

Original Investigation

Association Between Atopic Disease and Anemia in US Children

Kerry E. Drury, BA; Matt Schaeffer, BS; Jonathan I. Silverberg, MD, PhD, MPH

IMPORTANCE Atopic disease is associated with chronic inflammation, food allergen avoidance, and use of systemic immunosuppressant medications. All these factors have been shown to be associated with anemia.

OBJECTIVE To investigate whether atopic disease is associated with increased risk of childhood anemia.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional survey and laboratory assessment were conducted using data from the 1997-2013 US National Health Interview Survey (NHIS) that included 207 007 children and adolescents and the 1999-2012 National Health and Nutrition Examination Survey (NHANES) that included 30 673 children and adolescents. Analysis of the data was conducted between August 1, 2014, and August 28, 2015.

EXPOSURES Caregiver-reported history of eczema, asthma, hay fever, and/or food allergy.

MAIN OUTCOMES AND MEASURES Anemia was defined by caregiver report in the NHIS and by hemoglobin levels for age and sex in the NHANES.

RESULTS Data were collected on 207 007 children and adolescents from NHIS, representing all pediatric age, sex, racial/ethnic, household educational level, and income groups. The US prevalence was 9.5% (95% CI, 9.4%-9.7%) from all years of the NHIS for health care–diagnosed eczema, 12.8% (95% CI, 12.6%-13.0%) for asthma, 17.1% (95% CI, 16.9%-17.3%) for hay fever, 4.2% (95% CI, 4.1%-4.3%) for food allergy, and 1.1% (95% CI, 1.1%-1.2%) for anemia. In multivariable logistic regression models controlling for age, sex, race/ethnicity, annual household income, highest educational level in the family, insurance coverage, number of persons in the household, birthplace in the United States, and history of asthma, hay fever, and food allergy, anemia was associated with eczema in 14 of 17 studies, asthma in 11, hay fever in 12, and food allergy in 12. In multivariable analysis across the NHIS (with results reported as adjusted odds ratios [95% CIs]), children with any eczema (1.83; 1.58-2.13), asthma (1.31; 1.14-1.51), hay fever (1.57; 1.36-1.81), and food allergy (2.08; 1.71-2.52) had higher odds of anemia ($P < .001$ for all). In the NHANES, current history of asthma (1.33; 1.04-1.70; $P = .02$) and eczema (1.93; 1.04-3.59; $P = .04$) were associated with higher odds of anemia, particularly microcytic anemia (asthma: 1.61; 1.09-2.38; $P = .02$; eczema: 2.03; 1.20-3.46; $P = .009$) while history of hay fever was not associated with anemia (0.85; 0.62-1.17; $P = .33$).

CONCLUSIONS AND RELEVANCE The association between atopic disease and anemia was reproducible in multiple cohorts. Future studies are needed to identify the determinants of association between atopic disease and anemia.

JAMA Pediatr. 2016;170(1):29-34. doi:10.1001/jamapediatrics.2015.3065
Published online November 30, 2015.

 Supplemental content at
jamapediatrics.com

Author Affiliations: Department of Dermatology, Northwestern University Feinberg School of Medicine, Chicago, Illinois (Drury, Schaeffer, Silverberg); Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, Illinois (Silverberg); Department of Medical Social Sciences, Northwestern University Feinberg School of Medicine, Chicago, Illinois (Silverberg); Northwestern Medicine Multidisciplinary Eczema Center, Chicago, Illinois (Silverberg).

Corresponding Author: Jonathan I. Silverberg, MD, PhD, MPH, Department of Dermatology, Northwestern University Feinberg School of Medicine, Ste 1600, 676 N St. Clair St, Chicago, IL 60611 (jonathanisilverberg@gmail.com).

Atopic disease is associated with chronic systemic inflammation.^{1,2} Childhood atopic disease (ie, asthma, eczema, hay fever, and food allergy) is associated with multiple comorbid chronic health conditions, including impaired sleep,³⁻⁵ obesity,⁶⁻⁸ hypertension and cardiovascular disease,⁹⁻¹² warts and extracutaneous infections,^{13,14} and depression, anxiety, and multiple other mental comorbidities.^{15,16} Some patients with atopic disease are at higher risk for low bone mineral density.^{17,18} All these factors have been shown to be associated with anemia. In addition, children with moderate to severe eczema are often treated with long-term immunosuppressant medications, such as methotrexate and cyclosporine, which can cause anemia and other hematologic abnormalities. Yet, little is known about whether atopic disease is associated with increased risk for anemia. We analyzed data from 2 large-scale studies to determine whether atopic disease is associated with increased risk of childhood anemia.

Methods

Study Sources

Deidentified data were assessed from the 1997-2013 US National Health Interview Survey (NHIS) child health surveys and the 1999-2012 National Health and Nutrition Examination Survey (NHANES). Analysis of the data was conducted between August 1, 2014, and August 28, 2015. Study characteristics are presented in eTable 1 in the [Supplement](#). The NHIS and NHANES are prospectively collected household questionnaire-based studies. Households were selected through a stratified, randomized, multistage, probability-cluster design. Health interviews were conducted in the participant's home in either English or Spanish. In the NHANES, blood collection was performed in mobile examination centers.

Using data from the US Census Bureau, sample weights were created for each study by their sponsors that used a multistage area probability sampling design to adjust for age, sex, race/ethnicity, household size, and educational level of the most educated household member. These sample weights allow for nationally representative prevalence estimates for each state's population of noninstitutionalized children. The complex weighting is reflected in all prevalence estimates presented in this study. The sample designs and methods were consistent across all years of the NHIS and NHANES, respectively. Therefore, it was possible to include the sample weights in analyses across multiple years in addition to individual analyses. Weighted prevalence estimates are presented for analyses across multiple years. The study was approved by the Northwestern University Feinberg School of Medicine Institutional Review Board.

Caregiver- and Self-reported Measures

Caregiver-reported sociodemographics included age (year), sex, race/ethnicity (Hispanic, white, black, multiracial or other ethnicity), educational level (less than high school graduate, high school graduate or General Educational Development certificate, or beyond high school), annual household income (<100%, 100%-299%, 300%-399%, and ≥400% of the federal

At a Glance

- Data were analyzed from 2 large-scale US population-based studies to investigate whether atopic disease is associated with childhood anemia.
- Children with eczema, asthma, hay fever, and food allergy had higher odds of having been diagnosed with anemia in the past year.
- In the National Health and Nutrition Examination Survey, current history of asthma and eczema was associated with higher odds of anemia, particularly microcytic anemia, while history of hay fever was not associated with anemia.

poverty level), birthplace in the United States (yes or no), and health insurance status (yes or no). Caregiver-reported history of smoking in the household (yes or no) was assessed for adults from the child's household. The questions used in the study to assess for history of atopic disease and anemia in children (NHIS and NHANES) and parents (NHIS) are presented in eTable 2 in the [Supplement](#).

Definition of Anemia by Laboratory Values

Participants provided blood samples, which were analyzed for hemoglobin level and mean corpuscular volume (21 674 samples from the NHANES 1999-2012). Anemia was determined using age- and sex-specific cutoffs for hemoglobin level as previously described.¹⁹ The type of anemia was determined by a combination of anemia and mean corpuscular volume (microcytic, <80 μm^3 ; normocytic, 80-99.9 μm^3 ; macrocytic, ≥100 μm^3 [to convert mean corpuscular volume to femtoliters, multiply by 1.0]). Further details about the blood sampling and analytics are described on the NHANES website.²⁰

Statistical Analysis

The frequency of missing values is presented in eTable 3 in the [Supplement](#). There were low frequencies of missing values for history of atopic disease, anemia, and other covariates. Complete data analysis was performed for all variables; that is, participants with missing data were excluded, except for annual household income in the 1997-2013 NHIS, where 18.6% of respondents had missing values. Therefore, we used multiple imputation of missing household income levels that were generated by the National Center for Health Statistics. The sociodemographic composition of the complete case analysis cohort was nearly identical to that of the original NHIS cohort (eTable 4 in the [Supplement](#)).

All analyses used procedures that accounted for the surveys' complex weighting factors. For caregiver-reported history of anemia, multivariable survey weighted binary logistic regression models were constructed for individual studies and analysis across all 17 years of the NHIS. Analysis for anemia (low hemoglobin level for age and sex) was performed across all years of the NHANES for asthma and hay fever, and in 2005-2006 for eczema. The dependent variable was anemia and the independent variable was history of atopic diseases (yes or no). In the NHIS, multivariable models included age, sex, race/ethnicity, family size and annual household income, highest educational level in the family, birthplace in the United States,

and insurance coverage as covariates. In the NHANES, multivariable models included age, sex, and race/ethnicity. Domain analysis was performed to yield appropriate estimates of variance. Crude and adjusted odds ratios (aORs) and 95% CIs were estimated. All data processing and statistical analyses were performed in SAS, version 9.4 (SAS Institute).

