



Dog and Cat Allergies and Allergen Avoidance Measures in Korean Adult Pet Owners Who Participated in a Pet Exhibition

Min Suk Yang,¹ Sang Pyo Lee,² Young Jae Kwon,² Sang Min Lee^{2*}

¹Department of Internal Medicine, Seoul Metropolitan Government-Seoul National University Boramae Medical Center, Seoul, Korea

²Department of Internal Medicine, Gachon University Gil Medical Center, Incheon, Korea

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Purpose: This study evaluated dog and cat allergies and their association with allergen avoidance measures in Korean adults. **Methods:** The study population consisted of 537 adults who currently kept dogs or cats and participated in a pet exhibition in Korea. The subjects were asked to complete questionnaires regarding pet ownership, allergen avoidance, and allergy symptoms, and underwent skin prick tests. They were considered to have a dog or cat allergy if they suffered from one or more of allergy symptoms during contact with their pets. **Results:** In total, 103 of 407 dog owners (25.3%) and 45 of 130 cat owners (34.6%) had a dog or cat allergy, respectively. Dog owners kept 1.3 ± 1.5 dogs; this number did not differ according to the presence of dog allergy. Dog owners with a dog allergy had owned their dogs longer than those without (88.0 ± 72.0 vs 67.5 ± 72.7 months, $P < 0.05$). Cat owners kept 2.1 ± 3.6 cats; this number did not differ according to the presence of cat allergy, nor did the duration of cat ownership. Cat owners with a cat allergy had facial contact and slept with their cats less frequently (8.6 ± 11.9 vs 18.3 ± 27.0 times/day, $P < 0.01$; 71.1% vs 81.2%, $P < 0.05$); however, they had their cats shaved and beds cleaned less frequently than those without (1.8 ± 3.3 vs 3.2 ± 4.4 times/year, $P < 0.05$; 1.5 ± 1.5 vs 3.9 ± 6.0 times/month, $P < 0.01$). **Conclusions:** Cat owners with a cat allergy tried to minimize contact with their cats, but efforts to avoid indoor cat allergens were lower than those without. In comparison, dog owners with a dog allergy had kept their dogs for longer time than those without; however, current contact with their dogs and allergen avoidance measures did not differ between the 2 groups.

Key Words: Dogs; cats; allergy

INTRODUCTION

Pet allergens are aeroallergens whose size is small enough to be inhaled and to induce asthma as well as other allergic diseases.¹ As early as 1975, it was suggested that contact with certain pets, such as dogs, cats, rabbits, guinea pigs, budgerigars, and hamsters, could lead to sensitization to those pets and to elevated reactions on skin prick tests (SPTs).² Thereafter, keeping a pet has also been reported to increase the risk of sensitization to pet allergens in Westernized countries, including Turkey, Kuwait, Japan, and Korea.³⁻⁶ In addition to sensitization to pet allergens, pet exposure is associated with allergic diseases, such as asthma, allergic rhinitis, atopic dermatitis, and other respiratory and skin allergy-related conditions.^{1,7-13} Indeed, many studies have suggested that exposure to pets is associated with exacerbation of asthma, poor lung function, increased airway inflammation, airway hyper-responsiveness (AHR), and increased inhaled corticosteroid (ICS) dose.^{1,7-9,11-13}

However, many other studies have yielded conflicting results. Many reports focusing on the early life of birth cohorts or chil-

dren, when allergies have not fully developed, have suggested that keeping pets is not associated with development of an allergic disease or a protective effect against an allergy.^{2-4,9,11-20} However, relatively few such studies have been performed in adults.^{5,7,10,21,22} In 2000, it was reported that asthmatics with pets suffered from allergy symptoms related to animal exposure more frequently than diabetics, and that higher doses of ICS were required in pet-owning asthmatics than non-pet-owning asthmatics.⁷ It has also been reported that the prevalence of rhinitis, skin allergy, and asthma was significantly more common in adults with animals than in those without.¹⁰ In contrast, cat ownership is associated with a lower prevalence of sensitiza-

Correspondence to: Sang Min Lee, MD, PhD, Division of Pulmonology and Allergy, Department of Internal Medicine, Gachon University Gil Medical Center, 21 Namdong-daero 774beon-gil, Namdong-gu, Incheon 21565, Korea. Tel: +82-32-460-2634; Fax: +82-32-469-4320; E-mail: sangminlee77@naver.com
 Received: August 10, 2017; Revised: December 2, 2017; Accepted: December 6, 2017

- Min Suk Yang and Sang Pyo Lee contributed equally to this study.
- There are no financial or other issues that might lead to conflict of interest.

tion to cats and dogs among English adults, and current exposure to pets is not related to sensitization to pets in adult French asthma sufferers.^{21,22} Furthermore, few studies have been conducted regarding pet ownership and pet allergy in regions other than Europe and the US, especially Korea.^{3,5,6,10,12,15,16,23}

Thus, this study was performed to evaluate dog and cat allergies and their association with allergen avoidance measures in Korean adult pet owners who participated in a pet exhibition, under the hypothesis that pet owners with dog or cat allergies try to minimize contact with their pets and reduce environmental indoor allergens.

MATERIALS AND METHODS

Study population

The study population consisted of current pet owners aged ≥ 19 years who attended a pet exhibition entitled the “Korea Pet (KOPET) Show” during November 25-27, 2015. Subjects who owned pets other than a dog or cat and those who kept both dogs and cats were excluded to rule out the influence of allergy to other pets and the interaction between dog and cat allergy.

Questionnaires regarding demographics, pet ownership, and pet allergy

After providing informed consent, subjects were asked to complete questionnaires regarding their age, gender, current allergic diseases, family history of allergic diseases, duration of pet ownership, duration of space sharing with pets, frequency of direct or facial contact with pets, pet residence,²⁴ pet defecation site, pet species, and pet breed.

We defined allergic diseases as follows: allergic rhinitis, if the subjects suffered from one or more of watery rhinorrhea, sneezing, nasal congestion, postnasal drip, and itchy nose, perennially or seasonally when they did not have a cold or the flu; allergic conjunctivitis, if the subjects suffered from itchy eyes with or without tears perennially or seasonally; urticaria, if the subjects suffered from one or more itchy hives on their skin; atopic dermatitis, if the subjects suffered from itchy eczema that fluctuated with remission and relapse, with affected sites including the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, and eyes; asthma, if the subjects suffered from dyspnea accompanied by wheezing that fluctuated with nocturnal aggravation; food allergy, if the subjects suffered from one or more of oropharyngeal itching, angioedema, whole body itching, hives, skin rash, dyspnea, wheezing, and hypotension after ingestion of certain foods; and drug allergy, if the subjects suffered from one or more of angioedema, whole body itching, hives, skin rash, dyspnea, wheezing, and hypotension after the administration of certain drugs. We also considered subjects to have allergic diseases if their conditions were diagnosed by a doctor.

