²⁴ These approaches include, but are not limited to a:

1. Critical period model: exposure to a factor or occurrence of an event during a specific time window of development leads to the disease.
2. Cumulative dose model: the cumulative exposure (or lack of exposure) to a factor over a period of time leads to the disease.

It is probable that disease causation can be linked to multiple models or versions of these models that are likely not mutually exclusive.

The purpose of this study was to extensively evaluate the possible role that indoor pets play in allergic sensitization in teens using these principles of disease causation to guide us. Specifically, using data from our birth cohort study with follow up of participants to age 18 years, we examined whether the following exposure patterns are associated with total IgE and the risk of sensitization (positive allergen-specific IgE ≥ 0.35 kU/L) at age 18 years: 1) presence of pets in the first year of life; and 2) high lifetime cumulative exposure to pets in the home. We also examined whether exposure to pets in any of the following age periods was more strongly associated with the outcomes: 1st year of life, ages 1–5 years, ages 6–12 years and ages 13 and older. In prior analyses of this cohort, we reported multiple pets in the first year of life were associated with a decreased risk of allergic sensitization at age 6 years.

¹ This current work will allow us to examine whether this protective association persisted to age 18 years.

METHODS

The relationship between pet-keeping and allergy is complex and the questions are factorial with various ways to consider exposure associated with various outcomes. With respect to pet exposure, at least four primary elements can be identified: timing (e.g.; first year of life), duration (number of years), dose (number of pets) and type of animal (cat, dog, both). A cluster of outcomes has been hypothesized to be affected by these exposures including both allergic symptoms and allergic sensitization (as measured by presence of allergen-specific IgE) and whether symptoms or sensitization are related to the exposure-specific animal, both animals or to other non-pet allergens. All these exposure and outcome elements may be studied separately or in combination with each other. Due to sample size constraints, we

chose to focus on exposure to either dogs or cats and the outcomes of total IgE and allergic sensitization to any of 7 common allergens (including dog and cat) at 18–20 years of age.

Study Population

Details of recruitment for the Childhood Allergy Study (CAS), has been fully described elsewhere.²⁵ Briefly, pregnant women 18 years and older from a geographically defined area of metropolitan Detroit, Michigan who belonged to a health maintenance organization, were seeing a Henry Ford Health System (HFHS) provider and were to deliver between April 15, 1987 and August 31, 1989 were eligible for study inclusion. Study enrollment included providing written informed consent, completing a prenatal interview and having cord blood collected at delivery. Women completed annual telephone questionnaires on the anniversary of their child's birth until (and including) the child's sixth birthday. Of the 1194 women who were eligible for CAS, 953 women consented to participate. Infants from 106 of these women were excluded from study because their cord blood was not obtained for analysis. Of the remaining 847 infants, six had cord blood that was believed to be contaminated by maternal blood and six more were determined to be ineligible at subsequent review of eligibility criteria. Mothers of the remaining 835 children were asked to complete interviews annually to discuss the health of the child for the previous year. Recently, we contacted these 835 children to obtain updated health information through age 18 years. After their eighteenth birthday, teens were contacted to complete: (1) a telephone administered interview and (2) a clinic visit with blood sample collection.

Of the 835 teens eligible at age 6 years, 15 withdrew from the study, died, or otherwise became ineligible prior to the follow-up at age 18 years. Of the remaining 820 teens, 40 were missing valid telephone numbers and were not contacted, 3 were enlisted in the military and unable to participate in the study, 3 had physical disabilities precluding them from completing interviews and 2 were incarcerated leaving a total of 772 teens eligible to provide interviews. Of these 772 teens, 671 (86.9%) consented to study enrollment although blood was not collected from all participants. The HFHS Internal Review Board (IRB) approved this research.

