

# Food Allergy Among Children in the United States

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## KEY WORDS

food allergy, food hypersensitivity, surveys

## ABBREVIATIONS

NHIS—National Health Interview Survey  
 NHANES—National Health and Nutrition Examination Survey  
 NHAMCS—National Hospital Ambulatory Medical Care Survey  
 NAMCS—National Ambulatory Medical Care Survey  
 NHDS—National Hospital Discharge Survey  
 ICD-9-CM—International Classification of Diseases, Ninth Revision, Clinical Modification  
 IgE—immunoglobulin E  
 CI—confidence interval  
 ED—emergency department

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**WHAT'S KNOWN ON THIS SUBJECT:** Food allergy awareness and prevalence reportedly have been increasing among children in recent years.



**WHAT THIS STUDY ADDS:** This study is the first to make nationally representative trend estimates of food allergy prevalence and health care utilization in the United States. In addition, this study characterizes some food allergy characteristics according to race/ethnicity, which few studies reported previously.

## abstract

**OBJECTIVES:** The goals were to estimate the prevalence of food allergy and to describe trends in food allergy prevalence and health care use among US children.

**METHODS:** A cross-sectional survey of data on food allergy among children <18 years of age, as reported in the 1997–2007 National Health Interview Survey, 2005–2006 National Health and Nutrition Examination Survey, 1993–2006 National Hospital Ambulatory Medical Care Survey and National Ambulatory Medical Care Survey, and 1998–2006 National Hospital Discharge Survey, was performed. Reported food allergies, serum immunoglobulin E antibody levels for specific foods, ambulatory care visits, and hospitalizations were assessed.

**RESULTS:** In 2007, 3.9% of US children <18 years of age had reported food allergy. The prevalence of reported food allergy increased 18% ( $z = 3.4$ ;  $P < .01$ ) from 1997 through 2007. In 2005–2006, serum immunoglobulin E antibodies to peanut were detectable for an estimated 9% of US children. Ambulatory care visits tripled between 1993 and 2006 ( $P < .01$ ). From 2003 through 2006, an estimated average of 317 000 food allergy-related, ambulatory care visits per year (95% confidence interval: 195 000–438 000 visits per year) to emergency and outpatient departments and physician's offices were reported. Hospitalizations with any recorded diagnoses related to food allergy also increased between 1998–2000 and 2004–2006, from an average of 2600 discharges per year to 9500 discharges per year ( $z = 3.4$ ;  $P < .01$ ), possibly because of increased use of food allergy V codes.

**CONCLUSION:** Several national health surveys indicate that food allergy prevalence and/or awareness has increased among US children in recent years. *Pediatrics* 2009;124:1549–1555

Food allergy among children is a serious health issue that can be life-threatening. Reports indicate that the prevalence of food allergy, particularly allergy to peanuts, may be increasing among children.<sup>1–3</sup> However, there are few data sources available that can be used to make statistically reliable estimates of food allergy among all children in the United States, on a nationally representative basis. As a result, descriptions of food allergy among US children are lacking information about allergies in specific demographic groups (ie, according to age, gender, or race/ethnicity). Such information could reveal disparities in food allergy among subgroups of children. In addition, there is limited knowledge about health care utilization for food allergy among affected children on a national basis. Therefore, the purpose of this analysis was to describe trends in the prevalence of food allergy and food allergy-related health care use among children in the United States, by using nationally representative survey data.

## METHODS

### Data Sources

This analysis used multiple US national surveys collected or coordinated by the National Center for Health Statistics. Because the results presented were from secondary data analyses, National Center for Health Statistics institutional review board approval was not required.

### Prevalence Data

Prevalence estimates of food allergy among children 0 to 17 years of age were from the National Health Interview Survey (NHIS) for the years 1997–2007. The NHIS, conducted continuously, is a large-scale household interview survey of the civilian noninstitutionalized population in the United States. The NHIS is based on a nationally representative sample of house-

holds, uses a multistage probability sampling design, and serves as the main source of data on various health conditions in the US population.<sup>4</sup> This analysis used data from the sample child component (in which 1 child was sampled from each eligible household) of the NHIS, which had a final response rate of 77% in 2007. Since 1997, a question about food allergy (“During the past 12 months, has [child] had any kind of food or digestive allergy?”) has been included in the NHIS; results were used to calculate prevalence estimates. For children, this question is answered by an adult proxy, most often the parent. In 1999, the question was not asked for 2-year-old participants because of a skip pattern error. For comparison, prevalence estimates for other allergic conditions asked about in the NHIS, including eczema/skin allergy, respiratory allergy, and hay fever, also were calculated for each year from 1997 through 2007, on the basis of responses to questions with the same format as that for food allergy. Prevalence estimates from the NHIS were calculated as proportions of all sampled children for each individual year.

