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Changes in Food-specific IgE Over Time in the National Health and Nutrition Examination Survey (NHANES)

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Abstract

Background—Food allergy prevalence appears to have recently risen, with larger increases among non-Hispanic blacks. However, it is unclear whether these trends represent shifts in recognition of food allergy or in sensitization.

Objective—To determine whether sensitization to common food allergens increased in U.S. children from 1988–1994 to 2005–2006 and whether these trends differed by race/ethnicity.

Methods—Food-specific IgE (to peanut, milk, egg and shrimp) was measured by ImmunoCap in stored sera from subjects aged 6–19 in the National Health and Nutrition Examination Survey (NHANES) III (1988–1994) and was compared to NHANES 2005–2006. Sensitization to foods was defined as overall (IgE $\geq$ 0.35 kU/L), moderate-level (IgE $\geq$ 2 kU/L) and high-level (IgE commonly used 95% predictive values). Sensitization to individual and combined foods was compared between surveys, with analyses further stratified by race/ethnicity.

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Results—7,896 subjects (NHANES III: n=4995, NHANES 2005–2006: n=2,901) were included. In NHANES III, prevalence of food sensitization was 24.3% (95% CI:22.1–26.5) compared to 21.6% (95% CI:19.5–23.7) in NHANES 2005–2006. There were no significant changes in the prevalence of any level of milk, egg or peanut sensitization, but shrimp sensitization at all levels decreased markedly; overall sensitization NHANES III: 11.2% (95% CI:10.0–12.5) versus NHANES 2005–2006: 6.1% (95% CI:4.5–7.7). There was a trend towards increased prevalence of moderate- and high-level sensitization to the combination of milk, egg and peanut among non-Hispanic blacks but not other groups.

Conclusion—In contrast to our expectations, sensitization to common food allergens did not increase between the late-1980s/early-1990s and mid-2000s among U.S. 6–19 year olds, and in fact decreased to shrimp.

Keywords

Food allergy; NHANES; Food sensitization; Epidemiology

Introduction

Food allergy is a common childhood condition that appears to have increased rapidly in prevalence over the past few decades.(1–4) This increase has led to substantial efforts to understand the causes of the “food allergy epidemic,” such as the timing of food introduction,(5) changes in diet and nutrition,(6, 7) and microbial exposures.(8) The data demonstrating an increase in prevalence, however, are based largely on self-reported food allergy and health care utilization for manifestations of food allergy, but there are currently no data on national time trends in laboratory correlates of food allergy. Thus, it is not known whether this increased prevalence observed in questionnaires and health care utilization is accompanied by increases in serologic biomarkers of food allergy.(9)

In addition, current evidence points to large and widening disparities in the prevalence of food allergy by race/ethnicity. In a recent systematic review, the increase in prevalence of self-reported food allergy was significantly higher in children of non-Hispanic Black race/ethnicity compared to Non-Hispanic White and Hispanic children over the past two decades. (2) It is not currently known, however, whether this rapid increase in self-reported food allergy in Non-Hispanic Blacks is correlated with changes in allergic sensitization.

Prior to this study, only one national survey in the U.S., The National Health and Nutrition Examination Survey (NHANES) 2005–2006, measured food-specific IgE. Here we measured food-specific IgE to milk, egg, peanut, and shrimp, in stored sera from NHANES III, which was conducted between 1988 and 1994. Our objective was to directly compare food-specific IgE levels to common food allergens in representative samples of the United States population over a span of approximately 15 years, in order to determine whether the increase observed in self-reported and diagnosed food allergy during this time period has been associated with changes in allergic sensitization.

Methods

The National Health and Nutrition Examination Surveys (NHANES) are a series of cross-sectional studies conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control (CDC). NHANES III was conducted from 1988–1994, and since 1999, NHANES has been conducted continuously in 2-year blocks.(10) Sampling is designed to be representative of the overall non-institutionalized U.S. population, with over-sampling of certain groups to ensure power for sub-group analyses. Interviews are initially conducted in subject's homes, followed by physical exams in mobile centers. Response rate for the examination portion of the survey was 78% for NHANES III and 77% for NHANES 2005–2006. The NHANES and use of stored sera were approved by the IRB of the NCHS and all subjects provided informed consent. Children 12 and older for NHANES III and 7 and older for NHANES 2005–6 provided informed assent.