Results

Population Characteristics

Data were collected on 207 007 children and adolescents from NHIS, representing all pediatric age, sex, racial/ethnic, household educational level, and income groups. The US prevalence was 9.5% (95% CI, 9.4%-9.7%) from all years of the NHIS for health care-diagnosed eczema, 12.8% (95% CI, 12.6%-13.0%) for asthma, 17.1% (95% CI, 16.9%-17.3%) for hay fever, 4.2% (95% CI, 4.1%-4.3%) for food allergy, and 1.1% (95% CI, 1.1%-1.2%) for anemia. Associations of each of these disorders with sociodemographic factors are presented in eTable 5 in the [Supplement](#).

Association Between Caregiver-reported Atopic Disease and Anemia

In bivariate models of data from the NHIS, eczema was associated with significantly higher odds of anemia in 15 of 17 years and marginally significantly higher odds of anemia in 1 of 17 years (eTable 6 in the [Supplement](#)). In multivariable models controlling for age, sex, race/ethnicity, annual household income, highest educational level in the family, insurance coverage, number of persons in the household, and birthplace in the United States, the association between eczema and anemia remained significant in 14 of 17 studies (eTable 6 in the [Supplement](#)).

Similarly, using data from the NHIS, there was a significant association between asthma and anemia in 11 of 17 studies in bivariate models and 11 of 17 studies in multivariable models (eTable 7 in the [Supplement](#)). Likewise, there was a significant association between hay fever and anemia in 13 of 17 studies in bivariate models and 12 of 17 studies in multivariable models (eTable 8 in the [Supplement](#)). Finally, there was a significant association between food allergy and anemia in 14 of 17 studies in bivariate models and 12 of 17 studies in multivariable models (eTable 9 in the [Supplement](#)). For the years in which the associations did not remain significant, we constructed models that tested each covariate individually and found that none of them were confounders by themselves.

In multivariable analysis across the NHIS, children and adolescents with any eczema (aOR, 1.83; 95% CI, 1.58-2.13; $P < .001$), particularly intrinsic (aOR, 1.95; 95% CI, 1.57-2.41; $P < .001$) or extrinsic eczema (aOR, 2.69; 95% CI, 2.26-3.21; $P < .001$), asthma (aOR, 1.31; 95% CI, 1.14-1.51; $P < .001$), hay fever (aOR, 1.57; 95% CI, 1.36-1.81; $P < .001$), and food allergy (aOR, 2.08; 95% CI, 1.71-2.52; $P < .001$) had significantly higher odds of anemia compared with children without these disorders (Table 1).

The number of comorbid atopic disorders was also associated with anemia. That is, having a single atopic disorder was associated with modestly increased odds of anemia (aOR, 1.84; 95% CI, 1.60-2.11; $P < .001$) (Table 1). However, having all 4 atopic

disorders was associated with demonstrably increased odds of anemia (aOR, 7.87; 95% CI, 5.17-12.00; $P < .001$).

Association Between Asthma and Microcytic Anemia

We analyzed data on objective laboratory measures for 30 673 children and adolescents from the 1999-2012 NHANES to confirm the association between atopic disease and anemia. Current history of asthma was associated with higher odds of anemia in multivariable models controlling for age, sex, and race/ethnicity (aOR, 1.33; 95% CI, 1.04-1.70; $P = .02$); however, hay fever was not associated with anemia overall (aOR, 0.85; 95% CI, 0.62-1.17; $P = .33$) (Table 2). In particular, asthma was associated with higher odds of microcytic anemia (aOR, 1.61; 95% CI, 1.09-2.38; $P = .02$) whereas hay fever was inversely associated with microcytic anemia (aOR, 0.60; 95% CI, 0.37-0.98; $P = .04$). Both asthma and hay fever were associated with lower odds of macrocytic anemia (aOR, <0.01 ; 95% CI, <0.01 to <0.01 ; $P < .001$) and not associated with normocytic anemia (asthma: aOR, 1.10; 95% CI, 0.82-1.49; $P = .52$; hay fever: aOR, 1.18; 95% CI, 0.83-1.68; $P = .37$). In the 2005-2006 NHANES, history of eczema was associated with anemia (aOR, 1.93; 95% CI, 1.04-3.59; $P = .04$), particularly microcytic anemia (aOR, 2.03; 95% CI, 1.20-3.46; $P = .009$), but not normocytic (aOR, 1.89; 95% CI, 0.75-4.78; $P = .18$) or macrocytic (aOR, <0.01 ; 95% CI, <0.01 to <0.01 ; $P < .001$) anemia.

Discussion

We analyzed data from 2 US population-based studies and found that history of caregiver-reported eczema, asthma, hay fever, and food allergy is associated with increased odds of anemia. The odds of anemia increased with the number of atopic disorders present. Childhood asthma and eczema were associated with higher odds of microcytic anemia as defined by laboratory assay test results in the NHANES. In contrast, hay fever was not associated with anemia overall but was inversely associated with microcytic anemia.

Atopic disease has been shown to be associated with several different comorbid conditions, many of which are known to increase the risk for anemia. The chronic inflammation present in atopic disease, use of systemic immunosuppressant medications, increased incidence of malnutrition^{17,21,22} and/or obesity,⁶⁻⁸ and increased use of alternative medicines²³ are examples of such comorbidities. Nevertheless, there is a paucity of data examining the association between atopic disease and anemia. The present study demonstrates higher rates of anemia in atopic disease.

The precise mechanism of the association between atopic disease and anemia is unknown. The increased odds of microcytic anemia in children with asthma and eczema demonstrated in our study suggest that iron deficiency anemia and/or anemia of chronic disease (ACD) might be occurring. It is likely that the association between atopic disease and anemia is multifactorial. Regardless of the underlying mechanisms, awareness of the association between atopic disease and anemia is important. Physicians who care for children with atopic disease should be aware that fatigue may be related to unrecog-

Table 1. Association Between Pediatric Atopic Disease and Anemia in the NHIS, 1997-2013^a

	No Anemia		Anemia					
Atopic Disease	Frequency	% Prevalence (95% CI)	Frequency	% Prevalence (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
Any eczema								
No	184 260	99.0 (99.0-99.1)	1993	1.0 (0.9-1.1)	1 [Reference]		1 [Reference]	
Yes	19 107	97.3 (97.1-97.6)	521	2.7 (2.4-2.9)	2.46 (2.16-2.79)	<.001	1.83 (1.58-2.13)	<.001
Type of eczema								
None	184 260	99.0 (99.0-99.1)	1993	1.0 (0.9-1.1)	1 [Reference]		1 [Reference]	
Intrinsic	9506	98.0 (97.7-98.4)	203	2.0 (1.6-2.3)	2.06 (1.67-2.54)	<.001	1.95 (1.57-2.41)	<.001
Extrinsic	9601	97.2 (96.8-97.6)	318	2.8 (2.4-3.2)	2.72 (2.28-3.24)	<.001	2.69 (2.26-3.21)	<.001
Asthma								
No	177 097	98.9 (98.8-98.9)	1978	1.1 (1.1-1.2)	1 [Reference]		1 [Reference]	
Yes	26 166	98.0 (97.8-98.1)	540	2.0 (1.9-2.2)	1.83 (1.62-2.07)	<.001	1.31 (1.14-1.51)	<.001
Hay fever								
No	168 753	98.9 (98.9-99.0)	1810	1.1 (1.0-1.1)	1 [Reference]		1 [Reference]	
Yes	34 163	98.0 (97.9-98.1)	697	2.0 (1.9-2.1)	1.85 (1.64-2.10)	<.001	1.57 (1.36-1.81)	<.001
Food allergy								
No	194 848	98.9 (98.8-98.9)	2220	1.1 (1.1-1.2)	1 [Reference]		1 [Reference]	
Yes	8414	96.7 (96.3-97.1)	286	3.3 (2.9-3.7)	2.95 (2.51-3.48)	<.001	2.08 (1.71-2.52)	<.001
Atopic diseases, No.								
0	140 512	99.1 (99.1-99.2)	1274	0.9 (0.8-0.9)	1 [Reference]		1 [Reference]	
1	43 543	98.4 (98.3-98.5)	694	1.6 (1.5-1.7)	1.76 (1.54-2.02)	<.001	1.84 (1.60-2.11)	<.001
2	14 867	97.7 (97.5-98.0)	346	2.3 (2.0-2.5)	2.31 (1.94-2.73)	<.001	2.43 (2.04-2.89)	<.001
3	3863	96.0 (95.4-96.6)	162	4.0 (3.4-4.6)	4.07 (3.14-5.26)	<.001	4.35 (3.37-5.62)	<.001
4	746	94.6 (93.0-96.1)	43	5.4 (3.9-7.0)	7.56 (4.97-11.50)	<.001	7.87 (5.17-12.00)	<.001

Abbreviations: NHIS, National Health Interview Survey; OR, odds ratio.