Period prevalence rates for serum immunoglobulin E (IgE) antibodies to certain foods were derived from the allergy component of the 2005–2006 National Health and Nutrition Examination Survey (NHANES).<sup>5</sup> The response rate for the examined sample was 77%. Survey participants  $\geq 1$  year of age who took part in the examination portion of the NHANES were eligible for measurement of serum IgE antibodies to peanut, egg, and milk. IgE antibodies to shrimp were measured in examinees  $\geq 6$  years of age. The range of detectable serum IgE levels was 0.35 to 1000 kU/L. Serum IgE levels were measured by using the Pharmacia Diagnostics ImmunoCap 1000 system (Pharmacia Diagnostics, Kalamazoo,

MI). More information about this test and laboratory procedures can be found elsewhere.<sup>6</sup>

### Ambulatory Care Visits and Hospitalizations

Data on food allergy-related ambulatory care visits to hospital facilities and physician offices and hospitalizations were derived from the National Ambulatory Medical Care Survey (NAMCS), the National Hospital Ambulatory Medical Care Survey (NHAMCS), and the National Hospital Discharge Survey (NHDS). Data from the NAMCS and NHAMCS were included for 1993–2006 and data from the NHDS for 1998–2006.

The NAMCS is a survey of visits to non-federally employed, office-based physicians who are engaged primarily in direct patient care. The NHAMCS is based on a national sample of visits to emergency departments (EDs) and outpatient departments of noninstitutional general and short-stay hospitals. Both the NAMCS and the NHAMCS use multistage probability sampling.<sup>7,8</sup> In 2006, response rates were 64% for the NAMCS, 73% for the NHAMCS outpatient component, and 89% for the NHAMCS ED component. The NHDS is conducted annually and is a nationally representative survey of hospital discharges from non-federal, short-stay hospitals. In 2006, the NHDS response rate was 92%. Sampling is based on a multistage approach, and discharges are selected at random from sampled hospitals.<sup>9</sup>

In 1993–2006, the NAMCS/NHAMCS collected up to 3 physician diagnoses, by using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, and the NHDS collected up to 7 diagnoses. Any listed, food allergy-related diagnoses from these surveys among children  $< 18$  years of age were identified by using the ICD-9-CM codes shown in

**TABLE 1** ICD-9-CM Codes Used to Identify Food Allergy Visits and Hospitalizations

Description	ICD-9-CM Code
Allergic rhinitis attributable to food	477.1
Allergic gastroenteritis and colitis	558.3
General food allergy according to specific type of food	
Peanuts	V15.01
Milk products	V15.02
Eggs	V15.03
Seafood	V15.04
Other foods	V15.05
Contact dermatitis attributable to food in contact with skin	692.5
Dermatitis attributable to food taken internally	693.1
Toxic effect of fish and shellfish	988.0 <sup>a</sup>
Anaphylactic shock attributable to adverse food reaction, specifically for	995.6
Unspecified food	995.60
Peanuts	995.61
Crustaceans	995.62
Fruits and vegetables	995.63
Tree nuts and seeds	995.64
Fish	995.65
Food additives	995.66
Milk products	995.67
Eggs	995.68
Other specified food	995.69
Other adverse food reactions, not elsewhere classified	995.7

<sup>a</sup> This diagnosis was used only in conjunction with an additional diagnosis related to allergy.

Table 1. ICD-9-CM code 988.0, for toxic effects of fish or shellfish eaten, was included if there was any other code on the same record related to allergy. For these surveys, the unit of analysis is the visit (NAMCS/NHAMCS) or hospital discharge (NHDS) and not the individual.

