






Health care resource use and costs in patients with food allergies: a United States insurance claims database analysis

Sayantani B. Sindher^a , Christopher Warren^b , Christina Ciaccio^c , Arpamas Seetasith^d , Yutong Liu^e, Sachin Gupta^{d,f}  and Ruchi Gupta^b

^aSchool of Medicine, Stanford University, Stanford, CA, USA; ^bFeinberg School of Medicine, Northwestern University, Chicago, IL, USA; ^cUniversity of Chicago Medicine, Chicago, IL, USA; ^dGenentech, Inc., South San Francisco, CA, USA; ^eGenesis Research, Hoboken, NJ, USA; ^fDepartment of Pulmonary Medicine, Alameda Health System, Oakland, CA, USA

ABSTRACT

Aims: Food allergies impose a large clinical and financial burden on patients and the health care system. However, little is known about the factors associated with health care resource use and costs. The aim of this study was to investigate health care resource use and costs in individuals with food allergies utilizing health care in the United States.

Methods: We conducted a retrospective analysis of insurance claims data from the Merative MarketScan Research Databases (indexed from 1 January 2015 to 30 June 2022). All-cause and food allergy-related health care resource use, direct medical, and out-of-pocket costs for medical services were estimated for 12 months post-index using *International Classification of Diseases [ICD]* codes.

Results: Of 355,520 individuals with food allergies continuously enrolled in a health insurance plan for ≥ 12 months pre- and post-index, 17% had a food allergy-related emergency department visit and 0.9% were hospitalized. The top patient characteristic associated with all-cause and food allergy-related hospitalizations, all-cause costs, and food allergy-related outpatient visit costs was a Charlson Comorbidity Index score of ≥ 2 . Food allergy-related direct medical and out-of-pocket costs were high among patients with a food allergy-related visit. Out-of-pocket cost per patient per year for outpatient visits, emergency department visits, and hospitalizations had an estimated mean of \$1631 for patients with food allergy-related visits, which is $\sim 11\%$ of the total costs for these services (\$14,395 per patient per year).

Limitations: Study limitations are primarily related to the nature of claims databases, including generalizability and reliance on *ICD* codes. Nevertheless, MarketScan databases provide robust patient-level insights into health care resource use and costs from a large, commercially insured patient population.

Conclusion: The health care resource use of patients with food allergies imposes a burden on both the health care system and on patients and their families, especially if patients had comorbidities.

PLAIN LANGUAGE SUMMARY

Some people with food allergies might need extra visits to the doctor or hospital to manage allergic reactions to food, and these visits add to the cost of medical services for both families and for health care providers. Using records of health insurance claims, we looked into the factors affecting medical visits and costs in people with food allergies in the United States. For people with food allergies, having additional medical conditions (measured using the Charlson Comorbidity Index) were linked with extra medical visits and costs. Out-of-pocket costs were high for people who visited a doctor or hospital for their food allergies (costing each person more than \$1,600 per year). The total medical cost of food allergy-related care was \$14,395 per person per year, paid for by families and health care providers. Our findings might help to better manage and treat people with food allergies and reduce medical costs.

ARTICLE HISTORY

Received 20 May 2024
Revised 25 July 2024
Accepted 26 July 2024

KEYWORDS

Food allergy; food hypersensitivity; health care costs; health care resource use; health insurance

JEL CLASSIFICATION CODES

I10; I1; I; I11

Introduction

Food allergies, which affect up to 8% of children and 11% of adults in the United States (US)^{1,2}, can impose a significant clinical, psychosocial, and financial burden for patients, their families, and health care systems around the world^{3–10}. Data

from a 2015–2016 nationwide survey suggested that 19% of children with food allergies in the US had at least one food allergy-related emergency department visit within the past year, and $\sim 40\%$ of both adults and children with food allergies reported at least one food allergy-related emergency

CONTACT Arpamas Seetasith  seetasith.arpamas@gene.com  Genentech, Inc., 1 DNA Way, South San Francisco, CA 94080, USA

 Supplemental data for this article is available online at <https://doi.org/10.1080/13696998.2024.2386819>.

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department visit within their lifetime^{1,2}. In addition, some studies suggest that the rates of food allergy-related hospital visits and admissions are rising^{11–15}. Given this high individual and societal burden, food allergies present a significant concern for patients, their families, health care providers, and payers.

Not surprisingly, patients with food allergies and their families have higher health care costs than those without food allergies in the general population, and the population-level economic burden is substantial^{6,7,10,16}. From a 2011–2012 survey, the annual direct medical cost of food allergies was estimated at \$4.3 billion in children alone³. Another retrospective analysis of 2010–2016 claims data from patients with peanut allergies estimated that all-cause and food allergy-related health care resource use (HRU) and costs were significantly higher per patient than in the general population¹⁷. In addition to direct medical costs borne by the health care system (such as the cost of clinician and allied health professional services, as well as hospital services), patients and their caregivers bear considerable out-of-pocket costs for medical services that are not covered by private or public health insurance, along with indirect costs, such as loss of time, productivity, and job opportunities^{7,18}.

