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Correlation of specific IgE to shrimp with cockroach and dust mite exposure and sensitization in an inner city population

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Abstract

Background—Studies have demonstrated that IgE-binding cross-reactive epitopes between shrimp, cockroach and house dust mite tropomyosins can account for the presence of detectable IgE to shrimp in people who have cockroach and dust mite allergies.

Objective—We investigated the correlation between IgE-mediated sensitization to shrimp, cockroach, and dust mite in relation to allergen exposure in inner-city children.

Methods—Five hundred and four serum samples from the National Cooperative Inner City Asthma Study (NCICAS) were evaluated for specific IgE to shrimp and the results were compared to specific IgE to cockroach (*Blattella germanica*) and dust mite (*Dermatophagoides farinae*). Associations between IgE sensitization to these allergens and environmental exposures were determined.

Results—There was a strong positive correlation between shrimp, cockroach, and dust mite IgE levels. High exposure to cockroach (Bla g) in the home, particularly in the bedroom and television room, was significantly correlated with higher shrimp and cockroach IgE levels. In contrast, high exposure to dust mite in the home was highly correlated with IgE to *D.farinae*, but not with shrimp IgE levels. There is a synergistic relationship between cockroach IgE and exposure in predicting shrimp IgE levels.

Conclusions—For children with evidence of IgE-mediated sensitization to cockroach and shrimp, having high exposure to cockroach in the home can contribute to higher shrimp IgE levels, which may not correlate with clinical reactivity. Further patient evaluations with clinical histories of shrimp exposure and reactions as well as oral food challenges would have to be performed to confirm these findings.

Keywords

cockroach; dust mite; shrimp; tropomyosin; cross-reactivity

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Clinical Implications: Shrimp IgE is correlated with cockroach IgE and exposure to cockroach allergen in the home, suggesting that shrimp IgE may need to be interpreted in the context of environmental exposures.

Introduction

Food allergy affects nearly 4% of the US population [1], and a recent study by Liu *et al*. [2] suggests that black male children have the highest rates of food allergy. Over 8,000 participants in the NHANES 2005–2006 had serum-specific IgE measured to egg, milk, peanut, and shrimp. The prevalence of sensitization to any of these foods was 16.8% and was significantly higher in children (23.2%), males (20.4%), non-Hispanic blacks (27.0%) and persons of lower income (19.0%). The largest disparity between estimated clinical allergy rates between races/ethnicities, high versus low poverty income ratio, and high versus low household education level was seen for shrimp allergy.

In the same study [2], the authors found that subjects with asthma had increased risk of all measures of food sensitization, adding further support for the association between food allergy and asthma [3–5]. However, it is well known that IgE-binding cross-reactive epitopes between food allergens and environmental allergens may contribute to elevated IgE levels [6–8]. In particular, house dust mite and cockroach tropomyosins can account for the presence of detectable IgE to shrimp, even in unexposed individuals [9].

Since inner city children tend to have high rates of exposure to environmental allergens, we hypothesized that sensitization to cockroach and dust mite might correlate with sensitization to shrimp. This could be an important factor to consider when assessing prevalence of food allergies based only on serologic tests. If environmental allergen exposure does have an influence on food-specific IgE levels, this may have a significant impact on management of food allergies, particularly when deciding whether to perform oral food challenges.

Methods

Study population

NCICAS included 1528 children 4–9 years of age with asthma who were recruited from emergency departments and clinics in inner city areas in the United States (Bronx, New York; East Harlem, New York; St. Louis; Washington, D.C.; Baltimore; Chicago; Cleveland; and Detroit) [10,11]. The study was approved by the institutional review board at each site, and written informed consent was obtained from the parents or legal guardians of participants. At enrollment, participants were invited to provide a voluntary blood sample with the understanding that it would be stored for future analyses of markers of atopy (i.e. allergen-specific IgE). Five hundred four of the children had serum samples available for IgE analysis.