### Analyses

For all of the surveys, SEs and confidence intervals (CIs) for the appropriate unit of measure were derived by using SAS 9 (SAS Institute, Cary, NC) and SUDAAN (Research Triangle Institute, Research Triangle Park, NC) to account for the complex sampling design, and all data were weighted by using the designated sampling weights to reflect national estimates. Estimates with  $\geq 30$  unweighted events per

cell and a relative SE (SE divided by its estimate) of  $<0.3$  were considered reliable and are reported. Trend analysis using all data points for a given time period was performed by using weighted, least-squares regression to account for the variances derived from the complex sampling design. Differences between demographic groups in the NHANES data were tested by using the Rao-Scott F-adjusted  $\chi^2$  test, as recommended in the NHANES analytic guidelines.<sup>10</sup> After the initial analysis, it was determined that there were not enough unweighted visits to allow separate time trend estimates for visits to EDs, hospital outpatient facilities, and physician offices. Therefore, the data from the NHAMCS and NAMCS were combined for assessment of time trends for food allergy-related visits to all ambulatory emergency and outpatient hospital facilities and physician offices.

### RESULTS

From 1997 through 2007, rates of food allergy among all children increased significantly ( $z = 3.4$ ;  $P < .01$ ) (Table 2). By 2007, 3.9% of children 0 to 17 years of age reported having had a food or digestive allergy in the previous 12 months. In addition, rates of reported skin allergy or eczema increased significantly, whereas rates of reported respiratory allergy showed no significant trend and rates of reported hay fever decreased slightly (Table 2). Trends in rates of reported food allergy according to gender were similar over time (Table 3). There also were statistically significant, increasing trends in rates of food allergy among non-Hispanic white, non-Hispanic black, and Hispanic children from 1997 through 2007 (Table 3). Although Hispanic children had a significantly lower prevalence of reported food allergy in 2007, compared with non-Hispanic white and non-Hispanic black children,<sup>11</sup> they experienced the

greatest increase in the prevalence of reported food allergy over the time period analyzed.

In 2005–2006, serum IgE antibodies to peanut were detectable in an estimated 9% of US children. Antibodies to egg, milk, and shrimp were detectable in 7%, 12%, and 5% of children, respectively (Table 4). Because detectable levels of IgE alone were not a reliable indicator of true clinical disease, 90th percentile values of the detectable ranges of peanut-, milk-, and egg-specific serum IgE levels also were assessed (Table 4).

Non-Hispanic black children were twice as likely as non-Hispanic white children to have detectable levels of IgE antibodies to peanut and were nearly twice as likely to have detectable levels of IgE antibodies to milk. In addition, non-Hispanic black children were 4 times as likely as non-Hispanic white children to have detectable antibodies to shellfish (Fig 1). Hispanic children were between non-Hispanic white and non-Hispanic black children in the proportion with detectable levels of any food-specific IgE antibody. Unweighted sample sizes were too small for investigations of differences according to race/ethnicity, according to 90th percentile values of serum IgE levels for all foods.

From the NAMCS and NHAMCS data, the average number of ambulatory care visits with food allergy-related diagnoses per year nearly tripled from 1993–1997 through 2003–2006 ( $z = 2.7$ ;  $P < .01$ ) (Table 5). Between 2003 and 2006, an average of  $\sim 317\,000$  visits to ambulatory care facilities per year with food allergy-related diagnoses were reported. Using the NHDS data, we demonstrated previously an increase in hospitalizations with any diagnosis of food allergy.<sup>11</sup> For the current analysis, a sensitivity analysis of the NHDS data was conducted to determine whether the significant increase

**TABLE 2** Food, Skin, and Respiratory Allergy and Hay Fever Prevalence Estimates Among Children <18 Years of Age in the United States in Selected Years

Condition	Prevalence, No. of Cases (% Estimate ± SE)					
	1997	1999 <sup>a</sup>	2001	2003	2005	2007
Food allergy <sup>b</sup>	491 (3.3 ± 0.2)	384 (3.2 ± 0.2)	473 (3.5 ± 0.2)	444 (3.6 ± 0.2)	515 (4.0 ± 0.2)	378 (3.9 ± 0.3)
Skin allergy/eczema <sup>c</sup>	1086 (7.9 ± 0.3)	808 (7.0 ± 0.3)	1105 (8.4 ± 0.3)	1066 (9.1 ± 0.3)	1222 (9.9 ± 0.3)	856 (8.9 ± 0.3)
Respiratory allergy	1684 (12.0 ± 0.3)	1313 (10.8 ± 0.4)	1667 (12.6 ± 0.4)	1386 (11.5 ± 0.4)	1490 (11.7 ± 0.4)	856 (9.6 ± 0.4)
Hay fever <sup>d</sup>	1485 (10.4 ± 0.3)	1223 (10.3 ± 0.3)	1319 (10.2 ± 0.4)	1178 (9.7 ± 0.3)	1309 (10.5 ± 0.3)	931 (10.1 ± 0.4)

The data source was the NHIS.

