



The Peanut Allergy Burden Study: Real-world impact of peanut allergy on resource utilization and productivity

William McCann^a, Steven L. Hass^b, Kevin Norrett^c, Ann Cameron^d, Martine Etschmaier^d, Amy Duhig^d and Shengsheng Yu^{c*}

ABSTRACT

Background: There is limited research demonstrating the real-world economic burden of peanut allergy (PA) in the United States. The Peanut Allergy Burden Study (PABS) is a cross-sectional quantitative survey designed to determine the real-world experience of patients and caregivers with PA. The objective of the study was to understand the real-world utilization of PA-related healthcare resources and the impact of PA on productivity.

Methods: Participants completed an online survey to examine the real-world 12-month and lifetime healthcare utilization and past week productivity impact of PA in children (as reported by caregiver proxy), adolescents with PA, adults with PA, and caregivers of children with PA.

Results: Healthcare resource use over the past 12 months was frequent for adults (n = 153), adolescents (n = 102), and children (as reported by caregivers) (n = 382) with PA. Patients and caregivers reported the following rates of PA-related utilization in the past 12 months: at least 3 regular allergist appointments (28.8%–39.3%), unscheduled allergist appointments (15.6%–18.3%), general practitioner appointments (16.7%–24.2%), over-the-counter (OTC) medication usage (28.5%–35.7%), and epinephrine autoinjector usage (17.7%–26.2%). Additionally, over half of patients and caregivers reported ≥ 1 PA-related emergency department (ED)/urgent care visit (57.5%–59.9%), overnight hospital admission (36.3%–47.4%), IV epinephrine use (37.2%–52.3%), or intubation (26.2%–39.8%) over the past 12 months for PA. Healthcare resource use was high among all groups. Regarding productivity, PA significantly impacted household work, schoolwork, and employed work for patients and caregivers. PA-related reactions also impacted school attendance of children with PA.

Conclusion: Many healthcare resources were utilized by patients with PA and there was a loss of productivity associated with PA for patients and caregivers. New treatments to prevent or lower the risk of PA reactions could potentially help reduce healthcare resource utilization and PA-related productivity loss among patients and their families, particularly for patients for whom avoidance as a treatment strategy has not been reliable.

Keywords: Burden, Healthcare resource utilization, Peanut allergy, Productivity

^aAllergy Partners, Asheville, NC, USA

*Corresponding author. 8000 Marina Blvd, Suite 300, Brisbane, CA, 94005.

E-mail: syu@aimmune.com

Full list of author information is available at the end of the article

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INTRODUCTION

Peanut allergy (PA), a common type of food allergy in the United States, has become increasingly prevalent in recent years, particularly among children.¹ A large, population-based survey of parents conducted in 2015–2016 estimated that 2.2% of all children and adolescents in the United States have PA.² Although children may outgrow many food-related allergies, PA is more likely to persist into adulthood compared to other types of food allergies.³ Population-level estimates were inferred from a survey of food allergy among US adults (N = 40,443) that was administered via the internet and telephone from 2015 to 2016, and suggest that 1.8% of US adults have PA.⁴

Individuals with PA who are exposed to peanuts can develop symptoms that range in both severity and speed of onset. The most severe systemic allergic reaction is severe anaphylaxis, which can be life-threatening and requires immediate treatment with epinephrine.⁵ Regardless of a child's prior reaction history, PA exposure can lead to life-threatening anaphylactic reactions.⁶ Currently, recommended management strategies include avoiding peanuts and appropriately treating the symptoms of a reaction when the allergen is accidentally consumed.^{5,7} With the first treatment for PA approved by the US Food & Drug Administration in January 2020 (Palforzia™ [Peanut (*Arachis Hypogaea*) allergen powder-dnfp]) and other treatments under investigation, this may be changing.⁸

Given the potential severity of symptoms and need for close management, living with food allergies such as PA presents day-to-day concerns and challenges that can place significant burden on both peanut-allergic individuals and their families.^{2,4,9} Accidental exposures to peanuts are inevitable, and there is currently no reliable way to predict the severity of an allergic reaction from an exposure because PA reactions are complex, highly variable, and involve several risk factors.^{10,11} One study using a cross-sectional survey assessed the caregiver-reported impact of living with PA on children's health-related quality of life found these children experience high levels of psychosocial burden, particularly those with more severe PA and a reaction history.¹²

Food allergies overall are associated with a notable financial burden. Based on a cross-sectional survey of caregivers of children with food allergy (28.7% with PA) conducted in 2011–2012, the average annual cost of childhood food allergy was estimated at \$24.8 billion (or \$4184 per child), and included direct medical costs, out-of-pocket costs, lost labor productivity, and lost opportunity costs (the percentage of caregivers reporting lost opportunity in the labor market multiplied by the mean caregiver-reported cost and the number of US children with food allergies).¹³ Direct medical costs (ie, clinician visits, emergency department [ED] visits, and hospitalizations) were \$4.3 billion annually, whereas \$20.5 billion annually was attributed to lost labor productivity, out-of-pocket costs to the family, and opportunity costs (ie, caregiver needing to leave or change jobs). A recent review of the economic burden of food allergy found that lost opportunity costs imposed the largest economic burden attributable to food allergy at the household level (ie, costs for a household with a food-allergic patient).¹⁴

A significant proportion (42.3%) of children with food allergy have had symptoms indicative of a severe reaction, with PA being the most common allergy (59.2% of children with food allergy).² Similarly, a history of severe reactions was more common among adults with PA (67.8%) compared to those with other food allergies.⁴ Most direct medical costs associated with food allergies were related to ED visits and inpatient hospitalizations due to anaphylaxis.¹⁵ Among individuals with PA, 59.2% of children had been treated in the ED for a PA reaction at some point in their life, with 22.9% treated in the ED within the past year.² Further, 62.3% of adults with PA had ≥ 1 allergy-related ED visits in their lifetime, with 19.8% reporting ≥ 1 PA-related ED visits in the past year.⁴

Although there are some data on PA, the literature is limited and the real-world experience of peanut-allergic individuals in the United States has not been thoroughly assessed. To address this gap in the literature, a large survey study, the Peanut Allergy Burden Study (PABS), was conducted to investigate the real-world burden of PA on patients

and caregivers in the United States. Given that PA may affect individuals differently across the life-span, it is important to understand the impact of PA between different age groups; as such, the objective of this analysis was to understand the use of allergy-related healthcare resources and the impact of PA on productivity among children, adolescents, and adults with PA, as well as caregivers of children with PA.

