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Cat and Dog Exposure and Respiratory Morbidities in Cystic Fibrosis

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Abstract

Objective—To understand the triggers that may impact respiratory health in cystic fibrosis (CF), including the effects of pets, because environmental factors contribute to one-half of the variation in lung function in patients with CF.

Study design—A total of 703 subjects with CF were recruited through the U.S. CF Twin-Sibling Study. Questionnaires were used to determine the presence/absence of cats and dogs in households with a child with CF. Questionnaires, chart review, and U.S. CF Foundation Patient Registry data were used to track respiratory and infection outcomes.

Results—Within the sample 47% of subjects reported owning a dog, and 28% reported owning a cat. After adjustment for demographic factors, dog ownership was not associated with any adverse clinical outcomes, and cat ownership was associated an increased risk in developing nasal polyps (adjusted OR 1.66; $p=0.024$) compared with non-cat owners. Subjects who owned both cats and dogs were twice as likely to report wheezing compared with other subjects (adjusted OR: 2.01; $p=0.009$). There were no differences in prevalence and age of acquisition for the common CF respiratory pathogens *Pseudomonas aeruginosa* and methicillin-resistant *Staphylococcus aureus* between cat/dog owners and non-cat/dog owners.

Conclusions—Cat ownership was associated with a higher frequency of developing nasal polyps and combined cat-dog ownership was associated with a higher rate of wheezing. Prospective studies are needed to confirm these associations and the potential psychosocial benefits of cat and/or dog ownership.

Keywords

Cystic Fibrosis; Pet; Dog; Cat; Lung Function; FEV₁; Allergies; Sinus Disease; Nasal Polyps; *Pseudomonas aeruginosa*; MRSA

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A substantial source of morbidity and mortality in patients with cystic fibrosis (CF) is recurrent respiratory infections with an associated decline in lung function. Familial studies suggest that environmental factors contribute to half of the variation in CF lung function,(1, 2) thus highlighting the importance of understanding environmental triggers that may impact respiratory health in CF. Several environmental factors have been shown to impact lung function in CF including secondhand tobacco smoke,(3-5) health insurance,(6, 7) household income,(8) air pollution,(9) ambient temperature,(10) and environmental allergies.(11) The presence of pets in a household with a child with CF constitutes an additional environmental factor that may impact CF lung function.

Exposure to environmental allergens like pet dander has been linked to worse respiratory outcomes in other obstructive lung diseases such as asthma.(12, 13) The effect that pet exposure has on respiratory morbidities in CF remains unclear. The possibility of pets serving as a source of respiratory pathogens is also a potential concern as a limited sampling of patients with CF and their pets (n=20) identified them as carrying the same bacteria and fungi.(14) Case reports describe the interspecies transmission of *Pseudomonas aeruginosa* from a patient with CF to a pet cat,(15) and transmission of *Bordetella bronchiseptica* from a kitten to a patient with CF,(16) as well as from dogs to lung transplant recipients with a history of CF.(17) However, it is unclear if these incidents represent a common phenomenon. Other reports and studies suggest that pets like cats and dogs may be potential sources for methicillin-resistant *Staphylococcus aureus* (MRSA) infection,(18-21) including one patient with CF.(22)

Using data from the CF Twin and Sibling Study, we examined the relationship between dog and cat ownership and common CF morbidities. Specifically, we hypothesized that ownership of a cat or dog was associated with lower lung function (FEV₁), increased risk of wheezing, increased risk of nasal polyps, increased risk of environmental allergies, increased risk of sinus disease, and/or increased risk of allergic bronchopulmonary aspergillosis (ABPA). Secondary analyses involved determining whether ownership of a cat or dog was associated with presence and/or earlier acquisition of *P. aeruginosa* or MRSA.

METHODS

All subjects (n=703 individuals) were part of the CF Twin-Sibling Study and recruited from CF centers between 10/27/2000 and 3/31/2013 on the basis of having CF and a twin or sibling with CF. Clinical data were supplemented with data obtained from the U.S. CF Foundation Patient Registry. Written consent was obtained from all subjects and the study was approved by the Johns Hopkins University Institutional Review Board (Protocol #: NA_00035659).

Age for each subject was defined by the date the questionnaire was completed. Race/ethnicity was self-defined with subjects with any reported non-white ancestry defined as non-white for regression analyses. Pancreatic status was defined by genotype as having one or more “pancreatic sufficient” mutations or 2 “insufficient” mutations (638 subjects), and by clinical data where genotype data was indeterminate or not available (61 subjects); for 4 subjects pancreatic status could not be determined.

Baseline questionnaires from subjects were obtained on enrollment and included questions on the presence and type of pets in the household. The presence of cats or dogs was defined from the questionnaire as any report of cats and/or dogs living in the household between the time of diagnosis of CF and the time of questionnaire completion. Analysis was limited to include only cat and/or dog ownership and not other animals. For the purposes of analysis, the group of non-dog owners did include individuals who owned cats, but not dogs, and conversely non-cat owners did include individuals who may have owned dogs.