Home visits were performed in a subset of participants and allergen levels for *Dermatophagoides farinae* (Der f 1), *D. pteronyssinus* (Der p 1), and *Blattella germanica* (Bla g 1) were measured from settled dust in 198 homes of participants who also had serum available [12].

Assays

The serum samples were evaluated for specific IgE (ImmunoCAP® system; Phadia; Uppsala, Sweden) to shrimp (boiled, frozen Atlantic shrimp and raw, frozen prawns from the Indo-West-Pacific). A specific IgE (SIgE) level ≥ 0.35 kUA/L indicated sensitization. From a previous study, specific IgE levels (ImmunoCAP® system; Phadia; Uppsala, Sweden) to w hole body cockroach (*Blattella germanica*) and whole body culture of *Dermatophagoides farinae* were available.

Statistical analysis

We used χ^2- statistics to test differences in the prevalence of shrimp-specific IgE levels by population characteristics. Pearson correlations were used to assess the association between serum specific IgE to shrimp, cockroach *(Blattella germanica)*, dust mite (*Dermatophagoides farinae*) and home allergen exposure levels. Effect modification of the relationship of home exposures to shrimp-specific IgE levels stratified by sensitivity to other allergens were tested with an interaction term. Allergen-specific serum IgEs and allergen exposure levels were logarithmically transformed (base 10) for the statistical analysis because of skewed distributions.

The nationally representative NHANES 2005–2006 data were analyzed using the sampling weights and survey design variables to account for the complex sample design. All analyses were conducted using the R system for statistical computing (version 2.12.1). Statistical significance was established a priori at 0.05.

Results

Overall, 32.7% of the children in the NCICAS study had a positive shrimp-specific IgE result. Positive shrimp-specific IgE was associated with age and race, but not sex or caretaker's education level (Table 1).

Shrimp IgE and cockroach and dust mite IgE levels were highly correlated (Figure 1). High exposure to cockroach (Bla g 1) in the home, particularly in the bedroom and television room, was significantly correlated with higher shrimp and cockroach IgE levels. In contrast, high exposure to dust mite (Der f 1) in the home was significantly correlated with IgE to *D.farinae*, but not with shrimp IgE levels (Table 2).

When examining the roles of sensitization and exposure to cockroach on shrimp IgE levels, a synergistic relationship is found between cockroach IgE and exposure in predicting shrimp IgE (interaction p-value = 0.01). For those with sensitization to cockroach, there is a strong correlation between exposure to cockroach in the home and shrimp IgE level, indicating that exposure may be an important contributor to elevations in shrimp IgE in some individuals (Figure 2).

Discussion

Results from the NHANES data indicate that young males of lower socio-economic status are at highest risk for food allergies [2]. Prevalence of shrimp sensitization demonstrated the greatest disparity between race, poverty income ratio and education. This raises the question of how these demographic categorizations are associated with shrimp sensitization. One possibility is environmental exposures, as it is well known that cockroach allergen exposure is a big factor for inner city asthmatics. Therefore, we sought to investigate the role of environmental exposure to allergens in relation to shrimp sensitization.

Nationally representative data from NHANES 2005–2006 demonstrate similar associations to NCICAS between high shrimp sensitization in non-hispanic blacks of lower socio-economic status (Table 3). It is well-known that cockroach, dust mite and shrimp tropomyosins share high sequence identity (~80%) [8] and with the additional exposure data that was collected in thi s population, we not only found a high correlation between both cockroach IgE and shrimp IgE, but a high correlation between exposure to cockroach and shrimp IgE as well. In contrast, we did not find a correlation between dust mite exposure and shrimp IgE.

These findings provide a potential explanation for the higher observed rates of sensitization to shrimp in black male children from the inner city. Shrimp IgE levels may need to be interpreted in the context of environmental exposures for this particular population. Studies have reported different predictive values for food-specific IgE levels depending on the study population, which likely is a reflection of diet, demographics (i.e. age), and disease states (i.e. presence or absence of atopic dermatitis) [13–17]. The results of this study suggest that there may be racial or socio-economic differences for food-specific IgE cutoff levels as well. Further studies using oral food challenges to confirm clinical reactivity will be necessary to further explore this possibility.

