Chapter 2
A Review of the Distribution and Costs of Food Allergy

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2.1 Introduction

Food allergy is a significant disease and requires attention in both medicine and society. It affects 8% of U.S. children (Gupta et al. 2011) and there is no established cure for food allergy yet. Moreover, potential allergen exposure and the risk of severe allergic reactions are part of daily life. Epinephrine auto-injectors (EAIs) are the only approved treatment for severe allergic reactions, and access to these devices among food-allergic children is not always possible. Food-allergic people and their caretakers are forced to be constantly vigilant, often at great psychological and financial cost.

Food allergy is more likely to occur in African American and Asian children than White children, and the rate of reactions requiring emergency department (ED) visits or hospitalizations is growing fastest among Hispanic children (Dyer et al. 2015). Importantly, formal diagnoses and access to treatment are less likely among racial/ethnic minorities than among White children. Lower income families also have limited access to preventative measures but spend more than twice what higher-income families do on emergency department visits for food-allergic reactions. Urban children

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have also been shown to have higher numbers of food allergy diagnosis and higher rates of ED visits than those living the in suburbs. These disparities, together with the large size of the affected population, make childhood food allergy a serious public health problem. Increasing public access to information about food allergy and its treatment is vital.

It has been demonstrated that the quality of life among parents of children with food allergy is worse than that of parents of non-allergic children. This difference exists even among parents who feel comfortable with controlling their children's food allergies. Avenues to improve quality of life among food-allergic children and their caregivers have been largely unexplored. At the consumer level, there is a great deal of ambiguity in the regulation and meaning of allergen warnings on packaged foods, which may lead to misinformed and potentially dangerous food purchases. From an economic standpoint, food allergy costs the US $24.8 billion annually (Gupta et al. 2013); much of this cost is borne by the families of food-allergic children (Gupta et al. 2013).

Schools exist at the intersection of the many spheres discussed above and represent an opportunity to improve outcomes for food-allergic children around the country. Chicago Public Schools (CPS) is the largest school system to date to implement a program to make undesignated epinephrine available for any student experiencing anaphylaxis. This program has potentially saved dozens of lives but has also cast into sharp relief about the disparities in and necessity of access to EAIs. The data gleaned from the CPS initiative should motivate us to increase safety and awareness around food allergy.

This chapter will aim to make clear the state of food allergy in the U.S., and on which parties the burden of the disease lies. The studies discussed herein aimed to gather and organize population-level information on the prevalence, distribution, and cost of food allergy, as well as to understand some of the social and psychological responses to the challenges of food allergy.

2.2 The Prevalence, Severity, and Distribution of Childhood Food Allergy in the U.S.

There is a lack of comprehensive data on both the number of children in the U.S. living with food allergy, and their demographics. Efforts to characterize the scope of the disease have been limited by small and non-representative samples as well as by the use of non-standardized diagnostic criteria (Gupta et al. 2011). We therefore conducted a population-based, cross-sectional survey of a large representative population of U.S. children ($n = 38{,}480$) in an attempt to define the prevalence and severity of pediatric food allergy in the U.S. Recruitment employed a dual-sample approach, in which a probability-based sample statistically representative of U.S. households with children was used to identify and correct for a sampling and non-sampling bias introduced by a larger, opted-in online sample (Gupta et al. 2011). In this survey, prevalence estimates include report of both *convincing* allergy, defined as participant report of a food allergy plus a history of one or more common symptoms, and *confirmed* allergy, defined by the criteria of a convincing allergy plus confirmatory physician diagnosis by serum specific immunoglobulin E (IgE) testing, skin prick testing (SPT), or oral food challenge (OFC).

2.2.1 Prevalence

Based on our primary research survey (Table 2.1), 8% of U.S. children were found to have food allergy. Thirty-four percent of these children, or approximately 2.5% of the total population, were allergic to more than one food and were therefore at an increased risk of severe reaction. Additionally, 3.1% of all children and 39% of food-allergic children were found to have *severe* food allergy, defined as a history of at least one reaction of one or more of the following symptoms: anaphylaxis, hypotension, trouble breathing, or wheezing. Males were significantly more likely than females to have severe allergies. There were no significant differences between genders in the frequencies of convincing allergy or confirmed allergy.

2.2.1.1 Prevalence by Age

The overall prevalence of food allergy varied significantly by age and was highest among children 3–5 years old (9.2%) (Table 2.1). Significant variance in prevalence according to age was observed for peanut, shellfish, tree nut, wheat, and egg allergy. Adolescents were at significantly higher risk for severe allergic reactions than were children aged 0–2 (odds ratio [OR] = 2.1). The odds of having a confirmed food allergy did not vary significantly with age (Gupta et al. 2011).

2.2.1.2 Prevalence by Allergen

Peanut was the most common food allergen, with 2% of all children and of 25% of food-allergic children in this survey allergic to peanuts. This estimate is two times higher than that made by a Canadian study (Ben-Shoshan et al. 2010). The prevalence of fin fish allergy (0.5%), was also higher than the previously reported 0.3% of children and adults (Ben-Shoshan et al. 2010). The prevalence of other common food allergens assessed in this survey was consistent with previous findings (Gupta et al. 2011). Severe reactions were most common among children with tree nut, peanut, shellfish, soy, and fin fish allergies (Gupta et al. 2011).

2.2.1.3 Prevalence by Race/Ethnicity

African American and Asian children were significantly more likely than White children to have food allergies (OR = 1.8 and 1.4, respectively) but less likely to have physician-confirmed diagnoses (OR = 0.8 and 0.7, respectively). Hispanic children were also significantly less likely than White children to have physician-confirmed allergies (OR = 0.8) (Gupta et al. 2011).

Table 2.1 Prevalence of common food allergies according to age group

Age group	Frequency, % (95% CI)									
	All allergens ($N = 3339$)	Peanut ($N = 767$)	Milk ($N = 702$)	Shellfish ($N = 509$)	Tree Nut ($N = 430$)	Egg ($N = 304$)	Fin Fish ($N = 188$)	Strawberry ($N = 189$)	Wheat ($N = 170$)	Soy ($N = 162$)
Prevalence among all children surveyed										
All ages ($N = 38\,480$)	8.0 (7.7–8.3)	2.0 (1.8–2.2)	1.7 (1.5–1.8)	1.4 (1.2–1.5)	1.0 (0.9–1.2)	0.8 (0.7–0.9)	0.5 (0.4–0.6)	0.4 (0.4–0.5)	0.4 (0.3–0.5)	0.4 (0.3–0.4)
0–2 years ($n = 5429$)	6.3 (5.6–7.0)	1.4 (1.1–1.8)	2.0 (1.6–2.4)	0.5 (0.3–0.8)	0.2 (0.2–0.5)	1.0 (0.7–1.3)	0.3 (0.1–0.4)	0.5 (0.3–0.7)	0.3 (0.1–0.5)	0.3 (0.2–0.4)
3–5 years ($n = 5910$)	9.2 (8.3–10.1)	2.8 (2.3–3.4)	2.0 (1.7–2.5)	1.2 (0.8–1.6)	1.3 (1.0–1.7)	1.3 (0.9–1.7)	0.5 (0.3–0.8)	0.5 (0.3–0.8)	0.5 (0.3–0.7)	0.5 (0.3–0.7)
6–10 years ($n = 9911$)	7.6 (7.0–8.2)	1.9 (1.6–2.3)	1.5 (1.2–1.8)	1.3 (1.1–1.6)	1.1 (0.87–1.4)	0.8 (0.6–1,1)	0.5 (0.3–0.7)	0.4 (0.3–0.5)	0.4 (0.3–0.5)	0.3 (0.2–0.5)
11–13 years ($n = 6716$)	8.2 (7.4–9.0)	2.3 (1.9–2.8)	1.4 (1.1–1.8)	1.7 (1.3–2.1)	1.2 (1.0–1.6)	0.5 (0.4–0.8)	0.6 (0.4–0.8)	0.4 (0.3–0.6)	0.7 (0.5–0.9)	0.6 (0.4–0.8)
2:14 years ($n = 10\,514$)	8.6 (7.9–9.3)	1.7 (1.4–2.1)	1.6 (1.3–1.9)	2.0 (1.7–2.5)	1.2 (0.9–1.5)	0.4 (0.2–0.5)	0.6 (0.4–0.9)	0.4 (0.3–0.6)	0.3 (0.2–0.4)	0.3 (0.2–0.4)
P	0.0000	0.0001	0.0504	0.0000	0.0000	0.0000	0.1045	0.7700	0.0089	0.0509
Prevalence among children surveyed with food allergy										
All ages ($N = 3339$)	—	25.2 (23.3–27.1)	21.1 (19.4–22.8)	17.2 (15.6–18.9)	13.1 (11.7–14.6)	9.8 (8.5–11.1)	6.2 (5.2–7.3)	5.3 (4.4–6.3)	5.0 (4.2–6.0)	4.6 (3.8–5.6)
0–2 years ($n = 469$)	—	22.2 (17.4–27.8)	31.5 (26.6–36.8)	7.5 (4.7–11.9)	5.4 (3.6–8.1)	15.8 (12.0–20.4)	4.0 (2.3–6.9)	7.5 (5.2–8.2)	4.0 (2.2–7.2)	4.2 (2.7–6.5)
3–5 years ($n = 539$)	—	30.3 (25.8–35.3)	22.1 (18.3–26.5)	12.9 (9.7–16.9)	14.3 (11.1–18.2)	13.7 (10.5–17.6)	5.7 (3.8–8.6)	5.5 (3.6–8.2)	5.0 (3.2–7.7)	5.1 (3.3–7.8)

