

Accepted Manuscript

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PII: S0002-9394(15)00093-8

DOI: [10.1016/j.ajo.2015.02.007](https://doi.org/10.1016/j.ajo.2015.02.007)

Reference: AJOPHT 9239

To appear in: *American Journal of Ophthalmology*

Received Date: 7 November 2014

Revised Date: 15 February 2015

Accepted Date: 17 February 2015

Please cite this article as: Tseng VL, Yoo GL, Shaikh Y, Yu F, Coleman AL, The Association between Glaucoma and Immunoglobulin E Antibody Response to Indoor Allergens, *American Journal of Ophthalmology* (2015), doi: 10.1016/j.ajo.2015.02.007.

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Abstract

Purpose: To evaluate the association between sensitization to indoor allergens and glaucoma in participants of the National Health and Nutrition Examination Survey (NHANES).

Design: Retrospective cross-sectional study

Methods: This study examined the association between serum immunoglobulin E (IgE) levels for a panel of common indoor allergens and glaucoma for 2005-2006 NHANES participants. The exposures of interest were serum IgE levels to a panel of common indoor allergens. The outcome of interest was a clinical diagnosis of glaucoma based on the Rotterdam criteria. Logistic regression modeling was performed to assess the association between each type of IgE and glaucoma, while controlling for age, ethnicity, and steroid use. All estimates were weighted based on the multistage NHANES sampling design.

Results: Among a weighted total of 83,308,318 participants the overall prevalence of glaucoma was 3.2% (95% confidence interval [CI]: 2.8%, 3.6%). The majority of patients were non-Hispanic white ($n=10,547,654$; 77.1%). The American dust mite antigen had the highest proportion of participants with positive IgE values ($n=12,093,038$; 14.5%). In the full model including all allergen-specific IgE subtypes as predictors, there were statistically significant associations between IgE subtypes and glaucoma for the cockroach (odds ratio [OR]=2.78; 95% CI=1.34, 5.76), cat (OR=3.42; 95% CI=1.10, 10.67), and dog (OR=0.24; 95% CI=0.06, 0.86) antigens.

Conclusions: In NHANES, participants with glaucoma had significantly higher odds of sensitization to the cockroach and cat allergens compared to those without glaucoma. These findings indicate the need for further research to elucidate the role of chronic indoor allergen exposure in the development of glaucomatous optic neuropathy.

The Association between Glaucoma and Immunoglobulin E Antibody Response to Indoor Allergens

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Introduction

Glaucoma is the second leading cause of blindness worldwide.¹ Its etiology is multifactorial, and autoimmune dysregulation has been proposed as a contributing factor.²⁻⁶ Wax and colleagues⁷ reported that several patients with normal tension glaucoma who tested positive for anti-Ro/Sjogren's syndrome antigen A (SSA) antibodies had elevated titers for additional autoimmune antibodies including antinuclear antibody, rheumatoid factor, antiribonuclear protein, anti-Smith protein, and immunoglobulin G (IgG). Another study by Wax⁸ revealed that several glaucoma patients had elevated levels of monoclonal paraproteins and nonspecific antibodies to deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Allergies are a specific type of immunologic abnormality where the body is abnormally sensitized to environmental allergens, leading to pathologic autoimmune responses such as rhinitis, asthma, and anaphylaxis. Previous researchers have proposed that indoor and outdoor allergens lead to differing responses because of the duration and frequency of allergen exposure. Platts-Mills and colleagues⁹ suggested that outdoor allergens are only transiently inhaled because outdoor air is constantly moving, while indoor allergens are constantly inhaled because indoor air is still. Therefore, outdoor allergens have been observed to be associated with temporary conditions such as conjunctivitis and rhinitis, while indoor allergens are associated with chronic inflammatory diseases such as asthma.¹⁰

Given that glaucoma is a chronic condition and that previous literature has suggested an inflammatory component in glaucoma pathophysiology, our hypothesis was that exposure to indoor allergens could be a potential autoimmune mechanism contributing to the development of glaucoma. To this end, the purpose of this study was to examine the association between serum immunoglobulin E (IgE) levels for indoor allergens and glaucoma in participants of the 2005-2006 National Health and Nutrition Examination Survey (NHANES).