Participants aged 6–19 with frozen stored surplus sera in NHANES III or with food-specific measurements in NHANES 2005–2006 were included. These cut-offs were chosen because stored sera was not available in children younger than age 6 in NHANES III and the NCHS preferred to use 19 as a cut-off for analyses of stored sera. The sera were collected using similar standardized protocols in both NHANES III and NHANES 2005–2006 and were stored at –70C.

Definitions

Food-specific IgE to cow's milk ("milk"), hen's egg white ("egg"), peanut, and shrimp was measured at the same clinical laboratory (Elmhurst Reference Laboratory, Elmhurst, Illinois) using standard techniques (ImmunoCap, Phadia. Upsalla, Sweden) for both surveys.(1) Food-specific IgE from NHANES III was analyzed between 2014 and 2015. Data are reported as the concentration of allergen specific units (kU/L), and the lower limit of detection was 0.35 kU/L.

Food-specific IgE levels for each food were used to define three *a priori* overlapping categories: overall, moderate-level, and high-level sensitization. *Overall sensitization* was defined as food-specific IgE ≥ 0.35 kU/L for all foods, *moderate-level sensitization* as food-specific IgE ≥ 2 kU/L for all foods, and *high-level sensitization* as food-specific IgE at or above values that have previously been considered 95% predictive probability cut-offs (15 kU/L for milk, 7 kU/L for egg, and 14 kU/L for peanut).(11, 12) As there is not a well-established cut-off for shrimp, a value of 5 kU/L was chosen to define high-level sensitization, consistent with previous studies using NHANES.(1)

When considering the foods together, individuals were grouped into overall, moderate-level or high-level sensitization to "Milk, Egg, or Peanut" if they had at least one food-specific IgE in the cut-off range to these foods. As sensitization patterns for shrimp demonstrated a different trend than those seen with milk, egg, and peanut, we treated sensitization to this food separately.

Race/ethnicity was obtained by self-report, and was categorized as "Non-Hispanic White," "Non-Hispanic Black," "Mexican-American," and "Other" in NHANES III. In NHANES

2005–2006, the same categories were used with the addition of “Other Hispanic” (n=349), a population that had been included in “Other” in NHANES III. For the purpose of these analyses, “Non-Hispanic White,” “Non-Hispanic Black,” and “Mexican-American,” categories were used. Because there were so few subjects in the “Other” category, and because the composition of this category likely changed between surveys, stratified analyses in this category are not shown.

In order to define the allergic profile of the populations at both time points, prevalence of self-reported asthma and allergic rhinitis are presented. Asthma was defined as a positive response to the question, “Has a doctor (or other health professional) ever told you that you have asthma?” Similarly, allergic rhinitis was defined as a positive response to the question, “Has a doctor (or other health professional) ever told you that you had hay fever?”

Statistical Methods

To account for oversampling, complex sampling methods, and non-response, we used cluster sampling units, pseudo-strata and sampling weights provided by the CDC for all analyses using the “SVY” commands in STATA 12.1. As the sampling units and pseudo-strata could not be combined between these two surveys, the proportion of children with overall, moderate, and high-level sensitization to each food, as well as these proportions by race/ethnicity and age, were independently calculated for each survey. Risk difference estimates were then calculated for the proportions across surveys, with p-values and confidence intervals calculated with the delta equation using the computed estimates and standard errors.(13) Sensitivity analyses were done to evaluate the effect of changing demographics between the studies by direct standardization of NHANES III to match the racial/ethnic distribution of NHANES 2005–2006, using the techniques suggested in the NHANES documentation (http://www.cdc.gov/nchs/tutorials/NHANES/NHANESAnalyses/agestandardization/age_standardization_intro.htm).(14, 15) Two-tailed p values < 0.05 were considered statistically significant. All analyses were performed manually or using STATA 12.1 (College Station, TX).

Results

Study Population

A total of 7,896 children between the ages of 6 and 19 were included in this study (4,995 from NHANES III and 2,901 from NHANES 2005–2006). The two populations were similar in terms of age distribution and sex, but the percentage of Mexican-American individuals was higher in 2005–2006 (Table 1). The percentage of children with asthma was higher in 2005–2006, whereas the percentage with allergic rhinitis was lower (Table 1).