6–10 years (n = 847)	—	25.5 (22.0–29.5)	19.6 (16.6–23.0)	17.1 (14.0–20.6)	14.3 (11.6–17.5)	11.1 (8.6–14.3)	6.2 (4.5–8.5)	4.8 (3.4–6.9)	5.0 (3.5–7.1)	4.0 (2.6–6.2)
11–13 years (n = 584)	—	28.1 (23.7–32.9)	17.7 (14.2–22.0)	20.4 (16.8–24.7)	15.2 (12.0–19.2)	6.6 (4.4–9.9)	7.0 (4.8–10.1)	4.6 (3.1–6.8)	8.2 (5.9–11.2)	6.9 (4.7–10.0)
2:14 years (n = 900)	—	20.2 (17.0–23.7)	18.4 (15.3–22.1)	23.8 (20.1–27.9)	13.4 (10.7–16.6)	4.1 (2.9–5.9)	7.2 (5.2–9.8)	4.9 (3.3–7.3)	3.3 (2.1–5.0)	0.3 (0.2–0.4)
P	—	0.0050	0.0001	0.0000	0.0010	0.0000	0.4646	0.4486	0.0174	0.1296

Common food allergens are those reported with a frequency of $n > 150$

Gupta et al. (2011)

2.2.1.4 Prevalence by Socioeconomic Status

The odds of having food allergy were significantly lower for children in households with annual incomes of <$50,000 versus ≥$50,000 (OR = 0.5). Children in households with annual incomes of <$50,000 were also significantly less likely to have confirmed diagnoses (OR = 0.5) and severe allergies (OR = 0.8) (Gupta et al. 2011).

2.2.1.5 Prevalence by Geography

The odds of having food allergy were significantly higher for children from the Northeast (OR = 1.3), South (OR = 1.5), and West (OR = 1.3) regions of the U.S. versus children from the Midwest. There was no significant difference between regions in terms of the odds of having confirmed (versus convincing) allergy or severe (versus non-severe) allergy (Gupta et al. 2012).

2.2.2 What the Prevalence, Severity, and Distribution of Childhood Food Allergy Tell Us

Eight percent of children in this study had food allergy; this equates to an estimated 5.9 million affected children in the U.S. This prevalence is higher than many previous estimates and underscores the importance of food allergy as a public health concern. Furthermore, in this study, 39% of food-allergic children had severe food allergies, and 34% had multiple food allergies. To our knowledge, the prevalence of severe food allergy among a representative sample of U.S. children has not been previously reported. Importantly, the distribution of food allergy varies significantly among racial and socioeconomic groups as well as by geographic region. While food allergy was found to be more common among African American and Asian children, these children were less likely than their White counterparts to have physician-confirmed diagnoses. This difference is likely influenced by differences in healthcare access and utilization between these populations. Further work is needed to determine how biological, social, and economic factors influence the incidence as well as the diagnosis and management of food allergy in patients with different racial and socioeconomic backgrounds (Gupta et al. 2011).

2.3 Geographic Variability of Food Allergy in the U.S.

The same population-based, cross-sectional survey was used to determine the geographic distribution of food allergy prevalence in the U.S. (Gupta et al. 2012). Data were analyzed for 38,465 children. Geographic characteristics assessed included state, latitude, zip code, and urban/rural status. Latitude was assigned by zip code, and latitudes were collapsed into terciles: northern (≥41.8° N latitude), middle (34.3° N to 41.7° N latitude), and southern (≤34.2° N latitude). Urban/rural status was also determined by zip code and classified by the following designations, in order of decreasing population density: urban center, metropolitan city, urban outskirt, suburban area, small town, rural area. The primary outcome measure was food allergy prevalence. The prevalence of severe food allergy (defined in Sect. 2.2.1) was also measured. Multiple logistic regression models, adjusted for race/ethnicity, gender, age, household income, and latitude, were used to assess associations between geographic variables and the presence and severity of food allergy.

2.3.1 Food Allergy by Latitude

Odds of food allergy were significantly higher in southern and middle latitudes than they were in northern latitudes (OR = 1.5 and 1.3, respectively). The gradation of prevalence in our results suggests a north-to-south increase in the rate of food allergy. Odds of severe food allergy did not vary significantly with geographic region (Gupta et al. 2012).

2.3.2 Food Allergy by Urban/Rural Status

Prevalence of food allergy varied significantly with urban/rural status (Tables 2.2 and 2.3). Increasingly urban settings corresponded with increasing prevalence of food allergy, which ranged from 6.2% in rural areas to 9.8% in urban centers. Prevalence rates for many specific allergies varied significantly with population density. Only milk and soy allergies did not significantly vary with geographic area. Peanut was consistently among the two most common allergens and was the most common in all but rural areas, where it was replaced by milk allergy. The odds ratio for having food allergy was highest in urban versus rural environments. Odds of severe food allergy did not differ significantly by urban/rural status.

2.3.3 What the Geographic Distribution of Food Allergy in the U.S. Tells Us

To our knowledge, an urban/rural difference in food allergy prevalence in the U.S. has not been previously reported. This information contributes broad demographic information to the goal of understanding the etiology and impact of food allergy and may ultimately guide development of treatments. Importantly, urban/rural status may affect allergy prevalence but not morbidity (Gupta et al. 2012).

Table 2.2 Food allergy prevalence by geographic area: Overall and by common allergen

	Frequency, % (95% Confidence Interval)								
Area	All allergens	Peanut	Shellfish	Milk	Fin Fish	Egg	Tree Nut	Wheat	Soy
Urban centers	9.8	2.8	2.4	1.8	1.8	1.3	1.2	0.8	0.6
	(8.6–11.0)	(2.2–3.5)	(1.8–3.0)	(1.4–2.4)	(1.4–2.3)	(0.9–1.8)	(0.8–1.6)	(0.5–1.1)	(0.3–0.9)
Metro cities	9.2	2.4	1.4	1.8	0.9	1.0	1.3	0.9	0.4
	(8.4–10.1)	(2.0–2.9)	(1.1–1.8)	(1.5–2.2)	(0.6–1.2)	(0.7–1.3)	(1.0–1.7)	(0.7–1.2)	(0.3–0.6)
Urban outskirts	7.8	1.8	1.5	1.4	0.8	0.5	1.0	0.4	0.4
	(7.0–8.6)	(1.5–2.3)	(1.2–2.0)	(1.1–1.7)	(0.5–1.1)	(0.4–0.8)	(0.8–1.3)	(0.3–0.6)	(0.2–0.6)
Suburban areas	7.6	2.0	1.2	1.5	0.7	0.7	1.2	0.8	0.3
	(6.9–8.2)	(1.7–2.4)	(1.0–1.5)	(1.2–1.8)	(0.5–0.9)	(0.5–0.9)	(0.9–1.5)	(0.6–1.0)	(0.2–0.5)
Small towns	7.2	1.6	1.0	1.4	0.5	0.7	0.9	1.1	0.5
	(5.7–8.6)	(1.0–2.6)	(0.6–1.7)	(0.9–2.3)	(0.3–1.0)	(0.4–1.4)	(0.6–1.6)	(0.7–1.9)	(0.2–0.9)
Rural areas	6.2	1.3	0.8	1.5	0.2	0.5	0.6	0.5	0.2
	(5.6–6.8)	(1.0–1.6)	(0.6–1.1)	(1.2–1.8)	(0.1–0.4)	(0.3–0.7)	(0.4–0.8)	(0.3–0.7)	(0.1–0.4)
P	<0.0001	<0.0001	<0.0001	0.3993	<0.0001	0.0045	0.0001	0.0040	0.2658

Urban/rural status was assigned by zip code using the Rural-Urban Commuting Area Codes (RUCA) version 2.0
Gupta et al. (2012)

Table 2.3 Odds of food allergy and severe versus mild/moderate food allergy by geographic area, adjusted for race/ethnicity, gender, age, household income, and latitude