Although the nature and costs of HRU among people with food allergies have previously been reported, little is known about current HRU, patient demographic and clinical characteristics associated with HRU and costs, and the differences in food allergy-related HRU across adult and pediatric populations in the US. Therefore, we conducted an analysis of 2015–2022 insurance claims data from the Merative MarketScan Research Databases, which provide deidentified, longitudinal, and patient-level information in the context of the US health care system.

Methods

This was a retrospective study using insurance claims data from the Merative MarketScan Research Databases (Commercial, Multi-State Medicaid, and Medicare Supplemental). The MarketScan databases contain claims data for over 293 million US-based health plan members from more than 350 (primarily large) employers since 1995¹⁹. Analyses investigated: the 5-year proportion of patients with food allergies utilizing care in the US; specific HRU; the direct medical and out-of-pocket medical costs of providing that care; and patient demographics and clinical characteristics associated with HRU and costs in the US.

The data used in this study were deidentified according to the patient confidentiality requirement of the Health Insurance Portability and Accountability Act of 1996 and did not require approval from an institutional review board.

Analysis of patients utilizing health care

This analysis included data from 1 January 2015 to 31 December 2019 (most recent full calendar year that included Medicaid data at the time of analysis), and all patients with food allergy codes in a calendar year (*International Classification*

of Diseases [ICD] codes are specified in [Supplementary Table 1](#)). Patients were included in the analysis if they had enrolled in a health plan with medical coverage for at least one month (the denominator) and had at least one inpatient or outpatient food allergy claim or anaphylactic reaction to food (the numerator) ([Table 1](#)). Patients were excluded from the analysis if they had evidence of celiac disease, lactose or fructose intolerance, malabsorption disorders, or food protein-induced enteropathy (*ICD* codes are specified in [Supplementary Table 2](#)). In addition, claims with negative paid amounts were excluded. The proportion of patients utilizing health care was calculated as the number of patients with claims divided by the number of members enrolled in the database, without imputation.

Health care resource use and cost analysis

This analysis included data from 1 January 2015 to 30 June 2022 (Commercial and Medicare Supplemental databases) or 1 January 2015 to 31 December 2021 (Medicaid database). Care-utilizing patients with food allergies met the same criteria as those included in the prevalence analysis ([Table 1](#)) and in addition were required to be continuously enrolled in the health insurance plan for at least 12 months before and after the date of the first food allergy-related claim (index date). Based on available *ICD* codes ([Supplementary Table 1](#)), the specific food allergens included in this analysis were peanuts, tree nuts and seeds, milk and dairy products, eggs, shellfish, fish, and fruits and vegetables. For all patients with food allergies, patients with a single food allergy were defined as those with only one specified allergen without additional food allergy claims where the allergen was unspecified. Patients with multiple food allergies were defined as those with at least two known allergens, with or without additional food allergy claims where the allergen was unspecified. The remaining patients were those with claims of allergy to other foods or anaphylactic reaction due to other food products or unspecified foods.

Demographic and clinical characteristics and the presence of select comorbid conditions were determined using data from the baseline period (during the fixed 12-month pre-index period before the first food allergy claim). Comorbid conditions (allergic rhinitis, allergic conjunctivitis, atopic dermatitis, hives, asthma, gastroesophageal reflux disease [GERD], conjunctivitis, anxiety, and depression) were identified by claims with *ICD* codes for such conditions in any position. All-cause and food allergy-specific HRU was estimated in the fixed 12-month period after the index date (post-index). Food allergy-specific HRU was defined as claims with *ICD* codes for food allergies in any position. The cost analysis did not include patients with Medicaid and Commercial or Medicare with health maintenance organization or point-of-service with capitation plans, which use a capitated payment structure resulting in many \$0 claims. Therefore, cost reporting in patients with these plans is expected to be artificially low and not accurately reflected. Both total costs (sum of amount paid for services rendered by health plan and amount paid by patients [copay, coinsurance]) and patient out-of-pocket costs for medical services

Table 1. Patient attrition.

Description	Sample size
Analysis of patients utilizing health care	
• ≥ 1 month of enrollment in a health plan with medical coverage during the selection window	78,181,900
• ≥ 1 inpatient or outpatient visit	64,489,048
• ≥ 1 inpatient or outpatient claim with <i>ICD</i> codes for food allergy status or anaphylactic reaction due to food allergy in any position	761,909
• Exclude patients with claims for celiac disease, lactose intolerance (if evidence of milk allergy only), fructose intolerance, malabsorption disorders, or food protein-induced enteropathy during the selection window and after the index date	728,096
HRU and cost analysis	
• ≥ 1 month of enrollment in a health plan with medical coverage during the selection window	78,181,900
• ≥ 1 inpatient or outpatient visit	64,489,048
• ≥ 1 inpatient or outpatient claim with <i>ICD</i> codes for food allergy status or anaphylactic reaction due to food allergy in the primary position (for inpatient claims) and in any position (for outpatient claims)	897,914
• ≥ 12 months of continuous enrollment in a health plan with medical and pharmacy benefits before and after the index date	372,522
• Exclude patients with claims for celiac disease, lactose intolerance (if evidence of milk allergy only), fructose intolerance, malabsorption disorders, or food protein-induced enteropathy during the post-index period	355,520

Abbreviations: HRU, health care resource utilization; *ICD*, *International Classification of Diseases*.

were reported. Costs were assessed among all individuals with food allergies and among patients with a food allergy-related visit. All costs were adjusted to 2022 US dollars (USD) utilizing the medical care component of the Consumer Price Index.