METHODS

Study design and procedure

A cross-sectional survey design was employed to examine the real-world impact of PA in peanut-allergic adolescents and adults, as well as caregivers of peanut-allergic children. The study was reviewed and approved by the Solutions IRB (institutional review board). An email was sent to Lightspeed panel participants, a global market research firm that has a US panel size of 1.3 million individuals, to encourage them to participate in the survey. Those who completed the screening questions and met the inclusion criteria were invited to complete the study's full survey online. The survey consisted of demographic questions, questions about medical and treatment history related to PA; food allergy and general health-related quality of life (HRQOL) measures, mental, physical, and social well-being, treatment satisfaction, family dynamics and activities, caregiver burden, healthcare resource utilization, and questions about productivity related to work, home activities, and school. Caregivers completed an additional measure on parental burden. Results from the HRQOL measures will be reported in a separate manuscript, and therefore will not be described in the current manuscript. Study participants were compensated with "award points" that could be redeemed for gift certificates, merchandise or cash.

Study participants

Adolescent patients with PA, adult patients with PA and adult caregivers of children with PA were recruited via Lightspeed an online research panel. Participants first completed a screening questionnaire to determine eligibility (inclusion and exclusion criteria are described below) and eligible participants were invited to complete the online

survey. Data collection occurred from November 2018 through January 2019.

Three samples were recruited: peanut-allergic adolescents (aged 13-17 years), peanut-allergic adults (aged 18-55 years), and caregivers of peanut-allergic children (aged 1-17 years). Inclusion criteria for the adolescent and adult samples included: (a) aged 13-17 years (adolescent sample) or aged 18-55 years (adult sample); (b) self-reported physician-diagnosed PA; (c) use of medication or medical care to treat a PA reaction or patient/caregiver always carries emergency medication; (d) "agree completely" or "very much" that they avoid being around peanuts; and (e) English-speaking US resident. Inclusion criteria for the caregiver sample included: (a) primary caregiver or shared caregiver responsibility for at least 1 child between the ages of 1-17 years with a caregiver-reported physician-diagnosed PA; (b) child resides in the same household; (c) child required use of medication or medical care to treat a PA reaction or patient/caregiver always carries emergency medication; (d) "agree completely" or "very much" that they avoid being around peanuts; and (e) English-speaking US resident. Being part of a clinical study for PA treatment was not part of the inclusion or exclusion criteria. Recruitment quotas were set to ensure an approximate 50:50 male to female ratio of peanut-allergic children, adolescents, and adults, but were not applied to caregiver gender. Additionally, age quotas were set for the adult and caregiver samples to ensure a broad age perspective, such that 50% of peanut-allergic adults were between the ages of 18-25 years, and no more than 25% of caregivers had children between the ages of 1-3 years. Potential participants were excluded who did not meet the inclusion criteria or once gender or age quotas had already been met. The participation rate after inclusion and exclusion criteria were applied was 97% for adolescents, 96% for adult patients, and 93% for caregivers.

Measures

Medical history

Questions pertained to the patient's age at the first-ever allergic reaction to peanuts, age at which PA was diagnosed, method of diagnosis, severity of PA reactions experienced in the past 12 months

Characteristic		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
Age (years), mean (SD)		14.7 (1.4)	31.4 (11.8)	37.5 (9.8)
Age of caregiver's child (years), mean (SD)		-	-	8.7 (4.8)
Sex, n (%)	Male	57 (55.9%)	53 (34.6%)	153 (40.1%)
	Female	45 (44.1%)	100 (65.4%)	229 (60.0%)
Hispanic, Latino, or Spanish ethnicity, n (%)	Yes	21 (20.6%)	38 (24.8%)	85 (22.3%)
	No	81 (79.4%)	115 (75.2%)	297 (77.8%)
Race, n (%)	White	64 (62.8%)	98 (64.1%)	265 (69.4%)
	Black/African-American	19 (18.6%)	23 (15.0%)	76 (19.9%)
	Asian	5 (4.9%)	12 (7.8%)	23 (6.0%)
	American Indian or Alaska Native	2 (2.0%)	3 (2.0%)	5 (1.3%)
	Mixed race	10 (9.8%)	10 (6.5%)	5 (1.3%)
	Other	1 (1.0%)	5 (3.3%)	7 (1.8%)
	Prefer not to answer	1 (1.0%)	1 (0.7%)	0 (0.0%)

Table 1. Demographic characteristics of PABS participants. Key: PA - peanut allergy; PABS - Peanut Allergy Burden Study; SD - standard deviation

and over the lifetime, symptoms during the last allergic reaction, and the worst lifetime allergic reaction, treatment history, and satisfaction with treatment.

Healthcare resource utilization

Questions assessed PA-related healthcare resource utilization in the previous 12 months and over the lifetime, treatment received for the last allergic PA reaction, and worst lifetime allergic reaction, PA-related healthcare resource utilization (eg, number of regularly scheduled allergist appointments, number of unscheduled allergist appointments, number of appointments with general practitioner or other healthcare provider), over-the-counter (OTC) medication use, prescription of an epinephrine autoinjector, epinephrine autoinjector use, number of ED/urgent care visits, number of overnight or longer hospital admissions, number of times patient received IV epinephrine, and number of times patient required intubation. To ensure responses for healthcare resource utilization were PA-specific, questions

began with the following prompt: "Thinking about your medical care and allergic reactions due to peanut...". Caregivers provided information on healthcare resource utilization for their child with PA.