<sup>a</sup> In 1999, the allergy questions were not asked for 2-year-old subjects in the NHIS.

<sup>b</sup>  $P < .01$  for weighted, least-squares, regression trend test.

<sup>c</sup>  $P < .0001$  for weighted, least-squares, regression trend test.

<sup>d</sup>  $P < .05$  for weighted, least-squares, regression trend test.

**TABLE 3** Food Allergy Prevalence Estimates Among Children <18 Years of Age in the United States in Selected Years, According to Gender and Race/Ethnicity

	Prevalence, No. of Cases (% Estimate ± SE)					
	1997	1999 <sup>a</sup>	2001	2003	2005	2007
Gender						
Male <sup>b</sup>	246 (3.2 ± 0.2)	196 (3.3 ± 0.3)	238 (3.4 ± 0.3)	230 (3.6 ± 0.3)	267 (3.9 ± 0.3)	193 (3.8 ± 0.3)
Female <sup>c</sup>	245 (3.4 ± 0.3)	188 (3.0 ± 0.3)	235 (3.7 ± 0.3)	215 (3.5 ± 0.3)	248 (4.0 ± 0.3)	185 (4.1 ± 0.4)
Race/ethnicity						
Non-Hispanic white <sup>c</sup>	294 (3.5 ± 0.2)	249 (3.6 ± 0.3)	284 (3.9 ± 0.3)	265 (3.8 ± 0.3)	277 (4.3 ± 0.3)	184 (4.1 ± 0.4)
Non-Hispanic black <sup>b</sup>	78 (3.2 ± 0.4)	59 (3.0 ± 0.4)	73 (3.3 ± 0.4)	67 (3.6 ± 0.5)	86 (4.0 ± 0.5)	74 (4.0 ± 0.6)
Hispanic <sup>d</sup>	95 (2.3 ± 0.3)	63 (1.8 ± 0.2)	94 (2.2 ± 0.3)	88 (2.4 ± 0.3)	128 (3.1 ± 0.3)	88 (3.2 ± 0.4)

The data source was the NHIS.

<sup>a</sup> In 1999, the allergy questions were not asked for 2-year-old subjects in the NHIS.

<sup>b</sup>  $P < .01$  for weighted, least-squares, regression trend test.

<sup>c</sup>  $P < .05$  for weighted, least-squares, regression trend test.

<sup>d</sup>  $P < .0001$  for weighted, least-squares, regression trend test.

**TABLE 4** Numbers, Proportions, and 90th Percentile Values for Serum IgE Antibody Levels for Peanut, Egg, Milk, and Shellfish Among Children 1 to 17 Years of Age in the United States in 2005–2006

Food	Unweighted No.	Weighted No., Millions	Proportion, Estimate ± SE, %	90th Percentile, Estimate (95% CI), kU/L
Peanut	339	6.5	9.3 ± 0.8	11.1 (7.0–17.3)
Egg	236	4.7	6.7 ± 0.6	2.2 (1.4–3.1)
Milk	461	8.5	12.2 ± 0.9	2.0 (1.7–2.5)
Shrimp <sup>a</sup>	193	1.1	5.2 ± 0.6	— <sup>b</sup>

The data source was the NHANES.

<sup>a</sup> Shrimp IgE levels were measured for children ≥6 years of age.

<sup>b</sup> Reliable estimates could not be made because of small sample size.

in hospitalizations for food allergy was attributable to increases in diagnoses more primarily related to food allergy. Therefore, the data were restricted to the first 3 diagnoses with ≥1 diagnosis related to food allergy. An increasing trend in hospitalizations was still apparent (data not shown). A more in-depth examination of the types of food allergy diagnoses was undertaken to determine whether any specific diag-

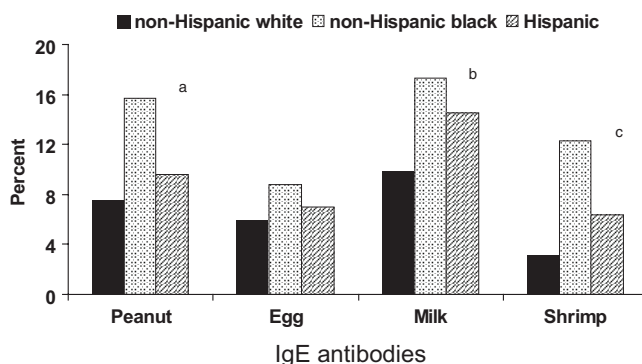
nosis was responsible for the increase in hospitalizations over time. This analysis revealed that a growing number of diagnoses were attributable to general food allergy and specific food allergy (ICD-9-CM codes V150.1–V150.5) coded secondary to other nonallergy indications for hospitalization. Therefore, the data were reanalyzed after exclusion of the V codes for food allergy. After this exclusion, the increasing

trend in hospitalizations with diagnoses related to food allergy was not statistically significant (Fig 2).