Area versus rural	Odds of food allergy		Odds of severe food allergy	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Urban centers	1.7 (1.5–2.0)	1.5 (1.3–1.8)	1.4 (1.0–1.8)	1.3 (0.9–1.8)
Metro cities	1.5 (1.3–1.7)	1.4 (1.2–1.6)	1.1 (0.9–1.5)	1.1 (0.8–1.4)
Urban outskirts	1.3 (1.1–1.5)	1.2 (1.1–1.4)	1.0 (0.8–1.3)	1.0 (0.8–1.3)
Suburban areas	1.2 (1.1–1.4)	1.2 (1.0–1.3)	1.1 (0.9–1.4)	1.0 (0.8–1.3)
Small towns	1.2 (0.9–1.4)	1.2 (0.9–1.5)	1.2 (0.8–1.8)	1.1 (0.7–1.7)

Gupta et al. (2012)

2.4 Food Allergy Sensitization and Presentation in Siblings of Children with Food Allergic

Parents of food-allergic children are often concerned about the risk of food allergy in their other children, and may ask about screening their asymptomatic children for food allergies. Little is known about the prevalence of sensitization and true food allergy in the siblings of food-allergic children or about the utility of screening asymptomatic siblings for sensitization or allergies to common food allergens. We therefore aimed to determine the prevalence of both sensitization and true food allergy among siblings of food-allergic children by evaluating a cohort of children with confirmed food allergy (n = 478) and their siblings (n = 642) (Gupta et al. 2015). Siblings were evaluated for laboratory evidence of food sensitization to nine common allergens using total and specific serum IgE as well as skin prick testing. Sensitization was defined as positive IgE and/or SPT in the absence of clinical symptoms of allergy. True food allergy was defined as positive IgE and/or SPT plus clinical symptoms consistent with food allergy.

2.4.1 Prevalence of Sensitization and True Allergy in Siblings of Food-Allergic Children

Approximately one third (33.4%) of siblings of children with food allergy had neither sensitization nor clinical symptoms to the foods tested. Approximately one half (53%) were sensitized to one or more foods, most commonly wheat (37%), milk (35%), and egg (35%). Thirteen percent of siblings were diagnosed with true food allergy. The most common true allergens among siblings of food-allergic children were milk (5.9%), egg (4.4%), and peanut (3.7%).

2.4.2 What the Prevalence and Sensitization of Food Allergy in Siblings of Food-Allergic Children Tells Us

In this study, the prevalence of true food allergy among siblings of food-allergic children was low. We therefore recommend against withholding foods containing common allergens from these patients in the absence of symptoms suggestive of allergy. We also recommend against the routine screening of asymptomatic siblings of food-allergic children, as the presence of laboratory sensitization alone is insufficient to diagnose food allergy, and misdiagnosis may lead to unnecessary elimination of foods from the sibling's diet (Gupta et al. 2015).

2.5 Pediatric Emergency Department Visits and Hospitalizations for Food-Induced Anaphylaxis in Illinois

Little is known about the frequency with which food-allergic children access emergency departments or are admitted to hospitals for acute allergic reactions; similarly, there is a paucity of data about the effects of race, ethnicity, and socioeconomic status on food allergy-related healthcare utilization. We therefore sought to quantify food allergy-related ED visits and hospitalizations by children from various racial and socioeconomic backgrounds using medical record data from 2008 to 2012 in Illinois (Dyer et al. 2015).

2.5.1 Pediatric ED Visits and Hospitalizations Over Time

The average annual rate of ED visits and hospital admissions for food-induced anaphylaxis among Illinois children over the 5-year study period was 10.9 per 100,000 (See Table 2.4 for demographic breakdown). Eleven percent of children who presented to an ED for food-induced anaphylaxis during the study period were hospitalized. Between 2008 and 2012, the rate of ED visits for food-induced anaphylaxis increased from 6.3 to 17.2 per 100,000 ($p < 0.001$), with an annual increase of 29%. The rate of hospitalizations for food-induced anaphylaxis increased 19% per year over this period, from 0.8 per 100,000 in 2008 to 1.5 per 100,000 in 2012 ($p < 0.001$). Increases in rates of ED visits and hospitalizations were seen among children of all ages, sexes, races/ethnicities, insurance types, and metropolitan statuses. The largest annual percent increases were seen among Hispanic children (44%, $p < 0.01$), children with public insurance (30%, $p < 0.01$), and children from urban neighborhoods outside Chicago (49%, $p < 0.01$). (Dyer et al. 2015).

Table 2.4 Rates of ED visits and hospitalization for food-induced anaphylaxis in Illinois 2008–2012

Variable	Rate of ED visits and hospital admissions for food-induced anaphylaxis per 100,000 children (95% CI)				
	2008 (*n* = 226)	2009 (*n* = 279)	2010 (*n* = 319)	2011 (*n* = 481)	2012 (*n* = 590)
Overall	6.3 (5.5–7.2)	7.8 (6.9–8.8)	9.1 (8.2–10.2)	13.9 (12.7–15.2)	17.2 (15.9–18.7)
Age group, year					
0–4 (*n* = 840)	11.9 (9.7–14.4)	15.0 (12.6–17.8)	16.8 (14.1–19.8)	25.5 (22.1–29.2)	30.5 (26.9–34.5)
5–9 (*n* = 419)	4.6 (3.3–6.2)	6.5 (4.9–8.4)	7.2 (5.5–9.2)	12.8 (10.5–15.4)	17.7 (15.0–20.7)
10–14 (*n* = 284)	3.4 (2.3–4.9)	5.1 (3.7–6.9)	5.7 (4.2–7.5)	8.5 (6.7–10.7)	9.9 (8.0–12.2)
15–19 (*n* = 351)	5.3 (4.0–7.1)	4.8 (3.5–6.4)	7.3 (5.6–9.2)	9.4 (7.5–11.6)	11.8 (9.7–14.2)
Sex					
Male (*n* = 1117)	7.2 (6.1–8.6)	9.9 (8.5–11.5)	11.4 (9.9–13.1)	15.2 (13.5–17.2)	18.9 (17.0–21.1)
Female (*n* = 777)	5.4 (4.4–6.6)	5.6 (4.6–6.9)	6.7 (5.6–8.1)	12.5 (10.8–14.3)	15.5 (13.7–17.5)
Race/ethnicity					
Asian, non-Hispanic (*n* = 124)	12.9 (7.8–20.2)	11.6 (6.7–18.5)	15.2 (9.8–22.7)	22.4 (15.3–31.6)	24.1 (16.9–33.3)
Black, non-Hispanic (*n* = 369)	8.0 (5.9–10.6)	9.4 (7.1–12.2)	9.2 (6.9–12.0)	17.5 (14.2–21.3)	20.2 (16.8–24.4)
White, non-Hispanic (*n* = 1009)	6.0 (5.0–7.3)	7.6 (6.4–8.9)	10.1 (8.7–11.7)	14.2 (12.5–16.0)	16.8 (15.0–18.8)
Hispanic (*n* = 248)	2.8 (1.8–4.2)	3.8 (2.6–5.3)	4.5 (3.1–6.2)	7.4 (5.6–9.5)	12.5 (10.2–15.2)
Insurance type					
Private insurance (*n* = 1374)	7.7 (6.6–8.9)	8.3 (7.2–9.6)	11.0 (9.7–11.2)	16.9 (15.3–18.8)	18.8 (17.1–20.8)
Public insurance (*n* = 519)	3.9 (2.9–5.1)	7.0 (5.6–8.6)	6.0 (4.7–7.5)	9.2 (7.7–10.9)	14.8 (12.8–17.0)
Metropolitan status					
Chicago, urban (*n* = 639)	11.0 (8.7–13.8)	14.0 (11.4–17.1)	14.0 (11.4–17.8)	24.7 (21.2–28.7)	27.6 (23.9–31.7)
Chicago, not urban (*n* = 978)	7.4 (6.2–8.9)	8.5 (7.2–10.0)	10.4 (9.0–12.1)	13.5 (11.8–15.4)	17.8 (15.9–19.9)
Outside Chicago, urban (*n* = 125)	3.2 (1.8–5.9)	2.7 (1.3–4.9)	5.3 (3.2–8.2)	9.8 (6.9–13.5)	12.2 (9.1–16.2)
Outside Chicago, not urban (*n* = 142)	1.4 (0.7–2.5)	3.7 (2.5–5.4)	3.3 (2.1–4.9)	5.2 (3.7–7.2)	5.9 (4.3–7.9)

(continued)

Table 2.4 (continued)

