Cats and dogs and the risk of atopy in childhood and adulthood

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Background: Exposure to cats and dogs during childhood has been linked to a lower risk of developing allergies. It remains unclear whether this is due to selective avoidance of pets by families with a history of allergies. The effects of pet ownership in adulthood are unknown.

Objectives: We sought to assess the association between cat and dog ownership in childhood and early adulthood and the development of atopy in a population-based birth cohort of 1037 subjects.

Methods: Ownership of cats or dogs between birth and age 9 years and between the ages of 18 and 32 years was reported. Skin prick tests to common allergens were performed at 13 and 32 years.

Results: There was no evidence that families with a history of atopy avoided owning pets. There were significant cat-by-dog interactions for the development of atopy in both childhood and adulthood. Children who had owned both a cat and a dog were less likely to be atopic at age 13 years. Living with only one of these animals was not protective against atopy. Among those who were not atopic by age 13 years, having both a cat and a dog in adulthood was associated with a lower risk of new atopy by age 32 years. This association was only significant among those with a parental history of atopy. These effects were independent of a range of potential confounding factors.

Conclusions: There is a synergistic interaction between cat and dog exposure that is associated with a lower risk of developing atopy in childhood and young adulthood. (J Allergy Clin Immunol 2009;124:745-50.)

Key words: *Animals, pets, risk factors, cat, dog, atopy, interaction*

There are numerous reports of a lower prevalence of allergic diseases among those living on farms or with pet cats or dogs in childhood.[1-10] These findings suggest that animal exposure protects against the development of atopy. However, the issues are complex. Several studies have not found a protective effect against allergic sensitization[11-14] and, in environments in which exposure to animals is uncommon, having a pet cat has been associated with increased sensitization.[15,16] Where an apparent protective effect of animal exposure has been observed, it is possible that this could be due to selective avoidance of pets by families with a history of atopic disease.[11,17-26] Similarly a "healthy worker" effect has been invoked as a possible explanation for the lower prevalence of atopy among children raised on farms.[27-29]

Studies also differ according to whether cats or dogs are most protective.[2,3,6,9,30-32] It remains unclear whether the protective effect (if any) of owning a pet is due to exposure to high levels of allergens or to other factors, such as microbial or endotoxin exposure. Among children living on farms, the apparent reduction in allergies might be attributable to drinking unpasteurized milk rather than animal exposure *per se*.[33]

Most studies investigating the associations between animal exposure and allergic diseases have focused on childhood exposures. One study reported that childhood pet ownership, but not current pet ownership, was associated with a lower prevalence of atopy in adults.[7] However, another cross-sectional study in adults found that ownership of cats was associated with reduced sensitization to both cats and dogs but not dust mite or grass.[31] In that study there appeared to be a combined effect of cat, dog, and dust mite exposure, with the highest prevalence of sensitization among the medium combined-exposure groups.[31] Few other studies have reported the effects of exposure to multiple animals, although Ownby et al[5] found that a reduced prevalence of atopy was only observed among children who have been exposed to at least 2 cats or dogs during infancy.

In the context of a longitudinal study of a birth cohort followed to age 32 years, we tested the hypothesis that living with cats or dogs was protective against the development of atopy during childhood. We further assessed whether having cats or dogs as an adult protected against the development of new atopy in adulthood, and we assessed the effects of combined cat and dog ownership. The Dunedin cohort provides objective outcomes and sufficient information to address many potentially confounding issues, in particular whether the association between pet ownership and development of atopy could be explained by avoidance of pets by families with a history of atopy.

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Abbreviation used
OR: Odds ratio

METHODS

The Dunedin Multidisciplinary Health and Development Study is a longitudinal investigation of health and behavior in an unselected birth cohort. Study members were born in Dunedin, New Zealand, between April 1972 and March 1973.[34-36] One thousand and thirty-seven children (91% of eligible births; 535 [52%] male) participated in the first follow-up at age 3 years. Cohort families represented the full range of socioeconomic status of the South Island of New Zealand. Follow-up assessments were subsequently completed at 5, 7, 9, 11, 13, 15, 18, 21, 26, and 32 years. Study members mostly identified themselves as New Zealand/European ethnicity. The Otago Ethics Committees approved the study, and written informed consent was obtained at each assessment.