Productivity

Productivity was assessed using the Health-Related Productivity Questionnaire.¹⁶ The Health-Related Productivity Questionnaire assesses the impact of an array of factors associated with PA, such as symptoms of a reaction to peanut, symptoms triggered by the presence of PA (eg, anxiety, depression), time required for outpatient or inpatient visits for PA, time for administration of PA treatments, and the impact of side-effects associated with PA treatments. Absenteeism refers to the amount of time missed on work, school or household chores due to PA or PA treatment (eg, number of hours of work missed because of PA or PA treatment), and presenteeism refers to the amount of time impacted while attempting to engage in activities related to work, school, or household

Characteristic		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
Age at first PA reaction, n (%)	0-3	28 (27.5%)	34 (22.2%)	200 (52.4%)
	4-6	39 (38.2%)	42 (27.5%)	108 (28.3%)
	7-9	27 (26.5%)	26 (17.0%)	52 (13.6%)
	10-13	7 (6.9%)	15 (9.8%)	13 (3.4%)
	14-17	1 (1.0%)	7 (4.6%)	3 (0.8%)
	18+	-	24 (15.7%)	-
	Don't know/ Don't remember	0 (0.0%)	5 (3.3%)	6 (1.6%)
Age at PA diagnosis, n (%)	0-3	25 (24.5%)	27 (17.7%)	192 (50.3%)
	4-6	37 (36.3%)	35 (22.9%)	116 (30.4%)
	7-9	28 (27.5%)	26 (17.0%)	51 (13.4%)
	10-13	10 (9.8%)	24 (15.7%)	16 (4.2%)
	14-17	2 (2.0%)	12 (7.8%)	2 (0.5%)
	18+	-	25 (16.3%)	-
	Don't know/ Don't remember	0 (0.0%)	4 (2.6%)	5 (1.3%)
Number of allergic reactions in the last 12 months, mean (median)	Mild	1.7 (1.0)	2.3 (1.0)	2.2 (1.0)
	Moderate	1.3 (1.0)	1.3 (1.0)	1.5 (1.0)
	Severe	0.9 (0.0)	0.9 (0.0)	1.4 (0.0)
Number of lifetime allergic reactions, mean (median)	Mild	7.6 (4.0)	13.9 (5.0)	7.7 (3.0)
	Moderate	5.2 (2.5)	7.7 (3.0)	3.5 (2.0)
	Severe	3.5 (1.0)	6.1 (1.0)	5.3 (1.0)
Prescribed epinephrine autoinjector? n (%)	Yes	95 (93.1%)	131 (85.6%)	345 (90.3%)
	No	4 (3.9%)	22 (14.4%)	36 (9.4%)
	Don't know	3 (2.9%)	0 (0.0%)	1 (0.3%)

Table 2. Medical history of PA. Key: PA - peanut allergy

chores due to PA or PA treatment (eg, percent impact of PA or PA treatment on work output for the hours worked during the past week). Questions assessed the impact of PA or PA treatment on absenteeism (adults, adolescents, and caregivers), presenteeism (adults, adolescents, and caregivers), total lost productivity at work (adults and

caregivers), school (adolescents and adults), and/or at home (adults, adolescents, and caregivers) during the last week. To ensure responses for productivity were PA-specific, questions were explicitly phrased to assess the impact of PA on productivity (eg, "Did your peanut allergy/

treatments keep you from doing any of your planned hours of homework or classes last week?”).

Statistical analyses

Data on demographics, clinical information, healthcare resource use and productivity were analyzed using descriptive statistics. Data from the 3 respondent groups were evaluated separately—adolescents, adult patients, and caregivers—using percentages for categorical variables and mean, median, and/or standard deviation (SD) for continuous variables.

RESULTS

Demographic characteristics

There were 102 adolescents, aged 13–17 years old, with a mean age of 14.6 years (SD = 1.3), and the adolescent sample was 55.9% male and 62.8% white (Table 1). There were 153 adult patients, aged 18–55 years old, with a mean age of 31.3 years (SD = 11.7) and who were 34.6% male and 64.1% white. There were 382 caregivers, aged 19–66 years old, with a mean age of 37.6 years (SD = 9.7), and the caregiver sample was 40.1% male and 69.4% white. The age of the caregiver's child with PA ranged from 1 to 17 years old, with a mean age of 8.6 years (SD = 4.7); 48.1%, 50.0%, 65.3%, and 56.4% were male among the children aged 1–3 years old, 4–6 years old, 7–12 years old, and 13–17 years old, respectively.

Medical history of peanut allergy PA

As shown in Table 2, adolescent patients with PA reported that 27.5% had their first reaction between the ages of 1–3 years, 38.2% had their first reaction between the ages of 4–6 years, and 26.5% had their first reaction between the ages of 7–9 years. Caregivers of children with PA reported that 52.4% of their PA children had their first reaction between the ages of 1–3 years, 28.3% had their first reaction between the ages of 4–6 years, and 13.6% had their first reaction between the ages of 7–9 years. Among adult patients, 22.2% had their first reaction between the ages of 1–3 years, 27.5% had their first reaction between the ages of 4–6 years, and 17.0% had their first reaction between the ages of 7–9 years.

Adolescents averaged 0.9 severe, 1.3 moderate, and 1.7 mild PA reactions in the previous 12 months, and 3.5 severe, 5.2 moderate, and 7.6 mild PA reactions in their lifetime. Adults showed a similar pattern, with an average of 0.9 severe, 1.3 moderate, and 2.3 mild PA reactions in the previous 12 months. As would be expected, they reported a higher number of reactions in their lifetime (6.1 severe, 7.7 moderate, and 13.9 mild). The children of the caregivers averaged 1.4 severe, 1.5 moderate, and 2.2 mild PA reactions in the previous 12 months and 5.3 severe, 3.5 moderate, and 7.7 mild PA reactions in their lifetime. Reviewing the medians of these variables indicates there are a limited number of individuals who had several PA reactions during the past year or in their lifetime.

Of the sample, 20.6% of adolescents, 32.0% of adults and 29.3% of children (as reported by caregivers) indicated receiving oral immunotherapy, and 9.8% of adolescents, 18.9% of adults, and 16.8% of children (as reported by caregivers) used oral immunotherapy in a clinical trial. Similarly, 17.7% of adolescents, 32.7% of adults and 27.8% of children (as reported by caregivers) indicated receiving epicutaneous immunotherapy, and 7.8% of adolescents, 19.6% of adults, and 27.7% of children (as reported by caregivers) used epicutaneous immunotherapy in a clinical trial.