Subjects were also asked how often they cleaned their homes

(per month) and beds (per month), removed pet hair from their clothes (per week), and had their pets shaved (per year).

Subjects were asked whether they suffered from any allergy symptoms, including eye itching, conjunctival engorgement, tears, eye burning, conjunctival edema, sneezing, rhinorrhea, nasal obstruction, nasal itching, postnasal drip, ear itching, palatine itching, cough, sputum, dyspnea, chest discomfort, wheezing, chest pain, skin itching, urticaria, skin rash, and angioedema during contact with their pets. They were considered to have a dog or cat allergy if they suffered from one or more of those allergy symptoms during contact with their dog or cat.

SPTs for animal and other indoor inhalant allergens

Subjects who agreed to participate, did not have dermatographism, and were not taking medications, including leukotriene modifiers, systemic glucocorticosteroids, and H₁ or H₂ antagonists within 3 days were asked to undergo SPTs for animal allergens (dog and cat) and other indoor inhalant allergens, including *Dermatophagoides farinae* (*Df*), *Dermatophagoides pteronyssinus* (*Dp*), American cockroach, German cockroach, and a mold mixture using the Lofarma Diagnostics Allergen (Lofarma, Milan, Italy). If the mean diameters of the wheals provoked by allergens in SPT were ≥ 3 mm, the results were considered positive for those allergens.

Statistical analysis

The statistical analysis was performed using PASW 20.0 software (SPSS Inc., Chicago, IL, USA). We hypothesized that subjects with a dog or cat allergy tend to contact with their pet less frequently than those without allergies. We further hypothesized that subjects with a dog or cat allergy have facial contact with their pets less frequently than those without (10 vs 20 times/day), based on the results of our pilot survey. The target sample size was calculated to be 107 in a 2-sided test with 95% confidence intervals ($\alpha/2=0.025$, $\beta=0.2$, and $\sigma=23.5$). Continuous variables were analyzed by Student's t test, whereas categorical variables were analyzed by the χ^2 test for parametric variables or Fisher's exact test for non-parametric variables. A *P* value < 0.05 was considered significant.

Ethics

The study was performed in accordance with the International Conference on Harmonization Good Clinical Practice and applicable legal requirements and was registered at ClinicalTrials.gov (NCT03101618). The study protocols and informed consent forms were reviewed and approved by the Institutional Review Board (GBIRB2016-155).

RESULTS

Demographic and clinical characteristics

In total, 654 of 19,956 participants in the KOPET Show visited

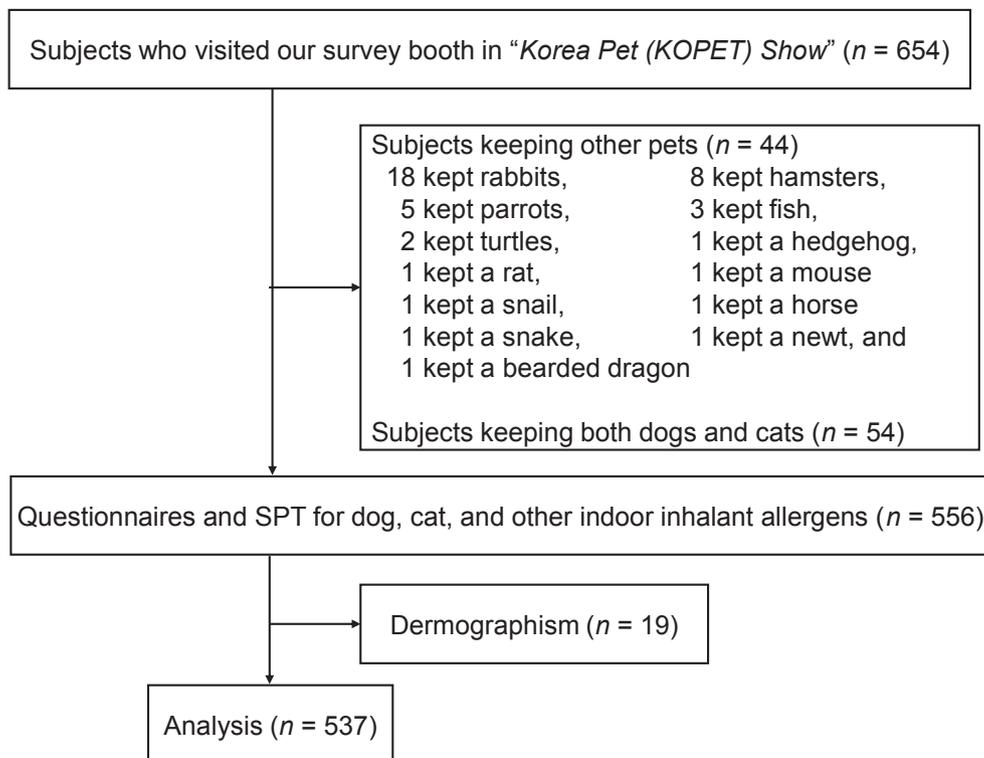


Fig. 1. Participant flowchart. Informed consent was obtained from 654 subjects who visited our survey booth. Among them, 44 dropped out because they owned pets other than a dog or cat, and 54 because they owned both dogs and cats. A total of 556 subjects were asked to respond to questionnaires regarding their dog or cat ownership and dog or cat allergy. They also underwent SPTs for dog, cat, and other indoor inhalant allergens. After the SPT, 19 dropped out due to dermographism. Thus, the final analysis was performed on 537 subjects. SPT, skin prick test.

our survey booth. Of these, 44 dropped out because they owned pets other than a dog or cat, and 54 because they owned both dogs and cats (Fig. 1). A total of 556 subjects were asked to respond to questionnaires regarding their dog or cat ownership and dog or cat allergy. Nineteen subjects dropped out due to dermographism following the SPT. Thus, the final analysis was performed on a total of 537 subjects, and their demographic characteristics are shown in Table 1.

Most of the subjects were female (80.1%), aged about 30 years. Among them, the most prevalent allergic disease was allergic rhinitis (39.1%), followed by allergic conjunctivitis (11.4%), atopic dermatitis (8.9%), urticaria (7.1%), food allergy (4.3%), drug allergy (3.4%), and asthma (1.3%). A total of 295 subjects (54.9%) had a family history of allergic diseases. Totals of 43 (8.0%), 44 (8.2%), 173 (32.2%), 160 (29.8%), 28 (5.2%), 10 (1.9%), and 23 (4.3%) had positive responses to dog, cat, *Df*, *Dp*, American cockroach, German cockroach, and a mold mixture allergen on the SPT, respectively.