^a Analyses were performed for all participants in the 1997-2013 NHIS. Binary survey logistic regression models were constructed with anemia as the binary dependent variable and history of eczema, asthma, hay fever, food allergy, and the number of atopic diseases as the binary independent variable. Multivariable models were constructed that included age, sex, race/ethnicity,

annual household income, highest educational level in the family, insurance coverage, number of persons in the household, and birthplace in the United States. In addition, multivariable models of any eczema, asthma, hay fever, and food allergy included each of the other atopic disorders. Crude and adjusted ORs and 95% CIs were estimated.

Table 2. Association of Pediatric Asthma and Eczema With Anemia in the NHANES, 1998-2010^a

	No Anemia		Anemia					
Atopic Disease	Frequency	% Prevalence (95% CI)	Frequency	% Prevalence (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
Current history of asthma						.005		.02
No	15 713	96.4 (96.0-96.7)	904	3.6 (3.3-4.0)	1 [Reference]		1 [Reference]	
Yes	1608	94.9 (93.8-96.1)	120	5.1 (3.9-6.2)	1.41 (1.11-1.79)		1.33 (1.04-1.70)	
1-y History of hay fever						.05		0.33
No	14 270	96.0 (95.6-96.3)	831	4.0 (3.7-4.4)	1 [Reference]		1 [Reference]	
Yes	1629	97.0 (96.2-97.8)	89	3.0 (2.2-3.8)	0.74 (0.55-1.00)		0.85 (0.62-1.17)	
Ever history of eczema ^b						.08		.04
No	2451	97.6 (96.9-98.2)	103	2.4 (1.8-3.1)	1 [Reference]		1 [Reference]	
Yes	323	96.2 (93.9-98.4)	19	3.8 (1.6-6.1)	1.59 (0.94-2.71)		1.93 (1.04-3.59)	

Abbreviations: NHANES, National Health and Nutrition Examination Survey; OR, odds ratio.

^a Binary survey logistic regression models were constructed with anemia (low hemoglobin for age and gender) as the binary dependent variable and history

of asthma and hay fever as the binary independent variables. Multivariable models were constructed that included age, sex, and race/ethnicity. Crude and adjusted ORs and 95% CIs were estimated.

^b History of eczema was only assessed in 2005-2006.

nized anemia and not merely sleep loss owing to atopic dermatitis or airway disease.

Iron deficiency anemia might occur secondary to food avoidance and malnutrition. Previous studies have demonstrated that

atopic disease is associated with malnutrition^{17,21,22,24} and that patients with atopic disease are at an increased risk for low bone mineral density^{17,18,25} and vitamin D deficiency.^{26,27} Iron deficiency anemia is estimated to affect 3% of US children aged

1 to 2 years and is the most common type of microcytic anemia in childhood.¹⁹ Iron deficiency can lead to fatigue, small-bowel dysfunction,²⁸ growth retardation,²⁹ and impaired cognitive development^{28,30-33} and has been linked to deficits in attention span, intelligence, sensory perception,²⁸ and altered behavior and emotion.³⁴ The restrictive diets followed by many patients with suspected food allergies or apparent exacerbation of skin or airway disease brought on by specific foods has been hypothesized to play a role in the malnutrition seen in patients with atopic disease. It has been established that diets devoid of milk products and other crucial foods can lead to malnutrition.^{17,21,22} In our study, history of food allergy was assessed by caregiver report that did not depend on a previous health care diagnosis of food allergy. Thus, it is possible that some or many of the children reported as having food allergies were not true food allergies. However, concerns or perceptions by parents that their child has a food allergy will likely result in empirical avoidance of the suspected food. This finding underscores the importance of properly evaluating and ruling out suspected food allergy in children rather than placing them on empirical avoidance diets that might contribute to anemia. Moreover, children and parents need to be cautioned about self-prescribing of strict diets that avoid the suspected food owing to concerns about the effect of such diets on the child's risk for anemia and overall health.

On the other hand, the association between atopic disease and microcytic anemia may be owing to ACD. This possibility may explain why a higher number of atopic disorders was associated with increasing odds of anemia in the NHIS. Previous studies found that children with atopic dermatitis as well as asthma and hay fever (so-called extrinsic disease)^{35,36} and children with more severe atopic dermatitis³⁷ are more likely to carry mutations of the *Filaggrin* gene (OMIM 135940). Nevertheless, anemia was associated with eczema even in the absence of allergic disease (ie, intrinsic eczema). This finding suggests that chronic inflammation occurring in eczema may contribute to ACD. In the NHANES, asthma and eczema but not hay fever, were associated with anemia overall and microcytic anemia in particular. There may be a specific subset of patients with atopic disease who have increased risk of anemia, perhaps secondary to more severe disease and chronic inflammation. Unfortunately, ferritin, transferrin, and serum iron levels, as well as iron binding capacity, were not measured consistently across all years of the NHANES or all pediatric age groups. Thus, we were unable to assess for specific associations between asthma, iron deficiency anemia, and/or ACD. Future studies are needed to further investigate whether atopic disease is associated with iron deficiency anemia per se vs ACD or other types of anemia and the mechanisms of such asso-

ciations. Moreover, further research appears warranted to investigate the association between mutations of the *Filaggrin* gene, disease severity, systemic inflammation, and the risk of anemia in children with atopic disease.

This study has several strengths that include that the data are derived from 2 US population-based studies with large random sampled and diverse samples and complex survey weighting, which demonstrate reproducibility and external validity. These sample weights for each study allow for nationally representative prevalence estimates, suggesting that our findings are likely generalizable to the entire US population. The availability of hemoglobin levels and mean corpuscular volume in the NHANES allowed for objective confirmation of anemia occurring in patients with asthma and revealed that asthma is associated with microcytic anemia.

This study also has limitations. History of atopic disease was reported by caregivers and was not verified with diagnostic testing. A recent multicenter validation study found that caregiver-reported history of health care-diagnosed eczema has very good sensitivity, specificity, and positive and negative predictive values.³⁸ Moreover, self- and caregiver-report of asthma have been validated and found to have strong correlation to clinical examination and diagnostic testing.³⁹ The cross-sectional nature of the studies precludes any conclusions about the directionality of the associations. Although a large sample size was obtained overall, there were smaller sample sizes for some individual subset analyses, particularly those using the NHANES data. Markers of iron storage were not consistently measured, precluding conclusions about the type of anemia occurring in children with atopic disease. Finally, while we did control for race/ethnicity, we were unable to control for history of thalassemia or sickle cell trait, which might also contribute toward microcytic anemia. Given these limitations, future studies with even larger cohorts and/or case-control studies and expanded diagnostic testing are needed to verify these findings.

Conclusions

Atopic disease was associated with increased odds of caregiver-reported anemia in the majority of years of the NHIS and in analyses of all 17 years of the NHIS. Childhood asthma and eczema were associated with higher odds of anemia, particularly microcytic anemia as defined by laboratory assay test results, in the NHANES. Future studies are needed to verify the determinants of association between asthma, eczema, other atopic disease, and anemia.

ARTICLE INFORMATION

Accepted for Publication: August 27, 2015.

Published Online: November 30, 2015.

doi:10.1001/jamapediatrics.2015.3065.

Author Contributions: Dr Silverberg had full access to all the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis.

Study concept and design: Drury, Silverberg.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: Drury, Silverberg.

Statistical analysis: Drury, Silverberg.

Obtained funding: Silverberg.

Administrative, technical, or material support: Silverberg.

Study supervision: Silverberg.

Conflict of Interest Disclosures: None reported.

Funding/Support: This study was supported by grant K12HS023011 from the Agency for Healthcare Research and Quality and the Dermatology Foundation.

Role of the Funder/Sponsor: The funding source had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or

approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

- Visness CM, London SJ, Daniels JL, et al. Association of obesity with IgE levels and allergy symptoms in children and adolescents: results from the National Health and Nutrition Examination Survey 2005-2006. *J Allergy Clin Immunol*. 2009;123(5):1163-1169.e1-4.
- Czarnowicki T, Gonzalez J, Shemer A, et al. Severe atopic dermatitis is characterized by selective expansion of circulating TH2/TC2 and TH22/TC22, but not TH17/TC17, cells within the skin-homing T-cell population. *J Allergy Clin Immunol*. 2015;136(1):104-115.e7.
- Silverberg JI, Garg NK, Paller AS, Fishbein AB, Zee PC. Sleep disturbances in adults with eczema are associated with impaired overall health: a US population-based study. *J Invest Dermatol*. 2015;135(1):56-66.
- González-Núñez V, Valero AL, Mullol J. Impact of sleep as a specific marker of quality of life in allergic rhinitis. *Curr Allergy Asthma Rep*. 2013;13(2):131-141.
- Brockmann PE, Bertrand P, Castro-Rodriguez JA. Influence of asthma on sleep disordered breathing in children: a systematic review. *Sleep Med Rev*. 2014;18(5):393-397.
- Silverberg JI, Kleiman E, Lev-Tov H, et al. Association between obesity and atopic dermatitis in childhood: a case-control study. *J Allergy Clin Immunol*. 2011;127(5):1180-1186.e1.
- Silverberg JI, Simpson EL. Association between obesity and eczema prevalence, severity and poorer health in US adolescents. *Dermatitis*. 2014;25(4):172-181.
- Zhang A, Silverberg JI. Association of atopic dermatitis with being overweight and obese: a systematic review and meta-analysis. *J Am Acad Dermatol*. 2015;72(4):606-616.e4.
- Silverberg JI, Becker L, Kwasny M, Menter A, Cordoro KM, Paller AS. Central obesity and high blood pressure in pediatric patients with atopic dermatitis. *JAMA Dermatol*. 2015;151(2):144-152.
- Tattersall MC, Guo M, Korcarz CE, et al. Asthma predicts cardiovascular disease events: the multi-ethnic study of atherosclerosis. *Arterioscler Thromb Vasc Biol*. 2015;35(6):1520-1525.
- Silverberg JI, Greenland P. Eczema and cardiovascular risk factors in 2 US adult population studies. *J Allergy Clin Immunol*. 2015;135(3):721-728.e6.
- Silverberg JI. Association between adult atopic dermatitis, cardiovascular disease, and increased heart attacks in three population-based studies. *Allergy*. 2015;70(10):1300-1308.
- Silverberg JI, Silverberg NB. Childhood atopic dermatitis and warts are associated with increased risk of infection: a US population-based study. *J Allergy Clin Immunol*. 2014;133(4):1041-1047.
- Juhn YJ. Risks for infection in patients with asthma (or other atopic conditions): is asthma more than a chronic airway disease? *J Allergy Clin Immunol*. 2014;134(2):247-259.
- Yaghmaie P, Koudelka CW, Simpson EL. Mental health comorbidity in patients with atopic dermatitis. *J Allergy Clin Immunol*. 2013;131(2):428-433.
- Di Marco F, Santus P, Centanni S. Anxiety and depression in asthma. *Curr Opin Pulm Med*. 2011;17(1):39-44.
- Silverberg JI. Association between childhood atopic dermatitis, malnutrition, and low bone mineral density: a US population-based study. *Pediatr Allergy Immunol*. 2015;26(1):54-61.
- Li P, Ghazala L, Wright E, Beach J, Morrish D, Vethanayagam D. Prevalence of osteopenia and osteoporosis in patients with moderate to severe asthma in Western Canada. *Clin Invest Med*. 2015;38(2):E23-E30.
- Looker AC, Dallman PR, Carroll MD, Gunter EW, Johnson CL. Prevalence of iron deficiency in the United States. *JAMA*. 1997;277(12):973-976.
- National Health and Nutrition Examination Survey. Laboratory procedures manual. http://www.cdc.gov/nchs/data/nhanes/nhanes_05_06/lab.pdf. Published January 2005. Accessed August 1, 2014.
- Hon KL, Nip SY, Cheung KL. A tragic case of atopic eczema: malnutrition and infections despite multivitamins and supplements. *Iran J Allergy Asthma Immunol*. 2012;11(3):267-270.
- Keller MD, Shuker M, Heimall J, Cianferoni A. Severe malnutrition resulting from use of rice milk in food elimination diets for atopic dermatitis. *Isr Med Assoc J*. 2012;14(1):40-42.
- Silverberg JI, Lee-Wong M, Silverberg NB. Complementary and alternative medicines and childhood eczema: a US population-based study. *Dermatitis*. 2014;25(5):246-254.
- Paasilta M, Kuusela E, Korppi M, Lemponen R, Kaila M, Nikkari ST. Food allergy in small children carries a risk of essential fatty acid deficiency, as detected by elevated serum mead acid proportion of total fatty acids. *Lipids Health Dis*. 2014;13:180.
- Nachshon L, Goldberg MR, Schwartz N, et al. Decreased bone mineral density in young adult IgE-mediated cow's milk-allergic patients. *J Allergy Clin Immunol*. 2014;134(5):1108-1113.e3.
- Akan A, Azkur D, Ginis T, et al. Vitamin D level in children is correlated with severity of atopic dermatitis but only in patients with allergic sensitizations. *Pediatr Dermatol*. 2013;30(3):359-363.
- Sharief S, Jariwala S, Kumar J, Muntner P, Melamed ML. Vitamin D levels and food and environmental allergies in the United States: results from the National Health and Nutrition Examination Survey 2005-2006. *J Allergy Clin Immunol*. 2011;127(5):1195-1202.
- Halterman JS, Kaczorowski JM, Aligne CA, Auinger P, Szilagyi PG. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. *Pediatrics*. 2001;107(6):1381-1386.
- Kwong WT, Friello P, Semba RD. Interactions between iron deficiency and lead poisoning: epidemiology and pathogenesis. *Sci Total Environ*. 2004;330(1-3):21-37.
- Huang SC, Yang YJ, Cheng CN, Chen JS, Lin CH. The etiology and treatment outcome of iron deficiency and iron deficiency anemia in children. *J Pediatr Hematol Oncol*. 2010;32(4):282-285.
- Mihaila C, Schramm J, Strathmann FG, et al. Identifying a window of vulnerability during fetal development in a maternal iron restriction model. *PLoS One*. 2011;6(3):e17483.
- Shaw NS. Iron deficiency and anemia in school children and adolescents. *J Formos Med Assoc*. 1996;95(9):692-698.
- Jáuregui-Lobera I. Iron deficiency and cognitive functions. *Neuropsychiatr Dis Treat*. 2014;10:2087-2095.
- Zimmermann MB, Chaouki N, Hurrell RF. Iron deficiency due to consumption of a habitual diet low in bioavailable iron: a longitudinal cohort study in Moroccan children. *Am J Clin Nutr*. 2005;81(1):115-121.
- Weidinger S, Rodríguez E, Stahl C, et al. Filaggrin mutations strongly predispose to early-onset and extrinsic atopic dermatitis. *J Invest Dermatol*. 2007;127(3):724-726.
- Weidinger S, Illig T, Baurecht H, et al. Loss-of-function variations within the filaggrin gene predispose for atopic dermatitis with allergic sensitizations. *J Allergy Clin Immunol*. 2006;118(1):214-219.
- Flohr C, England K, Radulovic S, et al. Filaggrin loss-of-function mutations are associated with early-onset eczema, eczema severity and transepidermal water loss at 3 months of age. *Br J Dermatol*. 2010;163(6):1333-1336.
- Silverberg JI, Patel N, Immaneni S, et al. Assessment of atopic dermatitis using self- and caregiver-report: a multicenter validation study [published online July 17, 2015]. *Br J Dermatol*.
- Deltos GL, Arif AA, Aday L, et al. Validation of an asthma questionnaire for use in healthcare workers. *Occup Environ Med*. 2006;63(3):173-179.

Supplementary Online Content

Drury KE, Schaeffer M, Silverberg JI. Association between atopic disease and anemia in US children. *JAMA Pediatr*. Published online November 30, 2015. doi:10.1001/jamapediatrics.2015.3065.

eTable 1. Survey Characteristics

eTable 2. Questions Used in This Study

eTable 3. Frequency of Missing Values for Variables Used in the Study

eTable 4. Comparison of Demographics in Entire NHIS Cohort vs Complete Case Analysis Cohort

eTable 5. Associations of Pediatric Allergic Disease and Anemia in NHIS, 1997-2013

eTable 6. Association Between Pediatric Eczema and Anemia in Individual Years of NHIS

eTable 7. Association Between Pediatric Asthma and Anemia in Individual Years of NHIS 1997-2013

eTable 8. Association Between Pediatric Hay Fever and Anemia in Individual Years of NHIS 1997-2013

eTable 9. Association Between Pediatric Food Allergy and Anemia in Individual Years of NHIS 1997-2013