Exposures

Current pet keeping was reported by families (usually the mother) at each annual interview through age 6 years. The question about pets in the house was: "Have you had any pets in your home for more than two weeks?" If yes, the type of animal (cat, dog, bird, etc.) and number of each type of animal were recorded as well as whether these animals were kept mostly indoors, outdoors or equally indoors and outdoors. Two weeks was chosen to differentiate household pets versus those being cared for on a temporary basis. Additional information collected through interview included tobacco smoke exposure throughout childhood, family size and parental allergy history.

The telephone interview administered to teens at age 18 years addressed questions on lifetime exposure to animals, cigarette or other forms of smoking, family history of allergic disease and demographic questions. Teens were asked "Have you ever lived with any pets or outdoor animals?" Follow-up questions included the type of animals owned and whether or not these animals were indoor or outdoor animals. Animals were categorized as indoors if the teen reported that the animal stayed indoors for 12 or more hours per day. If the teen had any pets other than fish, they were asked, "Please list all [indoor/outdoor] pets that you have ever lived with for at least one month." For each pet listed, information on type of pet, ages lived with, and categorization of amount of contact with the animal was asked. We did not have data on dog or cat allergen levels across the teens' life-spans.

Parental report of dogs or cats in the first 6 years of life and the teen's report of dog or cat exposure from ages 6 years through 18 years were used to define the exposures. The exposure definitions are:

1. Lived with dogs or cats in the first year of life (critical period): Teens whose parents reported there was an indoor dog or cat that was "in their home for at least 2 weeks" in the child's first year of life.
2. Cumulative exposure to dog or cat: Cumulative exposure was calculated as the total number of years in which a child lived in a home where a dog or cat was kept indoors at least half the day. The years did not have to be contiguous.
3. Additional Critical Periods: Exposure to pets during specific ages was calculated by whether during each age period (1st year of life, ages 1–5 years, ages 6–12 years and ages 13 and older) the child lived in a home where a dog or cat was kept indoors at least half the day. These groupings were chosen *a priori* based on the interest in exposure in the first year of life which is a period of rapid immune development, as well as ages before entering school, after entering school and around the likely peripubertal period. An indicator variable was created for each age period and a teen was defined as exposed for any specific age period if there was sufficient pet contact during at least 1 of the years in that age period.

Teen's sex, parental allergy history (maternal and/or paternal history) and firstborn status were considered as potential effect modifiers or confounders. Women were asked during the prenatal interview whether a physician had ever diagnosed them with "allergies" or told them that they had "hayfever". They were also asked if they had ever had "immunotherapy (allergy shots)". If the mother reported yes to any of these questions, she was classified as having an allergic history. A paternal allergic history was defined as the mother reporting the father being diagnosed with "hayfever" or "allergies" in the past. Information to define firstborn status was taken from parental report.

We also considered the role (effect modification, confounding) of exposure to environmental tobacco smoke (ETS) exposure in the first year of life in the association between dogs or cats and sensitization. ETS was defined as routine contact with a cigarette smoking adult who smoked at least 1 cigarette per day (included mother, father, female guardian, male guardian, other adult that lived in home and babysitter if they smoked in child's home for at least 20 days in the past month at time of interview). This information was taken from the parental interview.

Outcomes

Venous blood was collected for assessment of both total and allergen-specific IgE at age 18 years, and stored at -80°C until assayed. Measurements of total and allergen-specific IgE were performed following the standard manufacturer's protocols using the Pharmacia UniCAP system (Phadia, Portage, MI). Allergen-specific IgE was analyzed for *Dermatophagoides farinae* (*Der f*), peanut, dog, cat, Timothy grass, *Ambrosia artemisiifolia* (ragweed), and *Alternaria alternata*. For savings, we removed *D. pteronyssinus* (*Der p*) from the 18 year panel since only 5 of the 565 (0.9%) teens were sensitized to *Der p* and no other allergens in the 6 year panel. Sensitization was defined as having at least one allergen-specific IgE result ≥ 0.35 kU/L.