Female predominance was significantly higher in dog owners with a dog allergy than in those without a dog allergy (88.3% vs 78.9%), but gender did not differ between cat owners with and without. No difference in age was observed between the dog owners with and without a dog allergy or between cat owners with and without a cat allergy.

Allergic rhinitis, allergic conjunctivitis, atopic dermatitis, urticaria, and food allergy, but not drug allergy or asthma, were more prevalent in dog owners with a dog allergy than in those without (63.1%, 22.3%, 15.5%, 12.6%, and 8.7% vs 32.2%, 7.6%, 7.6%, 5.3%, and 3.3%; respectively). Only allergic rhinitis was more prevalent in cat owners with a cat allergy than in those without (51.1% vs 28.2%). Dog owners with a dog allergy and cat owners with a cat allergy had a family history of allergic diseases more frequently than those without (67.0% vs 51.0%), but no difference was found between cat owners with and without a cat allergy (51.1% vs 56.6%).

Dog owners with a dog allergy were positive to dog, cat, *Df*, and *Dp* allergens more frequently than those without (38.8%, 29.1%, 57.3%, and 57.3% vs 8.2%, 6.9%, 30.6%, and 27.6%; respectively). Cat owners with a cat allergy were positive to dog, cat, and *Df* allergens more frequently than those without (28.9%, 31.1%, and 64.4% vs 5.9%, 10.6%, and 32.9%; respectively).

Pet ownership

No difference was observed in the number of dogs kept currently between dog owners with and without a dog allergy, which was similar in cat owners (Table 2). The cumulative numbers of dogs and cats kept throughout life did not differ be-

Table 1. Demographic and clinical characteristics of the subjects

Variables	All subjects (n=537)	Dog owners			Cat owners		
		Dog allergy+ (n=103)	Dog allergy- (n=304)	Total (n=407)	Cat allergy+ (n=45)	Cat allergy- (n=85)	Total (n=130)
Female	430 (80.1)	91 (88.3)*	240 (78.9)	331 (81.3)	36 (80.0)	63 (74.1)	99 (76.2)
Age (year)	30.6±8.7	30.6±8.0	31.1±9.6	31.0±9.3	28.5±4.9	29.3±4.9	29.0±4.9
Comorbid allergic diseases							
Allergic rhinitis	210 (39.1)	65 (63.1) [†]	88 (32.2)	163 (40.0)	23 (51.1) [†]	24 (28.2)	47 (36.2)
Allergic conjunctivitis	61 (11.4)	23 (22.3) [†]	23 (7.6)	46 (11.3)	6 (13.3)	9 (10.6)	15 (11.5)
Atopic dermatitis	48 (8.9)	16 (15.5)*	23 (7.6)	39 (9.6)	3 (6.7)	6 (7.1)	9 (6.9)
Urticaria	38 (7.1)	13 (12.6)*	16 (5.3)	29 (7.1)	1 (2.2)	8 (9.4)	9 (6.9)
Food allergy	23 (4.3)	9 (8.7)*	10 (3.3)	19 (4.7)	0 (0.0)	4 (4.7)	4 (3.1)
Drug allergy	18 (3.4)	5 (4.9)	8 (2.6)	13 (3.2)	0 (0.0)	5 (5.9)	5 (3.8)
Asthma	7 (1.3)	2 (1.9)	3 (1.0)	5 (1.2)	2 (4.4)	0 (0.0)	2 (1.5)
Family history of allergic diseases	295 (54.9)	69 (67.0) [†]	155 (51.0)	224 (55.0)	23 (51.1)	48 (56.5)	71 (54.6)
Sensitization to dog and cat allergens							
Dog	83 (15.5)	40 (38.8) [†]	25 (8.2)	65 (16.0)	13 (28.9) [†]	5 (5.9)	18 (13.8)
Cat	74 (13.8)	30 (29.1) [†]	21 (6.9)	51 (12.5)	14 (31.1)*	9 (10.6)	23 (17.7)
Sensitization to other indoor inhalant allergens							
<i>Df</i>	209 (38.9)	59 (57.3) [†]	93 (30.6)	152 (37.3)	29 (64.4)*	28 (32.9)	57 (43.8)
<i>Dp</i>	197 (36.7)	59 (57.3) [†]	84 (27.6)	143 (35.1)	25 (55.6)	29 (34.1)	54 (41.5)
American cockroach	51 (9.5)	11 (10.7)	26 (8.6)	37 (9.1)	4 (8.9)	10 (11.8)	14 (10.8)
German cockroach	38 (7.1)	7 (6.8)	17 (5.6)	24 (5.9)	5 (11.1)	9 (10.6)	14 (10.8)
Mold mixture	23 (4.3)	15 (14.6)*	19 (6.3)	34 (8.4)	1 (2.2)	4 (4.7)	5 (3.8)

Data are means ± standard deviation or frequencies (%).

Df, *Dermatophagoides farinae*; *Dp*, *Dermatophagoides pteronyssinus*.

* $P < 0.05$ compared with dog owners without a dog allergy or cat owners without a cat allergy; [†] $P < 0.01$ compared with dog owners without a dog allergy or cat owners without a cat allergy; [‡] $P < 0.001$ compared with dog owners without a dog allergy or cat owners without a cat allergy.

tween dog owners with and without a dog allergy or between cat owners with and without a cat allergy.

Dog owners with a dog allergy had kept their dogs longer than those without (88.0 ± 72.0 vs 67.5 ± 72.7 months). No differences were observed in duration of space sharing or frequency of direct and facial contact. Cat owners with a cat allergy had facial contact less frequently than those without (8.6 ± 11.9 vs 18.3 ± 27.0 times/day), whereas the other above-mentioned variables did not differ between the 2 groups.

No difference in dogs' residence or defecation site was observed between dog owners with and without a dog allergy. In contrast, the number of cats that slept with their owners was lower in cat owners with a cat allergy than in those without (71.1% vs 81.2%), while the number of cats that must leave the bedroom during sleep was higher in cat owners with a cat allergy than in those without (13.3% vs 9.4%). No difference in cats' defecation site was observed between cat owners with and without a cat allergy.

Allergen avoidance measures

There was no difference in the frequencies of shaving, cleaning beds, pet hair removal from the clothes, or home cleaning

between dog owners with and without a dog allergy (Table 3). By contrast, cat owners with a cat allergy had their cats shaved less frequently than those without (1.8 ± 3.3 vs 3.2 ± 4.4 times/year), and cleaned their beds less frequently (1.5 ± 1.5 vs 3.9 ± 6.0 times/month). No difference in the frequency of pet hair removal from the clothes or home cleaning was observed between cat owners with and without cat allergy.