## DISCUSSION

This analysis of data from nationally representative health and health care surveys provides evidence of increased food allergy among US children and/or food allergy awareness by health care professionals and parents. In the past decade, the prevalence of reported food allergy and food allergy-related diagnoses in health care settings has increased. The results of this analysis also reveal potential racial disparities in food allergy prevalence among children.

It is important to note that the NHIS data are based on parental or proxy reports of food allergy rather than clinical diagnoses, which could potentially result in



**FIGURE 1**

Proportions of children >18 years of age with detectable levels of IgE antibodies to specific foods in the United States in 2005–2006, according to race/ethnicity. The data were from NHANES. <sup>a</sup>  $P < .01$ ; <sup>b</sup>  $P = .0001$ ; <sup>c</sup>  $P < .0001$ .

inflated estimates because it has been demonstrated that perceived food allergy is often misunderstood and overestimated, compared with clinically diagnosed food allergy.<sup>12–14</sup> It is important to note that parents are not given guidance in the NHIS on what constitutes “digestive allergy” and parental interpreta-

tions of the question might include conditions such as lactose intolerance or celiac disease, which are not true food allergic conditions.

However, we noted a similar proportion of children with food allergy in the NHIS, compared with estimates of food allergy in the US population that are based on smaller, less-representative samples with more-stringent definitions of food allergy.<sup>2</sup> In addition, another national survey, the National Survey of Children’s Health conducted in 2003–2004, asked about food allergy on the basis of parent reports but asked whether parents had been told by a doctor or health care professional that their child had a food allergy. The National Survey of Children’s Health

estimated that 3.6% of US children had some food or digestive allergy on the basis of this question, which was the same as that from the 2003 NHIS.<sup>15</sup> Therefore, it does not seem that reliance on parental determination of perceived food allergy overstates reported prevalence estimates for food allergy.

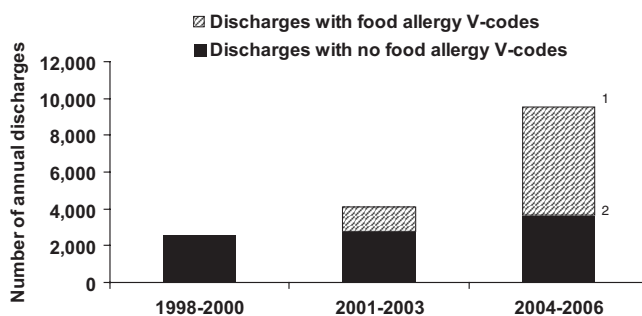
As expected, food sensitization measured on the basis of serum food-specific IgE levels was greater than the self-reports from the NHIS. Although serum IgE measurements cannot be used alone to determine the prevalence of food-specific allergies or to predict reactions to certain foods, they can give an indication of increased atopy and risk for allergic reactions to food. The data from NHANES might reflect children who demonstrated reactions to food previously and outgrew them or those who have a current food allergy and may or may not ever have a reaction to food.

Reported food allergy is increasing among children of all ages, among boys and girls, and among children of different races/ethnicities. Although the trend was significant for non-Hispanic white, non-Hispanic black, and Hispanic children, food allergy increased most among Hispanic children, although non-Hispanic black children generally had the largest proportions of detectable serum IgE antibodies to specific foods. This might demonstrate disparities in awareness and reporting among different demographic groups. Non-Hispanic white children had significantly smaller proportions of serum IgE antibodies to peanut, milk, and shellfish, compared with non-Hispanic black and Hispanic children, but had the highest reported prevalence of food allergy in the NHIS. Therefore, the increasing prevalence of food allergy in parent reports might indicate increasing recognition of food allergy among groups that previously regarded symptoms as those of non-

**TABLE 5** Average Numbers of Visits per Year to EDs, Hospital Outpatient Departments, and Physician Offices With Any Diagnosis of Food Allergy Among Children <18 Years of Age in the United States in 1993–2006

Year	Weighted Estimate (95% CI), Visits per Year
1993–1997	116 000 (61 000–171 000)
1998–2002	247 000 (126 000–368 000)
2003–2006	317 000 (196 000–438 000)

Data sources were the NHAMCS and NAMCS. Test for trend,  $P < .01$ .