Analytical Approach and Statistics

We used means with 95% confidence intervals (CI) to describe and Kruskal-Wallis and Jonckheere-Terpstra tests to compare continuous variables across groups (group differences and trend tests, respectively). Spearman correlations and linear regression models were used

to examine associations between continuous variables. Odds ratios (and 95% CIs) from logistic regression models were used to determine the association between cumulative pet exposure (continuous measure) and atopy. Chi-square tests and relative risks with 95% CIs were used to calculate associations between categorical pet variables and atopy. Associations were examined within the various subgroups (sex, parental history of allergy, firstborn status, exposed to tobacco in the first year).

RESULTS

Of the 671 teens who participated in the follow-up at age 18 years, 565 provided blood samples for analyses. Those who provided blood samples and those who did not participate in the 18 year contact were no different with respect to sex, pets in the first year of life, ever being exposed to pets, race, skin prick positive status at age 6 years, parental history of allergy, and whether or not they had a dog in the first year of life, had a cat in the first year of life or had a dog and cat in the first year of life (all Chi-square p values >0.05 ; Online Table I).

Pet Exposure in the First Year of Life

Interviews and IgE results were complete from 565 teens (296 females, 269 males) at age 18 years. Of these teens, 251 (44.4%) had dog and/or cat exposure in the first year of life. Table I provides the frequency of sensitization within pet exposure groups for all teens, as well as for males and females separately. The frequency to which the teens were sensitized to each allergen is summarized in an online table (Online Table II). Two teens were sensitized to only peanut (*no aeroallergens*) and were included in the analyses since their exclusion did not affect the final results.

The majority of teens were atopic and the proportions did not vary between those with pet exposure in the first year of life (136/251, 54.2%) and those without pet exposure (176/314, 56.1%) (Chi square test, $p=0.66$; Relative Risk=0.97, 95% CI=0.83, 1.12). This lack of association between pet exposure in the first year of life and sensitization at age 18 years was true for both females and males, and was independent of family history of allergy, firstborn status and tobacco smoke in the first year of life (Table II). While sensitization declined with exposure to multiple dog or cat exposures, these relationships were not statistically significant for any of the subgroups (Table III).

However, those living with pets in the first year had lower total IgE than those with no pets. This association is dose-dependent and was only seen among teens that were sensitized (Table IV).

Cumulative Exposure to Pets

The level of cumulative lifetime exposure to pets (Online Table III) was not associated with sensitization for all teens or any of the primary subgroups examined. However, among those with a positive family history of allergy and without a pet in the first year of life each year of subsequent cumulative pet exposure was associated with lowered odds of sensitization (one year increase: OR=0.93, 95% CI=0.88, 0.98). Among all teens, each one year increase in age at pet introduction was associated with an increased odds of being sensitized after adjusting for the cumulative years of pet exposure (one year increase in age: OR=1.05, 95% CI=1.00, 1.09).

The total years of pet exposure was not *even modestly* correlated with total IgE at 18 years. (Table V).

Exposure at Specific Ages

No particular age at exposure to pets was associated with atopy for the entire group or any subgroup analyzed (Online Table IV). Exposure to pets during ages 1–5 years was associated with very modest reductions in total IgE in some subgroups (females, those with a family history of allergy, firstborn teens, those not exposed to ETS in the first year, teens without sensitization) (Online Table V).

DISCUSSION

Neither duration nor timing of pet exposure was strongly associated with sensitization status at age 18 years. While prior work from our group found exposure to two or more dogs or cats in the first year of life was associated with less frequent sensitization (skin prick test positive, allergen specific IgE positive) at age 6 years, the continued study of that same cohort does not demonstrate a statistically significant persistence of an effect of the same magnitude to age 18 years.¹ While we did find that living with a cat or dog in the first year of life was associated with lower total IgE at 18 years among teens that were sensitized, we did not find an overall, consistent association between exposure to pets in the first year of life and protection for sensitization to at least 1 of 7 common allergens at age 18 years. However, although not statistically significant, there was a pattern of decreased odds of sensitization among those with two or more pets versus no pets. The data also indicated that later age at pet introduction was associated at increased odds of being sensitized at age 18 years. The effect on total IgE among atopic teens may be very important since it was recently reported that total IgE was strongly associated with asthma in atopic individuals in the cross-sectional analyses of NHANES data.²⁶