Prevalence of dog and cat allergies according to breed

A dog allergy was most prevalent in dog owners who kept Chihuahua (40.0%), followed by Yorkshire terrier (38.3%), Maltese (30.1%), Poodle (22.8%), Spitz (20.8%), and Shih Tzu (24.5%) (Fig. 2). The prevalence of dog allergy among all dog owners was 25.3%, and it did not differ significantly according to breed.

Cat allergy was the most prevalent in cat owners who kept Persian (47.8%), followed by Turkish Angora (41.7%), Korean Shorthair (38.3%), and Scottish Fold (26.7%) cats. The prevalence of cat allergy among all cat owners was 34.6%, and did not differ significantly according to breed.

Allergy symptoms during contact with pets

The most frequent allergy symptoms during contact with their

Table 2. Pet ownership

Variables	All subjects (n=537)	Dog owners			Cat owners		
		Dog allergy+ (n=103)	Dog allergy- (n=304)	Total (n=407)	Cat allergy+ (n=45)	Cat allergy- (n=85)	Total (n=130)
Number of pets kept currently							
Dogs	1.3±1.5	1.6±1.0	1.6±1.6	1.6±1.5	0	0	0
Cats	0.6±1.9	0	0	0	2.1±3.6	2.4±2.8	2.3±3.1
Cumulative number of pets kept ever in life							
Dogs	3.6±6.6	4.0±3.0	3.9±7.9	3.9±7.0	5.3±19.3	3.3±3.5	4.0±11.9
Cats	1.3±3.0	0.7±1.0	0.8±2.6	0.8±2.3	3.1±3.0	4.2±5.5	3.8±4.8
Exposure time							
Duration of pet keeping (month)	68.3±69.8	88.0±72.0*	67.5±72.7	72.7±73.0	50.9±56.3	66.5±58.1	61.1±57.8
Duration of space sharing (hour/day)	11.6±8.0	13.8±12.5	11.3±6.2	11.9±8.3	11.4±7.3	13.2±13.2	12.6±11.6
Frequency of direct contact (times/day)	30.3±37.3	31.0±33.0	30.7±36.7	30.7±35.8	33.5±58.5	29.0±35.1	30.5±44.4
Frequency of facial contact (times/day)	16.7±25.9	19.2±25.8	17.4±27.2	17.8±26.9	8.6±11.9 [†]	18.3±27.0	15.0±23.4
Pet residence							
Pet sleeps in bedroom with owner	420 (78.2)	84 (81.6)	235 (77.3)	319 (78.4)	32 (71.1)*	69 (81.2)	101 (77.7)
Pet can come into bedroom but must leave when sleeping	63 (11.7)	8 (7.8)	41 (13.5)	49 (12.0)	6 (13.3)*	8 (9.4)	14 (10.8)
Pet lives inside but cannot come into bedroom	36 (6.7)	7 (6.9)	19 (6.3)	26 (6.4)	3 (7.1)	7 (8.2)	10 (7.7)
Pet lives outside only	7 (1.3)	2 (2.0)	4 (1.3)	6 (1.5)	1 (2.4)	0 (0.0)	1 (0.8)
Pet lives outside but can come in	3 (0.6)	1 (1.0)	1 (0.3)	2 (0.5)	0 (0.0)	1 (1.2)	1 (0.8)
Defecation site							
Inside, predetermined place	471 (87.7)	86 (83.5)	265 (87.2)	351 (86.2)	40 (88.9)	80 (94.1)	120 (92.3)
Inside, anywhere	30 (5.6)	7 (6.8)	17 (5.6)	24 (5.9)	3 (6.7)	3 (3.5)	6 (4.6)
Outside	30 (5.6)	7 (6.8)	19 (6.3)	26 (6.4)	2 (4.4)	2 (2.4)	4 (3.1)

Data are means ± standard deviation or frequencies (%).

* $P<0.05$ compared with dog owners without a dog allergy or cat owners without a cat allergy; [†] $P<0.01$ compared with dog owners without a dog allergy or cat owners without a cat allergy.

Table 3. Allergen avoidance measures

Variables	All subjects (n=537)	Dog owners			Cat owners		
		Dog allergy+ (n=103)	Dog allergy- (n=304)	Total (n=407)	Cat allergy+ (n=45)	Cat allergy- (n=85)	Total (n=130)
Shaving (times/year)	4.8±17.2	4.9±3.9	5.7±21.3	5.5±18.6	1.8±3.3*	3.2±4.4	2.7±4.1
Cleaning beds (times/month)	2.4±3.5	2.5±2.8	2.3±2.8	2.3±2.8	1.5±1.5 [†]	3.9±6.0	3.1±5.1
Pet hair removal from clothes (times/week)	4.7±8.0	5.2±8.8	4.6±8.3	4.8±8.5	3.9±3.8	5.1±5.5	4.7±5.0
Home cleaning (times/month)	17.5±15.4	19.3±20.4	16.5±13.2	17.2±15.3	15.4±13.1	20.2±17.9	18.5±16.5

Data are means ± standard deviation.

* $P<0.05$ compared with dog owners without a dog allergy or cat owners without a cat allergy; [†] $P<0.01$ compared with dog owners without a dog allergy or cat owners without a cat allergy.

dogs in dog owners with a dog allergy were rhinitis (73.8%), followed by conjunctivitis (65.0%), cutaneous symptoms (55.3%), and lower respiratory symptoms (33.0%) (Table 4).

The most frequent allergy symptoms of cat owners with a cat allergy during contact with their cats were rhinitis (80.0%), followed by conjunctivitis (73.3%), cutaneous symptoms (33.3%), and lower respiratory symptoms (13.3%). Dog owners with a dog allergy suffered from cutaneous symptoms more frequently than cat owners with a cat allergy (53.3% vs 33.3%, $P<0.01$),

especially in terms of urticaria (35.9% vs 15.6%, $P<0.01$). Dog owners with a dog allergy also experienced lower respiratory symptoms more frequently than did cat owners with a cat allergy (33.3% vs 13.3%, $P<0.05$), especially cough (23.3% vs 6.7%, $P<0.05$).