Changes in Food-Specific IgE Over Time

Overall, 24.3% (95% CI 22.1–26.5) of children were sensitized (IgE ≥ 0.35 kU/L) to milk, egg, peanut, or shrimp in NHANES III, whereas 21.6% (95% CI 19.5–23.7) of children were sensitized in NHANES 2005–2006 (p = 0.07), as shown in Table 2 (unweighted numbers are given in Table 3). There was no change in the prevalence of moderate-level food-specific sensitization (≥ 2 kU/L) to any food, and the percentage of those with high-level food

sensitization actually decreased from 2.8% (95% CI 2.0–3.6) to 1.5% (95% CI 1.0–2.1, $p = 0.01$) between NHANES III and NHANES 2005–2006.

For the individual foods, there was no significant change in the prevalence of overall, moderate, or high-level sensitization to milk, egg, or peanut (Table 2). There was, however, a significant decrease in the prevalence of shrimp sensitization for overall (11.2; 95% CI 10.0 – 12.5 versus 6.1%; 95% CI 4.5 – 7.7; $p < 0.001$), moderate (4.1%; 95% CI 3.3 – 4.9 versus 1.7%; 95% CI 1.2 – 2.2; $p < 0.001$) and high-level sensitization (2.2%; 95% CI 1.6 – 2.9 versus 0.6%; 95% CI 0.4 – 0.9; $p < 0.001$).

To examine age-specific trends, we examined three age categories: 6–9 years, 10–15 years, and 16–19 years (Table 4). Overall shrimp sensitization decreased significantly between NHANES III and NHANES 2005–2006 in all age groups, whereas the decrease in moderate-level and high-level sensitization was only significant in children older than 10 years of age. In adolescents ages 16–19, a significant increase in high-level sensitization to the combination of milk, egg, or peanut was observed (0.1%; 95% CI 0 – 0.2 versus 0.7%; 95% CI 0.1 – 1.2; $p = 0.02$), which was due to an increase in high-level peanut sensitization (data not shown).

Standardization of NHANES III to match the racial/ethnic distribution that existed at the time of NHANES 2005–2006 did not affect the results (Table 5).

Ethnicity-specific Trends Over Time

Overall, non-Hispanic Black children had higher levels of sensitization to milk, egg, peanut, and shrimp than Mexican-American and non-Hispanic White children in both surveys (Figure 1 and Table 6). While a decrease in overall and moderate shrimp sensitization was observed in all race/ethnicities, there was a trend towards an increase in moderate-level (6.0%; 95% CI 4.4 – 7.5 versus 9.1%; 95% CI 5.6 – 12.6; $p = 0.08$) and high-level sensitization (0.7%; 95% CI 0.2 – 1.2 versus 2.3%; 95% CI 0.5 – 4.0; $p = 0.06$) to the combination of milk, egg, or peanut in non-Hispanic Blacks (Figure 1). This was largely due to an increase in prevalence of moderate and high-level sensitization to peanut (Table 6). Among non-Hispanic White and Mexican-American children, there was no significant change in the prevalence of overall or moderate-level food sensitization to milk, egg, or peanut over time (Figure 1).

Discussion

In this comparison of two nationally-representative surveys conducted in a similar fashion approximately 15 years apart, we found that sensitization to milk, peanut, and egg, as measured by food-specific IgE, remained constant, and sensitization to shrimp decreased. These findings are contrary to our hypothesis that sensitization to common food allergens increased in recent years, and stand in contrast with a body of literature showing increased prevalence of self-reported food allergy and increased health-care utilization for its manifestations.

Evidence supporting an increasing prevalence over the past several decades of food allergy in general, and peanut allergy in particular, comes from a variety of sources, but has not included biomarkers of food allergy. Within the National Health Interview Survey, parental-reported food allergy among children increased from 3.4% in 1997–1999 to 5.1% in 2009–2011(4), while Sicherer *et al* demonstrated that the proportion of children with self-reported peanut allergy increased from 0.4% in 1997 to 0.8% in 2002 to 1.2% in 2008 in a series of telephone surveys.(1) Similar trends have been seen in manifestations of food allergy, including emergency room visits,(16) hospital discharges,(17) and anaphylaxis.(18, 19) Although some of these studies, such as the National Health Interview Survey, were not designed to specifically elicit symptoms consistent with IgE-mediated allergy, Sicherer *et al*'s tailored questionnaires about peanut allergy and data on food-related anaphylaxis suggest increases in prevalence of IgE mediated allergy in general, and peanut allergy in particular, in the U.S. Because IgE sensitization is a necessary component of IgE-mediated food allergy, it would be reasonable to expect that sensitization to common food allergens would have increased over the time period when self and parental report of and manifestations of food allergy appear to have increased. Our surprising finding that sensitization did not increase, if true, suggests that changes in IgE sensitization to common food allergens is not the cause of the apparent increase in self-reported and diagnosed food allergy. Instead, we propose two possible hypotheses to reconcile our results with the large body of literature suggesting increases in self-reported and diagnosed food allergy: 1) it is the relationship between sensitization and IgE-mediated food allergy that has changed over time or 2) the apparent increase in food allergy prevalence is the result of increased recognition and diagnosis rather than a true increase in IgE-mediated food allergy.