Outcome Ascertainment

CF-specific lung function measures were derived from a 3-year mean of the pulmonary function test results available for a subject following the date of questionnaire completion. The 536 subjects with pulmonary function data had a mean ($\pm$ SD) of 12.5 ± 8.6 tests conducted during this time interval. We used CF-specific measures of FEV₁ as this measure allows the direct comparison of people with CF who may be of different ages,(23) thus accounting for the decline in lung function seen in people with CF over time. CF-specific FEV₁ reference equations incorporated over 287,000 FEV₁ observations obtained between 1994-2001 from over 21,000 patients with CF in the CF Foundation Data Registry were used courtesy of Kulich et al.(23) In addition, FEV₁ percent predicted was derived to determine baseline lung function (mean FEV₁ percent predicted in the year preceding cat/dog exposure ascertainment) and rate of lung function decline in the 5 years after cat/dog exposure ascertainment. Subjects had to have a minimum of 4 pulmonary function tests over a 2 year period in order for decline in lung function to be calculated. Allergic bronchopulmonary aspergillosis (ABPA), sinus disease, nasal polyps, environmental allergies, and wheezing were derived from data forms completed by research personnel with concurrent chart review, and were defined as occurring between the time of diagnosis of CF to the time of data form completion. Wheezing was also assessed on questionnaires from subjects, and any mention of wheezing on either questionnaire was treated as a history of wheezing; sinus disease was defined as a minimum of 1 episode of sinus disease longer than 3 months in duration or >3 episodes of at least 10 days duration per year. Infection with specific organisms, *P. aeruginosa* and MRSA, were defined as ever having a positive culture for that organism (n with culture data=643). Age of acquisition was defined by the date of the first positive culture for an organism with documentation of at least one negative prior culture (n=623 with data for *P. aeruginosa* and n=632 for MRSA).

Statistical Analyses

Differences in baseline characteristics and clinical outcomes were compared using *t*-tests for continuous variables and Pearson chi-square tests for categorical variables. The magnitude of effect of the presence of dogs and cats on outcomes was assessed using generalized estimating equations (GEE) methodology with an independent correlation structure clustered by family to account for possible family correlation. These clustered regressions were also adjusted for baseline characteristics that differed in those with dogs or cats compared with those without either such as age, race/ethnicity, and pancreatic function. Kaplan-Meier analysis was conducted using the age of acquisition of specific organisms with log rank tests. Testing for interactions with combined cat-dog ownership was only performed if cat or dog ownership was associated with an outcome after adjustment for demographic factors. *P*

values of less than 0.05 were considered statistically significant. All analyses were performed using Stata IC 11.0 (StataCorp LP, College Station, TX).

RESULTS

Of the 703 subjects in the study sample, 26% reported owning only a dog, 7% reported owning only a cat, 21% reported owning both, and 45% reported owning neither (Table I). Subjects who reported owning dogs were approximately 3 years older on average than those who did not own dogs ($p<0.001$) (Table II; available at www.jpeds.com). Subjects who reported owning cats were approximately 2.5 years older on average than those who did not own cats ($p<0.001$; Table 3 available at www.jpeds.com). Subjects owning dogs or cats were more likely to be white (dogs: $p=0.008$; cats: $p=0.015$). Subjects reporting dog ownership were more likely to be *CFTR F508del* homozygotes (48.2% vs. 40.0%; $p=0.028$) and were also more likely to be pancreatic insufficient ($p=0.012$). There were no significant differences in *F508del* genotype or pancreatic sufficiency by cat ownership.

Environmental Allergies and Respiratory Morbidities

We found no differences in FEV₁, self-reported wheezing or environmental allergies, sinus disease, or ABPA by dog ownership (Table IV). Although the percentage of dog owners with nasal polyps (34.3%) was higher than non-dog owners (25.7%; $p=0.030$), this difference was not significant after adjusting for demographic differences between dog owners and non-dog owners (age, race/ethnicity, insurance status, the presence of non-dog pets, *CFTR* genotype, and exocrine pancreatic status) using multivariate logistic regression clustered by family (co-efficient $p=0.67$). Cat ownership was associated with an increased risk of wheezing (70.7% vs. 56.5%; $p=0.002$) and an increased risk in developing nasal polyps (38.6% vs. 26.3%; $p=0.004$) (Table V), but not with other outcomes. We then performed logistic regressions adjusted for demographic factors that differed between those reporting cat ownership and those who did not, specifically age, race/ethnicity, and the presence of non-cat pets. We found that cat owners were 1.66 times more likely to have nasal polyps (adjusted OR: 1.66; 95% C.I. for adjusted OR: 1.07-2.57; $p=0.024$) and that cat owners were 1.84 times more likely to wheeze (adjusted OR: 1.84; 95% C.I. for adjusted OR: 1.15-2.94; $p=0.011$). We found no differences in FEV₁, self-reported environmental allergies, sinus disease, or ABPA by cat ownership (Table III).