**FIGURE 2**

Average numbers of hospital discharges per year with any diagnosis of food allergy, with and without food allergy-specific V codes, among children <18 years of age in the United States in 1998–2006. The data were from the NHDS. \* V codes for food allergy were introduced in 2000; therefore, no visits from 1998–2000 used food allergy V codes. <sup>1</sup> Overall trend statistically significant ( $z = 6.72$ ;  $P < .0001$ ); <sup>2</sup> trend among discharges with no food allergy V codes not statistically significant.

food allergy. Alternatively, racial differences between food-specific IgE levels and self-reported food allergies might be attributable to differences in dietary habits or other factors that differ among these racial/ethnic groups.

The increases in food allergy-related ambulatory care visits and hospitalizations also lend support to increasing awareness and use of food allergy-related diagnostic codes in the health care setting, in addition to supporting possible increases in rates of children seeking health care services because of food allergy. The results found in the current study corroborate other reports of increasing hospital stays for food allergy.<sup>16,17</sup> The apparent increase in food allergy-related hospitalizations seems to be attributable in large part to the increasing use of general V codes for food allergy in conjunction with other reasons for hospitalizations. The V codes were adopted in 2000, and increasing acceptance and awareness of the codes might help explain the increase in food allergy-related hospitalizations between the 1998–2000 and 2001–2003 time periods and possibly the large increase through 2004–2006. It is plausible that the increase in general food allergy diagnoses reflects increased food allergy prevalence that is being recorded when patients come to the hospital for other reasons or increased awareness by physicians and other medical personnel regarding the use of V codes to designate patients with food allergy who are staying in the hospital.

Although there have been no other estimates of food allergy-related visits in the United States from data comparable to the NHAMCS and NHDS in scope,

estimates from the National Electronic Injury Surveillance System, a national system used to identify adverse events presenting in EDs resulting from consumer product use, were similar to those made in this analysis. Ross et al<sup>18</sup> estimated that 20 821 food allergy-related visits to EDs occurred in a 2-month period, on the basis of medical chart review. Of those visits, approximately one fourth were among children <5 years of age, which yields an estimate of food allergy-related visits to EDs among preschool-aged children of ~5200 in a 2-month period. The NHAMCS data for the same period (1999–2000) yield an estimate for children of all ages of ~6600 visits to EDs and outpatient clinics combined in a 2-month period. Although they are not completely comparable, these estimates are similar enough to lend strength to the reporting of food allergy visits in the NHAMCS. However, it is important to note that there is evidence for underreporting of food allergy with the use of ICD-9-CM codes alone.<sup>18–20</sup>

This analysis is subject to other limitations, in addition to those discussed above. The NHIS provides no information on allergies to specific foods; therefore, the prevalence and trend of allergies to peanuts, milk, and shellfish cannot be determined with this national data source. As stated previously, the IgE data from NHANES do not indicate the severity of food allergy, and the other components of NHANES do not contain additional questions on food allergy. To capture food prevalence on a national level, a survey ideally would contain both clinical and self-reported measures of food allergy, which neither NHIS nor NHANES currently do. Therefore, the IgE data are limited in their ability to characterize children who may be at risk for ad-

verse reactions to food. In addition, the NAMCS, NHAMCS, and NHDS data are limited to ICD-9-CM codes and there is no way to validate these results.

Nevertheless, there are many advantages in using these data to estimate trends in food allergy prevalence and hospital visits. The NHIS, NAMCS, NHAMCS, and NHDS all generate nationally representative data that are collected in a consistent manner each year. This is imperative for continued tracking of future trends in food allergy prevalence and health care utilization. The NHIS also provides a large sample size for exploration of differences in food allergy according to race/ethnicity and gender, which previous reports of food allergy have not been able to describe.

## CONCLUSIONS

Data from nationally representative health and health care surveys indicate increases in reported food allergy estimates among US children. However, it cannot be determined how much of the increases in estimates are truly attributable to increases in clinical disease and how much are attributable to increased awareness by physicians, other health care providers, and parents. However, the consistent increases across surveys and among children in all age,<sup>11</sup> gender, and race/ethnicity groups provide evidence that the increases are not limited to a certain setting, reporting mechanism, or demographic group.

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