Cat and dog ownership at birth and ages 3, 5, 7, and 9 years was recorded retrospectively from parental recall when the children were seen at age 9 years. Children were regarded as having lived with these animals if cat or dog ownership was reported for any of these ages. At ages 18, 21, 26, and 32 years, the Study members were asked whether they currently had a cat or dog at home. Adult ownership of these animals was defined as a positive response at any of these ages.

Parental history of asthma or hay fever was recorded at the visits at age 7 and 18 years. A parental history of atopy was defined as a positive response for either parent at one of these ages. A number of other covariates, which have been shown to influence the risk of atopy in this cohort, were also considered. Breast-feeding was recorded retrospectively at age 3 years and validated from prospective visiting nurse records.[37] Parental smoking was reported at ages 7, 9, 11, and 13 years.[36] Current adult smoking was assessed at age 32 years and defined as smoking at least 1 cigarette a day for a month in the previous year.[36] An index of household crowding was developed according to the number of children in the house at the assessment at 3 years of age divided by the number of rooms (excluding kitchens and bathrooms; Hancox RJ, unpublished data). Socioeconomic status was recorded as the highest level for either parent based on occupational status and averaged over multiple assessments from birth to age 13 years.[38]

Skin prick testing was first performed at age 13 years and most recently at age 32 years.[34-36] Allergens tested at age 13 years were *Dermatophagoides pteronyssinus* (Bencard, Brentford, United Kingdom), grass, cat, dog, horse, kapok (seedhair from kapok tree), wool, *Aspergillus fumigatus*, *Alternaria* species, *Penicillium* species, and *Cladosporium* species (Hollister-Stier, Spokane, Wash). At age 32 years, these allergens were supplied by ALK (Allergy Canada, Thornhill, Ontario, Canada). A wheal 2 mm or greater in diameter than that elicited by the negative control was considered positive.

The ownership of cats or dogs during childhood and adulthood was compared for those with and without a parental history of atopy and tested using χ^2 statistics to assess whether a parental history of atopy influenced pet keeping. Adult cat and dog ownership was compared between those who did and did not have atopy by age 13 years to assess whether having atopy as a child influenced the likelihood of pet ownership in adulthood.

Associations between cat or dog ownership in childhood and the development of atopy were assessed by using logistic regression. The primary outcome for these analyses was any positive skin prick test response (any atopy) at age 13 years. Secondary outcomes included atopy for cats, dogs, house dust mite, and grass. Analyses tested whether the influence of cat or dog ownership on the development of atopy was different in those with and without a parental history of atopy by computing parental history-by-pet interaction terms. Analyses also tested whether the effect of owning either a cat or dog was influenced by ownership of the other animal by computing cat-by-dog interaction terms. Subsequent analyses adjusted for sex, parental history of atopy, breast-feeding, parental smoking, household crowding, and socioeconomic status.

Similar logistic regression analyses were used to assess the associations between adult cat and dog ownership and the development of new atopy between the ages of 13 and 32 years. These analyses excluded those already atopic at age 13 years. These analyses also tested parental history-by-pet and cat-by-dog interactions. Subsequent analyses adjusted for sex, parental history of atopy, pet ownership before age 9 years, current adult smoking, breast-feeding, household crowding, parental smoking, and socioeconomic status.

Statistical analyses were performed with STATA version 10 software (StataCorp, College Station, Tex). *P* values of less than .05 were considered statistically significant.

RESULTS

Of the 1035 living Study members at age 9 years, 815 (79%) provided data regarding cat and dog ownership during childhood, of whom 101 (12.4%) had had no cat or dog to age 9 years. The same number of participants also provided complete pet ownership data for ages 18, 21, 26, and 32, years, with 688 participants providing complete data for both childhood and adult exposures. Only 17 (2.5%) of these 688 participants had not had either a cat or dog at home at any age. The characteristics of those with and without pet data for childhood and adulthood are shown in Table E1 (available in this article's Online Repository at www.jacionline.org). Those with incomplete pet data were less likely to have atopy at ages 13 and 32 years.