Variable	Rate of ED visits and hospital admissions for food-induced anaphylaxis per 100,000 children (95% CI)				
	2008 (*n* = 226)	2009 (*n* = 279)	2010 (*n* = 319)	2011 (*n* = 481)	2012 (*n* = 590)
Hospitalization status					
Discharged from ED (*n* = 1753)	6.0 (5.3–6.9)	7.1 (6.2–8.0)	8.5 (7.5–9.5)	12.8 (11.6–14.0)	16.0 (14.7–17.4)
Admitted to hospital (*n* = 203)	0.8 (0.5–1.0)	1.0 (0.7–1.3)	1.2 (0.9–1.6)	1.4 (1.1–1.9)	1.5 (1.1–1.9)
Food allergen					
Peanut (*n* = 649)	2.2 (1.8–2.8)	2.2 (1.8–2.8)	3.7 (3.1–4.4)	4.8 (4.1–5.6)	5.6 (4.9–6.5)
Tree nut (*n* = 318)	0.9 (0.6–1.3)	1.5 (1.2–2.0)	1.5 (1.1–1.9)	2.3 (1.9–2.9)	2.9 (2.4–3.5)
Fin fish (*n* = 123)	0.4 (0.3–0.8)	0.7 (0.5–1.0)	0.4 (0.2–0.7)	0.9 (0.6–1.3)	1.1 (0.7–1.4)
Milk (*n* = 103)	0.4 (0.2–0.7)	0.4 (0.3–0.7)	0.3 (0.1–0.5)	0.8 (1.5–1.2)	1.0 (0.7–1.4)
Other food (*n* = 452)	1.8 (1.4–2.3)	2.0 (1.6–2.5)	2.0 (1.5–2.9)	3.1 (2.5–3.7)	4.1 (2.5–4.9)
Unknown food (*n* = 259)	0.6 (0.4–0.9)	1.0 (0.7–1.3)	1.3 (0.9–1.7)	2.0 (1.5–2.5)	2.6 (2.1–3.2)
Hospital type					
Dedicated pediatric hospital (*n* = 771)	2.6 (2.1–3.2)	3.5 (3.0–4.2)	3.4 (2.9–4.1)	5.7 (5.0–6.6)	6.8 (6.0–7.7)
Combined adult and pediatric hospital with PICU (*n* = 349)	1.5 (1.3–1.9)	1.2 (0.9–1.6)	1.9 (1.5–2.5)	2.3 (1.8–2.8)	3.1 (2.5–3.7)
Combined adult and pediatric hospital without PICU (*n* = 773)	2.2 (1.8–2.8)	3.1 (2.5–3.7)	3.7 (3.1–4.4)	5.8 (5.1–6.7)	7.4 (6.5–8.3)

Dyer et al. (2015)

2.5.2 *Pediatric ED Visits and Hospitalizations by Patient Demographics*

The highest rates of ED visits and hospitalizations were seen among children 0–4 years of age (12–30.5 per 100,000); however, the largest percent annual increase in visits (40%) was seen among children 5–9 years. Significantly more infants presenting to an ED for food-induced anaphylaxis were admitted (42%) than children 1 year or older (18%, p = 0.02) (Table 2.4). Hospital length of stay did not vary significantly by age (Dyer et al. 2015).

Differences in ED visit and hospitalization rates were also seen between races and ethnicities. The highest rates of ED visits and hospitalizations were seen among Asian children, while the lowest rates were seen among Hispanic children; however, as mentioned above, Hispanic children experienced the largest percent annual increase in visit rates (44%), while the percent annual increase was lowest among Asian children (21%) (Table 2.4). Rates of ED visits and hospitalizations as well as annual percent increases were similar between White and African American children. Hospital length of stay did not vary significantly by race or ethnicity (Dyer et al. 2015).

Variation in ED visit and hospitalization rates by socioeconomic and metropolitan statuses was also seen. ED visits and hospitalizations were significantly more frequent among those with private insurance (7.7–18.8 per 100,000) than among those with public insurance (3.9–14.8 per 100,000), and the annual percent increase was higher among privately insured children (39% versus 30%). Rates of ED visits and hospitalization were highest among children in urban Chicago neighborhoods, while children in suburban neighborhoods outside Chicago visited least frequently (Table 2.4). Annual percent increases in rates for all visit types were significantly increased for all metropolitan statuses, and children from urban neighborhoods outside Chicago had the most pronounced annual percent increase (49%). The highest rate of hospitalization was seen among children in suburban Chicago neighborhoods. Hospital length of stay did not vary significantly by insurance type or metropolitan status (Dyer et al. 2015).

Rates of ED visits and hospitalizations also varied by specific allergen. The most frequent overall rates of ED visits and hospitalizations were seen among children with peanut allergy (Table 2.4), while hospitalization was most frequent among children with milk-induced anaphylaxis (Dyer et al. 2015). The annual percent increase in ED visits and hospitalizations was most pronounced for children with tree-nut induced anaphylaxis. Hospital length of stay did not vary significantly by allergen (Dyer et al. 2015).

2.5.3 What Data on Pediatric ED and Hospital Visits Due to Food-Induced Anaphylaxis Tells Us

Food allergy-related ED visits and hospitalizations are increasing in frequency across socioeconomically and racially/ethnically diverse populations. Understanding these trends may help better target efforts aimed at preventing food-allergic reactions. Our work suggests the epidemiology of food allergy may be changing, as children with the lowest rates of ED visits and hospitalizations experienced the highest annual percent increases in visit rates over the study period. It is unclear whether these observations represent changes in disease prevalence or in healthcare access and utilization. In this study, children from urban Chicago neighborhoods visited most frequently, and those from suburban neighborhoods outside the city had the highest annual percent increase in visits. The first of these findings, at least, is consistent with those presented in Sect. 2.2, where we found that urban status was positively correlated with the prevalence of food allergy. This study also found that children with peanut and tree nut allergies are more likely to visit the ED than children with other food allergies, which is in keeping with previous literature reporting that children with peanut and tree nut allergies are more likely to have severe reactions (Dyer et al. 2015).

2.6 Differences in Empowerment and Quality of Life Among Parents of Children with Food Allergy

Given that food allergens are often difficult to avoid, and treatment for food allergy is limited, food allergies can strain relationships and demonstrably lower quality of life for allergic children and their families. We therefore aimed to describe the differences in empowerment to care for children with food allergies and food allergy-related quality of life (FAQOL) in mothers and fathers of a cohort of 876 children with food allergy (Warren et al. 2015). Empowerment was assessed through 16 items adapted from the Family Empowerment Scale (Koren et al. 1992). Empowerment scores derived largely from measures of parental confidence, parental involvement, perceived ability to act, and parental food allergy education. FAQOL was assessed through 15 items adapted from the Food Allergy-related Quality Of Life–Parental Burden scale (Cohen et al. 2004). The questionnaires (Table 2.5) used to measure both empowerment and FAQOL were negatively worded, meaning that a lower score represented greater empowerment or FAQOL. We also sought to understand how the relationships between perceived levels of support and resource access tracked with FAQOL. These relationships are summarized in Table 2.6.

2.6.1 Parental Empowerment and FAQOL

Significant differences were seen between mothers and fathers in both empowerment and FAQOL. Mothers reported significantly greater empowerment ($p < 0.001$) and significantly lower FAQOL ($p < 0.001$) than fathers, regardless of their children's allergy severity, specific allergen, or comorbidities. Empowerment was not significantly associated with FAQOL among mothers or fathers. Having "the support of friends and family to help care for your child" and "the resources you need to care for your child" were significant predictors of high FAQOL in both mother and fathers but had a significantly greater impact on mothers' FAQOL (Warren et al. 2015). Non-Hispanic White ethnicity was significantly associated with increased FAQOL among both mothers and fathers, while Hispanic ethnicity was associated with reduced FAQOL among fathers only. Child age was not associated with paternal FAQOL; however, high maternal FAQOL was positively associated with having a child 2–5, 6–10, and 11–13 years old. The presence of comorbid conditions was

Table 2.5 Parental food allergy-related empowerment and quality of life by child's food allergy type

	Children with peanut allergy			Children with milk allergy			Children with egg allergy			Children with tree nut allergy		
	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (fathers vs. mother)	Father	Mother	*P* value (father vs. mother)
Items for adapted Family Empowerment Scale	1.96	1.73	0.0168	2.01	1.85	0.0375	2.05	1.75	0.0251	2.04	1.85	0.2582
When problems arise with my child, I handle them pretty well	2.41	2.18	0.0045	2.51	2.23	0.0089	2.44	2.23	0.0120	2.40	2.14	0.0786
I know what to do when problems arise with my child	2.08	1.96	0.1714	2.12	2.09	0.5838	2.23	2.07	0.2750	2.17	1.94	0.0807
I feel like my family life is under control	2.03	1.61	0.0000	2.17	1.64	0.0000	2.19	1.60	0.0000	2.04	1.62	0.0015
I am able to make decisions about what my child needs medically	2.81	1.59	0.0000	2.94	1.61	0.0000	2.75	1.52	0.0000	2.55	1.61	0.0000
I make sure I stay in regular contact with physicians who are caring for my child	2.10	1.72	0.0000	2.18	1.81	0.0006	2.24	1.64	0.0000	2.09	1.71	0.0017
I believe I can solve problems with my child when they happen	1.87	1.64	0.0318	1.86	1.66	0.0295	1.94	1.63	0.0043	1.91	1.60	0.0078

(continued)

Table 2.5 (continued)

