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A dose-response association in the increased prevalence of asthma due to the interaction between pet exposure and the number of dogs and cats in contact with children

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Abstract

Background: The role of exposure to dogs or cats in the prevalence of asthma, allergic rhinitis, or atopic dermatitis remains controversial.

Objective. In this study, we aimed to analyze the association between exposure to dogs or cats and the prevalence of allergic diseases in children.

Material and methods: Parents of children attending childcare centers completed an online survey. Children were categorized by age (<5 years and ≥5 years). Exposure to dogs or cats was classified as never, only during the first year of life, only in the previous year, or prolonged exposure (first year and previous year). Logistic regression analyses were performed.

Results: A total of 525 children were included (51.4% aged ≥5 years, 33% born via cesarean section, 65.9% not breast-fed, and 7.2% never breast-fed). Exposure to dogs and cats was reported in 70.7% and 25.5% of cases, respectively. The prevalences of asthma, allergic rhinitis, and atopic dermatitis were 4.8%, 19.8%, and 12.4%, respectively. In children aged ≥5 years, prolonged exposure to dogs was associated with asthma (adjusted Odds Ratio [aOR] 10.04; P = 0.040) but not with allergic rhinitis or atopic dermatitis. Contact with more than one dog and more than one cat showed a strong significant association with asthma (aOR 23.7; P < 0.001).

Conclusions: Our findings suggest a dose-response association due to the interaction between prolonged exposure to dogs and cats and the increased prevalence of asthma in children.

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Introduction

Pets have been with humans for millennia. Currently, 66% of households in the United States own a pet, primarily dogs (65 million) and cats (46.5 million). Generational groups from *baby boomers* to *millennials* show the highest percentage of pet ownership according to social generation classifications.¹ These considerations have increased the likelihood that new generations of humans will live with pets throughout their lives. Moreover, the recent SARS-CoV-2 pandemic, which necessitated prolonged lockdowns, fostered closer interaction with pets and, consequently, increased the probability of allergic sensitization to dogs and cats.²

The impact of living with dogs and cats on the prevalence of asthma remains a topic of debate. Some studies suggest that exposure to cats may reduce the risk of allergic rhinitis³ and that living with female dogs or two or more dogs decreases the likelihood of developing asthma.⁴ On the other hand, early and prolonged exposure to pets has been associated with asthma.⁵ Similarly, two recent meta-analyses have presented inconsistent results.^{6,7}

While rarely addressed in previous studies, it is also interesting to examine the effect of living with multiple pets in the household. Such as in China, where living with two or more dogs, cats, or rodents was associated with a higher frequency of wheezing and chronic cough, but not with asthma.⁸ A large-scale study in the United States found no relationship between the number of pets and development of asthma in children.⁶

Most studies aimed at evaluating the role of pet exposure have focused on either early exposure (within the first year of life) or late exposure (in the previous year) but not on both periods (prolonged exposure), which could influence the risk of developing allergic diseases. Therefore, the purpose of this study is to analyze the role of early, late, or prolonged exposure to dogs and cats on the prevalence of asthma, allergic rhinitis, and atopic dermatitis in children.

Material and Methods

Design

This report shares part of the methodology published in a previous study.⁹ In summary, a cross-sectional analysis was conducted on children from the System for the Family Integral Development (DIF, being its acronym in Spanish) care unit. This public center, which is located in Guadalajara, Mexico, is dependent of Mexico's Government and offers free daycare and educational services. In May 2022, 525 children aged 6-78 months were consecutively included. The informants were the parents or legal guardians who answered the survey online anonymously.

Variables

The primary independent variable investigated was exposure to dogs or cats inside the household. It was defined according to the time of occurrence and duration as

follows: only during the first year of life, only during the previous year of life prior to the application of the questionnaire, or prolonged exposure (both above categories: first year or previous year). Other variables measured were gender, age (<5 years vs. ≥5 years), mode of delivery (vaginal vs. cesarean section), prematurity, breastfeeding (1-5 months, ≥6 months vs. non-breastfeeding), current smoking (maternal vs. paternal), and familial atopy (maternal vs. paternal).

The dependent variables were asthma, allergic rhinitis, or atopic dermatitis, which were investigated through parents' self-report. Briefly, whether a doctor had diagnosed asthma, allergic rhinitis, or atopic dermatitis was noted. It was also inquired whether in the last 12 months children presented chest wheezing or whistling (asthma), sneezes, runny or stuffed nose (allergic rhinitis), or had itchy rashes (atopic dermatitis). An affirmative answer to these questions was defined as the presence of the corresponding allergic disease.