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Abbreviations

NCICAS	National Cooperative Inner City Asthma Study
IgE	Immunoglobulin E
Bla g 1	Blattella germanica 1
Der f 1	Dermatophagoides farinae 1
SIgE	Specific IgE
SIgG	Specific IgG

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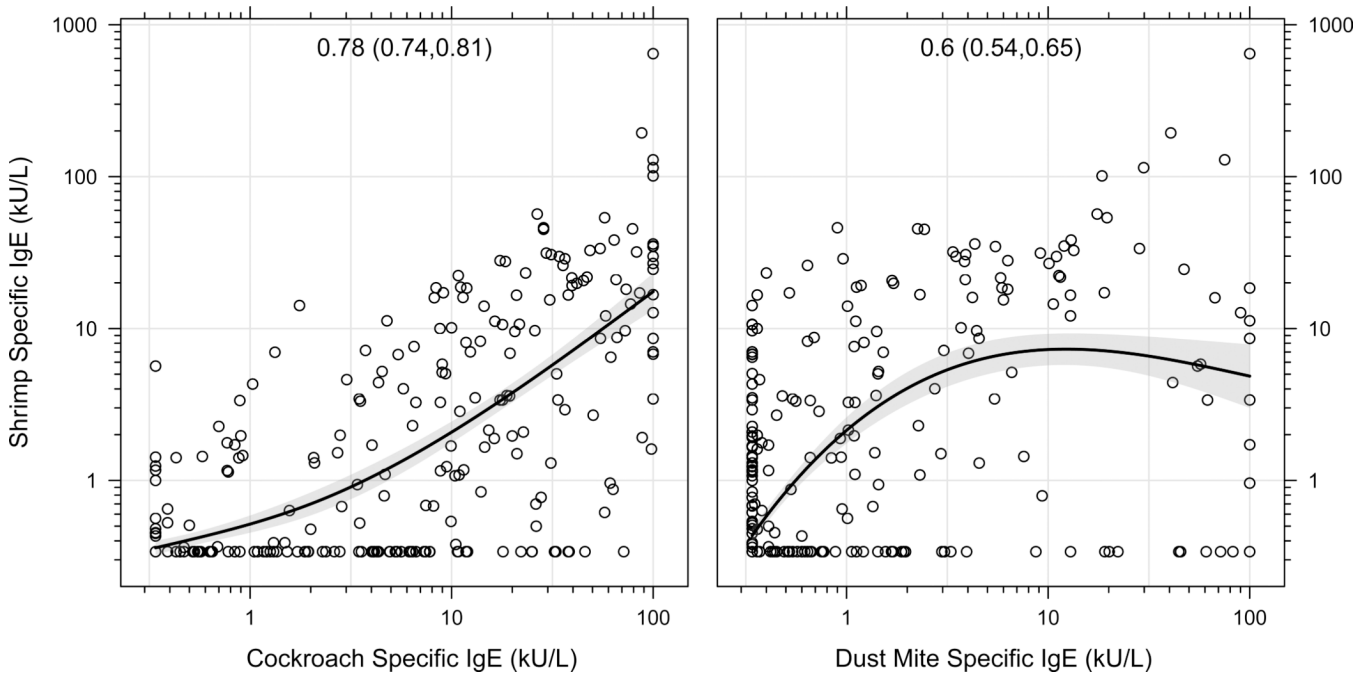

Figure 1.
Shrimp IgE and cockroach and dust mite IgE levels were highly correlated