Methods

Study design and description of database

This was a retrospective cross-sectional study using data from the 2005-2006 NHANES database. The NHANES program began in the early 1960s and was designed to assess the health and nutritional status of adults and children in the United States (US).¹¹ The survey includes interviews, physical exams, and blood draws. In 2005-2006, the NHANES performed additional examination and laboratory testing that included Humphrey Matrix frequency doubling perimetry testing (N30-5 FDT), optic disc photographs, and serum IgE levels for a panel of common environmental allergens. The survey examines a nationally representative sample of about 10,000 persons per iteration and produces weighted estimates meant to be representative of the US population. Data accumulation was performed by the National Center for Health Statistics (NCHS) with approval from the NCHS Ethics Review Board (Protocol #2005-06).¹² Data from NHANES are publicly available and anonymous, so this study received Institutional Review Board exemption from the University of California, Los Angeles.

Baseline characteristics

Participants with optic disc photographs and FDT visual fields available in the 2005-2006 NHANES sample were included in the study. Participants with the following characteristics were excluded: (1) missing optic disc photographs or FDT visual fields, (2) age <40 years because optic disc photos and FDT visual fields were not collected for participants under age 40, and (3) documented alternative explanation for cup-to-disc ratio (CDR) findings (dysplastic disc or marked anisometropia) or for a visual field defect (retinal vascular disease, macular degeneration, or cerebrovascular disease).¹³ The presence of dysplastic disc, retinal vascular disease, and macular degeneration was assessed based on fundus photographs taken as part of the NHANES 2005-2006 study.¹⁴ The presence of anisometropia was assessed based on an objective refraction conducted as part of the NHANES 2005-2006 study.¹⁵ Cerebrovascular disease was based on self-report from the NHANES interview.¹⁶ Basic demographics that were analyzed included age and ethnicity, as both factors are known risk factors for glaucoma. Steroid use was also included as a covariate due to its potential to be a confounder in the potential association between allergies and glaucoma. Steroid use was determined through the NHANES personal interview. Participants were asked during the household interview whether they had taken a prescription medication during the past month. Those who responded “yes” were asked to show containers of all their prescription medications to the interviewer. The interviewer entered the name of each prescription medication into a computer. For medications where no container was available, the interviewer asked the participant to verbally report the name of the medication.¹⁷ Steroid use was coded as a binary variable of steroid use versus no steroid use. Participants who reported use of any oral, ophthalmic, topical, inhaled, or injected steroids were counted as using steroids, and the remainder of participants were counted as not using steroids. Glaucoma medication use was not included as a covariate because it was presumed that only participants with glaucoma would be taking glaucoma medications, and that comparisons of glaucoma medication use in participants with versus without glaucoma would thus not be reliable.

The exposures of interest were total serum IgE levels and IgE levels specific to a panel of indoor allergens. Indoor allergens were chosen based on a nationally representative sample of household dust. Analysis of serum samples was conducted using the Pharmacia Diagnostics ImmunoCAP 1000 SystemTM. Total serum IgE was measured by the extent of its reaction to anti-IgE covalently coupled to the ImmunoCapTM reaction vessel, after washing, incubating with a developing agent, and comparison of the resulting eluate fluorescence with the response of calibrators. Allergen-specific IgE was measured by its reaction to specific allergens covalently bound to the reaction vessel. The IgE antibodies to specific indoor allergens that were tested included: *Dermatophagoides farinae* (American dust mite), *Dermatophagoides pteronyssinus* (European dust mite), cockroach, cat, dog, mouse, and rat. For participants where allergen-specific IgE measurements exceeded the total IgE value due to cross-reactivity or conformationally equivalent epitopes of antigens for the allergens, total IgE measurements were coded as missing. For allergen-specific IgE levels, participants were considered negative if their serum IgE levels were <0.35 kilounits per liter (kU/L), while levels ≥0.35kU/L were considered positive. For total IgE levels, values ≤119 kU/L were considered negative, while those >119 kU/L were

considered positive. Cutoff values for allergen-specific and total IgE levels were based on the standard lower limit of detection for the lab assay used by NHANES. Quality control and quality assurance protocols met 1988 Clinical Laboratory Improvement Act mandates.¹⁸

Outcome

The primary outcome of interest was the prevalence of glaucoma as defined by the Rotterdam criteria¹⁹, which defines open angle glaucoma based on optic nerve appearance and visual field defects. Within NHANES, optic nerve appearance was assessed based on optic nerve photos, and glaucomatous visual field defects were assessed by FDT visual fields. A clinical diagnosis of glaucoma was defined as having two or more abnormal points in at least one eye on the N30-5 FDT on two tests in the same eye²⁰ along with CDR in one eye or CDR asymmetry between eyes $\geq 97.5\%$ of the normal NHANES population.²¹ The Rotterdam criteria were chosen to assess glaucoma because of the ability to produce an objective clinical definition of glaucoma with data available within NHANES based on these criteria, as reported by a recent study.²² Information on the incidence and subtype of glaucoma was not available in the 2005-2006 NHANES database.