	Children with peanut allergy			Children with milk allergy			Children with egg allergy			Children with tree nut allergy		
	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (fathers vs. mother)	Father	Mother	*P* value (father vs. mother)
When dealing with my child, I focus on good things as well as the problems	1.75	1.65	0.5265	1.76	1.60	0.1218	1.79	1.63	0.3266	1.81	1.62	0.1084
I feel I am a good parent I can calmly handle a crisis situation involving my child	1.93	1.92	0.0926	1.93	2.02	0.0366	2.00	1.92	0.7533	2.09	1.99	0.9311
I am confident in my abilities to protect my child from danger	1.69	1.65	0.5983	1.74	1.72	0.8809	1.75	1.70	0.9377	1.72	1.74	0.9928
I trust my physician	1.91	1.65	0.0011	2.06	1.74	0.0000	1.95	1.70	0.0074	1.95	1.74	0.0988
I am decisive and act quickly	2.03	1.97	0.4728	2.11	2.08	0.4816	2.11	1.95	0.3541	2.13	2.04	0.8025
I feel confident in my ability to deal with my child's medical problems	2.02	1.67	0.0002	2.08	1.76	0.0001	2.17	1.74	0.0008	2.08	1.71	0.0474
I know the steps to take when my child is having an allergic reaction	1.80	1.47	0.0000	1.86	1.55	0.0000	1.87	1.45	0.0000	1.81	1.52	0.0482
I make efforts to learn new ways to help my child cope with his/her medical condition	2.38	1.61	0.0000	2.36	1.51	0.0000	2.32	1.51	0.0000	2.50	1.55	0.0000

I have a good understanding of my child's disorder	2.03	1.61	0.0000	2.09	1.62	0.0000	2.10	1.65	0.0000	2.15	1.58	0.0000
Composite Score	32.67	27.13	0.0000	33.70	28.26	0.0002	33.95	27.25	0.0000	33.43	27.41	0.0012
Items for Food Allergy-related Quality of Life–Parental Burden Scale	2.85	3.40	0.0000	3.43	4.30	0.0000	3.16	3.94	0.0000	2.65	3.01	0.0061
If you and your family were planning a holiday or vacation, how much would your choice of vacation be limited by your child's food allergy?	4.24	4.50	0.0013	4.58	5.16	0.0000	4.44	4.95	0.0000	3.70	4.14	0.0036
If you and your family were planning to go to a restaurant, how much would your choice of restaurant be limited by your child's food allergy?	3.49	3.56	0.4568	3.72	4.06	0.0015	3.64	3.91	0.0704	3.18	3.30	0.3374
If you and your family were planning to participate in social activities with others involving food, how limited would your ability to participate be because of your child's food allergy?	1.96	2.38	0.0000	2.33	3.18	0.0000	2.22	2.87	0.0000	1.90	2.49	0.0000

(continued)

Table 2.5 (continued)

	Children with peanut allergy			Children with milk allergy			Children with egg allergy			Children with tree nut allergy		
	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (fathers vs. mother)	Father	Mother	*P* value (father vs. mother)
In the past week, how troubled have you been by your need to spend extra time preparing meals (i.e., label reading, extra time shopping, etc.) due to your child's FA?	2.11	2.42	0.0001	2.37	3.08	0.0000	2.33	2.79	0.0000	2.05	2.56	0.0010
In the past week, how troubled have you been about your need to take special precautions before going out of the home with your child because of their food allergy?	2.01	2.54	0.0000	2.28	2.95	0.0000	2.17	2.79	0.0000	1.97	2.52	0.0000
In the past week, how troubled have you been that your child may not overcome their FA?	2.29	2.72	0.0005	2.74	3.29	0.0001	2.57	3.00	0.0040	2.30	2.54	0.1297

In the past week, how troubled have you been by the possibility of or actually leaving your child in the care of others because of their food allergy?	2.59	2.98	0.0001	2.93	3.38	0.0025	2.83	3.22	0.0128	2.48	3.02	0.0002
In the past week, how troubled have you been by frustration over other's lack of appreciation for the seriousness of food allergy?	2.53	2.94	0.0009	2.91	3.34	0.0116	2.72	3.02	0.1350	2.55	2.99	0.0245
In the past week, how troubled have you been by sadness regarding the burden your child carries because of their food allergy?	2.24	2.70	0.0006	2.55	2.98	0.0004	2.37	2.80	0.0022	2.19	2.70	0.0064
In the past week, how troubled have you been about your child's attending school, camp, daycare, or other group activity with children because of their food allergy?	2.44	3.01	0.0000	2.73	3.25	0.0005	2.61	3.11	0.0005	2.38	2.96	0.0006

(continued)

Table 2.5 (continued)

	Children with peanut allergy			Children with milk allergy			Children with egg allergy			Children with tree nut allergy		
	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (father vs. mother)	Father	Mother	*P* value (fathers vs. mother)	Father	Mother	*P* value (father vs. mother)
In the past week, how troubled have you been by your concerns for your child's health because of their food allergy?	2.34	2.62	0.0123	2.59	3.03	0.0006	2.50	2.84	0.0225	2.27	2.60	0.0211
In the past week, how troubled have you been with the worry that you will not be able to help your child if they have an allergic reaction to food?	2.10	2.32	0.0413	2.28	2.49	0.3938	2.20	2.33	0.5591	1.92	2.33	0.0145
In the past week, how troubled have you been with issues concerning your child being near others while eating because of their food allergy?	2.48	2.70	0.0229	2.76	3.09	0.0487	2.57	2.80	0.3487	2.29	2.55	0.0474
In the past week how troubled have you been with being frightened by the thought that your child will have a food allergic reaction?	2.32	2.74	0.0000	2.64	3.01	0.0190	2.47	2.77	0.0574	2.25	2.80	0.0008
Composite score	37.81	43.59	0.0000	42.80	50.60	0.0000	40.56	47.35	0.0000	36.13	42.21	0.0005

FA food allergy
Warren et al. (2015)

Table 2.6 Predictors of parental food allergy-related quality of life

Dependent variable: quality of life among parents of children with FA	Mother (n = 801)		Father (n = 723)	
	Coefficient (95% CI)	*P* value	Coefficient (95% CI)	*P* value
Empowerment composite score	0.008 (−0.083, 0.010)	0.862	0.002 (−0.0666, 0.071)	0.946
Food allergy severity	3.729 (0.856, 6.602)	0.011	4.476 (1.726, 7.225)	0.001
Other chronic condition	5.559 (2.418, 8.699)	0.001	1.364 (−1.553, 4.281)	0.359
Age (vs 0–1 years)				
2–5 years	−7.233 (−12.313, −2.152)	0.005	−2.282 (−7.102, 2.538)	0.353
6–10 years	−11.250 (−17.959, −4.521)	0.001	−2.926 (−9.143, 3.291)	0.356
11–13 years	−12.295 (−20.263, −4.327)	0.003	−3.082 (−11.369, 5.205)	0.465
≥14 years	5.032 (−9.587, 19.651)	0.499	−8.146 (−22.073, 5.782)	0.251
Male sex	1.139 (−1.580, 3.858)	0.411	2.697 (0.127, 5.266)	0.040
Race or ethnicity (vs other)				
Non-Hispanic white	−17.663 (−24.871, −10.456)	0.000	−7.881 (−15.039, −0.722)	0.031
Non-Hispanic black	−0.723 (−5.306, 3.860)	0.757	2.678 (−1.727, 7.082)	0.233
Hispanic	1.372 (−7.187, 9.931)	0.753	9.218 (0.905, 17.531)	0.030
Asian	−1.212 (−5.947, 3.522)	0.615	2.747 (−1.863, 7.357)	0.242
Number of siblings	−0.102 (−1.854, 1.65)	0.909	−1.437 (−3.0854, 0.212)	0.087
Health insurance (vs public)				
Private	−0.704 (−7.102, 5.694)	0.829	2.188 (−4.377, 8.753)	0.513
Other	1.725 (−9.413, 12.863)	0.761	1.805 (−8.522, 12.132)	0.732
Parental education (vs no college)				
College educated	−3.753 (−7.929, 0.422)	0.078	−0.818 (−4.756, 3.121)	0.684
Income (vs <$50,000)				
$50,000–$99,999	−1.950 (−8.286, 4.386)	0.546	1.293 (−5.265, 7.851)	0.699
≥$100,000	−1.487 (−7.798, 4.823)	0.644	−2.052 (−8.557, 4.453)	0.536
Unknown	−5.111 (−13.812, 3.590)	0.249	−3.700 (−12.413, 5.012)	0.405
Support from family and friends	−14.769 (−19.835, −9.703)	0.000	−10.145 (−15.104, −5.186)	0.000
Resources needed to care for child	−17.773 (−26.064, −9.483)	0.000	−11.458 (−21.612, −1.303)	0.027

Warren et al. (2015)

associated with significantly decreased FAQOL among mothers but not fathers. The presence of comorbid conditions resulted in no significant differences in parental empowerment. FAQOL was significantly lower for mothers and fathers of children with a history of food-induced anaphylaxis compared to parents of children with mild or moderate food allergy. Mothers of children with peanut, milk, egg, and tree nut allergies reported significantly greater empowerment and lower FAQOL than did fathers of children with these specific allergies. Parents of children with milk and egg allergies had significantly lower FAQOL scores, despite being similarly empowered to parents of children with all other allergies, even after correcting for the younger age of children with milk and egg allergies.