Children who had been exposed to a dog by age 9 years were also more likely to have been exposed to cats (Table I). However, adults who had a dog between the ages of 18 and 32 years were no more likely to have had a cat (Table I). Children who had had a cat or dog at home by age 9 years were more likely to live with these animals between the ages of 18 and 32 years ($P < .001$ for both cats and dogs).

Influence of atopic history on cat and dog ownership

There were no significant differences in cat or dog ownership in childhood between those with and without a parental history of atopy (Table II). Neither retention of cats or dogs between birth and age 9 years nor acquisition of a cat or dog by those without one at birth differed between those with and without a parental history of atopy (all $P > .8$). There were also no differences by parental history in the proportion of children who had had both pets by age 9 years (41.7% of children of atopic parents vs 38.7% of children of nonatopic parents, $P = .390$) or in the proportion who had had neither pet (13.5% of children of atopic parents vs 12.1% of children of nonatopic parents, $P = .566$).

There were also no significant differences in adult cat or dog ownership between those with and without a parental history of atopy (Table II). Those who were atopic to any allergen at age 13 years and those atopic to dogs specifically were slightly less likely to have a dog in adulthood, although these differences were not significant ($P = .350$ and $P = .209$, respectively). Neither atopy to any allergen nor atopy to cats specifically at age 13 years appeared to influence cat ownership in adulthood ($P = .573$ and $P = .521$, respectively).

Cat and dog ownership in childhood and risk of atopy

The association between ownership of a pet and the development of atopy by age 13 years was not influenced by a parental

TABLE I. Cat and dog ownership in childhood and adulthood

		Dog					
		Birth to age 9 y			Ages 18-32 y		
		No	Yes	Total	No	Yes	Total
Cat	No	101 (12.4%)	74 (9.8%)	175 (21.5%)	44 (5.4%)	68 (8.3%)	112 (13.7%)
	Yes	308 (37.8%)	332 (40.7%)	640 (78.5%)	248 (30.4%)	455 (55.8%)	703 (86.3%)
	Total	409 (50.2%)	406 (49.8%)	815	292 (35.8%)	523 (64.2%)	815

The association between cat and dog ownership in childhood is significant (χ^2 [1] = 5.05, P = .025). The association between cat and dog ownership in adulthood is not significant (χ^2 [1] = 0.68, P = .411).

TABLE II. Cat and dog ownership at different ages according to parental history of atopy

	Cat			Dog		
Age	Parental history positive	Parental history negative	*P* value	Parental history positive	Parental history negative	*P* value
Birth to age 9 y	274/348 (78.7%)	347/445 (78.0%)	.797	172/348 (49.4%)	216/445 (48.5%)	.804
18-32 y	324/369 (87.8%)	368/433 (85.0%)	.248	236/369 (64.0%)	278/433 (64.2%)	.942
Any age birth to 32 y	284/308 (92.2%)	345/374 (92.3%)	.985	233/308 (75.7%)	280/374 (74.9%)	.814

Tests of significance by χ^2 analysis with 1 *df*. Only those with complete data for all of the relevant ages are included.

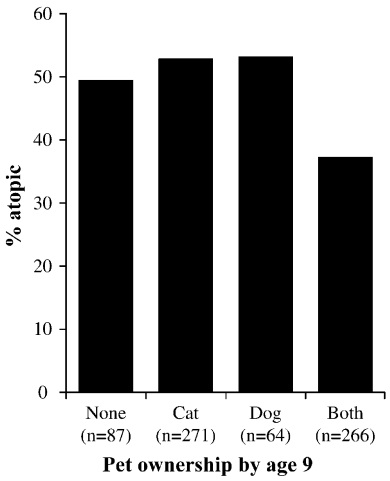

FIG 1. Atopy at age 13 years according to pet ownership by age 9 years. The difference between groups is significant (χ^2 [3] = 14.9, P = .002).

history of atopy: interaction terms between a parental history of atopy and ownership of a cat, dog, or both were not significant, and the influences of cat and dog ownership on atopy were similar in those with and without a parental history of atopy in stratified analyses.