Statistical analysis

Descriptive statistics were used to compare 1-year all-cause and disease-specific HRU (hospital admissions, emergency department visits, and outpatient visits). Pearson's chi-squared test was used to test for unadjusted differences between groups. Associations between patient demographic and clinical characteristics and 1-year post-index all-cause or food allergy-related HRU and costs were explored using multivariate analysis. Logistic regression analysis was used for inpatient and emergency department visits, and negative binomial regression was used for outpatient visits. For the cost analysis, a generalized linear model with log link and gamma distribution was used to account for skewed cost data. Covariates in the model included age (<18 or ≥ 18 years), sex, geographic region, payer type (Commercial, Medicare Supplemental, or Medicaid; for HRU analysis only), allergy type (single or multiple food allergies), Charlson Comorbidity Index (CCI 0, 1, or ≥ 2 , which summarizes patient comorbidities), presence of allergic comorbid condition (allergic rhinitis, allergic conjunctivitis, atopic dermatitis [eczema], hives [urticaria], asthma), anxiety, and depression.

Results

Proportion of patients with food allergies utilizing care

Among 78,181,900 individuals (Table 1) in the MarketScan databases (55,165,722 Commercial, 2,370,486 Medicare Supplemental, 20,645,692 Medicaid), 728,096 patients (0.9%) utilized health care services for food allergies during the 5-year period (499,852 Commercial, 5707 Medicare Supplemental, 222,537 Medicaid). The mean (standard deviation [SD]) age of patients with food allergies was 17.7 (17.6) years, and 53% of patients were female. From the MarketScan

databases, the proportion of individuals utilizing health care services for food allergies was highest in young children and decreased with age: 0–1 years, 2.5%; 2–5 years, 2.5%; 6–10 years, 2.1%; 11–17 years, 1.6%; ≥ 18 years, 0.5%.

Health care resource use and costs

Patient characteristics

A total of 355,520 individuals with food allergies with a continuous enrollment in a health insurance plan for ≥ 12 months before and after the index date were included in the HRU analysis (Table 1). Most patients were aged <18 years (62%; 220,356/355,520) and most patients (65%) were commercially insured (Table 2). Of the 355,520 patients with food allergies, 159,675 (45%) did not have a record of specific food allergy by *ICD* code; of the remaining 195,845 patients with an *ICD*-specified food allergy, 68% had a single food allergy and 15% had multiple food allergies to two or more known allergens. Adult patients had a higher mean CCI score than pediatric patients (mean, 0.51 vs. 0.26) and a higher incidence of anxiety and depression, but fewer adults had allergic comorbidities (allergic rhinitis, asthma, and atopic dermatitis) (Supplementary Table 3). Of note, 46% of pediatric patients were female, compared with 69% of adult patients.

Health care resource use

During 1-year post-index, 38% of patients with food allergies had an all-cause emergency department visit and 4.6% had an all-cause hospitalization (Figure 1(A)). Furthermore, 17% of patients had a food allergy-related emergency department visit, and 0.9% had a food allergy-related hospitalization (Figure 1(B)). All-cause and food allergy-related outpatient visits (e.g. regular allergist visits) were similar for patients with food allergies, with most patients having an outpatient visit during 1-year post-index (Figure 1). All-cause and food allergy-related HRU were generally similar for pediatric and adult patients with food allergies: for example, 37% of pediatric patients and 39% of adult patients had an all-cause emergency department visit (Supplementary Figure 1). The

Table 2. Patient characteristics.

Characteristic	Overall N = 355,520
Age, y, mean (SD)	20 (18)
Age group, n (%)	
0–1 y	16,390 (4.6)
2–5 y	60,984 (17)
6–10 y	66,764 (19)
11–17 y	76,218 (21)
18–25 y	36,977 (10)
26–30 y	11,365 (3.2)
31–64 y	82,730 (23)
≥65 y	4092 (1.2)
Sex, female, n (%)	193,528 (54)
Insured, n (%)	
Commercial	230,503 (65)
Medicaid	121,098 (34)
Medicare	3919 (1.1)
CCI score, mean (SD)	0.35 (0.74)
CCI score, n (%)	
0	258,653 (73)
1	81,857 (23)
2	8813 (2.5)
≥3	6197 (1.7)
Comorbidities, n (%)	
Allergic rhinitis	77,467 (22)
Asthma	73,349 (21)
Atopic dermatitis/eczema	34,321 (9.7)
Anxiety	31,163 (8.8)
GERD	27,090 (7.6)
Hives (urticaria, CSU)	22,520 (6.3)
Depression	20,313 (5.7)
Conjunctivitis	7142 (2.0)
Food allergy type, n (%)	
Specified food allergy	195,845 (55)
Single food allergy	132,959 (68)
Multiple food allergies	28,498 (15)
Unspecified food allergy	159,675 (45)
Food allergen type, n (%)	
Peanut	88,203 (24.8)
Shellfish	59,946 (16.9)
Milk	28,857 (8.1)
Egg	26,892 (7.6)
Tree nut	23,199 (6.5)
Unspecified	204,470 (57.5)
Epinephrine prescription, n (%) ^a	81,161 (22.8)