Owing to the observed associations between cat ownership and nasal polyps and wheezing, we tested the possibility that combined cat-dog ownership would lead to worse outcomes by including an interaction term for cat-dog ownership in clustered logistic regressions adjusted for age, race/ethnicity, *CFTR* genotype, and exocrine pancreatic status. The interaction term was not significant for nasal polyps, but for wheezing, the variables for cat ownership and dog ownership were non-significant, and the interaction term was significant ($p=0.009$; $n=547$). This result suggests that combined cat-dog owners are twice as likely to report wheezing than other subjects (adjusted OR: 2.01; 95% CI: 1.19, 3.40).

Dog and Cat Ownership and Infectious Organisms

Although we observed a greater prevalence of ever having *P. aeruginosa* among dog owners and cat owners, after adjustment for demographic differences through clustered logistic regression, dog ownership (co-efficient $p=0.78$) and cat ownership (co-efficient $p=0.21$) were not associated with an increased prevalence of *P. aeruginosa*. We did not observe a prevalence difference for MRSA with either dog or cat ownership. We also examined the age of acquisition of *P. aeruginosa* and MRSA between cat or dog owners and non-owners using Kaplan-Meier survival analysis. There was no difference in the age of acquisition of *P. aeruginosa* by dog or cat ownership (Figures 1 and 2; available at www.jpeds.com). Although we observed that dog owners had a later median age of acquisition of MRSA than non-dog owners (15.3 vs. 10.7; $n=632$; log rank $p=0.009$), after adjustment for demographic differences through clustered Cox regression, dog ownership was not associated with a later age of acquisition of MRSA (co-efficient $p=0.18$; Figure 3 available at www.jpeds.com). There was no difference in the age of acquisition of MRSA by cat ownership (Figure 4; available at www.jpeds.com).

DISCUSSION

In a multicenter sample of individuals with CF, 47.2% reported owning at least one dog, and this ownership rate is higher than reported in the general U.S. population (36.5%).(24) The rate of reported cat ownership in our population (28.1%) is similar to that in the general population (30.4%).(24) After appropriate adjustment for demographic factors, dog ownership by patients with CF was not associated with respiratory morbidities or increased prevalence/earlier acquisition of *P. aeruginosa* or MRSA. After appropriate adjustment, cat ownership was associated with 1.66 times increased likelihood of presence of nasal polyps, and combined cat-dog ownership was associated with 2.01 times increased likelihood of reporting wheezing.

The association between cat-dog exposure and wheezing may be important in CF as wheezing in young children with CF has been associated with reduced lung function between 6-8 years of age.(25) Although we did not observe a reduced lung function in cat or dog owners, we only assessed cross-sectional lung function and not longitudinal. Exposure to cats in early life has been reported to be associated with wheezing in the general population with postulated mechanisms to include allergen exposure, immune-modulation via bacterial endotoxins, and/or transmission of infectious organisms.(26) We did not see any association with cat or dog ownership and environmental allergies or specific respiratory pathogens, but we were unable to assess for cat- or dog-specific allergies. Furthermore, it should be noted that the association between cat exposure and asthma symptoms in the general population is not consistently observed.(26, 27)

We also hypothesized that cat or dog ownership may be associated with earlier infection from common respiratory pathogens in CF, specifically, *P. aeruginosa* and MRSA. We found no significant relationship between cat or dog ownership and the prevalence or age of acquisition of either organism after appropriate adjustment for demographic factors. Although there is evidence of transmission of infectious organisms between individuals with CF and their pets, the directionality of transmission is not well studied.(14-16, 22) It could

be possible that most transmission of these pathogens occurs from the patient with CF to the pet. If true, this would suggest that, at least for these organisms, the risk of acquisition and prevalence associated with cat or dog ownership is low. However, our study design does not allow us to test the directionality of transmission or whether the presence of an additional host in the household in the form of a cat or dog may accelerate the development of virulence or antibiotic resistance. Additionally, we only assessed for *P. aeruginosa* and MRSA, thus it is possible that other organisms may show an association of transmission to individuals with CF.