The mechanism explaining the role of pets in allergy development is still unexplained. We hypothesized that pet ownership is associated with exposure to distinct, more broadly diverse bacterial populations in household dust, and that these exposures influence bacterial colonization of the infant gastrointestinal tract, maturation of immune responsiveness, and development of allergy and atopic asthma. Our results did not support this hypothesis with respect to total IgE and general sensitization at age 18 years. However, it is still possible that the effects of pets on the home ecology impact the children's health in early life and those effects are no longer present in the late teen years. This would be supported by earlier findings in this cohort.¹ Additionally, because these analyses focused on various components of pet exposure and the outcomes of total IgE and overall sensitization, future work will investigate cat- and dog-specific exposure and cat- and dog-specific sensitization. There could be a separate and unique mechanism for such associations that could relate to allergen exposure.

Few studies have examined prospectively reported pet exposure in early life and the outcomes of atopy and clinical allergy in older teens or adults. Platts-Mills et al. studied cat allergen in dust from the homes of children ages 12–14 years, but did not include analyses of the presence of pets.⁷ Roost et al. and Svanes et al. studied >13,509 people ages 20–44 from 16 countries in the European Community Respiratory Health Survey.^{4, 5} Based on recalled pet exposure from childhood, among those with a family history of allergy, childhood exposure to cat was associated with decreased cat sensitization. In subjects with parental history of allergy, both (current) cat ownership and dog ownership were associated with less allergy. However, in those without a parental history, a protective effect was only found for dog ownership. It is difficult to directly compare our results with this cross-sectional study of adults who recalled pet exposure occurring up to 20–44 years prior. Stratified results were not presented for any groups other than those participants with and without family histories of allergy. Our methods are not quite comparable to those used in recent analyses of the longitudinal Dunedin cohort in which participants were followed to age 32 years.² The

authors reported a lowered risk of atopy in childhood and young adulthood in those who had a dog and cat at some point in their youth (through age 9 years).²

We attempted to include as many aspects of pet exposure as possible. Our approach borrowed concepts from life course epidemiology which has roots in evidence that early life factors (*in utero*, neonatal, early childhood) are central to adult disease development. Longitudinal birth cohort studies can serve as life course studies in which the roles of “experiences at different stages of the life course” in adult disease causation can be evaluated.²⁴

We examined two life-course models – critical periods and cumulative exposure. Moreover, the annual reports of living with pets, the sources of our exposure covariates, are still crude markers for what is undeniably a complex disease pathogenesis. Also, due to sample size constraints, we were not able to study a “chain of risk” or “pathway model” which could examine the temporal relationships between pet exposure and other possible allergic disease risk factors such as fever and antibiotic use that we have found to be important variables in this cohort.^{27, 28} We were also unable to analyze pet exposure in each year due to colinearity of covariates for annual pet exposure (more likely to have a pet in a year if you had one the prior year).

There is always a question about whether study results are affected by those whose pet keeping behaviors are affected by their allergies. We specifically looked for this in our analyses of the data through age 6 years and concluded there was no evidence of pet avoidance among allergic families.¹ Stratifying analyses by family history of allergy also facilitates addressing this concern. Additionally, the recent report from the Dunedin cohort did not find that a family history of atopy was associated with pet ownership.²

Limitations include incomplete follow up data on all participants enrolled in the original study. However, for the results to be biased, the association between pet keeping and allergic outcomes would have to be related to participation in the study. *This study has* strength in that the cohort is relatively uniform in terms of race (White), thus decreasing the possible effects of this factor, although decreasing the generalizability of these results. While data on respiratory health were also obtained for participants of this study adequate presentation of this information is beyond the focus of the current presentation.