This supplementary material has been provided by the authors to give readers additional information about their work

eTable 1. Survey Characteristics

Study	Size	Age (yr)	Type	Languages	Assessments
NHIS	14,290	0 – 17	Household	English	Caregiver-report
1997	36,116	18 – 85		Spanish	
NHIS	13,645	0 – 17	Household	English	Caregiver-report
1998	32,440	18 – 85		Spanish	
NHIS	12,910	0 – 17	Household	English	Caregiver-report
1999	30,801	18 – 85		Spanish	
NHIS	13,376	0 – 17	Household	English	Caregiver-report
2000	32,374	18 – 85		Spanish	
NHIS	13,579	0 – 17	Household	English	Caregiver-report
2001	33,326	18 – 85		Spanish	
NHIS	12,524	0 – 17	Household	English	Caregiver-report
2002	31,044	18 – 85		Spanish	
NHIS	12,229	0 – 17	Household	English	Caregiver-report
2003	30,852	18 – 85		Spanish	
NHIS	12,424	0 – 17	Household	English	Caregiver-report
2004	31,326	18 – 85		Spanish	
NHIS	12,523	0 – 17	Household	English	Caregiver-report
2005	31,428	18 – 85		Spanish	
NHIS	9,837	0 – 17	Household	English	Caregiver-report
2006	24,275	18 – 85		Spanish	
NHIS	9,417	0 – 17	Household	English	Caregiver-report
2007	23,393	18 – 85		Spanish	
NHIS	8,815	0 – 17	Household	English	Caregiver-report
2008	21,781	18 – 85		Spanish	
NHIS	11,156	0 – 17	Household	English	Caregiver-report
2009	27,731	18 – 85		Spanish	
NHIS	11,277	0 – 17	Household	English	Caregiver-report
2010	27,157	18 – 85		Spanish	
NHIS	12,850	0 – 17	Household	English	Caregiver-report
2011	33,014	18 – 85		Spanish	
NHIS	13,275	0 – 17	Household	English	Caregiver-report
2012	34,525	18 – 85		Spanish	
NHIS	12,860	0 – 17	Household	English	Caregiver-report
2013	34,557	18 – 85		Spanish	
NHANES	4,517	0 – 17	Household	English	Caregiver-report
1999-2000			Mobile Center	Spanish	Laboratory assessment
NHANES	5,046	0 – 17	Household	English	Caregiver-report
2001-2002			Mobile Center	Spanish	Laboratory assessment
NHANES	4,502	0 – 17	Household	English	Caregiver-report
2003-2004			Mobile Center	Spanish	Laboratory assessment
NHANES	4,785	0 – 17	Household	English	Caregiver-report
2005-2006			Mobile Center	Spanish	Laboratory assessment
NHANES	3,921	0 – 17	Household	English	Caregiver-report
2007-2008			Mobile Center	Spanish	Laboratory assessment
NHANES	4,010	0 – 17	Household	English	Caregiver-report
2009-2010			Mobile Center	Spanish	Laboratory assessment

**NHANES
2011-2012**

3,892

0 – 17

Household
Mobile Center

English
Spanish

Caregiver-report
Laboratory
assessment

eTable 2. Questions Used in This Study		
Variable	Question	Surveys asked
Eczema	Has a doctor or other health professional ever told you	NHANES 2005-2006
Eczema	During the past 12 months, has (child) had eczema or	NHIS 1997-2013
Ever asthma	Has a doctor or other health professional ever told you that (child) had asthma?	NHIS 1997-2013 NHANES 1999-2012
Current	Does (child) still have eczema?	NHANES 1999-2012
Hay fever	During the past 12 months, has (child) had an episode of	NHANES 1999-2012
Hay fever	During the past 12 months, has (child) had hay fever?	NHIS 1997-2013
Food	Does (child) have any food allergies?	NHANES 2007-2010
Food	During the past 12 months, has (child) had any kind of	NHIS 1997-2013
Eczema	Has a doctor or other health professional ever told you that (child) had eczema?	NHANES 2005-2006
Anemia	During the past 12 months, has (child) had anemia?	NHIS 1997-2013

eTable 3. Frequency of Missing Values for Variables Used in the Study

Study	Variable	Freq (%)	
NHANES 1999 – 2012	Eczema (2005-2006)	10	(0.30)
	Asthma (1999-2012)	28	(0.13)
	Hay fever (1999-2012)	70	(0.38)
	Food allergy (2007-2010)	14	(0.26)
	Household income (1999-2012)	129	(0.15)
	Age (1999-2012)	0	(0.00)
	Race/ethnicity (1999-2012)	0	(0.00)
	Sex (1999-2012)	0	(0.00)
NHIS 1997 – 2013	Anemia	957	(0.02)
	Eczema	1029	(0.50)
	Asthma	348	(0.17)
	Hay fever	1484	(0.72)
	Food allergy	1140	(0.55)
	Age	0	(0.00)
	Race/ethnicity	301	(0.1)
	Sex	0	(0.0)
	Household income	0	(0.0)
	Highest level of education in the household	1409	(0.68)
	US birthplace	830	(0.40)
	Insurance coverage	1444	(0.7)

eTable 4. Comparison of Demographics in Entire NHIS Cohort vs Complete Case Analysis Cohort

Variables	Entire NHIS cohort	Complete case analysis cohort
Sex		
Male	51.1%	51.1%
Female	48.9%	48.9%
Race/ethnicity		
White	58.9%	58.9%
Black/African-American	14.4%	14.4%
Hispanic	19.7%	19.7%
Multiracial/other	7.1%	7.0%
Household income (% FPL)		
0-99	19.5%	19.5%
100-199	23.0%	22.9%
200-399	31.4%	31.9%
≥400	26.2%	26.2%
Family size		
2	4.5%	4.5%
3-4	54.1%	54.1%
5-21	41.4%	41.4%
Highest level of education in the		
< High school	4.7%	4.7%
High school or graduate equivalence	8.1%	8.0%
> High school	86.8%	87.3%
US birthplace		
No	4.5%	4.5%
Yes	95.4%	95.5%
Insurance coverage		
No	9.3%	9.3%
Yes	90.4%	90.7%

eTable 5. Associations of pediatric allergic disease and anemia in NHIS 1997-2013 (n=207,007).

Variable-no. (%)	Eczema		Asthma		Hay fever		Food allergy		Anemia	
	% Prev (95%CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)
Sex										
Male	9.2 (9.1–9.4)	1.00 [ref]	14.9 (14.7–15.1)	1.00 [ref]	18.1 (17.9–18.4)	1.00 [ref]	4.3 (4.2–4.4)	1.00 [ref]	1.0 (0.9–1.0)	1.00 [ref]
Female	9.9 (9.7–10.1)	1.04 (1.01–1.08)	10.9 (10.7–11.1)	0.69 (0.67–0.71)	15.7 (15.5–16.0)	0.82 (0.80–0.85)	4.2 (4.1–4.3)	0.97 (0.92–1.03)	1.5 (1.4–1.5)	1.43 (1.29–1.58)
Age (yr)										
0-5	11.1 (10.8–11.4)	1.00 [ref]	8.5 (8.3–8.8)	1.00 [ref]	11.3 (11.0–11.6)	1.00 [ref]	4.5 (4.3–4.7)	1.00 [ref]	1.5 (1.4–1.6)	1.00 [ref]
6-10	10.1 (9.7–10.4)	0.76 (0.73–0.79)	13.5 (13.1–13.9)	1.68 (1.60–1.75)	18.2 (17.8–18.6)	1.75 (1.69–1.83)	4.1 (3.9–4.3)	0.90 (0.84–0.97)	0.8 (0.7–0.9)	0.72 (0.64–0.80)
11-17	8.7 (8.4–8.9)	0.90 (0.86–0.94)	15.9 (15.6–16.2)	2.03 (1.95–2.12)	21.2 (20.8–21.5)	2.11 (2.04–2.19)	4.1 (3.9–4.2)	0.89 (0.84–0.95)	1.1 (1.0–1.2)	0.52 (0.45–0.60)
Race										
Caucasian	9.4 (9.3–9.6)	1.00 [ref]	12.1 (11.8–12.3)	1.00 [ref]	19.7 (19.4–19.9)	1.00 [ref]	4.6 (4.5–4.7)	1.00 [ref]	0.8 (0.8–0.9)	1.00 [ref]
Black	12.9 (12.6–13.3)	1.40 (1.34–1.47)	18.3 (17.8–18.7)	1.63 (1.56–1.70)	16.4 (16.0–16.8)	0.76 (0.73–0.80)	4.3 (4.1–4.6)	0.97 (0.90–1.05)	1.9 (1.8–2.1)	2.42 (2.13–2.76)
Hispanic	7.3 (7.1–7.5)	0.80 (0.77–0.84)	11.6 (11.3–11.9)	0.99 (0.95–1.03)	12.9 (12.6–13.2)	0.61 (0.59–0.63)	3.2 (3.1–3.3)	0.76 (0.66–0.76)	1.5 (1.4–1.6)	1.80 (1.61–2.03)
Multiracial / other	11.6 (11.1–12.1)	1.24 (1.16–1.32)	13.0 (12.5–13.6)	1.16 (1.08–1.23)	16.3 (15.8–16.9)	0.83 (0.79–0.88)	5.6 (5.2–5.9)	1.22 (1.12–1.34)	1.1 (0.9–1.2)	1.14 (0.92–1.41)
No. of people in household										
1-2	11.5 (11.0–12.0)	1.00 [ref]	18.3 (17.7–18.9)	1.00 [ref]	20.8 (20.2–21.4)	1.00 [ref]	5.1 (4.7–5.4)	1.00 [ref]	1.4 (1.3–1.6)	1.00 [ref]
3-4	9.7 (9.5–9.9)	0.87 (0.82–0.92)	12.7 (11.8–12.9)	0.67 (0.64–0.70)	17.6 (17.4–17.8)	0.83 (0.79–0.87)	4.4 (4.3–4.5)	0.88 (0.81–0.95)	1.0 (1.0–1.1)	0.70 (0.61–0.81)
≥5	8.6 (8.4–8.9)	0.78 (0.73–0.83)	12.0 (11.8–12.3)	0.64 (0.61–0.68)	14.5 (14.2–14.8)	0.66 (0.63–0.70)	3.6 (3.4–3.7)	0.72 (0.66–0.79)	1.3 (1.2–1.4)	0.88 (0.75–1.03)

eTable 5 continued.