Use of medical services for pet allergy and recognition of allergy immunotherapy (AIT)

Only 35.3% of dog owners with a dog allergy consulted doc-

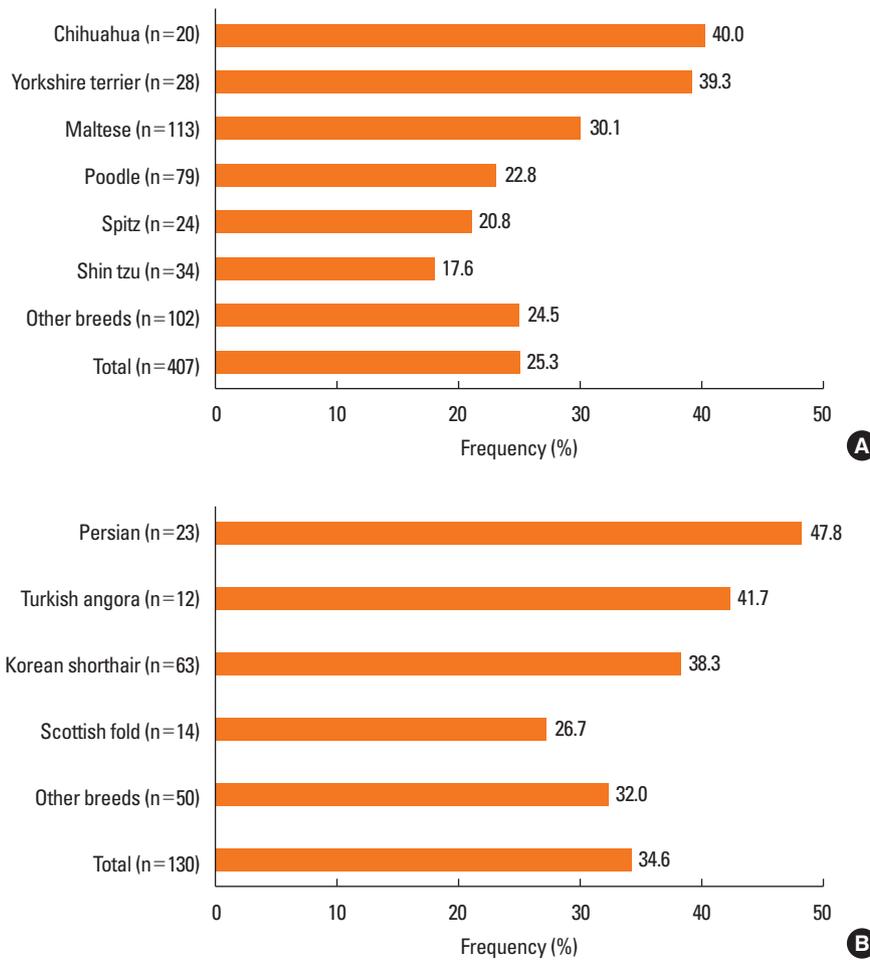


Fig. 2. The prevalence of dog and cat allergy according to breed. (A) Dog allergy. (B) Cat allergy.

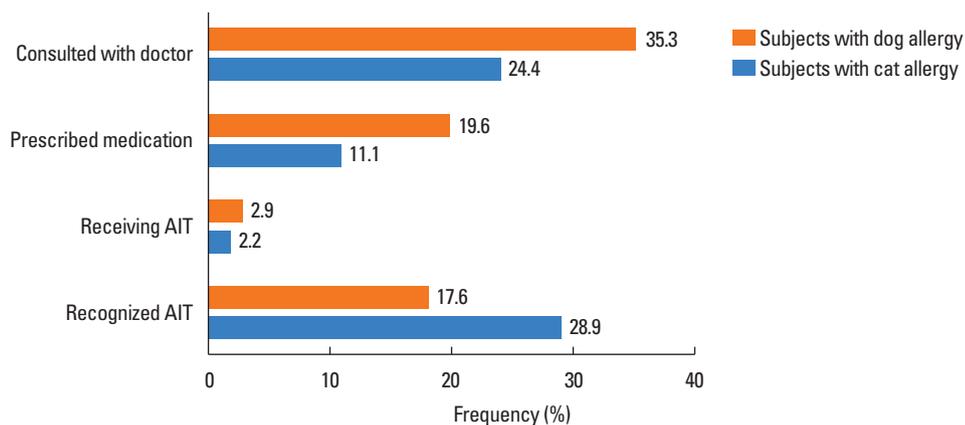


Fig. 3. The use of medical services for pet allergy and recognition of AIT in subjects with a dog or cat allergy. AIT, allergy immunotherapy.

tors due to their dog allergy and 19.6% received prescription medications. Although 17.6% of them recognized AIT, merely 2.9% received it (Fig. 3).

Only 24.4% of cat owners with a cat allergy consulted doctors due to their cat allergy and 11.1% received prescription medi-

cations. While 28.9% recognized AIT, only 2.2% received it.

The use of medical services for a pet allergy, and recognition of AIT, did not differ between dog owners with a dog allergy and cat owners with a cat allergy.

Table 4. Allergy symptoms during contact with pets

Symptoms	Dog owners with dog allergies (n=103)	Cat owners with cat allergies (n=45)	P value
Conjunctivitis symptoms	67 (65.0)	33 (73.3)	0.322
Eye itching	45 (43.7)	23 (51.1)	0.405
Conjunctival engorgement	38 (36.9)	16 (35.6)	0.876
Tears	34 (33.0)	13 (28.9)	0.620
Eye burning	35 (34.0)	12 (26.7)	0.379
Conjunctival edema	22 (21.4)	13 (28.9)	0.321
Rhinitis symptoms	76 (73.8)	36 (80.0)	0.418
Sneezing	67 (65.0)	29 (64.4)	0.944
Rhinoirrhoea	60 (58.3)	22 (48.9)	0.292
Nasal obstruction	44 (42.7)	13 (28.9)	0.112
Nasal itching	27 (26.2)	9 (20.0)	0.418
Postnasal drip	15 (14.6)	4 (8.9)	0.342
Ear itching	10 (9.7)	3 (6.7)	0.548
Palatine itching	8 (7.8)	4 (8.9)	0.818
Cutaneous symptoms	57 (55.3)	15 (33.3)	0.014
Skin itching	37 (35.9)	12 (26.7)	0.271
Urticaria	37 (35.9)	7 (15.6)	0.013
Skin rash	20 (19.4)	11 (24.4)	0.489
Angioedema	10 (9.7)	2 (4.4)	0.280
Lower respiratory tract symptoms	32 (33.0)	6 (13.3)	0.013
Cough	24 (23.3)	3 (6.7)	0.016
Sputum	12 (11.7)	2 (4.4)	0.168
Dyspnea	9 (8.7)	1 (2.2)	0.146
Chest discomfort	7 (6.8)	1 (2.2)	0.258
Wheezing	2 (1.9)	3 (6.7)	0.143
Chest pain	2 (1.9)	1 (2.2)	0.911

Variables are shown as frequencies (%). Allergy symptoms for which the frequency significantly differs between dog owners with dog allergies and cat owners with cat allergies ($P < 0.05$) are shown as bold font.