Abbreviations: CCI, Charlson Comorbidity Index; CSU, chronic spontaneous urticaria; GERD, gastroesophageal reflux disease; y, years.

Note: Race is not uniformly captured in the MarketScan databases and therefore is not included.

^aPatients who had an epinephrine pharmacy claim (National Drug Code: 49502-500-02 or 49502-500-01).

significant factors associated with all-cause and food allergy-related HRU varied between outcomes (Figure 2, Supplementary Table 4). The top factors (incidence rate ratio or odds ratio of ≥ 1.5) associated with outpatient visits, emergency department visits, and hospitalizations included multiple food allergies, Medicaid insurance, age ≥ 18 years, anxiety or depression, and a CCI score of 1 or ≥ 2 .

Direct medical costs

Mean (SD) estimated total 1-year all-cause direct medical cost per patient with food allergies was \$10,368 (\$37,015), comprising \$8005 (\$34,165) medical (Figure 3(A)) and \$2363 (\$11,027) pharmacy costs. Mean (SD) 1-year food allergy-related medical cost per patient was \$875 (\$2761) (Figure 3(B)). Food allergy-related costs for emergency department visits and hospitalizations were high among

patients who had a food allergy-related visit (Figure 3(C)). Mean (SD) total estimated 1-year all-cause direct medical costs were lower in pediatric patients compared with adult patients (mean \$6278 [\$22,238] vs. \$14,833 [\$47,830]), however, food allergy-related costs were similar (Supplementary Figure 2). The top factors (incidence rate ratio or odds ratio of ≥ 1.5) associated with all-cause direct medical costs included a CCI score of 1 or ≥ 2 , age ≥ 18 years, anxiety, and atopic dermatitis (Figure 4, Supplementary Table 5). Costs for food allergy-related outpatient visits were associated with a CCI score of ≥ 2 and multiple food allergies.

Out-of-pocket costs for medical services

Mean (SD) estimated total 1-year all-cause medical out-of-pocket cost per patient with food allergies was \$1438 (\$1753), comprising \$1163 (\$1545) medical (Figure 5(A)) and \$275 (\$673) pharmacy costs. Outpatient visits were the biggest contributor to all-cause and food allergy-related medical out-of-pocket costs per patient (Figures 5(A,B)). Mean (SD) estimated 1-year all-cause medical out-of-pocket costs per patient were \$880 (\$1271) for pediatric patients vs. \$1472 (\$1746) for adult patients; out-of-pocket costs were also lower in pediatric patients compared with adult patients for outpatient visits, emergency department visits, and hospitalizations (Supplementary Figure 3). However, food allergy-related medical out-of-pocket costs were generally similar among adult and pediatric patients (mean [SD] medical costs: \$205 [\$415] vs. \$219 [\$476]). Food allergy-related out-of-pocket costs among patients with a food allergy-related visit were high, particularly for hospitalization (mean [SD] of \$966 [\$1346]) (Figure 5(C)). With estimated mean out-of-pocket costs per patient of \$1631 per year for food allergy-related outpatient, emergency department, and inpatient visits, patients with food allergy-related visits carry $\sim 11\%$ of the total health care costs for these services (estimated mean of \$14,395 per patient per year).

Discussion

This analysis of the MarketScan health insurance claims databases quantifies direct medical costs in people of all ages with food allergies in the US and provides new insights into patient characteristics associated with HRU and costs. Although emergency department visits and hospitalizations related to food allergy were relatively uncommon, the costs pose a financial burden to patients requiring these services. Further, we found that adults and pediatric patients have similar food allergy-related HRU and costs. Although it has been estimated that up to 8–11% of the US population has a food allergy^{1,2}, our analysis of the MarketScan databases indicates that the overall proportion of individuals with food allergies utilizing health care services was only 0.9% of all individuals enrolled in a US health plan, which is likely reflective of the incident-driven nature of food allergies and is possibly underestimated in the MarketScan databases. Despite this, our data also indicate that nearly one in five care-seeking patients with known food allergies may have a