Healthcare resource utilization related to PA

Past 12 months

Healthcare resource utilization related to PA in the past 12 months was frequent, with 39.3% of adolescents, 28.8% of adults, and 36.2% of children (as reported by caregivers) having 3 or more reported regularly scheduled allergist appointments, and 15.6% of adolescents, 18.3% of adults, and 17.8% of children (as reported by caregivers) having 3 or more reported unscheduled allergist appointments due to a PA reaction (Table 3). Similarly, 16.7% of adolescents, 24.2% of adults, and 21.5% of children (as reported by caregivers) had 3 or more reported appointments with a general practitioner or other healthcare provider because of PA in the past 12 months. Over one-quarter to one-third of participants reported using OTC medications 3 or more times (adolescents: 28.5%, adult patients: 35.7%, caregivers:

Characteristic		During the Last 12 Months			During the Patient's Lifetime		
		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)	Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
Number of regularly scheduled appointments with an allergist, n (%)	0	16 (15.7%)	51 (33.3%)	60 (15.7%)	7 (6.9%)	23 (15.0%)	24 (6.3%)
	1	14 (13.7%)	26 (17.0%)	108 (28.3%)	5 (4.9%)	12 (7.8%)	50 (13.1%)
	2	32 (31.4%)	32 (20.9%)	76 (19.9%)	12 (11.8%)	21 (13.7%)	53 (13.9%)
	3	18 (17.7%)	18 (11.8%)	56 (14.7%)	10 (9.8%)	18 (11.8%)	49 (12.8%)
	4	12 (11.8%)	8 (5.2%)	38 (10.0%)	13 (12.8%)	14 (9.2%)	42 (11.0%)
	5+	10 (9.8%)	18 (11.8%)	44 (11.5%)	44 (43.1%)	53 (34.6%)	139 (36.4%)
	Don't know/ Don't remember	-	-	-	11 (10.8%)	12 (7.8%)	25 (6.5%)
Number of unscheduled appointments with an allergist due to a PA reaction, n (%)	0	46 (45.1%)	73 (47.7%)	172 (45.0%)	17 (16.7%)	43 (28.1%)	107 (28.0%)
	1	29 (28.4%)	30 (19.6%)	89 (23.3%)	21 (20.6%)	22 (14.4%)	65 (17.0%)
	2	11 (10.8%)	22 (14.4%)	53 (13.9%)	20 (19.6%)	27 (17.7%)	61 (16.0%)
	3	8 (7.8%)	11 (7.2%)	29 (7.6%)	12 (11.8%)	14 (9.2%)	41 (10.7%)
	4	5 (4.9%)	9 (5.9%)	24 (6.3%)	8 (7.8%)	14 (9.2%)	45 (11.8%)
	5+	3 (2.9%)	8 (5.2%)	15 (3.9%)	15 (14.7%)	25 (16.3%)	45 (11.8%)
	Don't know/ Don't remember	-	-	-	9 (8.8%)	8 (5.2%)	18 (4.7%)
Number of appointments with a general practitioner or other healthcare provider because of PA, n (%)	0	38 (37.3%)	55 (36.0%)	140 (36.7%)	14 (13.7%)	29 (19.0%)	76 (19.9%)
	1	26 (25.5%)	34 (22.2%)	96 (25.1%)	16 (15.7%)	21 (13.7%)	68 (17.8%)

(continued)

Characteristic		During the Last 12 Months			During the Patient's Lifetime		
		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)	Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
	2	21 (20.6%)	27 (17.7%)	64 (16.8%)	15 (14.7%)	23 (15.0%)	54 (14.1%)
	3	6 (5.9%)	18 (11.8%)	35 (9.2%)	10 (9.8%)	20 (13.1%)	60 (15.7%)
	4	4 (3.9%)	13 (8.5%)	21 (5.5%)	14 (13.7%)	18 (11.8%)	36 (9.4%)
	5+	7 (6.9%)	6 (3.9%)	26 (6.8%)	24 (23.5%)	32 (20.9%)	66 (17.3%)
	Don't know/ Don't remember	-	-	-	9 (8.8%)	10 (6.5%)	22 (5.8%)
Number of times using OTC medication, n (%)	0	35 (34.3%)	37 (24.2%)	130 (34.0%)	21 (20.6%)	17 (11.1%)	71 (18.6%)
	1	16 (15.7%)	35 (22.9%)	67 (17.5%)	8 (7.8%)	13 (8.5%)	37 (9.7%)
	2	22 (21.6%)	25 (16.3%)	69 (18.1%)	15 (14.7%)	17 (11.1%)	59 (15.5%)
	3	13 (12.8%)	14 (9.2%)	45 (11.8%)	15 (14.7%)	18 (11.8%)	48 (12.6%)
	4	6 (5.9%)	13 (8.5%)	30 (7.9%)	7 (6.9%)	15 (9.8%)	53 (13.9%)
	5+	10 (9.8%)	29 (19.0%)	41 (10.7%)	28 (27.5%)	59 (38.6%)	90 (23.6%)
	Don't know/ Don't remember	-	-	-	8 (7.8%)	14 (9.2%)	24 (6.3%)
Number of times using an epinephrine autoinjector, n (%)	0	42 (41.2%)	73 (47.7%)	157 (41.1%)	20 (19.6%)	44 (28.8%)	108 (28.3%)
	1	24 (23.5%)	25 (16.3%)	71 (18.6%)	18 (17.7%)	22 (14.4%)	59 (15.5%)
	2	18 (17.7%)	22 (14.4%)	54 (14.1%)	16 (15.7%)	15 (9.8%)	50 (13.1%)
	3	12 (11.8%)	16 (10.5%)	55 (14.4%)	10 (9.8%)	19 (12.4%)	41 (10.7%)
	4	1 (1.0%)	10 (6.5%)	19 (5.0%)	14 (13.7%)	18 (11.8%)	39 (10.2%)
	5+	5 (4.9%)	7 (4.6%)	26 (6.8%)	17 (16.7%)	25 (16.3%)	63 (14.5%)