The FDT exam was conducted in the dark by trained health technicians. A practice test was run prior to the actual test to determine whether the participant understood the procedure. The test always started with the right eye, followed by the left eye and then the test was repeated for each eye. Nineteen visual field locations were tested and each location was tested until the participant responded. During each test, reliability checks were performed at random times, which included three False Positive Tests and three Blind Spot Tests. Participants were then classified as having normal, positive, insufficient, or unreliable FDT exams; those with insufficient or unreliable exams were excluded from the study population. The CDR was determined by using retinal images. The exam consisted of two 45 degree non-mydratic digital images of the retina taken by trained technicians. The first image was centered on the macula and the second on the optic nerve. Trained graders at the University of Wisconsin assessed vertical CDR in each eye using digital images that were evaluated as they initially appeared on the back of the digital camera. The images were reviewed by at least two of nine trained graders. If the graders did not agree, a third grader reviewed the image. If there was a disagreement, an adjudicator made the final decision.²³

Statistical Analysis

Sampling within NHANES occurs in four stages, starting with primary sampling units (PSUs) and followed by segments within PSUs (usually city blocks), households, and individuals. Based on this multistage probability sampling design, data are weighted and adjusted for nonresponse to produce weighted estimates meant to be representative of the US population. All data analyses in this study were based on weighted estimates using sample weights provided by NHANES.²⁴

Descriptive statistics were used to describe baseline characteristics for the study population. Age was analyzed as a continuous variable, and ethnicity and steroid use were analyzed as categorical variables. Total and allergen-specific IgE were analyzed

as categorical variables, where participants with serum levels above the described cutoff values were considered positive and participants with serum levels below the cutoff values were considered negative. Glaucoma was assessed as a binary outcome based on the Rotterdam criteria.^{21,22}

Logistic regression modeling was used to examine the association between serum IgE levels and glaucoma. Separate unadjusted models were created for each allergen-specific IgE subtype as predictors of glaucoma. Partially adjusted models were then created including age, ethnicity, and steroid use as potential confounders for each IgE subtype and glaucoma. Because of the concern for cross-reactivity and epitope similarities, a final analysis was performed including all allergen-specific IgE subtypes, total IgE, and sensitization to any indoor allergen as predictors for glaucoma in the same model. All analyses were conducted with SAS version 9.3 (Cary, NC).

Results

There were 83,308,318 subjects who met inclusion criteria in the weighted 2005-2006 NHANES sample, and 1,652 actual subjects who met inclusion criteria. The overall prevalence of glaucoma was 3.2% (n=2,657,336; 95% confidence interval [CI]=2.8%, 3.6%) in the weighted sample, and 5.1% (n=84, 95% CI 4.0%, 6.1%) in the actual sample. In the weighted sample, the mean age was 57.1 years (standard error [SE]=0.7 years) in the overall population and 62.2 years (SE=1.3 years) in participants with glaucoma. In the actual sample, the mean age was 55.8 years (standard deviation [SD]=11.7 years) in the overall population and 62.8 years (SD=12.1 years) in participants with glaucoma. In the weighted sample, the majority of patients were non-Hispanic white in the overall population (n=10,547,654; 77.1%), in participants with glaucoma (n=1,404,960; 52.9%), and in participants without glaucoma (n=62,549,524; 77.6%). In the actual sample, the majority of patients were non-Hispanic white in the overall population (n=892; 53.2%) and in participants without glaucoma (n=866; 54.3%), but the majority of participants with glaucoma were non-Hispanic black (n=34; 40.5%). In the weighted sample, the American dust mite antigen had the highest proportion of participants with positive IgE values in the overall population (n=12,093,038; 14.5%), in participants with glaucoma (n=683,989; 25.7%), and in participants without glaucoma (n=11,409,049; 14.1%). The same pattern was observed in the actual sample, with 25.6% (n=425) of participants in the overall population with positive IgE values to the American dust mite antigen, 29.8% (n=25) in participants with glaucoma, and 25.4% (n=404) in participants without glaucoma. Additional descriptive statistics are outlined in Tables 1 and 2.