DISCUSSION

Most subjects in this study were female, aged about 30 years, as most participants in the KOPET Show were women of that age. As the gender and age of subjects in this study were skewed, they may not accurately represent Korean pet owners. In addition, there were more female dog owners with a dog allergy than those without; however, we could not exclude the possibility that male subjects were included less as dog owners with a dog allergy than in those without due to the female predominance in this study. Other studies that considered pet allergies did not find a female predominance in pet owners, nor did they find an association between female gender and pet allergy.^{1,7-13}

In this study, dog owners with a dog allergy suffered from allergic rhinitis, allergic conjunctivitis, atopic dermatitis, urticar-

ia, and food allergy, and had a family history of allergic diseases more frequently than those without. In addition, cat owners with a cat allergy also suffered from allergic rhinitis more frequently than those without. Furthermore, subjects with a dog or cat allergy in this study were positive for *Df* and/or *Dp*, which are the most common indoor inhalant allergens, more frequently than those without. These results are consistent with those of previous reports, suggesting an association between pet allergy, comorbid allergic diseases, and atopic inheritance.^{1,5,7-13} Regarding allergen sensitization, the sensitization rates of dog, cat, *Df*, and *Dp* allergens in the subjects of this study (15.5%, 13.8%, 38.9%, and 36.7%, respectively) were much or less similar to those in subjects of a previous hospital-based Korean study (20.4%, 15.0%, 47.4%, and 47.1%, respectively).⁵ The prevalence of allergic rhinitis, allergic conjunctivitis, atopic dermatitis, or asthma did not differ between dog or cat owners in another study of the Korean population.²⁵ However, in this study, dog owners with a dog allergy suffered from cutaneous and lower respiratory symptoms more frequently than did cat owners with a cat allergy, while rhinitis or conjunctivitis symptoms did not differ between the 2 groups. One possible explanation for this is that cat owners with a cat allergy tried to minimize direct and facial contact with their cats, which may have reduced cutaneous and respiratory symptoms, which are generally provoked by close contact with allergens.

In this study, dog owners with a dog allergy had kept their dogs for a longer time than those without. The risk of becoming sensitized to pet allergens and subsequent pet allergy has been suggested to be higher when people are exposed to intermediate levels of pet allergens for a certain period.²⁶ By contrast, patients with established pet allergen-induced allergic diseases can experience improvements in their disease symptoms, such as alleviation of AHR, and reduction of ICS dose in asthma patients after removal of their pets.²⁷⁻²⁹ Alleviation of allergic disease morbidity by removal of pets from the homes of all persons with a pet allergy would reduce healthcare costs.³⁰ In fact, subjects with a pet allergy or those with family members with a pet allergy tended to keep pets less frequently, and the levels of pet allergens in their households were lower.^{9,31-33} Whether pet owners allow their pets to enter their bedroom or a baby's room, and whether individuals regularly visit places where pets are kept or where pet allergens are pooled by pet allergen carriers (e.g., pet owners' clothes), such as schools or other public places, is also critical.^{24,34-36} Note that allergen avoidance measures at schools, involving school clothing or pet ownership bans, are equally effective in controlling the levels of airborne pet allergens.³⁷ Other measures for reducing pet allergens, such as the use of air filters, vacuum cleaners, or washing and drying systems, have also been considered.³⁸ However, one Cochrane review concluded that there was no significant difference between the effects of an active intervention using an air filter and those of control interventions.³⁹ In this study, entire or partial

removal of pets was extremely rare (data not shown). Instead, cat owners with a cat allergy had less frequent facial contact and slept with their cats less frequently than those without; this phenomenon was not observed in dog owners. Because dog or cat hairs are well-known reservoirs of pet allergens, we thought that shaving pets and removing pet hairs from clothes may have reduced indoor pet hair, and thus served as potential allergen avoidance measures in addition to cleaning the house and bed. Therefore, we asked the subjects how often they took these measures. Cats are frequently observed to swallow their hair when they groom themselves, and these swallowed hair are frequently observed to be mixed in their feces. Therefore, we considered pet feces as potential reservoirs of pet allergen, and asked the subjects about where their pets defecated. This showed that cat owners with a cat allergy had their cats shaved and cleaned their beds less frequently than those without, while other allergen avoidance measures did not differ between the 2 groups. In dog owners, allergen avoidance measures did not differ according to whether they had dog allergies.

In this study, dog or cat allergies tended to be more prevalent in subjects who kept certain breeds, such as Chihuahua and Yorkshire terrier dogs and Persian and Turkish Angora cats, although this difference was not significant. It has been suggested that dog or cat allergies do not differ by breed, and that so-called hypoallergenic pets have higher allergen levels in hair and environmental samples.⁴⁰ Instead, gender, age, and spay/neuter status, as suggested previously, influence glandular secretion and resulting allergenicity.⁴¹ Major pet allergens, such as Can f 1 (from dogs) and Fel d 1 (from cats), generally originate from salivary, sebaceous, or perianal glands, with the skin and hair serving as reservoirs, and their production may be influenced by sexual hormones, such as testosterone.⁴¹ Pets' gender, age, and spay/neuter status may affect hormonal and excretory status to a greater extent than whether a specific breed sheds more or less; therefore, these may be more important contributors to allergenicity. Note that one company in the US has produced and marketed "hypoallergenic" pets that are deficient in Can f 1 or Fel d 1.⁴¹

The most frequent allergy symptoms in subjects with a dog or cat allergy during contact with their pets were rhinitis symptoms, followed by conjunctivitis symptoms, cutaneous symptoms, and lower respiratory symptoms, which is consistent with those of previous studies.^{1,7-13}

As patients who are allergic to their pets are rarely willing to give up their pets, pharmacotherapy and AIT may become the main methods of controlling pet allergy.^{42,43} Pharmacotherapy for pet-allergic asthmatics requires a stepwise approach according to established asthma management guidelines.⁴³ In addition to short-acting beta-agonists and ICSs, prophylactic antihistamines before anticipated pet exposure, the use of intranasal steroids, and the use of leukotriene antagonists may also be considered as adjunctive therapy for pet-allergic patients with

asthma and/or allergic rhinitis.⁴³ Allergen-specific high-dose subcutaneous immunotherapy has been shown to be beneficial in cat-allergic patients with asthma and rhinoconjunctivitis, whereas the data for dog-allergic patients are less convincing.⁴³ Alternative immunotherapeutic approaches, including sublingual, subcutaneous, and intralymphatic routes, and allergen-derived peptide-based immunotherapy, have been tried recently. In particular, intralymphatic immunotherapy has rapid onset and a long-duration therapeutic effect after only 3 injections in patients with a dog or cat allergy.⁴⁴⁻⁴⁶ However, in this study, only a small portion of subjects with a dog or cat allergy consulted doctors, and received prescription medication or AIT, indicating unmet medical needs in this population.