Statistical analysis

Categorical variables were expressed as absolute frequencies and proportions. Multivariate models were developed using logistic regression to identify whether exposure to dogs or cats is a factor associated with asthma, allergic rhinitis, or atopic dermatitis according to the age group of the children (<5 years vs. ≥5 years). Independent covariates that were part of all models were gender of the children, current maternal smoking, current paternal smoking, prematurity, history of breastfeeding, history of maternal or paternal atopy, mode of delivery, and personal history of other allergic diseases. The interaction between exposure to the number of cats and dogs and their association with asthma was explored using the Chi-squared test for trends and multivariate analysis. The odds ratio (OR) and 95% confidence intervals (95% CI) were calculated using binary logistic regression. $P \leq 0.05$ was considered statistically significant.

Ethical considerations

Parents or legal guardians gave consent to participate in the study. Completing the anonymous online survey by either parent was considered as granting of informed consent. The Ethics and Research Committee of Hospital Civil de Guadalajara (No. CEI-00008, July 15, 2021) and the DIF authorities approved the protocol of this study.

Results

A total of 525 children were included, of whom 67.0% were aged <5 years, and 51.4% were females. Regarding dog exposure, 29.3% had never been exposed, while 35.8% had prolonged exposure. Concerning cat exposure 74.5% had never been exposed, while 6.9% had prolonged exposure to cats (Table 1).

When comparing the prevalence of allergic diseases with age group, asthma was more frequent in children

Table 1 Clinical characteristics of 525 children attending daycare centers.

Variable	Frequency
Gender	
Female	270 (51.4)
Male	255 (48.6)
Age	
<5 years	352 (67.0)
≥5 years	173 (33.0)
Mode of delivery	
Vaginal	179 (34.1)
Cesarean	346 (65.9)
Prematurity	32 (6.1)
Breastfeeding	
No	38 (7.2)
1-5 months	163 (31.0)
≥6 months	324 (61.7)
Dog exposure	
No	154 (29.3)
Just in the first year	134 (25.5)
Just in the previous year	49 (9.3)
Prolonged	188 (35.8)
Cat exposure	
No	391 (74.5)
Just in the first year	74 (14.1)
Just in the previous year	24 (4.6)
Prolonged	36 (6.9)
Active smoking	
Maternal	66 (12.6)
Paternal	120 (22.9)
Family history of atopy	
Maternal	97 (18.5)
Paternal	55 (10.5)
Atopic disease	
Asthma	25 (4.8)
Allergic rhinitis	104 (19.8)
Atopic dermatitis	65 (12.4)

Note: Values represent frequencies, with proportions in parentheses.

aged ≥5 years than in the <5 years group (7.5% vs. 3.4%, $P = 0.038$). However, there were no significant differences in the prevalence of allergic rhinitis (20.2% vs. 19.6%, $P = 0.865$) or atopic dermatitis (12.1% vs. 12.5%, $P = 0.906$).

Table 2 shows two multivariate models for each of the following dependent variables: asthma, allergic rhinitis, and atopic dermatitis, according to the age of the children (<5 years and ≥5 years) (six models in total).

Exposure to dogs or cats was not associated with asthma in children aged <5 years, but allergic rhinitis was associated. In children aged ≥5 years, prolonged exposure to dogs, but not cats, was significantly associated with asthma (adjusted Odds Ratio (aOR): 10.04, $P = 0.040$). Other factors that were associated included current maternal smoking (aOR: 7.01, $P = 0.008$) and allergic rhinitis (aOR: 6.28, $P = 0.006$) (Table 2, models 1 and 2).

Regarding allergic rhinitis in children aged <5 years, neither exposure to dogs nor cats acted as risk factors;

however, paternal atopy (aOR: 4.03, $P < 0.001$), asthma (aOR: 4.62, $P = 0.016$), and dermatitis (aOR: 3.80, $P < 0.001$) showed a positive association with allergic rhinitis. In children aged ≥5 years, as in the previous model, exposure to dogs or cats was not associated with allergic rhinitis. However, a maternal family history (aOR: 5.96, $P < 0.001$), a paternal family history (aOR: 5.54, $P = 0.009$), asthma (aOR: 7.17, $P = 0.004$), and atopic dermatitis (aOR: 5.73, $P = 0.002$) were associated (Table 2, models 3 and 4).

In the final model for atopic dermatitis in both children aged <5 years and ≥5 years, exposure to dogs or cats was not associated. Allergic rhinitis was the only factor that showed an association in the final model in both children aged <5 years and ≥5 years, with aOR of 3.92 ($P < 0.001$) and aOR of 4.62 ($P = 0.002$), respectively (Table 2, models 5 and 6).