The strengths of our study include the use of a well-characterized, diverse population of patients with CF. The most significant limitation of our study is the cross-sectional assessment of cat/dog ownership. We only had the ability to assess cat/dog ownership at a single point in time, whereas the presence of animals within a household may change over time. Our data do not permit us to estimate the onset of cat/dog exposure or the duration of cat/dog exposure, which may be very important as ownership at specific ages (eg, *in utero*, early infancy, childhood, etc.) could carry a different risk of certain outcomes. The cross-sectional design also prevents us from ascribing causality of outcomes to cat or dog ownership. Other limitations of our study include retrospective collection of some clinical data by medical personnel, which may lead to recall bias. Additionally, other data, such as sinus imaging and allergy testing, were not available for independent verification of clinical outcomes. Although infection and lung function data were obtained from actual objective testing and lung function data was measured within 3 years of cat/dog ownership, infection data may precede or lag behind actual cat/dog ownership. Lastly, we did not see an association between environmental allergies and cat or dog ownership, although we did see associations between related phenotypes of wheezing and nasal polyps; it is possible that our question about environmental allergies was not specific with reference to allergies to cats or dogs to detect a possible association between cat or dog ownership and environmental allergies.

This study examines several potential risks associated with cat/dog ownership in the CF population. Minimizing environmental risks is fundamental to maximizing health outcomes in CF. Although we found that cat ownership was associated with higher prevalence of nasal polyps, and cat/dog ownership was associated with a higher prevalence of wheezing, cat/dog ownership should not necessarily be avoided among individuals with CF. Several studies have examined the psychosocial benefits of pet ownership with chronic illness.(28, 29) It is likely that these benefits apply to pet owners in the CF population as well, especially given equivalent rates of cat ownership among individuals with CF compared with the general population, and higher rates of dog ownership than the general population. Prospective studies are needed to confirm the relationships between cats, dogs, respiratory outcomes, and infection. Follow-up studies examining potential benefits to cat and/or dog ownership in the CF population would also better inform the decision of whether or not it is worth introducing or excluding cats and/or dogs from a household with a child with CF.

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Reference List

- (1). Collaco JM, Blackman SM, McGready J, Naughton KM, Cutting GR. Quantification of the relative contribution of environmental and genetic factors to variation in cystic fibrosis lung function. *J Pediatr*. Nov.2010 157:802–7. [PubMed: 20580019]
- (2). Stanke F, Becker T, Kumar V, Hedtfeld S, Becker C, Cuppens H, et al. Genes that determine immunology and inflammation modify the basic defect of impaired ion conductance in cystic fibrosis epithelia. *J Med Genet*. Sep 12.2010 48:24–31. [PubMed: 20837493]
- (3). Campbell PW III, Parker RA, Roberts BT, Krishnamani MR, Phillips JA III. Association of poor clinical status and heavy exposure to tobacco smoke in patients with cystic fibrosis who are homozygous for the F508 deletion. *J Pediatr*. Feb.1992 120:261–4. [PubMed: 1735823]
- (4). Rubin BK. Exposure of children with cystic fibrosis to environmental tobacco smoke. *N Engl J Med*. 1990; 323:782–8. [PubMed: 2392132]
- (5). Collaco JM, Vanscoy L, Bremer L, McDougal K, Blackman SM, Bowers A, et al. Interactions between secondhand smoke and genes that affect cystic fibrosis lung disease. *JAMA*. Jan 30.2008 299:417–24. [PubMed: 18230779]
- (6). Curtis JR, Burke W, Kassner AW, Aitken ML. Absence of health insurance is associated with decreased life expectancy in patients with cystic fibrosis. *Am J Respir Crit Care Med*. Jun.1997 155:1921–4. [PubMed: 9196096]
- (7). Schechter MS, Shelton BJ, Margolis PA, Fitzsimmons SC. The association of socioeconomic status with outcomes in cystic fibrosis patients in the United States. *Am J Respir Crit Care Med*. May.2001 163:1331–7. [PubMed: 11371397]
- (8). O'Connor GT, Quinton HB, Kneeland T, Kahn R, Lever T, Maddock J, et al. Median household income and mortality rate in cystic fibrosis. *Pediatrics*. Apr.2003 111:e333–e339. [PubMed: 12671148]
- (9). Goss CH, Newsom SA, Schildcrout JS, Sheppard L, Kaufman JD. Effect of ambient air pollution on pulmonary exacerbations and lung function in cystic fibrosis. *Am J Respir Crit Care Med*. Apr 1.2004 169:816–21. [PubMed: 14718248]
- (10). Collaco JM, McGready J, Green DM, Naughton KM, Watson CP, Shields T, et al. Effect of Temperature on Cystic Fibrosis Lung Disease and Infections: A Replicated Cohort Study. *PLoS One*. 2011; 6:e27784. [PubMed: 22125624]
- (11). Collaco JM, Morrow CB, Green DM, Cutting GR, Mogayzel PJ Jr. Environmental allergies and respiratory morbidities in cystic fibrosis. *Pediatr Pulmonol*. Sep.2013 48:857–64. [PubMed: 23143815]
- (12). Peden D, Reed CE. Environmental and occupational allergies. *J Allergy Clin Immunol*. Feb.2010 125:S150–S160. [PubMed: 20176257]
- (13). Vital signs: asthma prevalence, disease characteristics, and self-management education: United States, 2001–2009. *MMWR Morb Mortal Wkly Rep*. May 6.2011 60:547–52. [PubMed: 21544044]
- (14). Heger N, Antweiler E, Staab D, Tintelnot K, Schwarz C. Is pet ownership a risk for bacterial or fungal infections in patients with CF? *J Cystic Fibrosis*. 2013:S89.
- (15). Mohan K, Fothergill JL, Storrar J, Ledson MJ, Winstanley C, Walshaw MJ. Transmission of *Pseudomonas aeruginosa* epidemic strain from a patient with cystic fibrosis to a pet cat. *Thorax*. Sep.2008 63:839–40. [PubMed: 18728207]
- (16). Register KB, Sukumar N, Palavecino EL, Rubin BK, Deora R. *Bordetella bronchiseptica* in a paediatric cystic fibrosis patient: possible transmission from a household cat. *Zoonoses Public Health*. Jun.2012 59:246–50. [PubMed: 22212633]