	Don't know/ Don't remember	-	-	-	7 (6.9%)	10 (6.5%)	22 (5.8%)
Number of visits to the ED/urgent care facility, n (%)	0	44 (43.1%)	65 (42.5%)	153 (40.1%)	19 (18.6%)	32 (20.9%)	87 (22.8%)
	1	33 (32.4%)	30 (19.6%)	90 (23.6%)	25 (24.5%)	23 (15.0%)	80 (20.9%)
	2	17 (16.7%)	24 (15.7%)	65 (17.0%)	20 (19.6%)	20 (13.1%)	70 (18.3%)
	3	3 (2.9%)	15 (9.8%)	31 (8.1%)	13 (12.8%)	26 (17.0%)	43 (11.3%)
	4	5 (4.9%)	11 (7.2%)	23 (6.0%)	4 (3.9%)	15 (9.8%)	33 (8.6%)
	5+	0 (0.0%)	8 (5.2%)	20 (5.2%)	14 (13.7%)	27 (17.7%)	51 (13.4%)
	Don't know/ Don't remember	-	-	-	7 (6.9%)	10 (6.5%)	18 (4.7%)
Number of overnight or longer hospital admissions, n (%)	0	65 (63.7%)	87 (56.9%)	201 (52.6%)	39 (38.2%)	62 (40.5%)	149 (39.0%)
	1	23 (22.6%)	30 (19.6%)	67 (17.5%)	20 (19.6%)	22 (14.4%)	63 (16.5%)
	2	6 (5.9%)	8 (5.2%)	42 (11.0%)	17 (16.7%)	17 (11.1%)	44 (11.5%)
	3	5 (4.9%)	15 (9.8%)	27 (7.1%)	10 (9.8%)	15 (9.8%)	31 (8.1%)
	4	2 (2.0%)	6 (3.9%)	29 (7.6%)	6 (5.9%)	13 (8.5%)	33 (8.6%)
	5+	1 (1.0%)	7 (4.6%)	16 (4.2%)	6 (5.9%)	15 (9.8%)	48 (12.6%)
	Don't know/ Don't remember	-	-	-	4 (3.9%)	9 (5.9%)	14 (3.7%)
Number of times receiving IV epinephrine, n (%)	0	64 (62.8%)	73 (47.7%)	190 (49.7%)	34 (33.3%)	44 (28.8%)	145 (38.0%)
	1	20 (19.6%)	31 (20.3%)	73 (19.1%)	23 (22.6%)	27 (17.7%)	66 (17.3%)
	2	11 (10.8%)	23 (15.0%)	43 (11.3%)	21 (20.6%)	19 (12.4%)	37 (9.7%)
	3	5 (4.9%)	9 (5.9%)	34 (8.9%)	7 (6.9%)	18 (17.8%)	41 (10.7%)

(continued)

Characteristic		During the Last 12 Months			During the Patient's Lifetime		
		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)	Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
	4	1 (1.0%)	8 (5.2%)	24 (6.3%)	5 (4.9%)	16 (10.5%)	33 (8.6%)
	5+	1 (1.0%)	9 (5.9%)	18 (4.7%)	5 (4.9%)	17 (11.1%)	46 (12.0%)
	Don't know/ Don't remember	-	-	-	7 (6.9%)	12 (7.8%)	14 (3.7%)
Number of times requiring intubation, n (%)	0	75 (73.5%)	93 (60.8%)	230 (60.2%)	56 (54.9%)	73 (47.7%)	186 (48.7%)
	1	13 (12.8%)	20 (13.1%)	53 (13.9%)	14 (13.7%)	14 (9.2%)	46 (12.0%)
	2	7 (6.9%)	13 (8.5%)	29 (7.6%)	10 (9.8%)	17 (11.1%)	41 (10.7%)
	3	6 (5.9%)	15 (9.8%)	31 (8.1%)	11 (10.8%)	15 (9.8%)	25 (6.5%)
	4	1 (1.0%)	5 (3.3%)	25 (6.5%)	1 (1.0%)	11 (7.2%)	26 (6.8%)
	5+	0 (0.0%)	7 (4.6%)	14 (3.7%)	4 (3.9%)	13 (8.5%)	43 (11.3%)
	Don't know/ Don't remember	-	-	-	6 (5.9%)	10 (6.5%)	15 (3.9%)

Table 3. (Continued) PA-related healthcare resource utilization. Key: ED - emergency department; IV - intravenous; OTC - over-the-counter; PA - peanut allergy

30.4%), and several participants reported using an epinephrine autoinjector 3 or more times (adolescents: 17.7%, adult patients: 21.6%, caregivers: 26.2%) in the past 12 months due to accidental peanut exposure. Over half of participants reported going to the ED or an urgent care facility at least once (adolescents: 56.9%, adult patients: 57.5%, caregivers: 59.9%) over the past 12 months for PA. Additionally, about one-third to one-half of participants reported at least 1 overnight or longer hospital admission (adolescents: 36.3%, adult patients: 43.1%, caregivers: 47.4%) over the past 12 months for PA. About one-third to one-half of participants reported receiving IV epinephrine (adolescents: 37.2%, adult patients: 52.3%, caregivers: 50.3%), and about one-quarter to one-third of participants reported requiring intubation (adolescents: 26.5%, adult patients: 39.2%, caregivers: 39.8%) over the past 12 months due to a severe reaction following accidental exposure to peanut. Given the high rates of ED/urgent care visits, IV epinephrine and intubation from this study, we have included some possible reasons for these findings in the discussion section.