Regarding the number of pets, it was found that increased contact with cats was associated with a higher prevalence of asthma ($P = 0.035$), which was not the case with increased contact with dogs ($P = 0.15$). However, there was a significant trend in increase in asthma prevalence with the history of combined exposure ($P = 0.013$), varying from 4.1% (no contact) to 30% (contact with both more than one cat and one dog) (Table 3). Based on this and considering a possible interaction between exposure to dogs and cats, Table 4 presents four multivariate logistic regression models exploring whether combined exposure to these two types of pets modifies their association with asthma. According to the final model (Table 4), after adjusting for other variables, the history of contact with both more than one dog and one cat showed a strong significant association with the prevalence of asthma (OR = 23.7; $P < 0.001$). In this same model, allergic rhinitis was also identified as an associated factor (OR = 4.2, $P = 0.01$).

Discussion

Our study highlights the role of exposure to dogs or cats on the prevalence of allergic diseases according to age, emphasizing that only prolonged exposure to dogs in children aged ≥5 years is positively associated with asthma. This finding is novel and is not reported previously. Additionally, we observed that contact with both more than one dog and one cat was also notably associated with the prevalence of asthma.

Analyzing the association of exposure to pets, primarily dogs and cats, is not new; however, the available evidence remains inconsistent. In our study, children aged ≥5 years who were exposed to dogs for prolonged periods showed a higher likelihood of developing asthma. This aligns with a meta-analysis conducted on nearly two million children⁷ but differs from another analysis that involved more than 77,000 European children.⁶ However, while the first meta-analysis found that living with dogs increased the likelihood of asthma by 12%, it had the limitation of not differentiating between the timing of exposure.⁷ In Sweden, early exposure to cats or dogs was associated with a lower risk of allergic sensitization to these animals. Specifically, exposure to cats reduced the risk of allergic rhinitis, while exposure to dogs did not alter asthma prevalence.³ Notably, children who were early exposed to female dogs or two or

Table 2 Multivariate analysis of the association between exposure to dogs or cats and asthma, allergic rhinitis, and atopic dermatitis.

	Age group					
	<5 years			≥5 years		
	aOR	95% CI	P	aOR	95% CI	P
Models 1 and 2						
Dependent variable: asthma ¹						
Dog exposure*						
Just first year	-	-	0.537	3.87	0.35-42.31	0.267
Just previous year	-	-	0.374	-	-	0.998
Prolonged	-	-	0.804	10.04	1.11-90.67	0.040
Cat exposure*						
Just first year	-	-	0.320	-	-	0.974
Just previous year	-	-	0.330	-	-	0.893
Prolonged	-	-	0.805	-	-	0.371
Maternal active smoking	-	-	0.396	7.01	1.67-29.35	0.008
Allergic rhinitis	4.40	1.37-14.1	0.013	6.28	1.69-23.27	0.006
Models 3 and 4						
Dependent variable: rhinitis alérgica ²						
Dog exposure*						
Just first year	-	-	0.722	-	-	0.608
Just previous year	-	-	0.104	-	-	0.192
Prolonged	-	-	0.931	-	-	0.962
Cat exposure*						
Just first year	-	-	0.828	-	-	0.717
Just previous year	-	-	0.129	-	-	0.095
Prolonged	-	-	0.814	-	-	0.155
Maternal atopy	-	-	0.063	5.96	2.28-15.52	<0.001
Paternal atopy	4.03	1.95-8.31	<0.001	5.54	1.54-19.94	0.009
Asthma	4.62	1.33-16.02	0.016	7.17	1.88-17.52	0.004
Atopic dermatitis	3.80	1.89-7.66	<0.001	5.73	1.87-17.52	0.002
Models 5 and 6						
Dependent variables: dermatitis atópica ³						
Dog exposure*						
Just first year	-	-	0.599	-	-	0.352
Just previous year	-	-	0.872	-	-	0.515
Prolonged	-	-	0.316	-	-	0.899
Cat exposure*						
Just first year	-	-	0.868	-	-	0.753
Just previous year	-	-	0.604	-	-	0.789
Prolonged	-	-	0.530	-	-	0.087
Allergic rhinitis	3.92	2.00-7.66	<0.001	4.62	1.77-12.03	0.002

Notes: aOR: adjusted odds ratio by binary logistic regression.

CI: confidence interval.

*Compared to non-exposed.

¹Asthma model adjusted for the following variables that did not show a significant association: gender (male), current smoking in father, prematurity, breastfeeding, maternal atopy, paternal atopy, mode of delivery (cesarean), and atopic dermatitis.