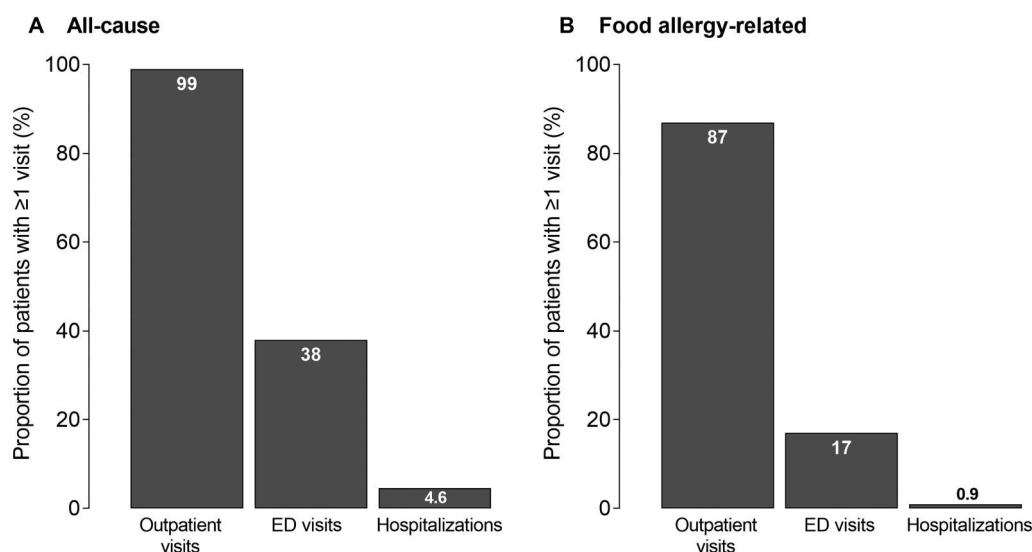


Figure 1. Health care resource use among patients with food allergies. Proportion of patients with one or more (A) all-cause visit and (B) food allergy-related visit. Abbreviation: ED, emergency department.

food allergy-related emergency department visit in a 12-month period, imposing a burden on the US health care system.

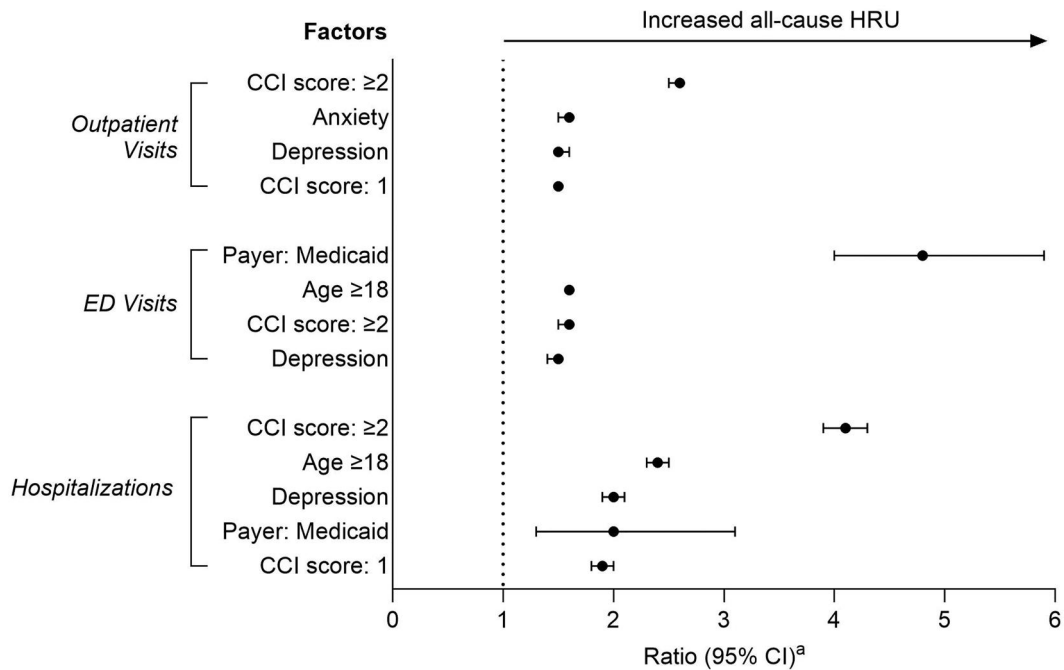
In keeping with previous studies^{20–24}, atopic comorbidities, such as allergic rhinitis and asthma were common in our cohort of patients with food allergies, co-occurring in 22% and 21% of patients, respectively. Indeed, the significant factors associated with both all-cause and food allergy-related HRU and direct medical costs included these atopic comorbidities along with a cohort of chronic conditions assessed by the CCI (including diabetes, heart failure, pulmonary disease, liver disease, and cancer). Perhaps surprisingly, the presence of comorbid asthma was not a key factor affecting HRU or costs in our study. This is in contrast to a claims database analysis which found that the presence of comorbid peanut allergy increased HRU and costs in patients with asthma¹⁷, and a survey study which found that HRU and costs in patients with asthma were increased in the presence of allergy²⁵. In addition to atopic comorbidities, psychological comorbidities (anxiety and depression) were also key factors associated with HRU and costs, although a causal relationship is unclear. This finding is consistent with other studies highlighting an association between psychological comorbidities and food allergies^{26–28}.