- (17). Ner Z, Ross LA, Horn MV, Keens TG, MacLaughlin EF, Starnes VA, et al. Bordetella bronchiseptica infection in pediatric lung transplant recipients. *Pediatr Transplant*. Oct.2003 7:413–7. [PubMed: 14738306]
- (18). Sing A, Tuschak C, Hormansdorfer S. Methicillin-resistant Staphylococcus aureus in a family and its pet cat. *N Engl J Med*. Mar 13.2008 358:1200–1. [PubMed: 18337614]
- (19). van DE, Wolfhagen MJ, Heck ME, Wannet WJ. Transmission of a Pantone-Valentine leucocidin-positive, methicillin-resistant Staphylococcus aureus strain between humans and a dog. *J Clin Microbiol*. Dec.2005 43:6209–11. [PubMed: 16333133]
- (20). Morris DO, Lautenbach E, Zaoutis T, Leckerman K, Edelstein PH, Rankin SC. Potential for pet animals to harbour methicillin-resistant Staphylococcus aureus when residing with human MRSA patients. *Zoonoses Public Health*. Jun.2012 59:286–93. [PubMed: 22233337]
- (21). Ferreira JP, Anderson KL, Correa MT, Lyman R, Ruffin F, Reller LB, et al. Transmission of MRSA between companion animals and infected human patients presenting to outpatient medical care facilities. *PLoS One*. 2011; 6(11):e26978. [PubMed: 22102871]
- (22). Pichon, B.; Undwerwood, A.; Flight, W.; Dryden, M.; Vickers, A.; Ganner, M., et al. New insights into long-term carriage of *mecC*-MRSA using whole genome sequencing. ECCMID; 2013. Abstract [http://registration.akm.ch/einsicht.php?XNABSTRACT_ID=165380&XNSPRACHE_ID=2&XNKONGRESS_ID=180&XNMASKEN_ID=900] [Last accessed on 03/20/14]
- (23). Kulich M, Rosenfeld M, Campbell J, Kronmal R, Gibson RL, Goss CH, et al. Disease-specific reference equations for lung function in patients with cystic fibrosis. *Am J Respir Crit Care Med*. Oct 1.2005 172:885–91. [PubMed: 15976373]
- (24). American Veterinary Medical Association. U.S. Pet Ownership & Demographics Sourcebook. Schaumburg, IL: 2012. 2012. Tables 1-8 and 1-13
- (25). Ren CL, Konstan MW, Rosenfeld M, Pasta DJ, Millar SJ, Morgan WJ. Early childhood wheezing is associated with lower lung function in cystic fibrosis. *Pediatr Pulmonol*. Oct 1.2013 Epub ahead of print.
- (26). Brunekreef B, von ME, Wong G, Odhiambo J, Garcia-Marcos L, Foliaki S. Exposure to cats and dogs, and symptoms of asthma, rhinoconjunctivitis, and eczema. *Epidemiology*. Sep; 2012 23(5): 742–50. [PubMed: 22828662]
- (27). Chen CM, Tischer C, Schnappinger M, Heinrich J. The role of cats and dogs in asthma and allergy- a systematic review. *Int J Hyg Environ Health*. Jan; 2010 213(1):1–31. [PubMed: 20053584]
- (28). Brooks HL, Rogers A, Kapadia D, Pilgrim J, Reeves D, Vassilev I. Creature comforts: personal communities, pets and the work of managing a long-term condition. *Chronic Illn*. Jun; 2013 9(2): 87–102. [PubMed: 22777565]
- (29). Fitzgerald FT. The therapeutic value of pets. *West J Med*. Jan; 1986 144(1):103–5. [PubMed: 3953064]

Figure 1.
Age of *P. aeruginosa* Acquisition and Dog Ownership

Figure 2.
Age of *P. aeruginosa* Acquisition and Cat Ownership

Figure 3.