There was a significant interaction between cat ownership and dog ownership for the development of atopy by age 13 years (P = .036). A reduced risk of atopy at age 13 years was observed in children who had both a cat and a dog at home by age 9 years (Fig 1 and Table III). Ownership of either pet alone was not associated with a reduction in risk. The reduction in risk associated with having both animals (compared with having none) was no longer statistically significant after adjustment for parental history of atopy, sex, breast-feeding, parental smoking, childhood socioeconomic status, and household crowding (Table III). However, having both a cat and a dog by age 9 years remained significantly associated with a reduced risk of atopy at age 13 years compared with the other categories of pet ownership combined (Table IV).

Combined cat and dog ownership was also associated with a significantly reduced risk of specific atopy to house dust mite, grass, and cat. There was also a trend toward reduced atopy to dogs, although dog atopy was relatively uncommon and this was not statistically significant (Table IV).

Cat and dog ownership in adulthood and risk of atopy

Among those who were not atopic at age 13 years, the risk of having atopy by age 32 years differed according to pet ownership in adulthood (Fig 2). There was a significant interaction between cat and dog ownership in adulthood in predicting new atopy at age 32 years (P = .009). The risk of new atopy by age 32 years was significantly lower among those who had had both a cat and a dog at some time during adulthood when compared with those who had only 1 or none of these pets (n = 333; odds ratio [OR], 0.57; P = .015). Those who had neither pet in adulthood also appeared to have a low risk of atopy, although there were only a small number of participants in this group (n = 22), and this difference was not statistically significant compared with the other categories of pet ownership.

There was a borderline-significant interaction between a parental history of atopy and combined cat and dog ownership on the development of new atopy between ages 13 and 32 years (P = .067). When tested as a 3-way interaction between cat, dog, and parental history (parental history of atopy-by-cat-by-dog), this was statistically significant (P = .024). The apparent protective effect of owning both a cat and a dog was greater among those with a parental history of atopy (n = 135; OR, 0.33; P = .003) than among those without (n = 195; OR, 0.80; P = .490; Table V). This association among those with atopic parents remained significant after adjustment for sex, parental smoking, adult smoking,

TABLE III. Childhood ownership of cats and dogs and development of any atopy by age 13 years

	Unadjusted (n = 688)					Adjusted (n = 674)				
Pet	**No.**	**Atopic (%)**	**OR**	**95% CI**	***P* value**	**No.**	**Atopic (%)**	**OR**	**95% CI**	***P* value**
None	87	43 (49.4)	1	–	–	87	43 (49.4)	1	–	–
Cat	271	143 (52.8)	1.14	0.71-1.85	.587	267	141 (52.8)	1.20	0.72-1.99	.487
Dog	64	34 (53.1)	1.16	0.61-2.21	.653	62	33 (53.2)	1.08	0.54-2.13	.832
Both	266	99 (37.2)	0.61	0.37-0.99	.045	258	97 (37.6)	0.70	0.41-1.17	.170

The total number of participants in each pet ownership category and the number (percentage) who were atopic at age 13 years are shown. ORs (95% CIs) and *P* values are from logistic regression analyses by using the group who had not lived with either pet by age 9 years as the reference category. Adjusted analyses adjust for sex, parental history of atopy, breast-feeding, parental smoking, socioeconomic status, and household crowding.

TABLE IV. Ownership of both a cat and a dog and development of any atopy and specific atopy by age 13 years

	Unadjusted (n = 688)				Adjusted (n = 674)			
Allergen	**Atopic (%)**	**OR**	**95% CI**	***P* value**	**Atopic (%)**	**OR**	**95% CI**	***P* value**
Any	319 (46.4%)	0.54	0.40-0.74	<.001	314 (46.6%)	0.61	0.44-0.86	.004
Dust mite	213 (31.0%)	0.58	0.41-0.82	.002	211 (31.3%)	0.65	0.45-0.93	.019
Grass	231 (33.6%)	0.58	0.41-0.81	.001	226 (33.5%)	0.66	0.46-0.94	.021
Cat	92 (13.4%)	0.58	0.36-0.95	.029	92 (13.6%)	0.68	0.41-1.13	.135
Dog	38 (5.5%)	0.63	0.31-1.29	.209	38 (5.5%)	0.73	0.35-1.56	.422

The numbers (percentages) of participants who were atopic to each allergen at age 13 years are shown. Analyses were performed with logistic regression using ownership of both a cat and a dog by age 9 years (compared with no pets or just 1 type of pet) as the predictor. Adjusted analyses adjust for sex, parental history of atopy, breast-feeding, parental smoking, socioeconomic status, and household crowding.