The recent LEAP trial of early peanut introduction provided persuasive evidence that peanut avoidance in infancy may increase the rate of clinical reactivity, but there was no difference in rates of IgE sensitization to peanut or mean peanut-specific IgE levels between those children who consumed or avoided the food.(5) Thus our findings could be consistent with the idea that delayed introduction to peanut and other allergens contributed to higher rates of clinical food allergy over the years studied, despite similar rates of sensitization. Besides delayed introduction, it is also possible that other changing environmental exposures may have affected the relationship between sensitization and clinical allergy during this time. Although it is well known that only a minority of those sensitized to foods have clinical manifestations of food allergy(20), little research has been done on the factors that may promote or protect against the development of clinical disease among those sensitized to foods. Screening data from the LEAP study suggested that specific IgE may have a weaker relationship to clinical disease among non-White populations for unclear reasons(21). For allergic rhinitis, there is some evidence from the International Study of Asthma and Allergies in Childhood that the relationship between sensitization to aeroallergens and clinical rhinitis and asthma is stronger in affluent than non-affluent countries(22, 23). One hypothesis for these findings is differences in infectious exposures, although geographic differences between sensitization and clinical disease are not fully understood. Further research into the environmental factors that may affect the relationship between sensitization and clinical allergy could identify modifiable targets for prevention of food allergy and other allergic diseases.

Alternatively, these findings could be consistent with changing recognition of food allergy. It is well known that over-perception of food allergy is common, and it is possible that perception of food allergy has changed over time as awareness has grown. When based on self-report, the prevalence of food allergy ranges from 3 to 35%, whereas when based on more objective measures, such as oral food challenges, the prevalence decreases to 1–11%. (9) Previous studies have further shown that among children with parental-reported food allergy, 30% were not diagnosed by a physician, and only 20% of those who were seen by a physician underwent an oral food challenge.(24) Physician diagnosis may also be unreliable, as food allergy is commonly over-diagnosed(25) and recognition and management of anaphylaxis can be quite variable.(26–28) Thus, it is possible that the apparent increase in food allergy seen in previous reports based on self-report and diagnosis codes is at least in part a result of changing recognition, rather than changing clinical disease.

While levels of overall sensitization to milk, egg, and peanut did not change between NHANES III and NHANES 2005–2006, there was a trend towards increased moderate and high-level sensitization to the combination of milk, egg, and peanut among children of Non-Hispanic Black race/ethnicity. Thus, we cannot fully exclude increased sensitization as an explanation for the trends towards increasing racial/ethnic disparities in self-reported food allergy.(2, 29) Whether these trends are due to gene-environment interactions, differences in the distribution of environmental risk factors or changes in recognition remains unclear and warrants further study.

Finally, we found that sensitization to shrimp decreased significantly between NHANES III and NHANES 2005–2006 across all racial/ethnic groups and ages. The major shrimp allergen, tropomyosin, is cross-reactive with cockroach, dust mite and nematodes(30). It has been suggested that cockroach and/or dust mite exposure may drive shrimp sensitization, and it is possible that changes in exposure and sensitization to these cross-reactive allergens could account for these findings.(31, 32) As there is little longitudinal data on either shellfish or cockroach allergy in the United States, this is an area that clearly requires further research.