Variable–no. (%)	Eczema		Asthma		Hay fever		Food allergy		Anemia	
	% Prev (95%CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)
Household income (% FPL)										
0–99	10.1 (9.8–10.5)	0.98 (0.92–1.04)	15.6 (15.2–16.0)	1.41 (1.33–1.48)	14.8 (14.4–15.2)	0.66 (0.63–0.69)	4.2 (4.0–4.5)	0.88 (0.80–0.95)	2.0 (1.9–2.2)	3.22 (2.74–3.79)
100–199	9.7 (9.4–10.0)	.93 (0.88–0.98)	13.2 (12.9–13.6)	1.15 (1.09–1.21)	15.6 (15.3–16.0)	0.71 (0.68–0.74)	4.2 (4.0–4.4)	0.88 (0.81–0.95)	1.4 (1.3–1.6)	2.25 (1.90–2.66)
200–399	10.0 (9.8–10.3)	0.95 (0.91–1.00)	12.9 (12.6–13.2)	1.04 (0.99–1.09)	18.5 (18.2–18.9)	0.86 (0.82–0.89)	4.4 (4.2–4.5)	0.89 (0.83–0.96)	0.9 (0.8–1.1)	1.48 (1.24–1.76)
≥ 400	10.8 (10.5–11.1)	1.00 [ref]	12.2 (11.9–12.5)	1.00 [ref]	20.9 (20.5–21.3)	1.00 [ref]	5.0 (4.8–5.2)	1.00 [ref]	0.6 (0.6–0.7)	1.00 [ref]
Highest level of household education										
<High school	5.4 (4.9–5.8)	0.58 (0.54–0.62)	11.6 (10.9–12.3)	0.88 (0.82–0.95)	11.4 (10.7–12.1)	0.60 (0.56–0.64)	2.3 (1.9–2.6)	0.49 (0.42–0.57)	1.7 (1.4–2.0)	1.07 (0.90–1.27)
High school or GED	6.3 (5.9–6.8)	0.49 (0.44–0.53)	11.9 (11.3–12.5)	0.91 (0.86–0.96)	14.4 (13.8–15.0)	0.78 (0.75–0.83)	2.8 (2.5–3.0)	0.60 (0.54–0.67)	1.2 (1.0–1.4)	1.54 (1.30–1.83)
>High school	10.5 (10.3–10.6)	1.00 [ref]	13.0 (12.8–13.2)	1.00 [ref]	17.7 (17.5–17.9)	1.00 [ref]	4.5 (4.4–4.6)	1.00 [ref]	1.1 (1.1–1.2)	1.00 [ref]
Birthplace in the US										
No	5.7 (5.2–6.3)	0.55 (0.49–0.61)	8.2 (7.6–8.9)	0.60 (0.55–0.65)	10.8 (10.0–11.5)	0.57 (0.53–0.62)	3.0 (2.6–3.4)	0.69 (0.60–0.78)	1.0 (0.8–1.2)	0.87 (0.69–1.10)
Yes	10.1 (9.9–10.2)	1.00 [ref]	13.0 (12.8–13.2)	1.00 [ref]	17.4 (17.2–17.6)	1.00 [ref]	4.3 (4.2–4.4)	1.00 [ref]	1.1 (1.1–1.2)	1.00 [ref]
Insurance coverage										
No	7.1 (6.6–7.5)	0.67 (0.63–0.72)	9.7 (9.2–10.2)	0.71 (0.67–0.76)	13.6 (13.0–14.1)	0.74 (0.70–0.78)	3.2 (2.9–3.5)	0.74 (0.66–0.82)	1.2 (1.0–1.4)	1.08 (0.92–1.26)
Yes	10.2 (10.0–10.3)	1.00 [ref]	13.1 (12.9–13.3)	1.00 [ref]	17.5 (17.3–17.7)	1.00 [ref]	4.3 (4.2–4.5)	1.00 [ref]	1.1 (1.1–1.2)	1.00 [ref]

eTable 6. Association Between Pediatric Eczema and Anemia in Individual Years of NHIS

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
1997								
No eczema	12966	98.6 (98.4–98.8)	188	1.4 (1.2–1.6)	1 [ref]	–	1 [ref]	–
Eczema	1046	96.8 (95.5–98.0)	37	3.2 (2.0–4.5)	2.36 (1.49–3.74)	0.0003	2.50 (1.54–4.06)	0.0002
1998								
No eczema	12457	98.8 (98.6–99.1)	153	1.2 (0.9–1.4)	1 [ref]	–	1 [ref]	–
Eczema	973	96.4 (95.0–97.7)	34	3.6 (2.3–5.0)	3.20 (2.00–5.12)	<0.0001	3.28 (1.96–5.48)	<0.0001
1999								
No eczema	11256	99.2 (98.9–99.4)	101	0.8 (0.6–1.1)	1 [ref]	–	1 [ref]	–
Eczema	788	97.5 (96.1–98.8)	20	2.5 (1.2–3.9)	3.04 (1.69–5.46)	0.0002	2.35 (1.20–4.60)	0.01
2000								
No eczema	12279	99.0 (98.8–99.2)	138	1.0 (0.8–1.2)	1 [ref]	–	1 [ref]	–
Eczema	913	97.3 (96.2–98.5)	27	2.7 (1.5–3.8)	2.74 (1.65–4.53)	<0.0001	2.75 (1.62–4.69)	0.0002
2001								
No eczema	12326	99.0 (98.8–99.2)	125	1.0 (0.8–1.2)	1 [ref]	–	1 [ref]	–
Eczema	1071	96.4 (94.6–98.3)	33	3.6 (1.7–5.4)	3.70 (2.06–6.66)	<0.0001	3.88 (2.08–7.22)	<0.0001
2002								
No eczema	11329	99.2 (99.0–99.4)	97	0.8 (0.6–1.0)	1 [ref]	–	1 [ref]	–
Eczema	1033	97.8 (96.9–98.6)	35	2.2 (1.4–3.1)	2.95 (1.93–4.50)	<0.0001	3.43 (2.14–5.49)	<0.0001
2003								
No eczema	11053	99.2 (99.0–99.4)	107	0.8 (0.6–1.0)	1 [ref]	–	1 [ref]	–
Eczema	1045	98.5 (97.7–99.3)	19	1.5 (0.7–2.3)	1.80 (1.05–3.07)	0.03	1.54 (0.81–2.92)	0.19
2004								
No eczema	11116	99.1 (98.9–99.3)	115	0.9 (0.7–1.1)	1 [ref]	–	1 [ref]	–
Eczema	1148	98.4 (97.5–99.3)	20	1.6 (0.7–2.5)	1.77 (0.97–3.24)	0.06	0.95 (0.47–1.95)	0.90
2005								
No eczema	11163	99.0 (98.7–99.2)	118	1.0 (0.8–1.3)	1 [ref]	–	1 [ref]	–
Eczema	1183	97.1 (96.0–98.2)	36	2.9 (1.8–4.0)	2.84 (1.76–4.57)	<0.0001	3.16 (1.86–5.39)	<0.0001
2006								
No eczema	8749	98.9 (98.7–99.2)	95	1.1 (0.8–1.3)	1 [ref]	–	1 [ref]	–
Eczema	950	98.9 (98.2–99.5)	17	1.1 (0.5–1.8)	1.06 (0.57–2.00)	0.85	0.81 (0.40–1.63)	0.55

eTable 6 continued.

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
2007								
No	8455	98.9 (98.6–99.1)	98	1.1 (0.9–1.4)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	832	97.7 (96.6–98.8)	23	2.3 (1.2–3.4)	2.06 (1.17–3.62)	0.01	2.33 (1.24–4.39)	0.009
2008								
No	7779	99.0 (98.7–99.2)	85	1.0 (0.8–1.3)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	914	97.5 (96.2–98.9)	25	2.5 (1.1–3.8)	2.44 (1.32–4.49)	0.004	2.28 (1.14–4.57)	0.02
2009								
No	9724	99.0 (98.7–99.3)	100	1.0 (0.7–1.3)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	1275	98.1 (97.3–98.9)	32	1.9 (1.1–2.7)	1.87 (1.11–3.17)	0.02	1.74 (1.01–3.00)	0.047
2010								
No	9787	99.1 (98.9–99.3)	100	0.9 (0.7–1.1)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	1329	97.0 (96.0–98.1)	39	3.0 (1.9–4.0)	3.29 (2.14–5.06)	<0.0001	3.23 (2.04–5.10)	<0.0001
2011								
No	11109	98.9 (98.7–99.1)	125	1.1 (0.9–1.3)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	1548	97.5 (96.6–98.3)	44	2.5 (1.7–3.4)	2.34 (1.49–3.66)	0.0002	1.98 (1.23–3.18)	0.005
2012								
No	11529	99.1 (98.9–99.3)	125	0.9 (0.7–1.1)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	1557	97.7 (96.9–98.6)	43	2.3 (1.4–3.1)	2.49 (1.57–3.96)	0.0001	2.37 (1.44–3.89)	0.0006
2013								
No	11183	99.1 (98.8–99.3)	123	0.9 (0.7–1.2)	1 [ref]	–	1 [ref]	–
eczema								
Eczema	1501	98.0 (97.0–99.0)	37	2.0 (1.1–3.0)	2.18 (1.34–3.56)	0.002	2.03 (1.19–3.45)	0.009