2.6.2 Parental Concerns and Possible Interventions to Improve Parental FAQOL

The constant risk, real or perceived, of potentially fatal anaphylaxis distinguishes food allergy from many other chronic conditions, and presents a substantial burden to parents as well as a challenge to researchers and policy-makers.

Parental concern in QOL assessments was greatest for items involving fear of allergen exposure outside the home. Elevated concern about allergic episodes occurring outside the home is in keeping with the relationship between FAQOL and empowerment presented here; in the case of food allergy, being aware of risks may lead to greater stress. Given the prevalence of poor QOL among parents of children with food allergy, there is a need for comprehensive means of addressing low FAQOL in this population. Ideally, knowing more about food allergy would mean a higher quality of life, however there are too many variables to be able to expect this sort of outcome in the near term for all parents. Similarly, in best cases, empowerment would positively correlate with FAQOL outcomes.

The differences seen between maternal and paternal QOL among parents of children with food allergy have also been demonstrated in asthma (Hederos et al. 2007), developmental disorders (Yamada et al. 2012), and other chronic conditions (Goldbeck 2006) as well. The cause of this difference between mothers and fathers needs further elucidation. Our findings support the importance of social networks for parents of food-allergic children, especially mothers. Building mutually supportive social networks may increase parental FAQOL (Warren et al. 2015).

2.7 Food Allergen Labeling and Purchasing Habits in the U.S. and Canada

Mandatory labeling for common food allergens exists in the U.S., with a similar set of guidelines in Canada. Standardization of labeling practices has increased safety for consumers with food allergies. However, precautionary labeling (e.g., “may contain,” "processed in a facility"), which is neither standardized nor regulated, has become more common, and its effects on the purchasing and eating habits of individuals with food allergy are largely unknown. We therefore sought to characterize the purchasing habits of a cohort of 6684 people with food allergy or their caretakers, from the U.S. and Canada (Marchisotto et al. 2016).

2.7.1 Labeling Knowledge and Purchasing Behavior

The results showed that 29% of respondents were unaware of laws requiring labeling of major allergens. Moreover, 46% of respondents were unaware of or mistaken about guidelines regarding advisory or precautionary labeling.

Purchasing habits were evaluated by type of labeling, severity of allergy, and country of purchase. Twelve percent of respondents reported purchasing food labeled to indicate that it "may contain" their allergen, whereas 40% reported purchasing foods labeled "manufactured in a facility that also processes" their allergen (Marchisotto et al. 2016).

2.7.2 Implications of Labeling Practices and Purchasing Behavior

None of the precautionary labels evaluated have specific legal definitions, leaving consumers without safety information. The potential danger of non-standardized precautionary labeling is especially salient for children and families with limited access to fresh food and greater dependence on packaged goods. This observation may influence the differences in food allergy outcomes seen among children of different socioeconomic statuses (Marchisotto et al. 2016). Children of families who predominantly have access to packaged foods may be more likely to suffer due to unclear labeling, simply as a product of their consuming more of these foods in their diets.

2.8 The Economic Impact of Childhood Food Allergy in the U.S.

Attempts to assess the economic burden of food allergy in the U.S. have been limited by the use of federal diagnosis code data, which may fail to capture all cases and does not take into consideration direct and indirect costs to families. We used a cross-sectional survey of parents and caregivers of children with food allergy (n = 1643) to quantify the costs associated with caring for a child with food allergy (Gupta et al. 2013). Costs considered included direct medical expenses (e.g., physician fees and fees for ED visits and hospitalizations), out-of-pocket expenses (e.g., safe foods, clinic or ED copays, medications), lost-labor costs (e.g., taking time off work for allergy-related reasons), and opportunity costs (e.g., needing to leave or change jobs). Caregivers were also questioned about their willingness to pay for effective food allergy treatments. We assessed the distribution of these costs to families across multiple demographic categories. The total cost of food allergy in the U.S. was estimated to be $24.8 billion annually (Gupta et al. 2013).

2.8.1 Direct Medical Costs of Childhood Food Allergy

Direct medical costs include costs of the health care system for the diagnosis, treatment, and prevention of childhood food allergy. Data were collected by asking caregivers of children with food allergy about outpatient, ED, and inpatient visits over a 1-year span. Costs for each type of encounter were estimated from several sources, including Medicare data, the Healthcare Cost and Utilization Project Nationwide Emergency Department Sample, and the Healthcare Cost and Utilization Project Nationwide Inpatient Sample.

Direct medical costs were estimated to be $4.3 billion per year (Table 2.7). Hospitalizations accounted for almost 50% of this figure, while ED visits made up 18% of annual direct medical costs. Specialist visits of other sorts made up the remainder of direct medical expenses.

2.8.2 Costs Borne by Families

Costs borne by families included out-of-pocket, lost labor productivity, and opportunity costs. The total cost borne by caregivers was $20.5 billion per year.

Table 2.7 Direct medical costs of childhood food allergy

Characteristic	Children with visit, % (SE)	Visits per child, mean (SE)	Cost, US$		
			Visit	Child	Overall annual (in millions)
Visits					
Pediatrician	42 (2)	0.82 (0.05)	112	92	543
Allergist	41 (2)	0.79 (0.05)	175	138	819
Pulmonologist	14 (1)	0.07 (0.01)	175	12	71
Nutritionist	17 (1)	0.16 (0.04)	100	16	96
Alternative provider	17 (1)	0.23 (0.05)	100	23	136
Emergency department	13 (1)	0.18 (0.02)	711	129	764
Inpatient hospitalization stays	4 (1)	0.05 (0.01)	6269	314	1863
Total direct medical costs				724	4292

Gupta et al. (2013)

Table 2.8 Out-of-pocket costs of childhood food allergy

Variable	% Reporting cost (SE)	Mean direct out-of-pocket costs, US$ (SE)	Cost per child, US$	Overall annual cost (in millions), US$
Visits to the physician's office or health clinic (including copays)	52.5 (2.2)	160 (14)	84	499
Visits to the emergency room (including copays)	16.1 (1.6)	247 (42)	40	235
Overnight stays at the hospital	10 (1.4)	411 (182)	41	244
Travel to and from health care visits (including ambulance use; parking expenses)	27.7 (1.8)	91 (14)	25	149
Epinephrine injectors (Epipen, Epipen Jr.)	35.9 (1.9)	87 (4)	31	184
Antihistamines (Allegra, Benadryl, Claritin, Zyrtec)	50.8 (2.2)	62 (4)	32	188
Other prescription/nonprescription medication	29.3 (1.9)	122 (13)	36	211
Non-traditional medicine (such as herbal products)	15 (1.6)	123 (30)	19	110
Costs associated with special diets and allergen-free foods	37.7 (2.0)	756 (59)	285	1689
Additional/change in child care	6.7 (0.8)	2158 (323)	145	857
Legal guidance	2.3 (0.6)	402 (122)	9	55
Counseling or mental health services	4.5 (0.7)	571 (123)	26	152
Special summer camp	3 (0.7)	702 (183)	21	125
A change in schools was needed due to this child's food allergy	4.2 (0.7)	2611 (497)	110	650
Other out-of-pocket expenses (e.g., cleaning supplies, skin care products, transportation)	9.2 (1.1)	396 (86)	36	216
Any out-of-pocket costs	74.3 (2.1)	1252 (90)	931	5516

Gupta et al. (2013)

2.8.3 *Out-of-Pocket Costs*

The total out-of-pocket cost to families was $5.5 billion per year (Table 2.8). Allergen-free foods were the greatest out-of-pocket expense, accounting for over 30% of the annual figure. Changes in child care and schooling together comprised 27% of all out-of-pocket costs.

2.8.4 *Lost Labor Costs to Families*

Lost labor was defined as the sum of unearned wages due to caregiver hours spent on food allergy-related healthcare visits, based on the mean national hourly labor wage. Lost labor costs totaled $773 million (Gupta et al. 2013).