This study is limited by the fact that food sensitization was only assessed in children 6 and older because stored sera was not available in younger children in NHANES III. While the prevalence of food allergy to milk and egg is greatest in infancy, and different trends may have been seen in this age group, the group studied represents sensitization trends observed in the clinically important category of persistent food allergy. However, we cannot exclude the possibility that food sensitization increased among those born after the year 2000, or alternatively prior to NHANES III. Our study is further limited by the lack of clinical data to support or refute a diagnosis of true food allergy in these surveys, and we cannot give an estimate of the true rate of clinical reactivity to foods based on this data. We used previously defined levels of IgE to indicate moderate- and high- level IgE, but it is not clear how these IgE levels relate to risk of clinical allergy.^{2,20} Similarly, we could not directly compare changes in self-reported food allergy over time to changes in sensitization in these surveys, so we cannot exclude the possibility that self-reported food allergy did not differ between these two study populations, although changes in self-reported food allergy have been shown in many other studies. Food-specific IgE was measured in stored sera, which may have

resulted in degradation of IgE, potentially resulting in measurement bias. However, given the similar sera collection, handling, and storage techniques, as well as the known stability of IgE in the setting of repeated freeze/thaw cycles, this measurement error is likely to be minimal. (33, 34) In addition, we only assessed IgE to milk, egg, peanut, and shrimp, so cannot exclude the possibility that other food allergens showed different sensitization trends. Finally, we did not measure allergen component-specific IgE (such as to Arah2), which might have provided further information on children more likely to be clinically reactive to certain foods.(35–37)

However, these weaknesses are balanced by several strengths: (1) NHANES are large cross-sectional surveys of the US population of children and are hence generalizable, (2) the same laboratory methods were performed by the same laboratory for both surveys, and (3) this is the only population-based comparison of food sensitization that has been performed to date in the U.S.

In conclusion, in this comparison of two nationally representative surveys conducted in a similar fashion approximately 15 years apart, we found that prevalence of positive food-specific IgE to milk, peanut, and egg remained constant among 6–19 year olds, whereas shrimp-specific IgE levels decreased. This finding is in sharp contrast to other studies that have reported a recent rise in self-report of food allergy and in health care utilization and suggests either changes in the relationship between sensitization and clinical allergy or changes in the recognition and diagnosis of food allergy.

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Abbreviations used

NHANES	National Health and Nutrition Examination Survey
NCHS	National Center for Health Statistics
CDC	Centers for Disease Control
PIR	Poverty Income Ratio
IgE	Immunoglobulin E

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Highlights

What is already known about this topic?

Many studies of self-reported food allergy and health care utilization for food allergy have shown increased prevalence in the past three decades, but there is no data about changes in biomarkers of food allergy.

What does this article add to our knowledge?

In this study of stored sera from NHANES III compared to analyses from NHANES 2005–6, we found that prevalence of IgE sensitization to peanut, milk, egg and shrimp did not increase from the late 1980s/early 1990s to the mid-2000s.

How does this study impact current management guidelines?

These surprising results suggest that changes in IgE sensitization to common food allergens is not the cause of the apparent increase in self-reported and diagnosed food allergy in the U.S. over the past several decades.

A.

B.

C.

Figure 1. Trends in food sensitization over time by race/ethnicity

Proportion of children ages 6–19 with overall, moderate-level, and high-level food-specific IgE levels to milk, egg, or peanut in NHANES III (red) and NHANES 2005–2006 (blue) by race/ethnicity. (A) Non-Hispanic White; (B) Non-Hispanic Black; (C) Mexican-American. Bars and whiskers represent 95% confidence intervals (CIs).

Table 1

Demographic Characteristics of Study Population in NHANES III and NHANES 2005–2006

Characteristic	NHANES III Percentage (95% CI) (n = 4995)	NHANES 2005–2006 Percentage (95% CI) (n = 2901)	p value [†]
Age (y)			
6–10	33 (30 – 35)	34 (30 – 38)	0.52
11–15	38 (36 – 41)	36 (34 – 39)	0.95
16–19	29 (26 – 32)	30 (26 – 33)	0.98
Sex			
Female	49 (47 – 52)	49 (46 – 51)	0.75
Race/Ethnicity			
Non-Hispanic White	66 (62 – 70)	64 (57 – 71)	0.55
Non-Hispanic Black	15 (13 – 17)	15 (9 – 21)	0.94
Mexican-American	9 (7 – 11)	13 (10 – 17)	0.01
Other	10 (7 – 13)	8 (4 – 11)	0.26
Poverty Income Ratio (PIR)			
1.0	23 (20 – 26)	19 (16 – 23)	0.09
Allergic Outcomes			
Asthma	11 (9 – 13)	17 (16 – 19)	<0.001
Allergic Rhinitis	8 (7 – 10)	5 (3 – 6)	0.001

Values are reported as percentages (95% CIs)