In estimates based on the weighted sample, no statistically significant associations were noted between total IgE levels and glaucoma in the models both with and without all specific indoor allergen IgE covariates. In the individual models with each allergen-specific IgE subtype as a predictor excluding other IgE subtypes, there was a statistically significant association between IgE subtype and glaucoma for the cockroach, (odds ratio [OR]=2.79; 95% CI=1.04, 7.49), American dust mite (OR=2.26; 95% CI=1.14, 4.47), and European dust mite (OR=2.16; 95% CI=1.05, 4.42) antigens. In the model including all allergen-specific IgE subtypes as predictors, there were statistically significant associations between IgE subtypes and glaucoma for the

cockroach (OR=2.78; 95% CI=1.34, 5.76), cat (OR=3.42; 95% CI=1.10, 10.67), and dog (OR=0.24; 95% CI=0.06, 0.86) antigens. Similar trends were observed in estimates based on the actual sample; these estimates and additional results from logistic regression modeling can be found in Table 3.

Discussion

This study found that after accounting for immune cross-reactivity in a panel of common indoor allergens, sensitization to the cockroach and cat antigens was associated with increased odds of glaucoma, while sensitization to the dog antigen was associated with decreased odds of glaucoma in the 2005-2006 NHANES population. Both the cockroach and cat antigens have been found to be important sources of indoor allergens leading to chronic allergic disease, especially asthma. Previous research has proposed that indoor allergens are more associated with chronic respiratory disease than outdoor allergens because prolonged time spent indoors and lack of air movement inside leads to increased and more consistent levels of exposure to allergen when compared to outdoor allergens.^{9,10,25} While the findings in the present study do not prove a causal or temporal relation between sensitization to indoor allergens and glaucoma, they suggest that prolonged allergen exposure to cockroaches and cats may be associated with increased odds of glaucoma. The dog antigen, conversely, was found to be possibly associated with decreased odds of glaucoma; the reason for this association is unclear but may be related to dogs spending increased time outdoors or to different mechanisms of allergen pathophysiology with dog allergens versus cat and cockroach allergens. Previous studies have reported strong positive associations between cockroach and cat allergen sensitization and asthma²⁵⁻²⁷, and one study²⁸ has also reported lower levels of sensitization to dog allergen compared to the cockroach and cat allergens in patients with asthma.

In the unadjusted models and the partially adjusted models that did not account for immune cross-reactivity, there were significant and borderline positive associations between sensitization to the American and European dust mite allergens and the odds of glaucoma. However, in the fully adjusted model accounting for immune cross-reactivity, these two allergens were no longer significantly associated with glaucoma. This suggests that the dust mite allergens may have biochemical or physical properties that are similar to the cat and cockroach allergens, though this study does not address the etiology of these potential similarities. Additionally, there were no statistically significant associations between sensitization to the cat allergen and glaucoma in the unadjusted model, and no significant associations between sensitization to the dog allergen and glaucoma in the unadjusted and partially adjusted models. However, in both types of models, the point estimates for the cat and dog allergens were in the same direction as their respective point estimates in the fully adjusted models, suggesting that the lack of statistical significance may have been related to decreased precision of the unadjusted and partially adjusted models.

While the existing literature on glaucoma and autoimmunity is limited, previous studies have found evidence of an inflammatory component in optic nerve pathophysiology. Studies have reported T helper cell 2 (Th2) cytokines including interleukin (IL) 4 and IL-6 to be associated with the development^{29,30} or lack of

development^{31,32} of retinal or glial neurodegeneration, and a recent study by Huang et al found that serum levels of IL-4 and 6 were higher among patients with glaucoma and even higher in those with severe optic neuropathy.³³ Huang additionally proposed that cytokine alterations may increase sensitivity of retinal ganglion cells to the effects of elevated intraocular pressure and other risk factors for glaucoma. This proposed mechanism could explain a potential association between allergies and glaucoma, as activated Th2 lymphocytes produce IL-4, IL-5, and IL-13 cytokines which activate B cells to produce IgE in allergic responses³⁴, and increased levels of these cytokines in the vicinity of the optic nerve could potentially predispose it to increased sensitization to glaucomatous damage.