The financial burden for people with food allergies is likely underestimated in this study, as we were unable to capture all non-medical (out-of-pocket) costs of food allergies from the claims database, including costs associated with purchasing specialized foods, as well as indirect costs, such as lost productivity at work, or the mental health costs associated with managing food allergy. However, the substantial burden of indirect costs is highlighted by a large Canadian survey of adults and children with food allergies ($N=2692$), in which indirect costs, such as unpaid labor and lost productivity (2020 Canadian dollars [CAD] \$7950) were more than three times higher than health care (CAD \$1267) and out-of-pocket (CAD \$2136) costs⁷. Similarly, in a US study, the costs borne by families of children with food allergy,

including out-of-pocket treatment costs (\$931), lost labor productivity (\$130), and job-related opportunity costs (\$2399) were almost five times greater per patient than the direct medical costs (\$724)³. Given that food allergies are a growing concern globally, assessment of HRU and costs in each country may provide insight into the global financial burden for patients with food allergies.

This study has several limitations, primarily related to the nature of health insurance claims databases and reliance on ICD codes, such as inherent issues with generalizability to the whole US population (especially those without insurance coverage), with most data being provided by large employers¹⁹, low representation of patients ≥ 65 years of age and those between 18 and 30 years of age (underinsured population), misreporting of food allergy history and comorbid conditions from administrative claims, missing data (particularly in relation to unspecified food allergies), upcoding, and coding errors. Of note, clinicians could choose to code single (only one known food allergen) or multiple (two or more known allergens with or without unspecified allergens) food allergies as unspecified food allergies. Based on this knowledge, we chose to assign patients with an unspecified food allergy diagnosis (without a claim specifying known allergen/s) into a separate category. Although our approach aimed to increase specificity and reduce false positives, it is possible that some patients with single or multiple food allergies were miscategorized as unspecified. Given that our estimated prevalence of multiple food allergies is much lower than existing literature²⁴, we may have underestimated the proportion of multiple food allergies with this approach. Further, the exclusion of patients with food protein-induced enteropathy (ICD-10 codes K52.21/K52.22) or celiac disease (ICD-10 code K90.0 and ICD-9 code 579.0) may underestimate the true prevalence of food allergies in this population, as these may occasionally be comorbid with immunoglobulin E (IgE)-mediated food allergy^{29,30}; IgE/non-IgE-mediated food allergies are not specified in the ICD codes. HRU (particularly emergency department visits) may have been lower during

A All-cause



B Food allergy-related

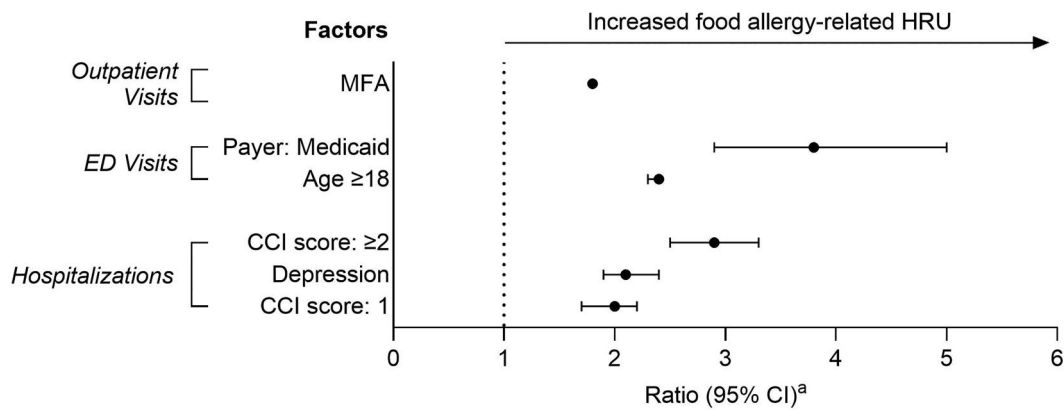


Figure 2. Top factors ($p < 0.05$) associated with (A) all-cause and (B) food allergy-related health care resource use (HRU) among patients with food allergies. Abbreviations: CCI, Charlson Comorbidity Index; MFA, multiple food allergies. ^aIncidence rate ratio is reported for outpatient visits, and odds ratios for emergency department (ED) visits and hospitalizations.