Table 2.9 Opportunity cost of childhood food allergy

Characteristic	Reporting, % (SE)	Opportunity, mean (SE)	Cost, US$ per child	Overall annual (in billions)
Choice of career has been restricted	5.7 (0.9)	15 655 (2471)	892	5.3
A job had to be given up	4.9 (0.7)	29 657 (4151)	1453	8.6
A job was lost through dismissal	1.9 (0.6)	14 849 (7479)	282	1.7
A job change was required	2.5 (0.6)	10 605 (3161)	265	1.6
Any job-related opportunity cost (total amount)	9.1 (1.0)	32 719 (4166)	2977	17.6
Any job-related opportunity cost (maximum amount)	9.1 (1.0)	26 363 (2545)	2399	14.2

Gupta et al. (2013)

2.8.5 Opportunity Costs to Families

A job-related opportunity cost was reported by 9.1% of caregivers. These costs consisted of restricted career choice, need to leave a job, need to change the jobs, or losing a job. The opportunity cost to families was calculated as the product of the percent of caregivers reporting lost opportunity in the labor market, the mean reported cost of these opportunities, and the number of children with food allergy in the U.S. The annual lost opportunity cost of forgone labor was estimated at $14 billion per year (Table 2.9).

2.8.6 Willingness to Pay

Willingness to pay (WTP) was calculated by surveying caregivers about the amount they would be willing to spend on a hypothetical treatment for food allergy that would allow their child to eat all foods. Annual WTP equaled $20.8 billion per year. This cost was not the same as their current medical costs, but instead asked about an imaginary treatment which would enable consumption of all foods without causing an allergic reaction.

2.8.7 What the Economic Impact of Childhood Food Allergy in the U.S. Tells Us

To our knowledge, this was the first study to comprehensively quantify the economic impact of food allergy in the U.S. We have shown that families affected by food allergy bear a substantial financial burden. The total cost of food allergy was estimated to be $24.8 billion annually. Over 80% of this cost is borne by families of those with allergies. To put these numbers in context, we compare them with those of asthma, as asthma affects a similar number of children in the U.S. (Fox et al. 2013). Direct medical costs for asthma have been estimated at $3259 per person (regardless of age) per year, which is roughly five times the cost per food-allergic child ($724 per child) (Barnett and Nurmagambetov 2011). Prescription medications account for over 50% of the direct medical costs associated with asthma (Fox et al. 2013). In comparison, few prescriptions exist to treat food allergy. Instead, food allergy requires families to make accommodations in many other areas of life, each with substantial financial costs to the family. Unlike prescription medicine, the opportunity cost of caregiver time is seldom covered by insurance. These sorts of expenses are especially burdensome to low-income families, who cannot easily afford special foods or to sacrifice hours at work.

Annual WTP was estimated at $20.8 billion per year. This figure is similar to the reported annual cost borne by caregivers ($20.5 billion) and therefore seems to confirm the validity and consistency of the two analytic approaches employed in this study. That is, the fact that WTP closely matches the amount actually spent by families supports the idea that the method of measuring WTP is a successful model (Gupta et al. 2013).

2.9 Socioeconomic Disparities in the Economic Impact of Childhood Food Allergy in the U.S.

Little is known about how food allergy-related costs are distributed across racial/ethnic and socioeconomic lines. We therefore set out to quantify disparities in the distribution of direct and out-of-pocket costs associated with childhood food allergy between socioeconomic and racial/ethnic groups (Bilaver et al. 2016). Data were obtained via cross-sectional survey of 1643 U.S. caregivers with a food-allergic child. Variables surveyed were direct medical costs (calculated from parent-reported outpatient visits), ED visits and hospitalizations, and out-of-pocket costs (calculated from parent-reported amounts spent on medication, insurance co-pays, mental health services, legal services, special schooling, child care, camp tuition, and special food). Five racial (African American, Asian, Hispanic, White, Other) and three socioeconomic (household income of: <$50K, $50–$99K, ≥$100K) groups were compared (Bilaver et al. 2016).

2.9.1 Examining Medical Access by Socioeconomic Status (SES) and Race/Ethnicity

We have previously shown that African American and Hispanic children are significantly less likely to have formal diagnoses of food allergy (Sect. 2.2.1.3). However, there has been no reported evidence of a relationship between race or ethnicity and food allergy severity. It is also known that children from higher income households are more likely than children from low-income households to be prescribed epinephrine auto-injectors (Coombs et al. 2011). Higher income families are also more likely to have administered epinephrine to their children before reaching the emergency department in cases of food-induced anaphylaxis (Huang et al. 2012). These higher rates of prescription and of epinephrine use are not indicative of children from high-income families; we have shown that children with public insurance have higher yearly rates of ED visits for food-induced anaphylaxis than children with private insurance. Instead, wealthier families may have an easier time accessing healthcare resources.

2.9.1.1 Medical Costs by SES

Households making <$50K spent 2.5 times the amount that higher-income families spent on ED visits and hospitalizations due to food allergy. Conversely, spending on specialists was significantly lower in the lowest income group than the highest income group. Families in the highest income group also spent significantly more (>2 times more) on medication than did the lowest income group (Table 2.10).

Table 2.10 Direct and out-of-pocket mean annual costs by socioeconomic status (household income in US$) (top) and by race/ethnicity (bottom)

Direct and out-of-pocket mean annual costs (SE), US$ by household income			
Type of cost	**<$50K**	**$50K–99K**	**≥$100K**
Total Direct Costs borne by health care system	1374 (274)	1024 (125)	940 (128)
ER and Hospitalization costs*	1021 (209)	434 (106)	416 (94)
Specialist costs**	228 (21)	330 (27)	311 (18)
Total Out-of-Pocket Costs borne by families	3174 (858)	3434 (658)	5062 (1168)
Medication costs***	171 (26)	275 (30)	366 (44)
Special food costs	744 (216)	941 (230)	1545 (347)
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ for F-test of equality of means across groups			
Bilaver et al. (2016)			

Type of cost	**White**	**African American**	**Hispanic**	**Asian**
Total Direct Costs borne by health care system***	999 (104)	493 (109)	643 (224)	885 (514)
ER and Hospitalization costs***	504 (79)	108 (60)	395 (220)	1271 (630)
Specialist costs***	310 (13)	157 (40)	127 (37)	101 (36)
Total Out-of-Pocket Costs borne by families***	4203 (750)	395 (452)	1093 (856)	1327 (1948)
Medication costs***	312 (28)	52 (18)	148 (78)	87 (37)
Special food costs***	1213 (200)	177 (501)	219 (281)	148 (290)
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ for F-test of equality of means across groups				
Bilaver et al. (2016)				

2.9.1.2 Medical Costs by Race/Ethnicity

Significant differences in spending were also seen across racial/ethnic lines. An F-test for equality of means across the five racial/ethnic groups, measuring total direct costs borne by the healthcare system, returned a *p*-value less than 0.001. The same level of significance was seen between groups for equality of means when examining total out-of-pocket costs. White families spent more on specialists, medications, and special foods than did families from other racial or ethnic groups. African American children incurred the lowest direct medical expenses and spent the least on out-of-pocket costs per year of all racial and ethnic groups (Table 2.10).

2.9.1.3 What Socioeconomic Disparities in the Economic Impact of Childhood Food Allergy Tell Us

Given these findings, we hypothesize that children from low income and non-White families may have reduced access to preventative health care and subspecialty visits, and often rely on emergency treatment for the acute adverse reactions. Increasing access to subspecialist care, safe foods, and epinephrine is therefore crucial. Epinephrine availability in public places and equity in the management of food allergy are issues that still needs more effort (Bilaver et al. 2016).

2.10 Asthma and Food Allergy Management and Emergency Epinephrine Use for Food Allergy Reactions in Chicago Public Schools

The provision of stock or undesignated epinephrine auto-injectors (EAIs) in schools and other public places is the subject of active investigation and debate. During the 2012–2013 school year, Chicago Publics Schools (CPS) began providing undesignated epinephrine to district schools. We collected data on epinephrine auto-injector use at the end of the school year and analyzed them to elucidate effects on food-allergy outcomes (Gupta et al. 2014). To our knowledge, these studies are the first to examine asthma and food allergy reporting and management, as well as the impact of providing stock epinephrine auto-injectors on food allergy outcomes, in a large urban school district.

2.10.1 Distribution of EAI Use in CPS

Thirty-eight district-issued EAIs were administered during the first year of the program. The majority of these injections were given in elementary schools. EAIs were most commonly used on Chicago's North-Northwest side (37%); however nearly three quarters as many EAIs were used in schools on Chicago's Far South Side as were used on the North-Northwest side. The overwhelming discrepancy in diagnosis of food allergies between these two parts of the city (47% versus 8%) is not reflected in the usage of EAIs. More than half of all district-issued EAIs were used for the recipient's first-time anaphylactic event. Food was identified as the trigger in more than half of all reactions, while the cause of over one-third of reactions was unknown (Table 2.11).