Age of MRSA Acquisition and Dog Ownership: In Cox regression clustered by family, after adjusting for age, race/ethnicity, *CFTR* genotype, and pancreatic status, dog ownership was no longer associated with a later acquisition of MRSA ($p=0.18$; $n=628$).

Figure 4.
Age of MRSA Acquisition and Cat Ownership

Table 1

Demographics of Pet Ownership

	Entire Study Sample (n = 703)	No Pets (n = 292)	Cats Only (n = 52)	Dogs Only (n = 186)	Cats and Dogs (n = 146)	Other Pets (n = 27)	Any Cat (n=198) vs. No Cats (n=505) P value	Any Dog (n=332) vs. No Dogs (n= 371) P value
Sex (% male)	52.2	49.0	61.5	58.1	45.2	66.7	0.92	0.92
Age (years, mean $\pm$ SD [range])	11.8 $\pm$ 8.8 [0.2, 57.8]	9.6 $\pm$ 7.8 [0.2, 54.6]	11.9 $\pm$ 8.6 [1.3, 51.4]	12.6 $\pm$ 8.2 [0.3, 55.1]	14.1 $\pm$ 9.4 [0.3, 57.8]	17.2 $\pm$ 12.8 [1.8, 50.4]	<0.001	<0.001
Race (%) [*]								
Am. Indian/Alaska Native	1.6	0.7	0.0	3.2	2.1	0.0		
Asian	0.9	2.1	0.0	0.0	0.0	0.0		
Black/African American	2.4	4.1	3.9	1.6	0.0	0.0	0.002	0.002
Native Hawaii/Pacific Isl.	0.0	0.0	0.0	0.0	0.0	0.0		
White	94.9	90.7	96.2	96.2	100.0	100.0		
Other race	2.0	3.8	0.0	1.6	0.0	0.0		
Ethnicity (%Hispanic or Latino)	4.4	6.9	0.0	3.2	3.4	0.0	0.18	0.18
Race/Ethnicity for regression analysis (% non-white)	8.7	13.7	3.9	6.5	4.8	0.0	0.008	0.008
Median Household Income (\$'000s)	62.9 $\pm$ 23.4 [18.8, 143.2] (n = 637)	64.2 $\pm$ 24.7 [20.1, 141.2] (n = 252)	62.7 $\pm$ 24.0 [30.9, 123.8] (n = 48)	60.6 $\pm$ 21.1 [21.1, 116.9] (n = 178)	63.5 $\pm$ 24.8 [18.8, 143.2] (n = 136)	63.1 $\pm$ 14.8 [43.9, 107.7] (n = 23)	0.26	0.26
Insurance (%)								
Private	64.4	50.3	65.4	76.9	71.9	88.9	<0.001**	<0.001**
Public	29.6	37.0	34.6	23.1	25.3	7.4		
Insurance, type unk.	4.1	8.9	0.0	0.0	2.1	0.0		
No Insurance	0.6	1.0	0.0	0.0	0.0	3.7		
Insurance status unk.	1.3	2.7	0.0	0.0	0.7	0.0		
Age at Diagnosis (years, mean $\pm$ SD [range])	2.1 $\pm$ 4.9 [0, 52.0]	2.1 $\pm$ 5.5 [0, 38.0]	2.4 $\pm$ 3.7 [0, 21.5]	1.5 $\pm$ 3.1 [0, 17.0]	2.4 $\pm$ 5.6 [0, 38.0]	3.4 $\pm$ 6.1 [0, 28.0]	0.31	0.31
CFTR genotype (% F508del homozygotes)	43.9 (n = 700)	38.4 (n = 289)	40.4	48.4	48.0	55.6	0.028	0.028

	Entire Study Sample (n = 703)	No Pets (n = 292)	Cats Only (n = 52)	Dogs Only (n = 186)	Cats and Dogs (n = 146)	Other Pets (n = 27)	Any Cat (n=198) vs. No Cats (n=505) P value	Any Dog (n=332) vs. No Dogs (n= 371) P value
Pancreatic Function (% insufficient)	85.8 (n = 699)	81.4 (n = 291)	90.4	89.1 (n = 184)	89.7 (n = 145)	81.5	0.012	0.012
Baseline FEV₁ *** (% predicted, year prior to ascertainment, mean $\pm$ SD [range])	83.9 $\pm$ 23.4 [13.7, 142.1] (n = 481)	86.2 $\pm$ 22.7 [13.7, 142.1] (n = 169)	78.4 $\pm$ 22.3 [31.5, 115.5] (n = 37)	84.8 $\pm$ 20.7 [26.7, 127.5] (n = 143)	79.4 $\pm$ 26.9 [18.7, 137.4] (n = 111)	92.3 $\pm$ 24.8 [43.0, 133.2] (n = 21)	0.08	0.08