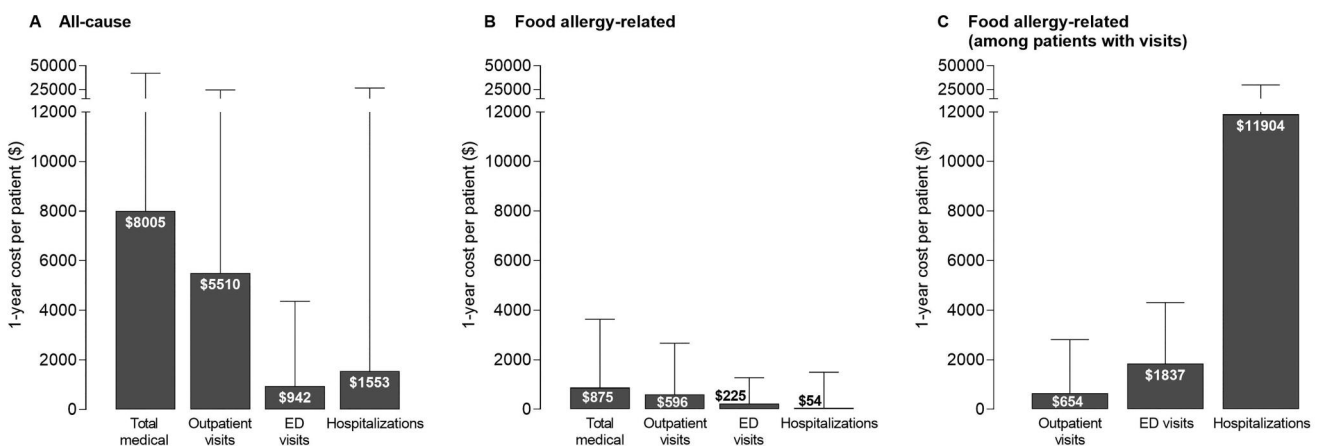
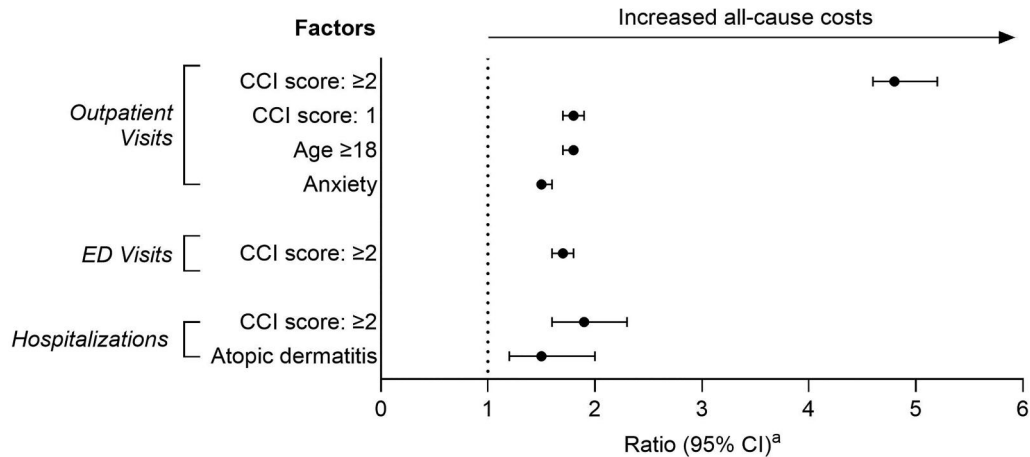


Figure 3. Estimated mean (SD) 1-year direct medical cost per patient with food allergies (2022 USD). (A) All-cause cost, (B) food allergy-related cost, and (C) food allergy-related cost among patients with visits (outpatient visits, ED visits, and hospitalizations). Abbreviations: ED, emergency department; USD, United States dollars.

A All-cause



B Food allergy-related

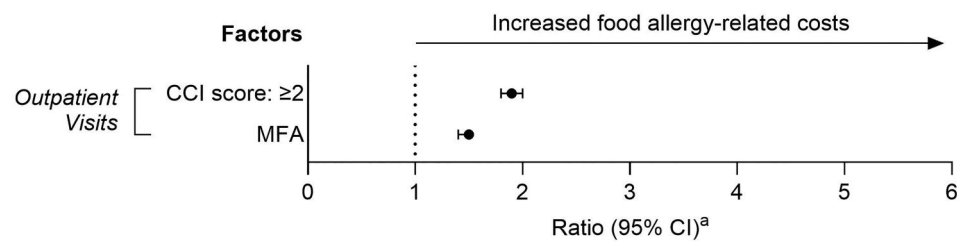


Figure 4. Top factors ($p < 0.05$) associated with (A) all-cause and (B) food allergy-related health care costs among patients with food allergies. Abbreviations: CCI, Charlson Comorbidity Index; MFA, multiple food allergies. ^aIncidence rate ratio is reported for outpatient visits, and odds ratios for emergency department (ED) visits and hospitalizations.