Lifetime

Significant healthcare resources were used due to PA over a patient's lifetime as well. About one-third to almost one-half of respondents indicated that the patient had 5 or more regular allergist appointments (adolescents: 43.1%, adults: 34.6%, children: 36.4%), several respondents indicated that the patient had 5 or more unscheduled appointments with an allergist due to a PA reaction (adolescents: 14.7%, adults: 16.3%, children: 11.8%), and 23.5%, 20.9%, and 17.3% of adolescents, adults, and children, respectively, had 5 or more reported appointments with a general practitioner or other healthcare provider due to PA. About one-quarter to one-third of respondents indicated that the patient has used OTC medications 5 or more times (adolescents: 27.5%, adults: 38.6%, children: 23.6%). Across the respondent groups, most (85.6%–93.1%) had been prescribed an epinephrine autoinjector during their lifetime, and 16.7%, 16.3%, and 14.5% of adolescents, adults, and children, respectively, have reportedly had to use an epinephrine autoinjector 5 or more times during the patient's lifetime. About one-third to one-half of patients reported 3 or more ED or

urgent care facility visits due to PA (adolescents: 30.4%, adults: 44.5%, children: 33.3%) and 21.6% of adolescents, 28.1% of adult patients, and 29.3% of caregivers had 3 or more reported overnight or longer hospital admissions during the patient's lifetime. In addition, 16.7% of adolescents, 39.4% of adult patients, and 24.3% of children reportedly received IV epinephrine 3 or more times, and 15.7% of adolescents, 25.5% of adult patients, and 24.6% of caregivers reportedly required intubation 3 or more times in the patient's lifetime. Patients who required at least 1 intubation over their lifetime included 45.1% of adolescents, 52.3% of adult patients, and 51.3% of caregivers. Given the high rates of ED/urgent care visits, IV epinephrine and intubation from this study, we have included some possible reasons for these findings in the discussion section.

Productivity

Adolescent patients

PA impacted productivity in terms of household work and schoolwork for adolescents who reported that they planned an average of 6.4 h (SD = 6.4) of household chores in the past week, of which 5.3% (SD = 18.0%) was lost due to PA-related absenteeism and 34.1% (SD = 30.8%) was lost due to presenteeism, for a total of 40.0% (SD = 35.3%), or 3.5 h (SD = 5.0), of household work lost per week (Table 4). Adolescents reported that they planned an average of 17.0 h (SD = 15.6) of schoolwork in the past week, of which 5.1% (SD = 19.9%) was lost due to PA-related absenteeism and 30.8% (SD = 29.1%) due to presenteeism, for a total of 36.3% (SD = 33.8%), or 5.4 h (SD = 6.4), of total schoolwork hours lost. In total, adolescents reported losing an average of 8.9 h (SD = 8.1) of work in the past week related to household chores and schoolwork due to PA. Additional analyses demonstrated that of adolescents reported a >10% impact on presenteeism for household work (57%) and schoolwork (41.1%; Table 5).

Adult patients

Adult patients reported decreased productivity in the areas of household work, schoolwork, and employment due to PA. Adult patients indicated that they planned on doing an average of 11.3 h (SD = 10.7) of household chores in the past week,

Work Type		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
Household	Number of hours of household chores planned to do during the last week, mean (SD)	6.4 (6.4)	11.3 (10.7)	13.6 (13.2)
	Number of hours lost due to PA-related absenteeism, mean (SD)	0.5 (2.6)	0.5 (1.9)	0.7 (2.5)
	% (SD) of hours lost due to PA-related absenteeism	5.3% (18.0%)	5.9% (19.4%)	6.6% (10.0%)
	Number of hours lost due to PA-related presenteeism, mean (SD)	2.2 (3.7)	2.3 (4.3)	3.8 (7.2)
	% (SD) of work lost due to PA-related presenteeism	34.1% (30.8%)	22.9% (30.4%)	24.5% (29.8%)
	Total number of hours lost due to PA, mean (SD)	3.5 (5.0)	2.8 (4.7)	4.4 (7.7)
	Total % (SD) of work lost due to PA	40.0% (35.3%)	28.3% (34.9%)	30.5% (34.9%)
Education	Number of hours of schoolwork planned to do during the last week, mean (SD)	17.0 (15.6)	6.7 (16.8)	-
	Number of hours lost due to PA-related absenteeism, mean (SD)	0.3 (1.3)	0.6 (1.7)	-
	% (SD) of hours lost due to PA-related absenteeism	5.1% (19.9%)	8.7% (25.1%)	-
	Number of hours lost due to PA-related presenteeism, mean (SD)	3.4 (6.4)	3.6 (6.0)	-
	% (SD) of work lost due to PA-related presenteeism	30.8% (29.1%)	41.7% (31.1%)	-
	Total number of hours lost due to PA, mean (SD)	5.4 (6.4)	5.3 (6.2)	-
	Total % (SD) of work lost due to PA	36.3% (33.8%)	46.3% (36.2%)	-
Employment	Number of hours of employment work planned to do during the last week, mean (SD)	-	37.2 (34.2)	36.0 (26.3)
	Number of hours lost due to PA-related absenteeism, mean (SD)	-	0.7 (2.8)	1.3 (4.0)
	% (SD) of hours lost due to PA-related absenteeism	-	2.2% (8.9%)	5.3% (16.2%)
	Number of hours lost due to PA-related presenteeism, mean (SD)	-	8.1 (11.3)	10.6 (21.5)
	% (SD) of work lost due to PA-related presenteeism	-	26.1% (29.8%)	32.5% (33.6%)

(continued)

Work Type		Adolescents (N = 102)	Adult Patients (N = 153)	Caregivers (N = 382)
	Total number of hours lost due to PA, mean (SD)	-	8.8 (12.3)	11.7 (22.3)
	Total % (SD) of work lost due to PA	-	28.4% (31.9%)	34.5% (35.0%)
Total	Total number of hours lost due to PA, mean (SD)	8.9 (8.1)	16.9 (14.6)	16.1 (12.5)

Table 4. (Continued) Effects of PA on past week productivity. Key: PA - peanut allergy; SD - standard deviation

of which 5.9% (SD = 19.4%) was lost to absenteeism and 22.9% (SD = 30.4%) to presenteeism, for a total of 28.3%, or 2.8 h (SD = 4.7) of household work lost due to PA (Table 4). On average, adult patients planned on doing 6.7 h of schoolwork during the past week, of which 8.7% (SD = 25.1%) was lost to absenteeism and 41.7% (SD = 31.1%) to presenteeism, for a total of 46.3% (SD = 36.2%), or 5.3 h (SD = 6.2) of schoolwork lost due to PA. Adult patients reported an average of 37.2 h (SD = 34.2) of planned work related to their employment in the past week, of which 2.2% (SD = 8.9%) was lost to absenteeism and 26.1% (SD = 29.8%) was lost to presenteeism, for a total of 28.4% (SD = 31.9%), or 8.8 h (SD = 12.3), of work lost. In total, adults reported losing an average of 16.9 h (SD = 14.6) of work in the past week related to household chores, school, and employment combined due to PA. Additional analyses demonstrated that adult patients reported a >10% impact on presenteeism for employed work (50.0%), household work (38.4%), and schoolwork (51.3%; Table 5).