Although glaucoma patients had higher odds of having positive serum levels of IgE to specific indoor allergens, total serum IgE levels were not associated with glaucoma. These findings further suggest that it is specifically the cockroach and cat allergens, rather than allergies overall, that are associated with the development of glaucoma. The cockroach and cat antigens may have specific properties such as size or chemical activity that predispose involvement of the optic nerve with sensitization to these antigens. A previous study suggested that pollen allergens are larger than common indoor allergens, so pollen antigens become trapped in the nose and lead to rhinitis while indoor allergens can travel farther and affect the lung.¹⁰ This study does not address whether similar mechanisms allow the cockroach and cat antigens to travel in the bloodstream to the optic nerve, predisposing to antibody formation in the vicinity of the nerve, or whether cockroach and cat antigens have biochemical properties similar to the optic nerve that lead to the formation of antibodies targeted at the optic nerve.

This study has several limitations mainly related to its observational and cross-sectional nature. The subtype of glaucoma could not be assessed based on optic nerve images and FDT visual fields alone. The incidence of glaucoma was not available due to the cross-sectional nature of the study, so a temporal association between allergies and glaucoma could not be established. Additionally, the FDT and optic nerve criteria diagnostic criteria used in this study were subject to misclassification bias with a 9% false positive rate and a 6% false negative rate.¹⁸ The identification of specific IgE levels may have been limited by possible cross-reactivity with other allergens with homologous epitopes, as trees, grasses, and dust mites have been shown to have co-reacting antibodies.³⁵⁻³⁸ Additionally, topical glaucoma medications have been shown to alter the inflammatory marker profile of the conjunctiva, and it is possible that serum IgE levels were also affected by the use of glaucoma medications.^{39,40} However, glaucoma medication use was not accounted for as a potential confounder in the present study as it was not possible to compare glaucoma medication use in participants with versus without glaucoma, since participants without glaucoma would presumably not be treated with glaucoma medications. At present, no evidence exists supporting whether IgE alterations in serum are directly correlated to the IgE level in the eyes, and it is unclear if elevated levels of serum IgE correspond directly to elevated cytokine levels. There is also the possibility of unmeasured or residual confounding that contributed to additional bias in this analysis. Finally, there were no additional data available within NHANES to validate glaucoma diagnoses in participants who met the Rotterdam criteria for glaucoma based on CDR and FDT visual fields. A future validation study comparing

clinical glaucoma diagnoses with diagnoses based on the Rotterdam criteria within NHANES would be of value.

In summary, in a panel of common indoor allergens, sensitization to the cat and cockroach antigens were associated with higher odds of glaucoma in the 2005-2006 NHANES population. Further research is needed to establish the importance of these findings and whether there is a role of chronic allergen exposure in the development of glaucomatous optic neuropathy.

Acknowledgments

A. Funding/support: This study was supported by the Center of Community Outreach and Policy, Stein Eye Institute, University of California, Los Angeles (Los Angeles, California, United States of America).

B. Financial disclosures: Anne L. Coleman receives payment for lectures including service on speaker bureaus from Allergan (Irvine, California, United States of America). None of the other authors have any financial interests to disclose.

C. Design and conduct of the study (VLT, GLY, ALC); collection, management, analysis, and interpretation of the data (VLT, GLY, YS, FY, ALC); preparation, review, and approval of the manuscript (VLT, GLY, YS, FY, ALC), responsibility for the integrity of the entire study and manuscript (ALC). Each author meets these 4 criteria set by the ICMJE required to claim authorship.

D. Other acknowledgments: None

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Table 1. Prevalence of covariates by glaucoma status within the National Health and Nutrition Examination Survey, 2005-2006.