Another limitation is that parental allergic history was based on maternal report. While not ideal, this is not unique in cohort studies of atopy (2, 5). Additionally, there were no lifetime measurements of the participants’ actual exposures to dog or cat allergen – through inhalation, ingestion or other route.

Prior literature suggests that genetic polymorphisms may modify the effects of environmental exposures (gene-environment interaction).²⁹ Certain subgroups defined by their genotypes could have had modified the risk of sensitization; however, we did not incorporate genotypes into our analyses and this could have obscured opposing results in subgroups.

An additional limitation is that the study participants were asked to recall pet exposure from ages 6–18 years. While we have not been able to validate the data accuracy, we concluded from prior analyses that CAS participants at age 18 years can recall very well pets they had in their first 6 years of life; accuracy of recall did not vary by the teens allergic symptoms around cats or dogs.³⁰ Thus, we believe that pet recall of more recent ages 6–18 is also excellent.

The *a priori* power calculation done for CAS analyses at age 18 resulted in a sample size goal of 554 teens. Our sample size of 565 with blood samples obtained met our sample size goal. The effect size detectable at 90% power with N=554 is 0.19 for the entire sample size and 0.24 for within strata (specifically gender). A small effect size is 0.10 and a medium is 0.30, thus, the study was powered to detect, at the very least, what is normally considered a medium effect size.³¹ With N=554 we would have had 90% power to detect an effect size of 0.24 or larger for within gender differences. Our earlier paper from CAS showed a RR of 0.28 (0.10, 0.76) for two or more pets to no pet.¹ The study was well-powered to detect that level of difference, thus we suggest that any observed effect in the current analyses is not as strong as the effect at age 6.

With few comparable studies in the literature, the context of these analyses is somewhat unique. In our cohort, effects seen in childhood with respect to atopy were not seen in the late teen years. However, lower total IgE at age 18 years was associated with early life pet exposure among atopic teens. Although the data presented do not provide a definitive answer about the relationship between pet exposure and allergic disease development, these data represent a methodological approach to investigate a complex question that could be repeated in larger cohort studies.

Key Message

- Pet exposure was not clearly associated with reduced risk of atopy at age 18 years.
- Pet exposure in the first year of life was associated with lower total IgE at age 18 years among sensitized individuals.

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Abbreviations

CAS	Childhood Allergy Study
HFHS	Henry Ford Health System
IRB	Institutional Review Board
IgE	Immunoglobulin E
ETS	Environmental tobacco smoke
kU/L	Standard International Unit
CI	Confidence Interval
<i>Der f</i>	<i>Dermatophagoides farinae</i>
<i>Der p</i>	<i>D. pteronyssinus</i>

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Table I

Frequency of sensitization with 95% confidence intervals at age 18 years by pet exposure in the first year of life.

Atopy*	No Dog or Cat Exposure	1 Dog or Cat	≥2 Dogs or Cats	P value for Chi Square test
All teens	56.1% (50.4%, 61.6%) n=314	58.2% (50.3%, 65.8%) n=165	46.5% (35.7%, 57.6%) n=86	0.19
Males only	59.3% (51.0%, 67.3%) n=150	56.4% (44.7%, 67.6%) n=78	53.7% (37.4%, 69.3%) n=41	0.78
Females only	53.0% (45.1%, 60.9%) n=164	59.8% (48.7%, 70.2%) n=87	40.0% (25.7%, 55.7%) n=45	0.10

* Sensitization is defined as ≥ 1 allergen-specific IgE ≥ 0.35 kU/L (dog, cat, ragweed, Der f, grass, *Alternaria*, peanut)

Table II

Relative risks (95% confidence intervals) of sensitization at 18 years associated with exposure to pets in the first year stratified by teen sex.*