Caregivers of children with PA

PA impacted productivity in terms of household work and employment for caregivers of children with PA. Caregivers indicated that they planned on doing 13.6 h (SD = 13.2) of household chores in the past week, of which 6.6% (SD = 10.0%) was lost to absenteeism and 24.5% (SD = 29.8%) was lost to presenteeism, for a total of 30.5% (SD = 34.9%), or 4.4 h (SD = 7.7), of household work lost in the past week due to PA (Table 4). Caregivers indicated that they planned on working 36.0 h (SD = 26.3) related to their employment in the

past week, of which 5.3% (SD = 16.2%) was lost to PA-related absenteeism and 32.5% (SD = 33.6%) was lost to presenteeism, for a total of 34.5% (SD = 35.0%), or 11.7 h (SD = 22.31), hours of work lost. In total, caregivers reported losing an average of 16.1 h (SD = 12.5) of work in the past week related to household chores and employment. Notably, patient and caregiver estimates of hours lost due to absenteeism and presenteeism in the past week had substantial variation, with standard deviations almost equal to or surpassing the averages, indicating that there is significant heterogeneity in how PA affects productivity and possibly reflecting the random nature of PA events. Additional analyses showed that caregivers of children with PA reported a >10% impact on presenteeism for employed work (55.5%) and household work (47.0%; Table 5).

Children with PA

Moreover, PA impacted school attendance, with 68% of caregivers indicating that their child missed at least part of a school day during the child's most recent PA reaction, 44% indicating that their child missed school at least once per month due to PA, and 21% indicating that their child missed school at least once per week due to PA.

DISCUSSION

These data suggest that PA is a contributor to patients' healthcare resource utilization in the past 12 months and over a lifetime for children, adolescents, and adults with PA. Further, these data also suggest that PA-related absenteeism and presenteeism contribute to the loss of productivity among children with PA, as well as their caregivers, adolescents and adults with PA for household

chores, education, and employment. The findings of the current study demonstrate that this is a population with substantial humanistic and economic burden, from school and work hours lost to the high number of PA reactions and resources needed to treat those reactions, from epinephrine autoinjector usage to hospitalizations.

Many healthcare resources were utilized in the past 12 months and over a patient's lifetime due to PA, including regularly scheduled allergist appointments, unscheduled allergist appointments, general practitioner appointments, OTC medication use, epinephrine use, ED/urgent care visits, overnight hospital visits, IV epinephrine and intubation. Notably, over the past 12 months, over one-half of all patients (52.6%–63.7%) went to the ED/urgent care and about one-third to one-half of patients were admitted overnight to the hospital due to a PA reaction. Compared to previous research that found that 22.9% of children and 19.8% of adults who had PA were admitted overnight to the hospital due to a PA reaction in the past year, results from the current study show that rates of overnight hospital admission in the past year may be even higher than previously estimated.^{2,4} A possible explanation for the difference in these numbers may be due to the fact that in the previous studies, not all participants had physician-diagnosed PA. Patients who had previous reactions related to accidental peanut exposure that required medical care are more likely to consume healthcare resources, while practice of peanut avoidance might be sufficient for other patients. Additionally, in the current study, about one-third to one-half of patients received IV epinephrine and one-quarter to over one-third of patients required intubation over the past 12 months for PA.

Aspects of lifetime resource use that were notable included that 30.4%–44.5% of PA patients having been to the ED/urgent care facility at least 3 times and 21.6%–29.3% of patients had been admitted to the hospital overnight or longer at least 3 times due to PA. Past research showing that 50.4% of children with PA and 62.3% of adults with PA had at least 1 lifetime ED visit are similar to the rates found in the current study (children: 57.3%, adolescents: 57.9%, adults: 53.6%).⁴ In addition, the current study found that 16.7%–39.4% of patients have received IV epinephrine and

15.7%–25.5% of patients required intubation at least 3 times over their lifetime. These high rates of IV epinephrine use and intubation may be due to self-report bias or misinterpretation of the questions.

Additionally, given that the current study enrolled patients that required either use of medication or medical care to treat a PA reaction or that the patient/caregiver always carried emergency medication, these patients may be at higher risk of additional healthcare resource use since they are unable to manage their PA by simply avoiding peanuts.

With regard to productivity, adolescents lost an average of 3.5 h of household work and 5.4 h of schoolwork per week due to PA. Adults, on average, lost 2.8 h of household work, 5.3 h of schoolwork, and 8.8 h of employment work per week due to PA. Caregivers of children with PA lost an average of 4.4 h of household work and 11.7 h of employment work per week due to their child's PA. The majority of hours lost were due to presenteeism, indicating that, for the most part, PA did not prevent patients from going to work or school, but that the ability to be fully present and successfully complete these responsibilities was affected. Productivity estimates for patients and caregivers, however, were subject to substantial variation, indicating a heterogeneous effect of PA on productivity. Additionally, almost half of caregivers indicated that their child missed school at least once a month and over two-thirds of caregivers indicated that their child missed at least part of a school day during the child's most recent PA reaction.