[†]P value for the risk difference estimate

Table 2

Prevalence of food sensitization in NHANES III and NHANES 2005–2006

Food Sensitization *	NHANES III Percentage (95% CI) (n = 4995 ^{**})	NHANES 2005–2006 Percentage (95% CI) (n = 2901)	p value [†]
Milk			
Overall	8.3 (7.0 – 9.8)	8.1 (6.1 – 10.2)	0.90
Moderate-level	0.4 (0.1 – 0.7)	0.5 (0.1 – 0.9)	0.70
High-level	0	0.008 (–0.01 – 0.03)	0.33
Egg			
Overall	3.2 (2.5 – 4.0)	4.0 (2.9 – 5.1)	0.2
Moderate-level	0.04 (0.007 – 0.08)	0.2 (–0.004 – 0.5)	0.09
High-level	0	0.05 (–0.01 – 0.1)	0.10
Peanut			
Overall	11.2 (9.5 – 13.1)	10.5 (8.4 – 12.7)	0.62
Moderate-level	3.7 (2.7 – 4.6)	4.5 (3.3 – 5.7)	0.26
High-level	0.7 (0.4 – 1.2)	0.9 (0.4 – 1.4)	0.39
Shrimp			
Overall	11.2 (10.0 – 12.5)	6.1 (4.5 – 7.7)	<0.001
Moderate-level	4.1 (3.3 – 4.9)	1.7 (1.2 – 2.2)	<0.001
High-level	2.2 (1.6 – 2.9)	0.6 (0.4 – 0.9)	<0.001
Milk, Egg, or Peanut			
Overall	18.2 (15.7 – 20.6)	18.2 (15.4 – 20.9)	>0.99
Moderate-level	4.0 (2.9 – 5.1)	4.9 (3.7 – 6.1)	0.23
High-level	0.6 (0.3 – 1.1)	0.9 (0.5 – 1.4)	0.35
All Foods			
Overall	24.3 (22.1 – 26.5)	21.6 (19.5 – 23.7)	0.07
Moderate-level	7.2 (6.0 – 8.5)	6.2 (4.8 – 7.5)	0.23
High-level	2.8 (2.0 – 3.6)	1.5 (1.0 – 2.1)	0.01

Values are reported as percentages (95% CIs)

[†]P value for the risk difference estimate

* Overall sensitization is defined as IgE ≥ 0.35 kU/L; moderate sensitization is defined as IgE ≥ 2 kU/L; high sensitization is defined as ≥ 15 kU/L for milk, ≥ 7 kU/L for egg, ≥ 14 kU/L for peanut, and ≥ 5 kU/L for shrimp.

** n=4991 for milk, 4994 for shrimp, and 4995 for egg and peanut.

Table 3Number[‡] of children with food sensitization in NHANES III and NHANES 2005–2006

Food Sensitization *	NHANES III (n = 4995^{**})	NHANES 2005–2006 (n = 2901)
Milk		
Overall	526	254
Moderate-level	34	14
High-level	0	1
Egg		
Overall	186	100
Moderate-level	7	7
High-level	0	3
Peanut		
Overall	568	347
Moderate-level	201	153
High-level	29	35
Shrimp		
Overall	712	257
Moderate-level	303	89
High-level	159	47
Milk, Egg, or Peanut		
Overall	1034	565
Moderate-level	485	231
High-level	29	37
All Foods		
Overall	1431	707
Moderate-level	485	231
High-level	182	80

[‡]Unweighted

* Overall sensitization is defined as IgE ≥ 0.35 kU/L; moderate sensitization is defined as IgE ≥ 2 kU/L; high sensitization is defined as ≥ 15 kU/L for milk, ≥ 7 kU/L for egg, ≥ 14 kU/L for peanut, and ≥ 5 kU/L for shrimp.