Binary survey logistic regression models were constructed with anemia as the binary dependent variable and history of eczema as the binary independent variable. Multivariable models were constructed that included age, sex, race/ethnicity, household income, highest level of education in the family, insurance coverage, number of persons in the household and birthplace in the US. Crude and adjusted OR and 95% CI were estimated.

eTable 7. Association Between Pediatric Asthma and Anemia in Individual Years of NHIS, 1997-2013

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
1997								
No asthma	12439	98.6 (98.4 – 98.8)	178	1.4 (1.2 – 1.6)	1 [ref]	–	1 [ref]	–
Asthma	1563	97.0 (96.2 – 97.9)	48	3.0 (2.1 – 3.8)	1.93 (1.33 – 2.80)	0.0006	1.92 (1.24 – 2.98)	0.004
1998								
No asthma	11826	98.8 (98.6 – 99.0)	144	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1583	97.4 (96.6 – 98.1)	43	2.6 (1.9 – 3.4)	2.43 (1.59 – 3.69)	<0.0001	2.49 (1.52 – 4.08)	0.0003
1999								
No asthma	10687	99.1 (98.9 – 99.2)	102	0.9 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Asthma	1348	98.6 (98.0 – 99.2)	19	1.4 (0.8 – 2.0)	1.67 (0.91 – 3.06)	0.10	1.96 (1.01 – 3.78)	0.046
2000								
No asthma	11588	98.9 (98.7 – 99.1)	128	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Asthma	1593	97.7 (97.0 – 98.5)	37	2.3 (1.5 – 3.0)	2.25 (1.41 – 3.58)	0.0007	2.14 (1.23 – 3.72)	0.007
2001								
No asthma	11722	98.9 (98.8 – 99.1)	126	1.1 (0.9 – 1.2)	1 [ref]	–	1 [ref]	–
Asthma	1674	98.1 (97.5 – 98.8)	32	1.9 (1.2 – 2.5)	1.52 (0.98 – 2.38)	0.06	1.38 (0.81 – 2.36)	0.24
2002								
No asthma	10816	99.1 (98.9 – 99.2)	102	0.9 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Asthma	1532	98.0 (97.3 – 98.7)	31	2.0 (1.3 – 2.7)	2.36 (1.39 – 4.02)	0.002	2.33 (1.19 – 4.54)	0.01
2003								
No asthma	10587	99.1 (98.9 – 99.2)	101	0.9 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Asthma	1508	98.3 (97.7 – 99.0)	26	1.7 (1.0 – 2.3)	1.73 (1.07 – 2.81)	0.03	1.85 (1.06 – 3.22)	0.03
2004								
No asthma	10727	99.0 (98.9 – 99.2)	104	1.0 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Asthma	1530	98.0 (97.3 – 98.7)	31	2.0 (1.3 – 2.7)	2.23 (1.34 – 3.70)	0.002	1.80 (1.03 – 3.13)	0.04
2005								
No asthma	10718	98.8 (98.6 – 99.0)	125	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1624	98.2 (97.6 – 98.9)	29	1.8 (1.1 – 2.4)	2.37 (1.44 – 3.90)	0.0007	2.13 (1.24 – 3.65)	0.006
2006								
No asthma	8390	99.0 (98.8 – 99.2)	86	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Asthma	1304	98.0 (97.3 – 98.8)	26	2.0 (1.2 – 2.7)	1.15 (0.67 – 1.98)	0.62	1.06 (0.55 – 2.04)	0.85

eTable 7 continued.
NHIS year

	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
2007								
No asthma	8088	98.8 (98.6 – 99.1)	96	1.2 (0.9 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1191	97.9 (97.1 – 98.7)	25	2.1 (1.3 – 2.9)	1.90 (1.06 – 3.41)	0.03	2.00 (1.06 – 3.79)	0.03
2008								
No asthma	7484	98.9 (98.6 – 99.1)	87	1.1 (0.9 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1202	98.2 (97.5 – 98.9)	22	1.8 (1.1 – 2.5)	1.52 (0.85 – 2.71)	0.16	1.31 (0.70 – 2.47)	0.40
2009								
No asthma	9442	98.9 (98.7 – 99.1)	105	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Asthma	1555	98.3 (97.7 – 98.9)	27	1.7 (1.1 – 2.3)	1.97 (1.16 – 3.36)	0.01	1.78 (0.99 – 3.16)	0.05
2010								
No asthma	9572	98.9 (98.7 – 99.1)	109	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Asthma	1537	98.1 (97.4 – 98.8)	30	1.9 (1.2 – 2.6)	1.44 (0.87 – 2.38)	0.16	1.22 (0.73 – 2.03)	0.45
2011								
No asthma	10868	98.8 (98.6 – 99.0)	127	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1797	97.7 (97.0 – 98.4)	42	2.3 (1.6 – 3.0)	2.01 (1.32 – 3.06)	0.001	1.82 (1.20 – 2.74)	0.005
2012								
No asthma	11206	98.9 (98.7 – 99.1)	127	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Asthma	1879	97.8 (97.2 – 98.5)	42	2.2 (1.5 – 2.8)	1.71 (1.13 – 2.59)	0.01	1.81 (1.16 – 2.84)	0.01
2013								
No asthma	10937	98.8 (98.6 – 99.0)	131	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Asthma	1746	98.3 (97.7 – 98.9)	30	1.7 (1.1 – 2.3)	1.59 (0.99 – 2.53)	0.05	1.54 (0.95 – 2.50)	0.08

Binary survey logistic regression models were constructed with anemia as the binary dependent variable and history of asthma as the binary independent variable. Multivariable models were constructed that included age, sex, race/ethnicity, household income, highest level of education in the family, insurance coverage, number of persons in the household and birthplace in the US. Crude and adjusted OR and 95% CI were estimated.

eTable 8. Association Between Pediatric Hay Fever and Anemia in Individual Years of NHIS 1997-2013

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
1997								
No hay fever	11536	98.6 (98.4 – 98.8)	161	1.4 (1.2 – 1.6)	1 [ref]	–	1 [ref]	–
Hay fever	2438	97.5 (96.9 – 98.1)	63	2.5 (1.9 – 3.1)	1.94 (1.39 – 2.70)	<0.0001	2.29 (1.58 – 3.32)	<0.0001
1998								
No hay fever	11081	98.8 (98.6 – 99.0)	130	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Hay fever	2310	97.7 (97.1 – 98.3)	55	2.3 (1.7 – 2.9)	2.03 (1.38 – 2.99)	0.0003	2.26 (1.46 – 3.49)	0.0002
1999								
No hay fever	10001	99.1 (98.9 – 99.3)	88	0.9 (0.7 – 1.1)	1 [ref]	–	1 [ref]	–
Hay fever	2000	98.4 (97.8 – 98.9)	33	1.6 (1.1 – 2.2)	1.89 (1.12 – 3.18)	0.02	1.90 (0.99 – 3.65)	0.06
2000								
No hay fever	10986	99.0 (98.8 – 99.2)	111	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	2164	97.6 (96.9 – 98.2)	54	2.4 (1.8 – 3.1)	2.28 (1.55 – 3.34)	<0.0001	2.88 (1.91 – 4.35)	<0.0001
2001								
No hay fever	11019	99.0 (98.8 – 99.2)	111	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	2343	98.0 (97.5 – 98.6)	47	2.0 (1.4 – 2.5)	2.49 (1.54 – 4.02)	0.0002	3.42 (2.14 – 5.47)	<0.0001
2002								
No hay fever	10150	99.2 (99.0 – 99.3)	87	0.8 (0.7 – 1.0)	1 [ref]	–	1 [ref]	–
Hay fever	2193	98.0 (97.5 – 98.6)	44	2.0 (1.4 – 2.5)	2.22 (1.37 – 3.59)	0.001	2.80 (1.57 – 4.97)	0.0005
2003								
No hay fever	10042	99.1 (99.0 – 99.3)	88	0.9 (0.7 – 1.0)	1 [ref]	–	1 [ref]	–
Hay fever	2025	98.2 (97.6 – 98.7)	38	1.8 (1.3 – 2.4)	1.83 (1.17 – 2.86)	0.008	2.04 (1.20 – 3.48)	0.009
2004								
No hay fever	10169	99.0 (98.8 – 99.2)	99	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	2064	98.3 (97.8 – 98.9)	35	1.7 (1.1 – 2.2)	1.90 (1.19 – 3.03)	0.007	1.82 (1.10 – 3.03)	0.02
2005								
No hay fever	10111	99.0 (98.8 – 99.2)	105	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	2208	97.8 (97.2 – 98.4)	49	2.2 (1.6 – 2.8)	2.56 (1.67 – 3.94)	<0.0001	2.57 (1.59 – 4.14)	0.0001
2006								
No hay fever	8069	99.0 (98.8 – 99.3)	78	1.0 (0.7 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	1602	98.0 (97.3 – 98.7)	33	2.0 (1.3 – 1.7)	1.87 (1.10 – 3.20)	0.02	1.67 (0.91 – 3.05)	0.10

eTable 8 continued.