Table 2.11 Characteristics and triggers of the administer of district-issued epinephrine

Variable	Frequency, % (*n*)
Person with allergic reaction	
Chicago public school student	92.1 (35)
Chicago public school staff	7.9 (3)
School type	
Elementary school	63.2 (24)
High school	36.8 (14)
Geographic collaborative	
Far South Side	26.3 (10)
North-Northwest	36.8 (14)
South Side	13.2 (5)
Southwest Side	10.5 (4)
West Side	13.2 (5)
First-time incident	
Yes	55.0 (21)
No	45.0 (17)
Administered by	
School nurse	76.3 (29)
Other school staff	18.4 (7)
Self-administered	5.3 (2)
Epinephrine dose	
Adult	57.9 (22)
Junior	23.7 (9)
Missing	18.4 (7)
911 Called	
Yes	81.6 (31)
No	2.6 (1)
Missing	15.8 (6)
Allergic trigger—food	55.3 (21)
Peanut	18.4 (7)
Tree nut	2.6 (1)
Shellfish	2.6 (1)
Fin fish	13.2 (5)
Food—other	13.2 (5)
Food—unknown	5.3 (2)
Allergic trigger—other	10.5 (4)
Insect venom	5.3 (2)
Animals	2.6 (1)
Grass	2.6 (1)
Allergic trigger—unknown	34.2 (13)

DeSantiago-Cardenas et al. (2015)

Table 2.12 Adjusted odds ratios of asthma and food allergy diagnoses among CPS students

Variable	Asthma	Food allergy
Age (vs 3–5 years)		
6–10	10.4 (5.7–19.2)**	1.3 (1.2–1.4)**
11–13	12.9 (7.0–23.8)**	1.0 (0.9–1.1)
$14	11.0 (6.0–20.2)**	0.7 (0.6–0.8)**
Gender		
Male versus female	1.4 (1.4–1.5)**	1.3 (1.2–1.4)**
Race/ethnicity (vs white)		
Black	2.3 (2.2–2.4)**	1.1 (1.0–1.3)*
Hispanic	1.3 (1.2–1.4)**	0.8 (0.7–0.9)**
Asian	0.8 (0.7–0.9)**	1.4 (1.2–1.6)**
Multiracial all	1.7 (1.5–2.0)**	1.5 (1.3–1.9)**
Other	1.1 (0.9–1.3)	1.0 (0.7–1.3)
Free/reduced lunch program (vs did not apply)		
Free	1.1 (0.9–1.1)	0.3 (0.3–0.4)**
Reduced	1.0 (0.9–1.0)	0.5 (0.4–0.5)**
45-day temporary free	1.0 (0.8–1.3)	0.5 (0.4–0.8)**
Denied	1.1 (1.0–1.2)*	0.8 (0.8–0.9)**
Geographic region (vs North-Northwest Side)		
Far South Side	0.7 (0.7–0.8)**	0.7 (0.6–0.7)**
South Side	0.7 (0.7–0.8)**	0.6 (0.6–0.7)**
Southwest Side	0.7 (0.7–0.8)**	0.5 (0.5–0.6)**
West Side	0.9 (0.9–0.9)**	0.6 (0.6–0.7)**

Data are presented as OR (95% CI). $^*p < 0.05$, $^{**}p < 0.001$
Gupta et al. (2014)

2.10.2 *CPS Food Allergy Data by Race, SES, and Geographic Region*

Odds of having food allergy were significantly higher among African American (OR = 1.1) and Asian students (OR = 1.4) than White students. African American and Hispanic students made up substantial portions of all food-allergic students (prevalence of food allergy and asthma is detailed in Table 2.12).

Odds of having food allergy were significantly lower among students who received free (OR = 0.3) or reduced (OR = 0.5) lunch than among those who did not. Odds of food allergy were also significantly lower among all other geographic regions when compared with the city's North-Northwest Side.

2.10.3 *Emergency Action Plan Data in CPS*

A 504 plan is an emergency action plan put together by parents and schools to ensure appropriate steps are taken in the event of anaphylaxis or an acute asthma exacerbation. Fifty-one percent of CPS students with food allergy had a 504 plan on file for the aforementioned school year. Among students with food allergy and/or asthma, odds of having a 504 Plan decreased as age increased. Overall odds of having a 504 plan were lower for boys than girls, African American and Hispanic students than White students, students who qualified for free or reduced lunch than those who did not, and among students from all other areas of Chicago when compared with the North-Northwest Side. Similar odds of having a 504 plan were found between students who had food allergy versus students who had asthma. Forty percent of all food-allergic students also had asthma, while only 9% of students with asthma also had food allergy. Whether this disparity is due to variability in disease prevalence or differences in reporting of chronic conditions to CPS is uncertain (Prevalence of 504 plans is detailed in Table 2.13).

Table 2.13 Adjusted odds ratios of having school health management plans (504 plans) among CPS students, by asthma and food allergy diagnosis

Variable	Asthma	Food allergy
Age (vs 3–5 years)		
6–10	1.2 (1.0–1.3)*	1.1 (0.9–1.3)
11–13	0.8 (0.7–0.8)**	0.7 (0.5–0.9)*
$14	0.5 (0.4–0.6)**	0.5 (0.4–0.6)**
Gender		
Male versus female	0.8 (0.7–0.8)**	0.7 (0.7–0.9)*
Race/ethnicity (vs white)		
Black	0.5 (0.4–0.6)**	0.6 (0.5–0.7)**
Hispanic	0.8 (0.7–0.9)*	0.9 (0.7–1.2)
Asian	1.0 (0.8–1.3)	0.9 (0.6–1.2)
Multiracial all	1.0 (0.8–1.4)	1.0 (0.7–1.6)
Oother	0.9 (0.6–1.4)	0.8 (0.4–1.5)
Free/reduced lunch program (vs did not apply)		
Free	0.6 (0.5–0.7)**	0.5 (0.4–0.6)**
Reduced	0.8 (0.6–0.9)*	0.7 (0.5–0.9)*
45-day temporary free	0.7 (0.4–1.2)	0.4 (0.2–0.9)*
Denied	1.0 (0.8–1.2)	0.9 (0.7–1.1)
Immunization status		
Compliant versus not compliant	1.4 (1.1–1.8)*	1.7 (1.1–2.7)*
Geographic region (vs North-Northwest Side)		
Far South Side	0.6 (0.5–0.7)**	0.4 (0.3–0.6)**
South Side	0.6 (0.5–0.6)**	0.5 (0.4–0.7)**
Southwest Side	0.6 (0.5–0.6)**	0.5 (0.4–0.6)**
West Side	0.5 (0.5–0.6)**	0.6 (0.5–0.7)**
Chronic condition		
Asthma	—	1.9 (1.7–2.2)**
Food allergy	4.1 (3.7–4.6)**	—

Data are presented as OR (95% CI). *$p < 0.05$, **$p < 0.001$
Gupta et al. (2014)

2.10.4 Conclusions and Recommendations based on EAI and Emergency Action Plan Data from CPS

CPS is the largest school district in the country to have taken on the challenge of providing its schools with undesignated EAI for the emergency treatment of anaphylaxis. We have described a discrepancy between documented food allergy and EAI usage in CPS. These findings reinforce previous evidence of underdiagnosis of food allergy among low income and minority populations, and therefore the need for undesignated EAIs. Research has shown that 20–25% of children experience their first reaction in schools. Moreover, 30% of nurses report that they have had to use one child's EAI on another. These facts, along with those already presented, make the necessity of undesignated EAIs and 504 plans clear.

Our data show that 504 plans are substantially underutilized among CPS students. Underutilization of management plans has been reported widely in the recent literature, suggesting it is a problem across school districts. Moreover, although African American and Hispanic students were disproportionately affected by asthma and food allergy, they were significantly less likely than white CPS students to have school health management plans on file. Low-income students (approximated as those who participated in the free/reduced lunch program) were also significantly less likely than more affluent students to have 504 plans on file. It is unclear whether racial and socioeconomic variability in food allergy is intrinsic to the disease process; however, it is possible that the disparities seen here are attributable, at least in part, to barriers to care and diagnosis among racial/ethnic minorities and economically disadvantaged households. Given the uneven geographic distribution of healthcare providers throughout Chicago and the difficulty that low-income families face in accessing healthcare resources, it is unsurprising that the diagnosis of food allergies does not mirror, its incidence.

Given that this study was performed using CPS data and therefore only includes students with physician-verified food allergies and asthma, rates of these conditions may be higher than reported among the low-income populations within CPS. Currently, a CPS student needs a physician's verification to create a 504 plan. Low-income students, who often depend on school support programs, may therefore be excluded due to limited access to healthcare resources. A potential low-cost solution would be to offer 504 plans without requiring physician verification of a food allergy diagnosis (Gupta et al. 2014).

2.11 Conclusion

We have detailed the prevalence of food allergy, its geographic distribution, and the burden it places on the medical system, families, minority and low-income communities, and schools. Under-privileged populations bear a disproportionate share of this burden. This review of our research provides a big-picture of the public health impact of food allergy. Given the economic, social, and psychological burdens that food allergy presents with, more systematic solutions are needed. These costs will eventually accumulate along with the increasing rates of food allergy diagnosis. While progress toward a cure is incremental, broad access to food allergy education and undesignated epinephrine can be implemented now. An understanding of best practices and the emergency care of food-allergic reactions are tools currently available. It is vital that we take strides to distribute these lifesaving resources.

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