** n=4991 for milk, 4994 for shrimp, and 4995 for egg and peanut.

Table 4

Changes in individual food sensitization by age

Food Sensitization	NHANES III	NHANES 2005–2006	p value [†]
6–9 Years Old			
Milk, Peanut, or Egg			
Overall	20.6 (17.0 – 24.3)	21.4 (16.5 – 26.2)	0.79
Moderate-level	3.9 (2.3 – 5.6)	4.3 (2.6 – 5.9)	0.76
High-level	0.9 (0.2 – 1.6)	0.9 (0.1 – 1.7)	0.97
Shrimp			
Overall	8.3 (6.7 – 9.9)	3.2 (1.7 – 4.6)	<0.00001
Moderate-level	2.3 (1.4 – 3.2)	1.6 (0.5 – 2.6)	0.31
High-level	0.7 (0.4 – 1.1)	0.4 (0.0 – 0.8)	0.26
10 – 15 Years Old			
Milk, Peanut, or Egg			
Overall	19.7 (15.5 – 23.9)	17.9 (14.5 – 21.4)	0.51
Moderate-level	4.5 (2.8 – 6.2)	6.1 (4.0 – 8.3)	0.21
High-level	0.9 (0.1 – 1.7)	1.2 (0.3 – 2.2)	0.56
Shrimp			
Overall	11.3 (9.0 – 13.5)	6.8 (4.8 – 8.7)	<0.01
Moderate-level	4.4 (2.9 – 5.8)	1.1 (0.6 – 1.5)	<0.00001
High-level	2.6 (1.5 – 3.7)	0.6 (0.3 – 1.0)	<0.001
16–19 Years Old			
Milk, Peanut, or Egg			
Overall	13.4 (10.1 – 16.7)	14.8 (9.8 – 19.8)	0.62
Moderate-level	3.5 (2.0 – 4.9)	4.2 (1.8 – 6.7)	0.57
High-level	0.1 (0.0 – 0.2)	0.7 (0.1 – 1.2)	0.02
Shrimp			
Overall	14.4 (11.5 – 17.3)	8.7 (5.6 – 11.8)	0.005
Moderate-level	5.9 (4.2 – 7.6)	2.6 (1.5 – 3.7)	0.001
High-level	3.4 (2.1 – 4.7)	0.9 (0.4 – 1.4)	0.0002

Values are % (95% CI)

[†] p value for the calculated risk difference between NHANES III and NHANES 2005–2006

Table 5

Prevalence of food sensitization in NHANES III and NHANES 2005–2006 with race/ethnicity standardization of NHANES III to NHANES 2005–6.

Food Sensitization *	NHANES III Percentage (95% CI) (n = 4995**)	NHANES 2005–2006 Percentage (95% CI) (n = 2901)	p value [†]
Milk			
Overall	8.2 (7.1 – 9.3)	8.1 (6.1 – 10.2)	0.94
Moderate-level	0.4 (0.2 – 0.6)	0.5 (0.1 – 0.9)	0.58
High-level	0	0.008 (–0.01 – 0.02)	0.33
Egg			
Overall	3.2 (2.5 – 4.0)	4.0 (2.9 – 5.1)	0.22
Moderate-level	0.05 (0.01 – 0.08)	0.2 (–0.004 – 0.5)	0.10
High-level	0	0.05 (–0.01 – 0.1)	0.10
Peanut			
Overall	11.1 (9.8 – 12.5)	10.5 (8.4 – 12.7)	0.60
Moderate-level	3.6 (2.9 – 4.4)	4.5 (3.3 – 5.7)	0.22
High-level	0.6 (0.3 – 1.0)	0.9 (0.4 – 1.4)	0.37
Shrimp			
Overall	11.1 (10.0 – 12.3)	6.1 (4.5 – 7.7)	<0.001
Moderate-level	4.0 (3.3 – 4.8)	1.7 (1.2 – 2.2)	<0.001
High-level	2.1 (1.6 – 2.7)	0.6 (0.4 – 0.9)	<0.001
Milk, Egg, or Peanut			
Overall	18.1 (16.5 – 19.7)	18.2 (15.4 – 20.0)	0.96
Moderate-level	4.0 (3.2 – 4.8)	4.9 (3.7 – 6.1)	0.17
High-level	0.6 (0.3 – 1.0)	0.9 (0.5 – 1.4)	0.32
All Foods			
Overall	24.1 (22.3 – 25.9)	21.6 (19.5 – 23.7)	0.056
Moderate-level	7.2 (6.2 – 8.1)	6.2 (4.8 – 7.5)	0.23
High-level	2.7 (2.0 – 3.3)	1.5 (1.0 – 2.1)	0.005

Values are reported as percentages (95% CIs)

[†] p value for the calculated risk difference between NHANES III and NHANES 2005–2006

* Overall sensitization is defined as IgE ≥ 0.35 kU/L; moderate sensitization is defined as IgE ≥ 2 kU/L; high sensitization is defined as ≥ 15 kU/L for milk, ≥ 7 kU/L for egg, ≥ 14 kU/L for peanut, and ≥ 5 kU/L for shrimp.