	Total (N=565)	Male Teens (N=269)	Female Teens (N=296)
All Teens	0.97 (0.83–1.12)	0.93 (0.76–1.15)	1.00 (0.81–1.24)
Parental History of Allergy	1.03 (0.87–1.23)	1.04 (0.81–1.33)	1.03 (0.81–1.30)
No Parental History of Allergy	0.86 (0.66–1.13)	0.80 (0.55–1.15)	0.93 (0.62–1.38)
Firstborn	0.96 (0.78–1.19)	0.97 (0.72–1.31)	0.95 (0.70–1.28)
Not Firstborn	0.96 (0.77–1.19)	0.89 (0.66–1.21)	1.04 (0.76–1.42)
Exposed to tobacco smoke in first year	0.97 (0.73–1.28)	0.83 (0.54–1.27)	1.10 (0.74–1.63)
Not exposed to tobacco smoke in first year	0.98 (0.82–1.17)	0.98 (0.78–1.25)	0.97 (0.74–1.27)

* Sensitization is defined as ≥ 1 allergen-specific IgE ≥ 0.35 kU/L (dog, cat, ragweed, Der f, grass, *Alternaria*, peanut).

Table III

Relative risks (95% confidence intervals) of sensitization at 18 years associated with exposure to pets in the first year.*

	One pet versus no pets	Two or more pets versus no pets
All Teens	1.04 (0.88–1.22)	0.83 (0.65–1.06)
Male	0.95 (0.75–1.20)	0.90 (0.66–1.24)
Female	1.13 (0.90–1.41)	0.75 (0.51–1.11)
Parental History of Allergy	1.12 (0.94–1.34)	0.86 (0.64–1.16)
No Parental History of Allergy	0.90 (0.66–1.22)	0.79 (0.52–1.20)
Firstborn	1.02 (0.81–1.28)	0.85 (0.62–1.18)
Not Firstborn	1.04 (0.83–1.31)	0.78 (0.53–1.15)
Exposed to tobacco smoke in first year	1.03 (0.76–1.41)	0.85 (0.56–1.29)
Not exposed to tobacco smoke in first year	1.05 (0.87–1.28)	0.84 (0.61–1.14)

* Sensitization is defined as ≥ 1 allergen-specific IgE ≥ 0.35 kU/L (dog, cat, ragweed, Der f, grass, *Alternaria*, peanut).

Table IV

Pet exposure in the first year of life and total IgE at 18 years.

Pet exposure	N	Mean IgE IU/mL (95% CI)
All Teens		
No cat or dog	314	44.6(37.6, 53.0)
1 cat or dog	165	33.4(26.3, 42.3)
≥2 cats or dogs	86	28.9(21.2, 39.4)
test for group differences *		p=0.053
test for trend [†]		p=0.017
Not Sensitized at 18 Years [‡]		
No cat or dog	138	14.7(12.0, 18.0)
1 cat or dog	69	10.6(7.6, 15.0)
≥2 cats or dogs	46	13.5(9.3, 19.6)
test for group differences *		p=0.47
test for trend [†]		p=0.48
Sensitized at 18 Years [‡]		
No cat or dog	176	106.6(89.7, 127.5)
1 cat or dog	96	75.9(61.5, 93.6)
≥ 2 cats or dogs	40	69.2(48.0, 99.8)
test for group differences *		p=0.029
test for trend [†]		p=0.007

* Test for group differences is Kruskal-Wallis.

[†] Test for trend is Jonckheere-Terpstra.[‡] Sensitization is defined as ≥1 allergen-specific IgE ≥ 0.35 kU/L (dog, cat, ragweed, Der f, grass, *Alternaria*, peanut)

Table V

Spearman correlations (95% confidence intervals) between total pet years of exposure and total IgE at 18 years.

	All teens	Teen atopic at 18 years [*]	Teen not atopic at 18 years [*]
N	565	312	253
r	−0.11	−0.17	−0.06
(95% confidence interval)	(−0.19, −0.02)	(−0.28, −0.06)	(−0.18, 0.07)
p value	0.012	0.001	0.36

^{*} Sensitization is defined as ≥ 1 allergen-specific IgE ≥ 0.35 kU/L (dog, cat, ragweed, Der f, grass, *Alternaria*, peanut)