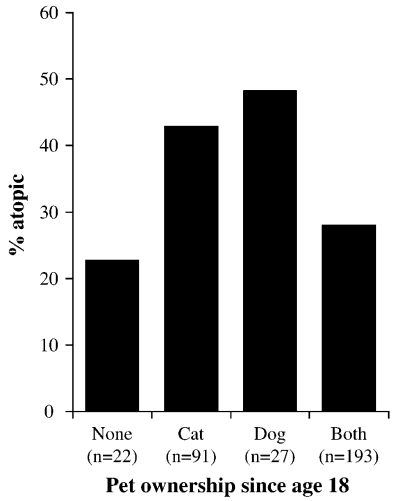

FIG 2. Atopy at age 32 years according to pet ownership since age 18 years. Analyses are restricted to these who were not atopic at age 13 years. The difference between groups is significant (χ^2 [3] = 10.0, *P* = .019).

household crowding, breast-feeding, childhood and adult socioeconomic status, and pet ownership in childhood (n = 127; OR, 0.33; *P* = .021). Pet ownership before age 9 years was not a significant predictor of the development of atopy in these models.

Combined cat and dog ownership was also associated with a lower risk of new atopy to house dust mite among those with atopic parents. The association with a reduced risk of grass atopy was of borderline significance (Table V). Among participants with a parental history of atopy, very few who were not already atopic by age 13 years had specific cat (n = 9) or dog (n = 1) atopy by age 32 years.

DISCUSSION

The findings from this study support the hypothesis that living with cats and dogs during childhood influences the development of atopy and suggest that these exposures also influence the development of atopy in young adults. The apparent protective effect of living with pets was only observed among those who had both a cat and a dog. The reduction in risk among those with cats and dogs was not specific to animal allergens but included multiple allergens, including house dust mite and grass. These associations were independent of a number of other known childhood risk factors for the development of atopy. However, in adulthood the protective effect of having both pets on the development of new atopy was only observed among those with a family history of atopy.

Importantly, our findings cannot be explained by selection or avoidance bias in pet ownership caused by a parental history of atopy. Parents with a history of asthma or hay fever were no less likely to have cats or dogs in the home at the time of the child's birth and were no more or less likely to acquire a cat or dog or to get rid of an existing cat or dog in the first 9 years of the child's life. Parents of children who had atopy by age 13 years were also no more or less likely to have acquired or removed a pet from the home before age 9 years, suggesting that household pet ownership was not influenced by allergies developing in the child. Adults whose parents were atopic were not less likely to have cats or dogs at home between the ages of 18 and 32 years. The development of specific cat atopy by age 13 years did not influence the likelihood of living with a cat as an adult, although there was a (nonsignificant) trend for those who were allergic to dogs at age 13 years to be less likely to have a dog in adulthood. It seems very unlikely that this trend influenced the findings because the analyses regarding new adult atopy were restricted to those who were not atopic at age 13 years. Thus it is improbable that these associations can be explained by avoidance of pets by those at higher risk of atopy ("reverse causation").

TABLE V. Ownership of both a cat and a dog and development of atopy between ages 13 and 32 years

	Parental history of atopy (n = 135)				No parental history of atopy (n = 195)			
Allergen	**Atopic (%)**	**OR**	**95% CI**	***P* value**	**Atopic (%)**	**OR**	**95% CI**	***P* value**
Any	51 (37.8%)	0.33	0.16-0.68	.003	59 (30.0%)	0.80	0.43-1.49	.490
Dust mite	27 (20.0%)	0.42	0.18-0.99	.049	40 (20.5%)	0.98	0.48-1.97	.949
Grass	28 (20.7%)	0.47	0.20-1.08	.076	28 (14.4%)	0.58	0.26-1.30	.185

The numbers (percentages) of participants who were atopic to each allergen at age 32 years are shown. Analyses are restricted to those who were not already atopic at age 13 years. Analyses were performed with logistic regression using ownership of both a cat and dog between ages 18 and 32 years (compared with no pets or just 1 type of pet) as the predictor.