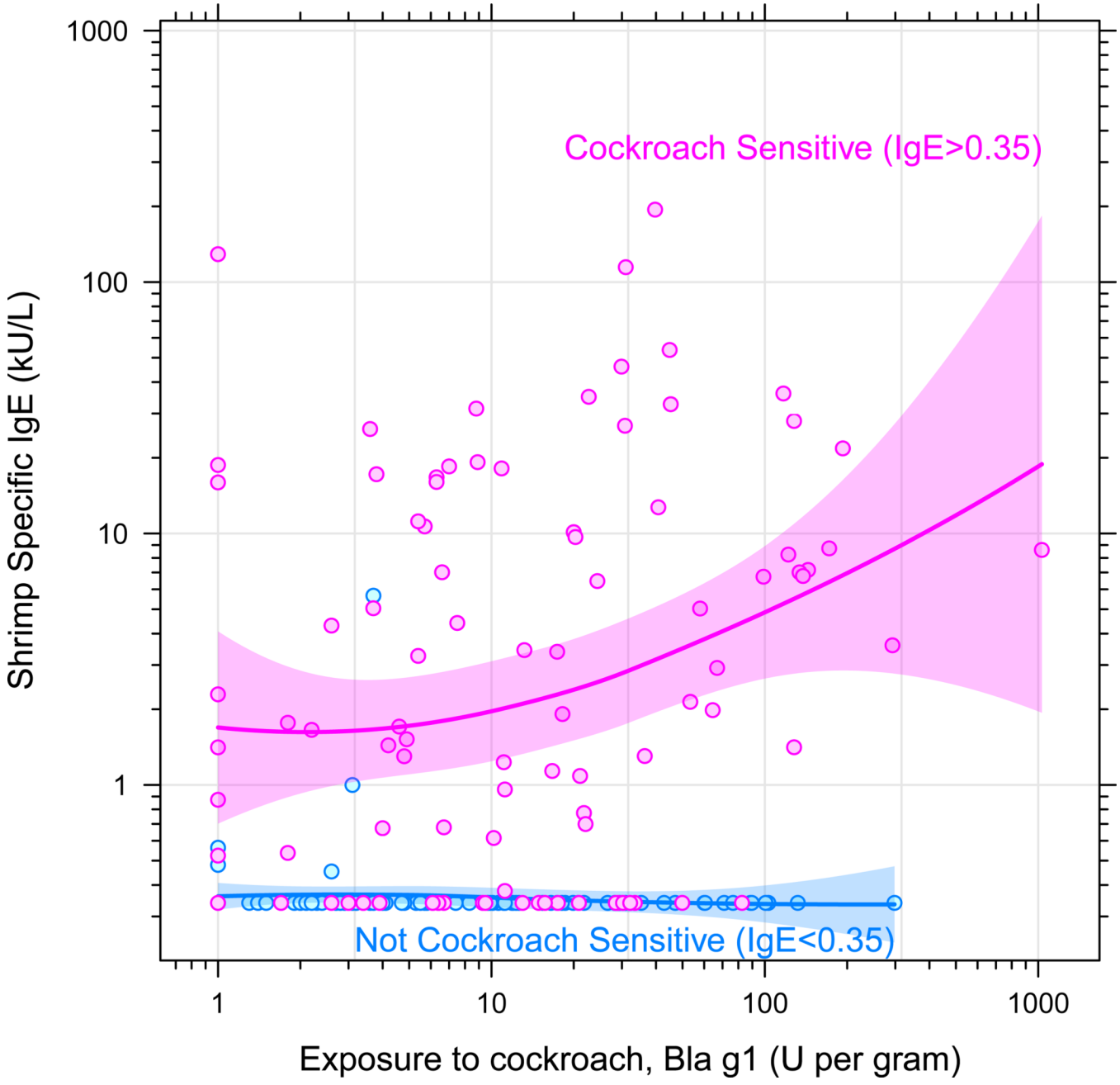

Figure 2.
Shrimp-specific IgE was correlated with exposure to cockroach, but only among children IgE positive to cockroach