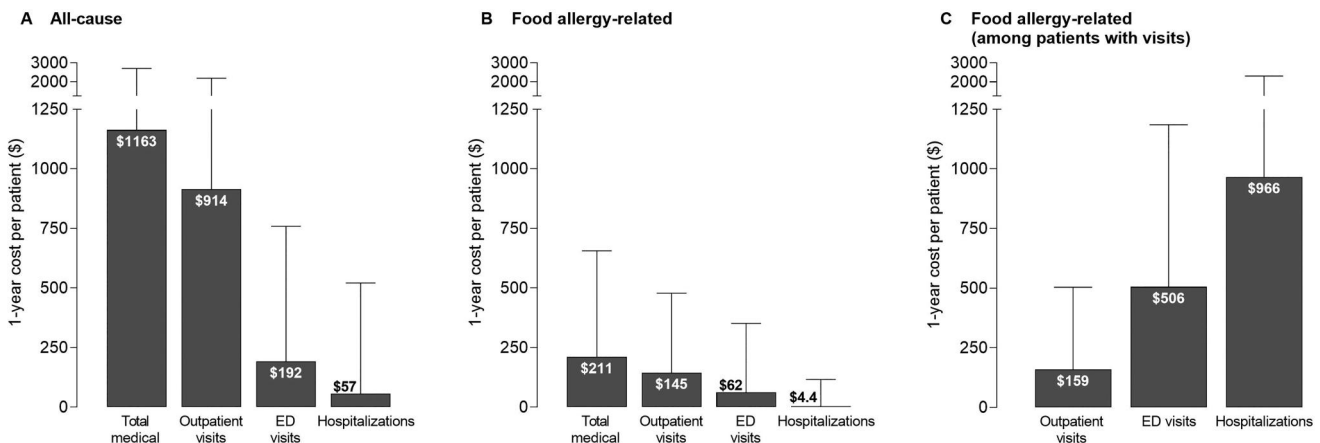


Figure 5. Estimated mean (SD) 1-year out-of-pocket cost for medical services per patient with food allergies (2022 USD). (A) All-cause cost, (B) food allergy-related cost, and (C) food allergy-related cost among patients with visits (outpatient visits, ED visits, and hospitalizations). Abbreviations: ED, emergency department; USD, United States dollars.

the COVID-19 pandemic, which overlapped in part with data collection, providing another reason why HRU and costs may be underestimated in this study. Finally, our study estimated the financial burden only in people with food allergies, but not the incremental burden associated with food allergy, which may require a comparator group¹⁷. Despite these limitations, the MarketScan databases provide robust patient-level insights into HRU and costs from a large and diverse patient population.

Conclusion

This retrospective analysis provides new and updated insights into HRU and medical costs in US-based patients with food allergies, particularly the out-of-pocket costs borne by patients and their families. Overall, patients with the highest HRU and costs were those with multiple comorbidities, multiple food allergies, and age ≥ 18 years. These findings may help to raise awareness about the financial burden for

people with food allergies (including policymakers) and could help clinicians identify and optimize management for patients at the highest risk of food allergy-related events.

Transparency

Declaration of funding

This analysis was funded by Genentech, Inc., a member of the Roche Group. Genentech, Inc. was involved in the analysis design, data interpretation, and preparation of the manuscript. Medical writing assistance was provided by Natalie Roberts, MSc and Nilisha Fernando, PhD of Envision Pharma Group, and was funded by Genentech, Inc., a member of the Roche Group. Envision Pharma Group's services complied with international guidelines for Good Publication Practice.

Declaration of financial/other relationships

SBS: grants from Aimmune, Consortium of Food Allergy Research (CoFAR), DBV, NIAID, Novartis, Regeneron, and Sanofi; advisory member for Genentech, Inc. CW: institutional research funding from FARE, NIH, and Sunshine Charitable Foundation. CC: research support from the Duchossois Foundation, Food Allergy Research & Education, National Institutes of Health, and Paul and Mary Yovovich; advisory board for Aimmune, ALK, DBV, Genentech, Inc., and Novartis. AS, SG: employees of Genentech, Inc.; stockholders of the Roche Group. YL: employee of Genesis Research, a paid vendor. RG: research grant support from Allergy & Asthma Network, FARE, Genentech, Inc., The Melchiorre Family Charitable Foundation Inc., National Confectioners Association, NIH, Sean N. Parker Center for Allergy & Asthma Research, Sunshine Charitable Foundation, Thermo Fisher Scientific, UnitedHealth Group, and Walder Foundation; medical consultant/advisor for FARE, Genentech, Inc., and Novartis; ownership interest in YoBee Care, Inc.

Author contributions

SBS, CW, CC, AS, YL, SG, and RG conceived the study, interpreted the results, and prepared the manuscript. AS and YL analyzed the data. All authors critically reviewed the manuscript and approved the final draft.

Acknowledgements

The authors would like to thank Denise Boudreau, of Genentech, Inc., for her contributions to this analysis.

Reviewer disclosures

Peer reviewers on this manuscript have no relevant financial or other relationships to disclose.

Previous presentations

Data from this study have been presented in part at the following congresses: American College of Allergy, Asthma & Immunology (ACAAI) 2021 and 2022 Annual Meetings; European Academy of Allergy & Clinical Immunology (EAACI) 2022 Congress; American Academy of Allergy, Asthma & Immunology (AAAAI) 2023 Annual Meeting; and the Academy of Managed Care Pharmacy (AMCP) 2023 Annual Meeting.

ORCID

Sayantani B. Sindher <http://orcid.org/0000-0003-0387-2800>
 Christopher Warren <http://orcid.org/0000-0002-8924-3329>
 Christina Ciaccio <http://orcid.org/0000-0002-5059-0550>

Arpamas Seetasith <http://orcid.org/0000-0003-0648-7764>
 Sachin Gupta <http://orcid.org/0000-0003-2912-5619>

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