* Percentages may not equal 100% as subjects could select multiple categories

** Chi square test for categories of private vs. public insurance only

Table 2

Demographics of Dog Ownership

	Entire Study Sample (n = 703)		Dogs (n = 332)	No Dogs (n = 371)	P value
Sex (% male)	52.2	52.4	52.0	52.0	0.92
Age (years, mean $\pm$ SD [range])	11.8 $\pm$ 8.8 [0.17, 57.8]	13.3 $\pm$ 8.8 [0.26, 57.8]	10.4 $\pm$ 8.6 [0.17, 54.6]		<0.001
Race (%) [*]					
Am. Indian/Alaska Native	1.6	2.4	0.5		
Asian	0.9	0.0	1.6		
Black/African American	2.4	0.9	3.8		0.002
Native Hawaii/Pacific Isl.	0.0	0.0	0.0		
White	94.9	97.9	92.2		
Other race	2.0	0.9	3.0		
Ethnicity (% Hispanic or Latino)	4.4	3.3	5.4		0.18
Race/Ethnicity for regression analysis (% non-white)	8.7	5.7	11.3		0.008
Median Household Income (\$'000s)	62.9 $\pm$ 23.4 [18.8, 143.2] (n = 637)	61.8 $\pm$ 22.8 [18.8, 143.2] (n = 314)	63.9 $\pm$ 24.0 [20.9, 141.2] (n = 323)		0.26
Insurance (%)					
Private	64.4	74.7	55.3		
Public	29.6	24.1	34.5		
Insurance, type unk.	4.1	0.9	7.0		<0.001 ^{**}
No Insurance	0.6	0.0	1.1		
Insurance status unk.	1.3	0.3	2.2		
Non-Dog Pet (% Yes)	36.7	21.3	53.9		<0.001
Age at Diagnosis (years, mean $\pm$ SD [range])	2.1 $\pm$ 4.9 [0, 52.0]	1.9 $\pm$ 4.4 [0, 38.0]	2.3 $\pm$ 5.3 [0, 52.0]		0.31

	Entire Study Sample (n = 703)	Dogs (n = 332)	No Dogs (n = 371)	P value
CFTR genotype (% F508del homozygotes)	43.9 (n = 700)	48.2	40.0 (n = 368)	0.028
Pancreatic Function (% insufficient)	85.8 (n = 699)	89.4 (n = 329)	82.7 (n = 370)	0.012
Baseline FEV₁ (% predicted, year prior to ascertainment, mean ± SD [range])	83.9 ± 23.4 [13.7, 142.1] (n = 481)	82.5 ± 23.7 [18.7, 137.3] (n = 254)	85.4 ± 23.0 [13.7, 142.1] (n = 227)	0.08

* Percentages may not equal 100% as subjects could select multiple categories

** Chi square test for categories of private vs. public insurance only

Table 3

Demographics of Cat Ownership

	Entire Study Sample (n = 703)	Cats (n = 198)	No Cats (n = 505)	P value
Sex (% male)	52.2	49.5	53.3	0.37
Age (years, mean $\pm$ SD [range])	11.8 $\pm$ 8.8 [0.17, 57.8]	13.6 $\pm$ 9.3 [0.29, 57.8]	11.1 $\pm$ 8.5 [0.17, 55.1]	<0.001
Race (%) [*]				
Am. Indian/Alaska Native	1.6	1.5	1.6	
Asian	0.9	0.0	1.2	
Black/African American	2.4	1.0	3.0	0.08
Native Hawaii/Pacific Isl.	0.0	0.0	0.0	
White	94.9	99.0	93.3	
Other race	2.0	0.0	2.8	
Ethnicity (% Hispanic or Latino)	4.4	2.5	5.2	0.13
Race/Ethnicity for regression analysis (% non-white)	8.7	4.6	10.3	0.015
Median Household Income (\$ 000s)	62.9 $\pm$ 23.4 [18.8, 143.2] (n = 637)	63.2 $\pm$ 24.5 [18.8, 143.2] (n = 184)	62.8 $\pm$ 23.0 [20.8, 141.2] (n = 453)	0.81
Insurance (%)				
Private	64.4	70.2	62.2	
Public	29.6	27.8	30.3	
Insurance, type unk.	4.1	1.5	5.2	0.27**
No Insurance	0.6	0.0	0.8	
Insurance status unk.	1.3	0.5	1.5	
Non-Cat Pet (% Yes)	51.8	42.3	76.3	<0.001
Age at Diagnosis (years, mean $\pm$ SD [range])	2.1 $\pm$ 4.9 [0, 52.0]	2.4 $\pm$ 5.1 [0, 38.0]	2.0 $\pm$ 4.8 [0, 52.0]	0.36