The findings of the current study are consistent with previous research on food allergies overall that have shown a significant economic burden on individuals with food allergies and their families.^{2,4,13-15} In particular, Gupta (2013) found that the majority of the average annual cost of childhood food allergy has been attributed to lost labor productivity, family out-of-pocket costs, and opportunity costs.¹³ In that study, caregiver time spent due to attending allergist visits, pediatrician visits, and ED visits accounted for the largest proportion of lost labor productivity. Additionally, direct medical costs were significant and included clinician visits, ED visits, and

Variable	Adolescents (N = 92)	Adult Patients (N = 138)	Caregivers (N = 377)
Impact of PA on household productivity during the past week			
% not completing planned household work due to PA	10.9%	10.9%	15.4%
Number of planned hours not worked due to PA, mean (SD)	5.2 (6.9)	5.0 (3.2)	4.6 (4.9)
% reporting >10% impact on presenteeism at household work due to PA	57.0%	38.4%	47.0%
Variable	Adolescents (N=90)	Adult Patients (N=76)	-
Impact of PA on education productivity during the past week			
% not completing planned schoolwork due to PA	10.0%	17.1%	-
Number of planned hours not worked due to PA, mean (SD)	3.0 (2.7)	4.7 (3.9)	-
% reporting >10% impact on presenteeism at schoolwork due to PA	41.1%	51.3%	-
Variable	-	Adult Patients (N=109)	Caregivers (N=328)
Impact of PA on employed work productivity during the past week			
% with employed work absenteeism due to PA	-	8.3%	18.3%
Number of hours of employed work absenteeism due to PA, mean (SD)	-	7.9 (6.7)	7.0 (7.1)
% reporting >10% impact on presenteeism at employed work due to PA	-	50.0%	55.5%

Table 5. Impact of PA on productivity during the past week. Note: The sample sizes for results presented in this table are smaller than the overall sample size because respondents who indicated that they did not have any household chores, schoolwork, or employed work were not included in the analysis. Key: PA - peanut allergy; SD - standard deviation

hospitalizations. The findings from Gupta (2013) are consistent with the findings from the current study indicating that lost labor productivity represents a significant portion of the economic burden of individuals with PA and their families, as well as frequent use of healthcare resources.¹³

One of the strengths of the PABS was the ability to examine the healthcare resource utilization and loss of productivity due to PA across the lifespan by including adolescent patients, adult patients, and caregivers who were able to report on the impact of PA of their children. Given that PA may impact children, their caregivers, adolescents, and adults differently, it is important to understand the

similar and differential impacts of PA on these groups. There are several limitations of the study that must be considered. First, the study relies on self-report measures for adolescent and adult patients, which may be subject to social desirability bias, response bias, misinterpretation of questions, and inability to accurately assess questions. Second, the questions regarding lifetime resource utilization may be subject to recall bias. Third, despite efforts to balance the enrollment, there may be some demographic, disease history, or treatment imbalances that would influence interpretation of these data. Fourth, about 16% and 17% of the total sample indicated that the patient used oral immunotherapy and epicutaneous

immunotherapy, respectively, in a clinical trial at some point over their lifetime. Participation in a clinical trial at the time of the study may have impacted productivity. Fifth, since one of the inclusion criteria was that patients either required medication or medical care because of a peanut reaction or that the patient or caregiver always carries emergency medication in case of accidental peanut exposure, results may not be generalizable to all individuals with PA, particularly for those in whom avoidance of peanuts is a successful strategy. Finally, rates of IV epinephrine use and intubation were remarkably high in the current study. These higher rates may be due to misinterpretation of the question, self-report bias, or a more severe population due to study recruitment procedures or sampling. It is also possible, however, that these rates reflect the current PA experience.

CONCLUSION

The PABS findings demonstrate that for patients who are unable to simply use peanut avoidance as a strategy to manage their PA, there is a need for healthcare resources to manage reactions to peanut and there is also a loss of productivity associated with PA for patients and caregivers. Despite currently available PA management approaches, there remains an unmet need for PA treatments that can reduce the risk of serious reactions from accidental exposure to peanuts. New treatments that can prevent or lower the risk of reactions would be able to decrease the healthcare resource utilization for patients due to accidental exposure to peanuts and decrease productivity loss related to PA. Given the first approval of a treatment for PA by the US Food and Drug Administration, it remains to be seen whether this therapy will be able to decrease healthcare resource utilization and productivity loss for this patient population and their caregivers.

Abbreviations

ED, emergency department; h, hour; HRQOL, health-related quality of life; IV, intravenous; OTC, over-the-counter; PA, peanut allergy; PABS, Peanut Allergy Burden Study; SD, standard deviation; US, United States.

Author contributions

William McCann: Conceptualization, methodology, supervision; writing, review and editing;

Steven L. Hass: Conceptualization, methodology, validation, formal analysis, investigation, supervision; writing, review and editing; and visualization;

Kevin Norrett: Conceptualization, methodology; writing, review, and editing; funding acquisition;

Ann Cameron: Conceptualization, methodology, validation, formal analysis, investigation, data curation, writing (original draft), review, and editing;

Martine Etschmaier: Conceptualization, methodology, validation, investigation, writing (original draft), review, and editing; visualization, and project administration;

Amy Duhig: Conceptualization, methodology, validation, writing, review, and editing;

Shengsheng Yu: Writing, review, and editing; visualization and project administration.

Ethics statement

The study was reviewed and approved by the Solutions IRB (institutional review board). All research was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments.

Availability of data statement

The data that support the findings of this study, which are captured in the current article, are available from the corresponding author upon reasonable request.

Consent for publication

All authors have reviewed this manuscript and consent to its publication.

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Declaration of competing interest

William McCann: Served as a paid consultant for Aimmune Therapeutics;

Steven L. Hass: Served as a paid consultant for Aimmune Therapeutics;

Kevin Norrett: Former employee of Aimmune Therapeutics at the time of the study;

Ann Cameron: Former employee of Xcenda during the development and finalization of the manuscript;

Martine Etschmaier: Employee of Xcenda;

Amy Duhig: Employee of Xcenda;

Shengsheng Yu: Employee of Aimmune Therapeutics; equity holder of Aimmune Therapeutics.

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Author details

^aAllergy Partners, Asheville, NC, USA. ^bH.E. Outcomes, LLC, Los Angeles, CA, USA. ^cAimmune Therapeutics, a Nestle Health Science Company, Brisbane, CA, USA. ^dXcenda, LLC, Palm Harbor, FL, USA.

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