Table 1

Demographic characteristics

Subject Characteristics	N	% Shrimp Positive (SE)	Chi-square p-value
Overall	504	32.7 (2.1)	
Age			
4–6	285	28.8 (2.7)	0.03
7–9	218	38.1 (3.3)	
Sex			
Male	319	33.5 (2.6)	0.64
Female	184	31.5 (3.4)	
Race-ethnicity			
Hispanic	58	53.4 (6.6)	0.001
Black	410	30.5 (2.3)	
Other	26	19.2 (7.8)	
Education (mother)			
< 12th grade	171	32.2 (3.6)	0.64
12th grade	193	30.6 (3.3)	
> 12th grade	132	35.6 (4.2)	
Cockroach Specific IgE			
Not detectable	280	3.6 (1.1)	<0.001
Detectable	224	69.2 (3.1)	

Table 2

Correlation between allergen lev els in settled dust and specific IgE levels

		Cockroach sIgE		Dust mite (Dermatophagoides farinae) sIgE		Shrimp sIgE	
Exposure		**Corr**	**P**	**Corr**	**P**	**Corr**	**P**
Bla g 1	Bedroom	**0.32**	**<0.001**	**0.14**	**<0.10**	**0.27**	**<0.001**
	TV room	**0.26**	**<0.001**	**0.13**	**<0.10**	**0.20**	**<0.01**
	Kitchen	**0.20**	**<0.01**	0.05	0.47	0.08	0.25
Der f 1	Bedroom	−0.03	0.65	**0.15**	**<0.05**	0.01	0.93
	TV room	−0.06	0.41	**0.25**	**<0.001**	0.04	0.60
	Kitchen	−0.04	0.56	0.02	0.76	−0.02	0.83

Table 3

Percent (SE) detectable shrimp- specific serum IgE in National U.S. Data: NHANES 2005–2006, Ages 6–19 years

Subject Characteristics	All Children Ages 6–19		Children w/ Asthma Ages 6–19	
	N	% (SE) Shrimp Positive	N	% (SE) Shrimp Positive
Overall	3433	6.1 (0.73)	360	9.9 (2.49)
Age		<0.01		0.15
6–11	1145	3.3 (0.65)	120	9.8 (3.78)
12–15	1128	7.2 (1.09)	121	5.7 (2.01)
16–19	1160	8.7 (1.46)	119	15.0 (4.54)
Sex		0.65		0.59
Male	1697	6.3 (0.91)	197	8.9 (3.24)
Female	1736	5.9 (0.86)	163	11.2 (3.29)
Race-ethnicity		<0.001		<0.01
Non-Hispanic white	882	4.2 (0.79)	102	6.5 (3.11)
Non-Hispanic black	1124	12.5 (1.57)	143	26.5 (4.78)
Mexican American	1130	7.8 (1.27)	87	11.5 (3.57)
Other	297	6.3 (2.23)	28	4.4 (4.21)
Education (family referent)		<0.01		0.09
< 12th grade	1030	10.1 (1.13)	94	20.8 (4.51)
12th grade	790	5.4 (0.98)	82	8.9 (3.23)
> 12th grade	1450	5.1 (0.98)	169	8.3 (3.53)
Missing/unknown	163	6.2 (3.22)	15	1.4 (1.42)
Poverty Index Quartiles		<0.01		0.37
1st [0 – 1.59]	1209	8.9 (0.78)	121	12.8 (2.71)
2nd [1.60 – 3.05]	901	5.1 (1.09)	97	7.7 (3.11)
3rd [3.06 – 4.96]	624	4.2 (0.90)	64	11.5 (6.40)
4th [4.97 – 5]	537	6.3 (1.81)	68	7.8 (4.06)
Missing/unknown	162	4.5 (1.45)	10	15.2 (13.99)
> 1 non-food positive specific IgE		<0.001		<0.001

Subject Characteristics	All Children Ages 6–19		Children w/ Asthma Ages 6–19	
	N	% (SE) Shrimp Positive	N	% (SE) Shrimp Positive
No	1427	0.2 (0.15)	92	0 (0)
Yes	1449	13.5 (1.44)	213	15.6 (3.45)
Missing/unknown	557	0 (0)	55	0 (0)
Cockroach Specific IgE		<0.001		<0.001
Not detectable	2456	1.9 (0.33)	227	3.6 (1.79)
Detectable	448	42.1 (3.68)	81	39.9 (7.06)