** n=4991 for milk, 4994 for shrimp, and 4995 for egg and peanut.

Table 6

Prevalence of food sensitization by survey and race/ethnicity

Food Sensitization	NHANES III	NHANES 2005–2006	p value [†]
<i>Non-Hispanic White</i>			
Milk			
IgE 0.35	5.7 (4.0 – 7.4)	7.3 (4.5 – 10.1)	0.32
IgE 2	0.03 (–0.03 – 0.09)	0.5 (–0.1 – 1.0)	0.11
IgE 15	0	0	1.0
Egg			
IgE 0.35	3.3 (2.1 – 4.4)	4.4 (2.8 – 5.9)	0.22
IgE 2	0	0.2 (–0.2 – 0.5)	0.33
IgE 7	0	0	>0.99
Peanut			
IgE 0.35	10.7 (8.7 – 12.7)	8.9 (5.8 – 11.9)	0.30
IgE 2	3.3 (2.4 – 4.2)	3.5 (2.1 – 5.0)	0.85
IgE 14	0.8 (0.2 – 1.4)	0.5 (–0.08 – 1.0)	0.38
Shrimp			
IgE 0.35	7.1 (5.9 – 8.3)	4.2 (2.5 – 5.9)	0.004
IgE 2	1.9 (1.3 – 2.4)	0.9 (0.2 – 1.5)	0.01
IgE 5	0.9 (0.4 – 1.3)	0	<0.001
<i>Non-Hispanic Black</i>			
Milk			
IgE 0.35	11.7 (10.1 – 13.3)	11.7 (8.7 – 14.6)	0.97
IgE 2	0.9 (0.4 – 1.3)	0.9 (0.3 – 1.5)	0.96
IgE 15	0	0.06 (–0.06 – 0.2)	0.30
Egg			
IgE 0.35	4.4 (3.3 – 5.6)	4.8 (3.2 – 6.3)	0.72
IgE 2	0.2 (–0.0009 – 0.4)	0.4 (–0.1 – 1.0)	0.43
IgE 7	0	0.2 (–0.01 – 0.5)	0.19
Peanut			
IgE 0.35	14.0 (11.6 – 16.5)	17.0 (12.2 – 21.7)	0.25
IgE 2	5.1 (3.6 – 6.7)	8.6 (5.1 – 12.0)	0.06
IgE 14	0.7 (0.2 – 1.2)	2.2 (0.5 – 3.9)	0.07
Shrimp			
IgE 0.35	21.1 (18.9 – 23.3)	12.5 (9.1 – 15.8)	<0.001
IgE 2	11.3 (9.7 – 12.8)	5.8 (3.6 – 8.1)	<0.001
IgE 5	6.7 (5.3 – 8.1)	3.5 (2.1 – 4.9)	<0.001
<i>Mexican-American</i>			
Milk			
IgE 0.35	10.7 (7.8 – 13.6)	9.0 (6.6 – 11.5)	0.36
IgE 2	0.4 (0.1 – 0.7)	0.3 (–0.2 – 0.8)	0.57

Food Sensitization		NHANES III	NHANES 2005–2006	p value [†]
IgE	15	0	0	>0.99
Egg				
IgE	0.35	2.7 (1.8 – 3.7)	2.8 (1.6 – 4.1)	0.92
IgE	2	0.5 (0.02 – 1.0)	0.1 (–0.2 – 0.4)	0.98
IgE	7	0	0.1 (–0.2 – 0.4)	0.32
Peanut				
IgE	0.35	10.2 (7.9 – 12.6)	10.1 (7.7 – 12.6)	0.98
IgE	2	3.3 (2.4 – 4.2)	3.9 (2.9 – 4.8)	0.36
IgE	14	0.3 (0.004 – 0.5)	0.9 (0.05 – 1.7)	0.14
Shrimp				
IgE	0.35	12.0 (8.8 – 15.1)	7.8 (5.1 – 10.5)	0.04
IgE	2	3.6 (2.1 – 5.2)	1.9 (1.0 – 2.8)	0.054
IgE	5	1.1 (0.6 – 1.7)	0.8 (0.2 – 1.5)	0.43

Values are % (95% CI)

[†] p value for the calculated risk difference between NHANES III and NHANES 2005–2006