Weighted Estimates			
Characteristic	Total Number (%); n=83,308,317	Number (%) with Glaucoma; n=2,657,336	Number (%) without Glaucoma; n=80,650,982
Age	Mean=57.5 (standard error=0.7)	Mean=62.2 (standard error=1.3)	Mean=53.4 (standard error=0.6)
Ethnicity			
Non-Hispanic White	63,954,484 (76.7)	1,404,960 (52.9)	62,549,524 (77.6)
Non-Hispanic Black	8,131,513 (9.8)	644,521 (24.3)	7,486,992 (9.3)
Mexican American	4,612,275 (5.5)	208,338 (7.8)	4,403,937 (5.5)
Other Hispanic	2,416,147 (2.9)	110,661 (4.3)	2,305,486 (2.9)
Other	4,193,898 (5.0)	288,856 (10.9)	3,905,042 (4.8)
History of Steroid Use			
Yes	5,243,910 (6.3)	61,378 (2.3)	5,182,533 (6.4)
No	78,064,407 (93.7)	2,595,958 (97.7)	75,468,449 (93.6)
Actual Frequencies			
Characteristic	Total Number (%); n=1,678	Number (%) with Glaucoma; n=84	Number (%) without Glaucoma; n=1,594
Age	Mean=55.8 (standard deviation=11.7)	Mean=62.8 (standard deviation=12.1)	Mean=55.4 (standard deviation=11.6)
Ethnicity			
Non-Hispanic White	892 (53.2)	26 (31.0)	866 (54.3)
Non-Hispanic Black	384 (22.9)	34 (40.5)	350 (22.0)
Mexican American	293 (17.5)	16 (19.1)	277 (17.4)
Other Hispanic	44 (2.6)	3 (3.6)	41 (2.6)
Other	65 (3.9)	5 (6.0)	60 (3.8)
History of Steroid Use			
Yes	91 (5.4)	3 (3.6)	88 (5.5)
No	1,587 (94.6)	81 (96.4)	1,506 (94.5)

Table 2. Prevalence and average values of immunoglobulin E (IgE) antibody subtypes by glaucoma status within the National Health and Nutrition Examination Survey, 2005-2006.

Weighted Estimates			
IgE Type	Total Number (%) with Positive Levels; n=83,308,318	Number (%) with Glaucoma with Positive Levels; n=2,657,336	Number (%) without Glaucoma with Positive Levels; n=80,650,982
Total IgE	17,796,528 (21.4)	749,780 (28.2)	17,046,748 (21.1)
D. farinae ^a	12,093,038 (14.5)	683,989 (25.7)	11,409,049 (14.1)
D. pteronyssinus ^a	11,816,519 (14.2)	633,007 (23.8)	11,183,512 (13.9)
Cockroach	7,435,150 (8.9)	518,540 (19.5)	6,916,609 (8.6)
Cat	9,149,283 (11.0)	445,774 (16.8)	8,703,509 (10.8)
Dog	8,057,392 (9.7)	149,454 (5.6)	7,907,938 (9.8)
Mouse	434,765 (0.5)	0 (0.0)	434,765 (0.5)
Rat	1,019,167 (1.2)	0 (0.0)	1,019,167 (1.3)
IgE Type	Mean kU/L ^a of IgE (Standard Error) in All Participants; n=83,308,318	Mean kU/L ^a of IgE (Standard Error) in Participants with Glaucoma; n=2,657,336	Mean kU/L ^a of IgE (Standard Error) in Participants without Glaucoma; n=80,650,982
Total IgE	128.7 (9.4)	163.1 (50.5)	127.6 (9.4)
D. farinae ^a	1.5 (0.2)	0.7 (0.2)	1.5 (0.2)
D. pteronyssinus ^a	1.6 (0.2)	0.7 (0.2)	1.7 (0.2)
Cockroach	0.5 (0.0)	0.7 (0.2)	0.5 (0.1)
Cat	0.9 (0.2)	1.5 (1.1)	0.9 (0.2)
Dog	0.5 (0.1)	0.4 (0.2)	0.5 (0.1)
Mouse	0.3 (0.0)	0.3 (0.0)	0.3 (0.0)
Rat	0.3 (0.0)	0.3 (0.0)	0.3 (0.0)
Actual Frequencies			
IgE Type	Total Number (%) with Positive Levels; n=1,678	Number (%) with Glaucoma with Positive Levels; n=84	Number (%) without Glaucoma with Positive Levels; n=1,594
Total IgE	429 (25.6)	25 (29.8)	404 (25.4)
D. farinae ^a	265 (15.8)	20 (23.8)	245 (15.4)
D. pteronyssinus ^a	255 (15.2)	18 (21.4)	237 (14.9)
Cockroach	173 (10.3)	16 (19.1)	157 (9.9)
Cat	172 (10.3)	12 (14.3)	160 (10.0)
Dog	151 (9.0)	5 (6.0)	146 (9.2)
Mouse	12 (0.7)	0 (0.0)	12 (0.8)
Rat	21 (1.3)	0 (0.0)	21 (1.3)
IgE Type	Mean kU/L ^a of IgE (Standard Deviation) in All Participants; n=1,678	Mean kU/L ^a of IgE (Standard Deviation) in Participants with Glaucoma; n=84	Mean kU/L ^a of IgE (Standard Deviation) in Participants without Glaucoma; n=1,594
Total IgE	158.9 (525.4)	153.9 (248.7)	159.2 (536.1)
D. farinae ^a	1.7 (11.9)	1.0 (4.3)	1.7 (12.1)
D. pteronyssinus ^a	1.7 (11.8)	0.9 (2.9)	1.8 (12.1)
Cockroach	0.6 (2.5)	0.7 (1.9)	0.6 (2.5)
Cat	0.9 (5.5)	1.0 (5.3)	0.9 (5.5)
Dog	0.5 (2.0)	0.4 (0.7)	0.5 (2.1)
Mouse	0.3 (1.0)	0.3 (0.0)	0.3 (1.0)
Rat	0.3 (0.9)	0.3 (0.0)	0.3 (0.9)