²Allergic rhinitis model adjusted for the following variables that did not show a significant association: gender (male), current smoking in mother, current smoking in father, prematurity, breastfeeding, and mode of delivery (cesarean).

³Atopic dermatitis model adjusted for the following variables that did not show a significant association: gender (male), current smoking in mother, current smoking in father, prematurity, breastfeeding, maternal atopy, paternal atopy, mode of delivery (cesarean), and asthma.

The variables were included in each model using the "Forward: conditional" method. If in the last step, the variable shows $P > 0.05$, it is automatically excluded from the final model, so the OR value and its confidence interval are not calculated.

more dogs had a lower frequency of asthma, compared to those exposed to male dogs, a single dog, or none.⁴

When evaluating lifetime pet exposure, from birth to the age of 17 years, no association was found with the development of asthma.⁵ Recently, a study conducted in Poland analyzed pet exposure similarly to our study. In that

study, children who had recently lived with a dog were less likely to develop asthma and experience a lower frequency of wheezing in the past year; however, when dog exposure occurred in both the past and the present, this effect disappeared.¹⁰

The methodology used by the Global Asthma Network has provided more information on this topic. In Mexico, contradictory results were observed using this methodology. Regarding asthma, exposure to dogs during the first year of life increased the risk in boys aged 6-7 years but not in adolescents or girls.¹¹ Conversely, exposure to cats in the previous year increased the likelihood of allergic rhinitis in adolescents but not in school-aged children. Additionally, exposure to dogs in the first year of life was related to allergic rhinitis but only in girls.¹² Both school-aged boys and girls with atopic dermatitis had an increased likelihood of the condition when exposed to dogs but not cats during the first year of life. In adolescents, only girls had an increased risk if contact had occurred in the previous 12 months.¹³ Two other studies conducted in Mexico provided additional information about the relationship between pet exposure and allergic diseases. In the first study, school-going children, aged 6-7 years, had a lower risk of atopic dermatitis when exposed early to dogs. This effect was observed regardless of whether the dog was inside or outside the house.¹⁴ In the second study, late adolescents exposed to indoor dogs (but not cats) in the previous year had an increased likelihood of developing asthma, but not allergic rhinitis or atopic dermatitis.¹⁵ In summary, unlike previous studies that focused primarily on pet exposure during the first year of life, our study evaluated for the first time the role of contact with dogs and cats at different levels of exposure on the prevalence of

Table 3 Prevalence of asthma according to the number of pets in contact.

	Asthma		P for tendency
	Yes n (%)	No n (%)	
Contact with dogs			0.15
0	12 (4.2)	276 (95.8)	
1	5 (3.4)	141 (96.6)	
>1	8 (8.8)	83 (91.2)	
Contact with cats			0.035
0	19 (4.1)	446 (95.9)	
1	3 (8.6)	32 (91.4)	
>1	3 (12.0)	22 (88.0)	
Contact with both			0.013
None	11 (4.1)	255 (95.9)	
1 cat or 1 dog	4 (2.7)	143 (97.3)	
1 cat and 1 dog	2 (11.8)	15 (88.2)	
>1 cat and >1 dog	3 (30.0)	7 (70.0)	

Note: P value obtained by Chi-squared for tendencies (linear-by-linear association).

Table 4 Multivariate analysis of the interaction between the number of pets and its association with asthma in the presence of other explanatory variables.

	Model 1		Model 2		Model 3		Model 4	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Contact with pets*								
1 dog or 1 cat	0.6 (0.2-2.1)	0.47	0.6 (0.2-2.0)	0.44	0.6 (0.2-1.9)	0.38	0.5 (0.2-1.9)	0.34
1 dog and 1 cat	3.1 (0.6-15.2)	0.17	3.0 (0.6-15.0)	0.18	2.5 (0.5-13.2)	0.30	2.6 (0.4-15.6)	0.30
>1 dog and >1 cat	9.9 (2.3-43.7)	0.002	10.1 (2.3-45.0)	0.002	13.1 (2.5-70.0)	0.003	23.7 (3.7-151.7)	<0.001
Gender (male)			0.7 (0.3-1.8)	0.49	0.7 (0.3-1.9)	0.50	0.6 (0.2-1.7)	0.35
Age (≥5 years)			1.8 (0.7-4.6)	0.21	1.8 (0.7-4.6)	0.24	1.9 (0.7-5.2)	0.21
Maternal active smoking					3.0 (1.0-9.1)	0.052	3.3 (1.0-11.3)	0.053
Paternal active smoking					0.5 (0.2-1.8)	0.33	0.6 (0.2-2.1)	0.40
Mode of delivery (cesarean)**					1.7 (0.6-5.1)	0.35	1.8 (0.6-6.0)	0.31
Prematurity					2.2 (0.5-10.8)	0.32	2.5 (0.5-13.5)	0.27
Breastfeeding					2.5 (0.3-21.9)	0.40	1.5 (0.2-14.3)	0.71
Allergic rhinitis							4.2 (1.4-12.6)	0.01
Atopic dermatitis							1.7 (0.5-5.9)	0.41
Maternal atopy							2.5 (0.8-7.7)	0.10
Paternal atopy							1.1 (0.3-4.8)	0.90

Method of variable entry into each model: "Enter."