The definition of a positive skin prick test response varies in different studies and circumstances. A wheal size of 3 mm is widely used clinically, but this might not be sufficiently sensitive for epidemiologic research. Indeed, a recent report suggests that any wheal (ie, >0 mm) is the most appropriate criterion for epidemiologic studies.[39] In keeping with previous publications from this cohort, we defined atopy as a wheal with a diameter at least 2 mm larger than that produced by the negative control.[34,36-38] However, analyses using a cutoff point of 3 mm provided similar findings (see Tables E2 and E3 in this article's Online Repository at www.jacionline.org).

As far as we are aware, this is the first time that an interaction between living with a cat and living with a dog has been reported. As such, this finding should be interpreted with caution, although the fact that this was a consistent finding for both childhood and adulthood suggests that this is unlikely to be a type I error. This observation might help to explain some of the inconsistency in the literature on pet keeping and atopy. Those who owned just one of these types of animal were not less likely to have atopy. However, if ownership of dogs and cats was considered separately, dog owners appeared to be protected against atopy because more than 80% of dog owners also had a cat. By contrast, cat ownership appeared less protective against atopy because a lower proportion of cat owners also had a dog (Table I). Hence the frequency of cat and dog ownership within the population and the pattern of co-ownership of these animals might influence their apparent effects on the risk for atopy. It is possible that differences in the frequency of combined cat and dog ownership in different populations explain some of the conflicting findings with regard to the effects of pet ownership on atopy and whether cats or dogs are most protective.

It is not clear why both dogs and cats appear necessary to protect against atopy. It is possible that this is simply a dose effect: those with both animals at home might have greater exposure to these animals. On the other hand, cat and dog allergens have different biochemical and pathogenic characteristics.[40,41] Fel d 1, the main cat allergen, belongs to the group of secretoglobins, whereas Can f 1, the major dog allergen, belongs to the family of lipocalins. It is possible that exposure to a range of different allergens has immunomodulatory effects that do not occur with exposure to a single allergen. Hence exposure to both animals appeared to protect against atopy to indoor and outdoor allergens, such as house dust mite and grass, as well as against specific animal atopy. Living with animals also results in endotoxin and bacterial exposures,[12,42] which might also be immunomodulatory. It is plausible that having both animals results in a wider range of these exposures and that it is this, rather than exposure to animal allergens *per se*, that influences the risk of atopy. Unfortunately, we do not have measures of allergen or endotoxin exposure to explore these questions.

The main limitation of this analysis is the fact that although 101 (12.4%) Study members had no cat or dog at home during the first 9 years of life, only 22 of those at risk for atopy in adulthood (ie, not already atopic at age 13 years) had not had either a pet cat or dog at home between the ages of 18 and 32 years. Only 7 of these had a history of parental history of atopy. Hence our ability to assess the influence of not having either pet in adulthood was limited. Therefore our analyses of adult-onset atopy primarily compared living with 1 animal to living with both. The high rate of pet ownership (particularly cats) might also limit the generalizability of these findings to populations with lower rates of pet ownership. Another limitation is that information on childhood dog and cat ownership was obtained retrospectively at age 9 years. This might have introduced some recall errors for the ages at which the Study members were exposed, but it seems unlikely that there will have been substantial misclassification as to whether the Study members had ever had a dog or cat at home. Those with missing data on pet ownership were less likely to be atopic, although this seems unlikely to bias the findings of the analyses among those with complete information.

This study also has a number of strengths. It is a population-based cohort with a high rate of participation and a long duration of follow-up. Atopy was objectively assessed with skin prick tests. Information on parental history of asthma and hay fever enables us to assess the (lack of) pet avoidance by families with a history of atopic disease. Taken together, these findings add considerable support to previous observations that pet ownership is associated with a lower risk for allergic sensitization during childhood and provide an additional observation that this protective effect might continue into adult life. We have observed for the first time that there may also be a synergistic interaction between cat and dog ownership in protecting against the development of atopy.