^aD. farinae=Dermatophagoides farinae, D. pteronyssinus=Dermatophagoides pteronyssinus, kU/L=kilounits per liter

Table 3. Association between allergen-specific immunoglobulin E (IgE) and glaucoma in NHANES 2005-2006.

Estimates Based on Weighted Frequencies			
IgE Type	Unadjusted OR ^{a,b}	OR (95% CI) ^a Adjusted for Age, Ethnicity, and Steroid Use ^b	OR (95% CI) ^a Adjusted for Age, Ethnicity, Steroid Use, and Immune Cross-Reactivity ^b
Total IgE	1.47 (0.72, 2.97)	1.24 (0.62, 2.50)	0.86 (0.44, 1.71)
D. Farinae ^a	<i>2.10 (1.13, 3.92)</i>	<i>2.26 (1.14, 4.47)</i>	<i>2.00 (0.71, 5.66)</i>
D. Pteronyssinus ^a	1.94 (0.99, 3.80)	<i>2.16 (1.05, 4.42)</i>	0.84 (0.28, 2.51)
Cockroach	<i>2.59 (1.34, 5.00)</i>	<i>3.01 (1.37, 6.64)</i>	<i>2.78 (1.34, 5.76)</i>
Cat	1.67 (0.75, 3.69)	2.23 (0.99, 5.03)	<i>3.42 (1.10, 10.67)</i>
Dog	0.55 (0.18, 1.66)	0.78 (0.25, 2.50)	<i>0.24 (0.06, 0.96)</i>
Mouse	--- ^c	--- ^c	--- ^c
Rat	--- ^c	--- ^c	--- ^c
Estimates Based on Actual Frequencies			
IgE Type	Unadjusted OR ^{a,b}	OR (95% CI) ^a Adjusted for Age, Ethnicity, and Steroid Use ^b	OR (95% CI) ^a Adjusted for Age, Ethnicity, Steroid Use, and Immune Cross-Reactivity ^b
Total IgE	1.25 (0.77, 2.02)	1.03 (0.63, 1.69)	0.75 (0.42, 1.34)
D. Farinae ^a	<i>1.72 (1.02, 2.90)</i>	<i>1.67 (0.97, 2.87)</i>	<i>1.76 (0.56, 5.53)</i>
D. Pteronyssinus ^a	1.56 (0.91, 2.70)	<i>1.59 (0.91, 2.78)</i>	0.79 (0.25, 2.54)
Cockroach	<i>2.15 (1.22, 3.81)</i>	<i>2.31 (1.27, 4.20)</i>	<i>2.62 (1.29, 5.32)</i>
Cat	1.49 (0.79, 2.81)	<i>1.92 (0.99, 3.71)</i>	<i>3.29 (1.50, 7.25)</i>
Dog	0.63 (0.25, 1.58)	0.74 (0.29, 1.89)	<i>0.29 (0.09, 0.89)</i>
Mouse	--- ^c	--- ^c	--- ^c
Rat	--- ^c	--- ^c	--- ^c

^aOR=odds ratio, CI=confidence interval, D. farinae = Dermatophagoides farinae, D. pteronyssinus = Dermatophagoides pteronyssinus

^bStatistically significant associations are in italics

^cStatistically unstable estimates due to small cell counts

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