*Notes: Reference category: "not exposed to pets."

**Reference category: "vaginal birth."

Odds ratios obtained through binary logistic regression.

allergic diseases. We observed that prolonged exposure to dogs, both during the first year of life and in the year prior to the study, was positively associated with asthma prevalence but not with allergic rhinitis or atopic dermatitis in children aged ≥ 5 years.

Our study is among the first studies to show that the gradient of exposure to living with dogs and cats increases the likelihood of asthma in children attending childcare centers. In the United States, no evidence of association was observed when the presence of more than one dog or more than one cat was independently evaluated in relation to asthma in school-aged children. It is important to note that despite the large number of children included in the study, the interaction between pets was not evaluated.⁶ In China, a study observed a dose-response effect between living with two or more dogs, cats, or rodents and a higher frequency of wheezing and chronic cough in children aged < 9 years, but not with the prevalence of asthma or allergic rhinitis.⁸ Further studies are needed to analyze not only the gradient of pet exposure but also the interaction between different types of animals in the household.

Although it has been hypothesized that early exposure to dogs, but not cats, is associated with a lower likelihood of asthma, our study did not support this assertion. On the contrary, we found that prolonged exposure acted as an independent risk factor. Genetic and environmental interactions potentially play an important role in development of asthma. In the United Kingdom, *rs2305480* expression, a genetic variant on chromosome 17q21, was associated with persistent wheezing (OR 1.37; 95% CI: 1.25-1.51), but the effect was attenuated with early exposure to dogs in the household.¹⁶ Another possibility is that prolonged exposure to dogs increases exposure to their allergens, thereby increasing asthma risk. During the COVID-19 pandemic, sensitization to cats and dogs significantly increased compared to the pre-pandemic period following a prolonged exposure period.²

The role of the microbiota also has been proposed as an explanation for the relationship between pets and asthma. The arrival of a dog in the household has noticeable early and late implications for the household microbiota;^{17,18} perhaps the protective effect only occurs when exposure is transient and not prolonged, as observed in our study. Finally, families with a history of asthma may avoid exposure to dogs, possibly because of prior allergic sensitization, which would make it appear that asthma prevalence is higher among those exposed to dogs (selection bias).

This study has several limitations, most of which are related to the evaluation of pet exposure. First, exposure was only investigated within the household, without considering other places where inadvertent pet exposure could occur.¹⁹ Additionally, the breed, gender of the pets, and the presence of other types of creatures, such as birds, rabbits, and mice, were not assessed. Another limitation is that the study did not explore whether living with pets began before or during pregnancy, or whether there was a close contact with the baby after birth, factors that have been associated with a reduced risk of food allergies.²⁰ It also did not evaluate whether strategies were implemented to minimize contact with pets. It is important to note that the children analyzed in this study were the progeny of workers who attended public childcare centers,

and therefore do not represent the reality of children attending private centers, where different socioeconomic conditions prevail. The diagnosis of allergic diseases was based on a survey rather than on a clinical history; skin prick tests, specific IgE determination, or respiratory function tests were also not performed to support the diagnosis. Likewise, pet exposure was determined based on self-reported information provided by parents or guardians. Finally, the inherent limitations of cross-sectional studies should also be considered.

Conclusion

Prolonged exposure to dogs increases the likelihood of asthma. While this was initially observed only in children aged ≥ 5 years, the interaction between living with more than one dog and more than one cat was found to be a factor associated with asthma in all children studied. These findings suggest that dogs are not recommended as an intervention to prevent asthma, allergic rhinitis, or atopic dermatitis. Further studies addressing the limitations of our research may provide greater clarity on this matter.

Mandatory Disclosure on Use of Artificial Intelligence

The authors declare that no AI-assisted tools were used in the preparation of this manuscript. All references have been manually verified for accuracy and relevance.

Author Contributions

All authors contributed equally to this article.

Conflicts of Interest

The authors declared no potential conflict of interest with respect to research, authorship, and/or publication of this article.

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