These findings might create difficulties in making decisions regarding the potential health effects of owning a pet. Parents with allergies are often advised not to have cats or dogs in the home. However, avoiding these pets appears to increase the risk of their child developing allergies. On the other hand, if a child becomes sensitized to his or her pet, studies indicate that continuing exposure can lead to increasing symptoms and less satisfactory asthma control.[43] If parents with atopy decide to own a pet, our data suggest that combined cat and dog ownership might be necessary to confer a protective effect.

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Key messages

- **Children living with cats and dogs had a lower risk of atopy.**
- **Adults living with cats and dogs also had a lower risk of atopy.**
- **The reduced risk of atopy was only found in those who had both animals: exposure to just a cat or dog alone was not protective.**

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TABLE E1. Comparisons of those with complete pet data for childhood and adulthood with those with missing data

	Complete pet data		Missing pet data		
	Total	No. (%)	Total	No. (%)	*P* value
Male sex	688	359 (52)	284	136 (48)	.223
Parental history of atopy	682	308 (45)	233	98 (42)	.411
Breast-fed	686	348 (51)	284	133 (47)	.269
Parents smoked	688	418 (61)	238	142 (60)	.766
Crowding*	688	272 (40)	284	127 (45)	.135
High childhood SES†	687	237 (35)	281	98 (35)	.911
High adult SES†	687	349 (51)	284	134 (47)	.305
Smoking at age 32 y	688	237 (34)	284	106 (37)	.393
Atopy at 13 y	602	286 (48)	97	29 (30)	.001
Atopy at 32 y	680	416 (61)	266	144 (54)	.048

The total number of participants available for these comparisons is based on the 972 participants assessed at age 32 years (96% of the surviving cohort). The number for each comparison is less than this if data on the variable are also missing. *P* values are from χ^2 analyses of 2 × 2 contingency tables.

SES, Socioeconomic status.

*Crowding is defined as 2 rooms per child or less.

†High childhood and adult socioeconomic status are defined as an Elley-Irving score of 3 or less. This is a 6-point scale of the Study members' (or their parents') occupation. The scale is based on the educational level and income associated with that occupation in the New Zealand census (6 = unskilled laborer, 1 = professional).[E1,E2]

TABLE E2. Childhood ownership of cats and dogs and atopy at age 13 years using a 3-mm wheal cutoff point

	Unadjusted (n = 688)					Adjusted (n = 674)				
Pet	**No.**	**Atopic (%)**	**OR**	**95% CI**	***P* value**	**No.**	**Atopic (%)**	**OR**	**95% CI**	***P* value**
None	87	36 (41.4)	1	–	–	87	36 (41.4)	1	–	–
Cat	271	119 (43.9)	1.11	0.68-1.81	.678	267	118 (44.2)	1.16	0.69-1.95	.566
Dog	64	28 (43.8)	1.10	0.57-2.12	.771	62	27 (43.6)	0.99	0.50-1.98	.980
Both	266	79 (29.7)	0.60	0.36-0.99	.045	258	78 (30.2)	0.69	0.41-1.18	.173

The total number of participants in each pet ownership category and the number (percentage) who were atopic at age 13 years are shown. In these analyses atopy is defined as a wheal of at least 3 mm greater than the diluent control. Analyses were performed with logistic regression using the group with no pets as the reference category. The adjusted analyses adjust for sex, parental atopy, breast-feeding, parental smoking, socioeconomic status, and household crowding.

TABLE E3. Ownership of both a cat and a dog and development of atopy between the ages of 13 and 32 years using a 3-mm wheal cutoff point

Pet	No.	Atopic (%)	OR	95% CI	*P* value
Parental history positive	155	55 (35.5)	0.44	0.23-0.87	.017
Parental history negative	221	65 (29.4)	0.76	0.43-1.37	.362

The total number of participants in each pet ownership category and the number (percentage) who were atopic at age 32 years are shown. Atopy was defined by a wheal of at least 3 mm greater than that elicited by the diluent control. Univariate analyses by logistic regression using ownership of both a cat and dog between the ages of 18 and 32 years (compared with no pets or just 1 type of pet) as the predictor. Analyses are confined to those not atopic (ie, skin prick wheal <3 mm greater than that elicited by the diluent control) at age 13 years.