	Entire Study Sample (n = 703)	Cats (n = 198)	No Cats (n = 505)	P value
CFTR genotype (% F508del homozygotes)	43.9 (n = 700)	46.0	43.0 (n = 502)	0.48
Pancreatic Function (% insufficient)	85.8 (n = 699)	89.9 (n = 197)	84.3 (n = 502)	0.06
Baseline FEV₁ (% predicted, year prior to ascertainment, mean $\pm$ SD [range])	83.9 $\pm$ 23.4 [13.7, 142.1] (n = 481)	79.1 $\pm$ 25.6 [18.7, 137.3] (n = 148)	86.0 $\pm$ 22.0 [13.7, 142.1] (n = 333)	0.003

* Percentages may not equal 100% as subjects could select multiple categories

** Chi square test for categories of private vs. public insurance only

Table 4

Dog Ownership and Clinical Outcomes

	Entire Study Sample (n = 703)	Dogs (n = 332)	No Dogs (n = 371)	P value
CF-specific FEV₁ (Percentile)	59.7 ± 26.0 [0, 100] (n = 531)	59.4 ± 25.4 [0, 100] (n = 285)	60.0 ± 26.8 [0, 100] (n = 246)	0.77
FEV₁ Decline (% predicted per year)	-1.2 ± 3.8 [-14.9, 11.9] (n = 467)	-1.3 ± 3.9 [-14.9, 11.7] (n = 259)	-1.1 ± 3.7 [-13.8, 11.9] (n = 208)	0.54
Wheezing Ever (% Yes)	61.0 (n = 551)	63.6 (n = 291)	58.1 (n = 260)	0.19
Environmental Allergy (% Yes)	13.9 (n = 555)	14.2 (n = 295)	13.5 (n = 260)	0.79
Sinus Disease (% Yes)	40.2 (n = 548)	42.6 (n = 289)	37.5 (n = 259)	0.22
Nasal Polyps (% Yes)	30.2 (n = 543)	34.3 (n = 286)	25.7 (n = 257)	0.030*
Allergic Bronchopulmonary Aspergillosis (% Yes)	5.3 (n = 544)	5.6 (n = 288)	5.1 (n = 256)	0.81
<i>Pseudomonas aeruginosa</i> Ever (% Yes)	84.5 (n = 643)	87.7 (n = 311)	81.1 (n = 311)	0.021*
MRSA Ever (% Yes)	43.9 (n = 643)	44.6 (n = 311)	43.1 (n = 311)	0.70

* In clustered logistic regression, after adjusting for age, race/ethnicity, insurance status (public vs. private), presence of pets other than dogs, *CFTR* genotype, and pancreatic status, dog ownership was not associated with nasal polyps ($p=0.67$; $n=528$) or having positive respiratory cultures for *P. aeruginosa* ($p=0.78$; $n=626$).

Table 5

Cat Ownership and Clinical Outcomes

	Entire Study Sample (n = 703)	Cats (n = 198)	No Cats (n = 505)	P value
CF-specific FEV₁ (Percentile)	59.7 ± 26.0 [0, 100] (n = 531)	56.7 ± 27.2 [0, 99.7] (n = 168)	61.1 ± 25.4 [0, 100] (n = 363)	0.07
FEV₁ Decline (% predicted per year)	-1.2 ± 3.8 [-14.9, 11.9] (n = 467)	-1.2 ± 3.2 [-10.8, 7.5] (n = 147)	-1.2 ± 4.0 [-14.9, 11.9] (n = 320)	0.99
Wheezing Ever (% Yes)	61.0 (n = 551)	70.7 (n = 174)	56.5 (n = 377)	0.002*
Environmental Allergy (% Yes)	13.9 (n = 555)	13.7 (n = 175)	14.0 (n = 380)	0.94
Sinus Disease (% Yes)	40.2 (n = 548)	40.9 (n = 171)	39.8 (n = 377)	0.80
Nasal Polyps (% Yes)	30.2 (n = 543)	38.6 (n = 171)	26.3 (n = 372)	0.004*
Allergic Bronchopulmonary Aspergillosis (% Yes)	5.3 (n = 544)	5.3 (n = 170)	5.4 (n = 374)	0.98
<i>Pseudomonas aeruginosa</i> Ever (% Yes)	84.5 (n = 643)	89.9 (n = 170)	82.0 (n = 445)	0.011*
MRSA Ever (% Yes)	43.9 (n = 643)	46.5 (n = 170)	42.7 (n = 445)	0.37

* In logistic regression, after adjusting for age, race/ethnicity, and the presence of pets other than cats, cat ownership remained associated with nasal polyps ($p=0.024$; $n=543$) and ever wheezing ($p=0.011$, $n=551$), but not for having positive respiratory cultures for *P. aeruginosa* ($p=0.21$; $n=643$).