This study had several limitations. First, most subjects were adult females aged about 30 years, whereas there were relatively few male subjects or subjects in other age groups. Therefore, as mentioned previously, our study population was not representative of all pet owners in Korea. Second, we did not investigate the status of pets with regard to gender, age, or spay/neuter status, which would influence glandular secretions and resulting allergenicity. Instead, we focused on breeds of dogs and cats and found that pet owners keeping some breeds were prone to have a pet allergy more frequently. Further studies with a larger number of subjects are required to determine whether some breeds are more allergenic than others. Third, we performed SPTs with extracts from pets' dander to determine sensitization to pet allergens. However, major pet allergens are now thought to be derived from salivary, sebaceous, or perianal glands, and the serum-specific IgE for these allergens is generally measured to determine sensitization. Unfortunately, we could not measure serum-specific IgE for major pet allergens because of budget and personnel constraints. Note that less than half of the subjects with a dog or cat allergy (31.1%-38.8%) showed skin reactivity to the relevant pet.

Despite these limitations, our study also has some merits. First, we carried out SPTs with indoor inhalant allergens other than pet dander and found that subjects with a dog or cat allergy were more frequently sensitized to *Df* and *Dp*. Second, we thoroughly evaluated each allergy symptom and found that subjects with a dog or cat allergy frequently experienced some allergy symptoms, such as sneezing, rhinorrhea, eye itching, nasal obstruction, and conjunctival engorgement. Third, we investigated subjects' use of medical services for a dog or cat allergy and found that only a small portion of subjects with a dog or cat allergy consulted doctors, and even fewer received prescription medications and/or AIT. Finally, we surveyed subjects' pet ownership and allergen avoidance measures. The results indicated that cat owners with a cat allergy had less facial contact and slept with their cats less frequently than those without a cat allergy, while they had their cats shaved and cleaned their beds less frequently than those without, which may increase exposure to cat allergens.

In conclusion, cat owners with a cat allergy, but not dog owners with a dog allergy, tried to minimize contact with their cats, but their efforts to avoid cat allergens were lower than those without. Moreover, only a small portion of subjects with a dog or cat allergy used medical services. Further large-scale studies are needed to investigate pet ownership and dog or cat allergies in Korea.

ACKNOWLEDGMENTS

We thank Hyunju Im, Young-Ju Kim, Hyegyung Jung, Eunhee Kim, Eunhee Park, and Mil Hwang for their devotion to this study. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2015 RID1A1A02061943).

REFERENCES

- Patelis A, Dosanjh A, Gunnbjörnsdóttir M, Borres MP, Högman M, Alving K, et al. New data analysis in a population study raises the hypothesis that particle size contributes to the pro-asthmatic potential of small pet animal allergens. *Ups J Med Sci* 2016;121:25-32.
- Sarsfield JK, Boyle AG, Rowell EM, Moriarty SC. Pet sensitivities in asthmatic children. *Arch Dis Child* 1976;51:186-9.
- Al-Mousawi MS, Lovel H, Behbehani N, Arifhodzic N, Woodcock A, Custovic A. Asthma and sensitization in a community with low indoor allergen levels and low pet-keeping frequency. *J Allergy Clin Immunol* 2004;114:1389-94.
- Medjo B, Atanaskovic-Markovic M, Nikolic D, Spasojevic-Dimitrijeva B, Ivanovski P, Djukic S. Association between pet-keeping and asthma in school children. *Pediatr Int* 2013;55:133-7.
- Park YB, Mo EK, Lee JY, Kim JH, Kim CH, Hyun IG, et al. Association between pet ownership and the sensitization to pet allergens in adults with various allergic diseases. *Allergy Asthma Immunol Res* 2013;5:295-300.
- Mungan D, Celik G, Bavbek S, Misirligil Z. Pet allergy: how important for Turkey where there is a low pet ownership rate. *Allergy Asthma Proc* 2003;24:137-42.
- Simpson AJ, Matusiewicz SP, Greening AP, Crompton GK. Pet ownership and asthma morbidity. *Respir Med* 2000;94:91-2.
- Henriksen AH, Holmen TL, Bjermer L. Sensitization and exposure to pet allergens in asthmatics versus non-asthmatics with allergic rhinitis. *Respir Med* 2001;95:122-9.
- Anyo G, Brunekreef B, de Meer G, Aarts F, Janssen NA, van Vliet P. Early, current and past pet ownership: associations with sensitization, bronchial responsiveness and allergic symptoms in school children. *Clin Exp Allergy* 2002;32:361-6.
- Bener A, Mobayed H, Sattar HA, Al-Mohammed AA, Ibrahim AS, Sabbah A. Pet ownership: its effect on allergy and respiratory symptoms. *Eur Ann Allergy Clin Immunol* 2004;36:306-10.
- Lowe LA, Woodcock A, Murray CS, Morris J, Simpson A, Custovic A. Lung function at age 3 years: effect of pet ownership and exposure to indoor allergens. *Arch Pediatr Adolesc Med* 2004;158:996-1001.
- Dong GH, Ding HL, Ma YN, Jin J, Cao Y, Zhao YD, et al. Asthma and asthma-related symptoms in 16,789 Chinese children in relation to pet keeping and parental atopy. *J Investig Allergol Clin Immunol* 2008;18:207-13.
- Gergen PJ, Mitchell HE, Calatroni A, Sever ML, Cohn RD, Salo PM, et al. Sensitization and exposure to pets: the effect on asthma morbidity in the US population. *J Allergy Clin Immunol Pract*. Forthcoming 2017.
- Bråbäck L, Kjellman NI, Sandin A, Björkstén B. Atopy among schoolchildren in northern and southern Sweden in relation to pet ownership and early life events. *Pediatr Allergy Immunol* 2001;12:4-10.
- Karimi M, Mirzaei M, Baghiani Moghadam B, Fotouhi E, Zare Mehrjardi A. Pet exposure and the symptoms of asthma, allergic rhinitis and eczema in 6-7 years old children. *Iran J Allergy Asthma Immunol* 2011;10:123-7.
- Dong GH, Wang J, Liu MM, Wang D, Lee YL, Zhao YD. Allergic predisposition modifies the effects of pet exposure on respiratory disease in boys and girls: the seven northeast cities of China (SNECC) study. *Environ Health* 2012;11:50.
- Lødrup Carlsen KC, Roll S, Carlsen KH, Mowinckel P, Wijga AH, Brunekreef B, et al. Does pet ownership in infancy lead to asthma or allergy at school age? Pooled analysis of individual participant data from 11 European birth cohorts. *PLoS One* 2012;7:e43214.
- Pelucchi C, Galeone C, Bach JF, La Vecchia C, Chatenoud L. Pet exposure and risk of atopic dermatitis at the pediatric age: a meta-analysis of birth cohort studies. *J Allergy Clin Immunol* 2013;132:616-622.e7.
- Collin SM, Granell R, Westgarth C, Murray J, Paul E, Sterne JA, et al. Pet ownership is associated with increased risk of non-atopic asthma and reduced risk of atopy in childhood: findings from a UK birth cohort. *Clin Exp Allergy* 2015;45:200-10.
- Pyrhönen K, Näyhä S, Läärä E. Dog and cat exposure and respective pet allergy in early childhood. *Pediatr Allergy Immunol* 2015;26:247-55.
- Custovic A, Simpson BM, Simpson A, Hallam CL, Marolia H, Walsh D, et al. Current mite, cat, and dog allergen exposure, pet ownership, and sensitization to inhalant allergens in adults. *J Allergy Clin Immunol* 2003;111:402-7.
- Oryszczyn MP, Annesi-Maesano I, Charpin D, Kauffmann F. Allergy markers in adults in relation to the timing of pet exposure: the EGEA study. *Allergy* 2003;58:1136-43.
- Maeda Y, Kudoh M, Tomita S, Hasegawa M, Akiyama K. Annual change of the pet in allergic patients home for ten years. *Arerugi* 1999;48:27-32.
- Apfelbacher C, Frew E, Xiang A, Apfel A, Smith H. Assessment of pet exposure by self-report in epidemiological studies of allergy and asthma: a systematic review. *J Asthma* 2016;53:363-73.
- Lee SM, Ahn JS, Noh CS, Lee SW. Prevalence of allergic diseases and risk factors of wheezing in Korean military personnel. *J Korean Med Sci* 2011;26:201-6.
- Liccardi G, D'Amato G, D'Amato L, Salzillo A, Piccolo A, De Napoli I, et al. The effect of pet ownership on the risk of allergic sensitisation and bronchial asthma. *Respir Med* 2005;99:227-33.
- Ohgou T, Kishimoto T. Cough variant asthma improving with avoidance of pet rabbit. *Arerugi* 1999;48:23-6.
- Kawai K, Shirai T, Suzuki K, Chida K, Nakamura H. Mild intermittent aspirin-induced asthma in a patient who became asymptomatic after removal of pet hamsters from home. *Nihon Kokyuki Gakkai Zasshi* 2000;38:298-301.
- Shirai T, Matsui T, Suzuki K, Chida K. Effect of pet removal on pet