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
2007								
No hay fever	7826	98.7 (98.5 – 99.0)	102	1.3 (1.0 – 1.5)	1 [ref]	–	1 [ref]	–
Hay fever	1438	98.7 (98.1 – 99.3)	19	1.3 (0.7 – 1.9)	1.00 (0.56 – 1.80)	0.99	0.96 (0.47 – 1.98)	0.91
2008								
No hay fever	7222	98.9 (98.7 – 99.1)	80	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Hay fever	1455	98.0 (97.3 – 98.7)	30	2.0 (1.3 – 2.7)	1.94 (1.12 – 3.39)	0.02	1.68 (0.94 – 3.00)	0.08
2009								
No hay fever	9175	99.0 (98.8 – 99.2)	94	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Hay fever	1808	98.0 (97.4 – 98.6)	37	2.0 (1.4 – 2.6)	1.72 (1.04 – 2.85)	0.03	1.97 (1.19 – 3.25)	0.008
2010								
No hay fever	9219	98.9 (98.7 – 99.1)	105	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Hay fever	1881	98.3 (97.7 – 98.9)	33	1.7 (1.1 – 2.3)	1.40 (0.87 – 2.25)	0.17	1.71 (1.02 – 2.85)	0.04
2011								
No hay fever	10543	98.8 (98.6 – 99.0)	123	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Hay fever	2102	97.9 (97.2 – 98.5)	46	2.1 (1.5 – 2.8)	1.83 (1.19 – 2.81)	0.006	1.88 (1.20 – 2.95)	0.006
2012								
No hay fever	10954	98.9 (98.7 – 99.1)	127	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Hay fever	2118	98.1 (97.5 – 98.6)	42	1.9 (1.4 – 2.5)	1.51 (0.99 – 2.29)	0.05	1.85 (1.20 – 2.86)	0.005
2013								
No hay fever	10650	98.9 (98.7 – 99.1)	121	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Hay fever	2015	98.1 (97.5 – 98.7)	39	1.9 (1.3 – 2.5)	1.45 (0.93 – 2.26)	0.10	1.43 (0.91 – 2.27)	0.12

Binary survey logistic regression models were constructed with anemia as the binary dependent variable and history of hay fever as the binary independent variable. Multivariable models were constructed that included age, sex, race/ethnicity, household income, highest level of education in the family, insurance coverage, number of persons in the household and birthplace in the US. Crude and adjusted OR and 95% CI were estimated.

eTable 9. Association Between Pediatric Food Allergy and Anemia in Individual Years of NHIS 1997-2013

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
1997								
No food allergy	13541	98.5 (98.3 – 98.7)	206	1.5 (1.3 – 1.7)	1 [ref]	–	1 [ref]	–
Food allergy	469	95.9 (95.2 – 97.7)	20	4.1 (3.3 – 4.8)	2.83 (1.68 – 4.79)	<0.0001	2.91 (1.67 – 5.09)	0.0002
1998								
No food allergy	12950	98.7 (98.6 – 98.9)	165	1.3 (1.1 – 1.4)	1 [ref]	–	1 [ref]	–
Food allergy	470	95.7 (93.9 – 97.5)	21	4.3 (2.5 – 6.1)	4.41 (2.56 – 7.60)	<0.0001	4.93 (2.79 – 8.70)	<0.0001
1999								
No food allergy	11678	99.1 (98.9 – 99.2)	109	0.9 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Food allergy	370	96.9 (95.1 – 98.6)	12	3.1 (1.4 – 4.9)	2.47 (1.22 – 5.02)	0.01	2.96 (1.30 – 6.73)	0.01
2000								
No food allergy	12738	98.9 (98.7 – 99.1)	143	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	448	95.3 (93.4 – 97.2)	22	4.7 (2.8 – 6.6)	5.02 (2.83 – 8.88)	<0.0001	5.01 (2.54 – 9.86)	<0.0001
2001								
No food allergy	12934	98.9 (98.7 – 99.1)	142	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	457	96.6 (95.0 – 98.2)	16	3.4 (1.8 – 5.0)	5.26 (2.31 – 12.02)	<0.0001	6.90 (2.87 – 16.57)	<0.0001
2002								
No food allergy	11902	99.0 (98.8 – 99.2)	120	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Food allergy	451	97.4 (96.0 – 98.9)	12	2.6 (1.1 – 4.0)	2.56 (1.27 – 5.16)	0.009	1.77 (0.83 – 3.80)	0.14
2003								
No food allergy	11659	99.0 (98.9 – 99.2)	113	1.0 (0.8 – 1.1)	1 [ref]	–	1 [ref]	–
Food allergy	431	97.1 (95.5 – 98.6)	13	2.9 (1.4 – 4.5)	4.03 (1.94 – 8.40)	0.0002	4.17 (1.87 – 9.34)	0.0005
2004								
No food allergy	11758	99.0 (98.8 – 99.2)	116	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Food allergy	492	96.7 (95.1 – 98.2)	17	3.3 (1.8 – 3.9)	3.94 (2.16 – 7.18)	<0.0001	2.99 (1.54 – 5.82)	0.001
2005								
No food allergy	11836	98.9 (98.7 – 99.1)	135	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	496	96.5 (94.9 – 98.1)	18	3.5 (1.9 – 5.1)	3.26 (1.87 – 5.67)	<0.0001	3.19 (1.70 – 5.99)	0.0003
2006								
No food allergy	9275	99.0 (98.8 – 99.2)	96	1.0 (0.8 – 1.2)	1 [ref]	–	1 [ref]	–
Food allergy	416	96.7 (95.1 – 98.4)	14	3.3 (1.6 – 4.9)	2.94 (1.76 – 4.92)	<0.0001	2.17 (1.02 – 4.64)	0.046

eTable 9 continued.

NHIS year	No anemia		Anemia					
	Freq	% Prev (95% CI)	Freq	% Prev (95% CI)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
2007								
No food allergy	8920	98.8 (98.6 – 99.0)	109	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Food allergy	366	96.8 (95.1 – 98.6)	12	3.2 (1.4 – 4.9)	2.18 (1.00 – 4.74)	0.049	2.17 (0.83 – 5.66)	0.11
2008								
No food allergy	8277	98.8 (98.6 – 99.1)	98	1.2 (0.9 – 1.4)	1 [ref]	–	1 [ref]	–
Food allergy	411	97.2 (95.6 – 98.7)	12	2.8 (1.3 – 4.4)	1.85 (0.91 – 3.74)	0.09	2.19 (1.04 – 4.61)	0.04
2009								
No food allergy	10430	98.9 (98.7 – 99.1)	117	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	563	97.4 (96.1 – 98.7)	15	2.6 (1.3 – 3.9)	1.83 (0.91 – 3.68)	0.09	1.92 (0.96 – 3.84)	0.07
2010								
No food allergy	10609	98.9 (98.7 – 99.1)	121	1.1 (0.9 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	507	96.8 (95.2 – 98.3)	17	3.2 (1.7 – 4.8)	3.21 (1.87 – 5.51)	<0.0001	3.36 (1.81 – 6.23)	0.0001
2011								
No food allergy	11984	98.9 (98.7 – 99.0)	139	1.1 (1.0 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	670	95.9 (94.4 – 97.3)	29	4.1 (2.7 – 5.6)	3.83 (2.33 – 6.29)	<0.0001	3.72 (2.21 – 6.26)	<0.0001
2012								
No food allergy	12380	98.8 (98.6 – 99.0)	152	1.2 (1.0 – 1.4)	1 [ref]	–	1 [ref]	–
Food allergy	697	97.9 (96.8 – 98.9)	15	2.1 (1.1 – 3.2)	1.63 (0.82 – 3.23)	0.16	1.69 (0.84 – 3.42)	0.14
2013								
No food allergy	11977	98.9 (98.7 – 99.0)	139	1.1 (1.0 – 1.3)	1 [ref]	–	1 [ref]	–
Food allergy	700	97.1 (95.9 – 98.3)	21	2.9 (1.7 – 4.1)	1.87 (1.08 – 3.23)	0.03	1.56 (0.84 – 2.89)	0.16

Binary survey logistic regression models were constructed with anemia as the binary dependent variable and history of food allergy as the binary independent variable. Multivariable models were constructed that included age, sex, race/ethnicity, household income, highest level of education in the family, insurance coverage, number of persons in the household and birthplace in the US. Crude and adjusted OR and 95% CI were estimated.