- allergic asthma. *Chest* 2005;127:1565-71.
30. Ownby DR. Pet dander and difficult-to-control asthma: the burden of illness. *Allergy Asthma Proc* 2010;31:381-4.
 31. Svanes C, Zock JP, Antó J, Dharmage S, Norbäck D, Wjst M, et al. Do asthma and allergy influence subsequent pet keeping? An analysis of childhood and adulthood. *J Allergy Clin Immunol* 2006;118:691-8.
 32. Eller E, Roll S, Chen CM, Herbarth O, Wichmann HE, von Berg A, et al. Meta-analysis of determinants for pet ownership in 12 European birth cohorts on asthma and allergies: a GA2LEN initiative. *Allergy* 2008;63:1491-8.
 33. Ezell JM, Wegienka G, Havstad S, Ownby DR, Johnson CC, Zoratti EM. A cross-sectional analysis of pet-specific immunoglobulin E sensitization and allergic symptomatology and household pet keeping in a birth cohort population. *Allergy Asthma Proc* 2013;34:504-10.
 34. Gehring U, Triche E, van Strien RT, Belanger K, Holford T, Gold DR, et al. Prediction of residential pet and cockroach allergen levels using questionnaire information. *Environ Health Perspect* 2004;112:834-9.
 35. Downes MJ, Roy A, McGinn TG, Wisnivesky JP. Factors associated with furry pet ownership among patients with asthma. *J Asthma* 2010;47:742-9.
 36. Liccardi G, Salzillo A, Calzetta L, Pignatti P, Rogliani P. Can pet keeping be considered the only criterion of exposure to cat/dog allergens in the first year of life? *Allergol Immunopathol (Madr)* 2016;44:387-8.
 37. Karlsson AS, Andersson B, Renström A, Svedmyr J, Larsson K, Borres MP. Airborne cat allergen reduction in classrooms that use special school clothing or ban pet ownership. *J Allergy Clin Immunol* 2004;113:1172-7.
 38. Liccardi G, Cazzola M, Walter Canonica G, Passalacqua G, D'Amato G. New insights in allergen avoidance measures for mite and pet sensitized patients. A critical appraisal. *Respir Med* 2005;99:1363-76.
 39. Kilburn S, Lasserson TJ, McKean M. Pet allergen control measures for allergic asthma in children and adults. *Cochrane Database Syst Rev* 2003:CD002989.
 40. Vredegoor DW, Willemse T, Chapman MD, Heederik DJ, Krop EJ. Can f 1 levels in hair and homes of different dog breeds: lack of evidence to describe any dog breed as hypoallergenic. *J Allergy Clin Immunol* 2012;130:904-909.e7.
 41. Morris DO. Human allergy to environmental pet danders: a public health perspective. *Vet Dermatol* 2010;21:441-9.
 42. Wallace DV. Pet dander and perennial allergic rhinitis: therapeutic options. *Allergy Asthma Proc* 2009;30:573-83.
 43. Ling M, Long AA. Pet dander and difficult-to-control asthma: therapeutic options. *Allergy Asthma Proc* 2010;31:385-91.
 44. Senti G, Cramer R, Kuster D, Johansen P, Martinez-Gomez JM, Graf N, et al. Intralymphatic immunotherapy for cat allergy induces tolerance after only 3 injections. *J Allergy Clin Immunol* 2012;129:1290-6.
 45. Lee SP, Choi SJ, Joe E, Lee SM, Lee MW, Shim JW, et al. A pilot study of intralymphatic immunotherapy for house dust mite, cat, and dog allergies. *Allergy Asthma Immunol Res* 2017;9:272-7.
 46. Kim ST, Park SH, Lee SM, Lee SP. Allergen-specific intralymphatic immunotherapy in human and animal studies. *Asia Pac Allergy* 2017;7:131-7.