

Original Article

Economic burden of food allergy in Canada

Estimating costs and identifying determinants

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ABSTRACT

Background: Limited data exist on the economic burden of food allergy (FA).

Objective: To assess FA-related direct (healthcare and out-of-pocket) and indirect (lost productivity) costs and their determinants in Canadian children and adults self-reporting FA.

Methods: FA-individuals self-reporting a convincing history or physician diagnosis were recruited through FA registries, an anaphylaxis registry, and advocacy associations, and electronically surveyed regarding FA-related healthcare use, out-of-pocket expenditures, and time lost from paid and unpaid labor. Direct and indirect costs (2020 Canadian dollars [CAD]) were stratified on severe reaction vs mild, moderate or no reaction, and children vs adults; multivariate regressions assessed the association between costs and sociodemographic and disease characteristics.

Results: Between May 2018 and July 2019, 2692 eligible individuals responded (2189 convincing history and 503 physician diagnosis only); 1020 experienced a severe reaction; 1752 were children. Per FA-individual, annual healthcare, out-of-pocket, and indirect costs were \$1267, \$2136, and \$7950. Those with a severe reaction had higher healthcare and out-of-pocket costs than those with mild, moderate or no reaction. FA-children vs FA-adults had higher healthcare and out-of-pocket costs, and lower indirect costs. Multivariate results showed that lower age, a severe reaction ever, multiple FAs, and fair or poor general health were associated with higher healthcare and out-of-pocket costs. Higher age, lower household education and income, and fair or poor general health were associated with higher indirect costs.

Conclusion: The economic burden of FA in Canada is substantial, particularly for those with a severe reaction ever, multiple FAs, and fair or poor general health. It is crucial that those most adversely affected are allocated appropriate resources to support disease management.

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Introduction

Although there are a few cost-of-illness studies documenting the economic burden of food allergy (FA) in North America and Europe,^{1–15} there is a lack of consensus regarding costs to the healthcare system and families.¹ Furthermore, some studies are limited by small sample sizes,^{6,8,9,11–14} inclusion of patients based on administrative data codes,^{3,5,10} and omission of certain populations (eg, adults^{2,4,5,9,12–14}; those with mild or moderate allergy¹⁰) or cost components (eg, productivity losses in unpaid labor^{2,3,10}). Although some assess determinants of costs,^{4,7–9,11,14} we believe no study has examined determinants of all cost components.

To address these limitations and provide a more comprehensive understanding of the economic burden of FA and its determinants, we assessed FA-related costs by surveying a large national sample of Canadian children and adults self-reporting FA. Costs were assessed from a societal perspective and included those to the healthcare system and those incurred by affected individuals and their families, in the form of out-of-pocket expenditures and lost productivity in paid and unpaid labor. We explored both FA-related and demographic determinants of all cost components.

Methods

Recruitment

Respondents aged 18 years or older who self-reported a current FA, and caregivers of currently FA-individuals younger than 18 years were recruited between May 2018 and July 2019 from the following sources:

1. the Canadian peanut, sesame, and/or seafood allergy registry: individuals recruited through allergy clinics in Calgary, Alberta; the Montréal Children's Hospital; the British Columbia Children's Hospital; and Canadian FA advocacy associations (Food Allergy Canada, Allergies Québec)^{16–28}
2. the Cross-Canada Anaphylaxis Registry (C-CARE): individuals with any food-related anaphylaxis who presented to Canadian emergency departments (ED) or paramedics^{29–43}
3. Canadian FA advocacy associations (Food Allergy Canada, Allergies Québec): individuals with any FA.

The FA registries and C-CARE recruited via email and hard copy, and advocacy associations recruited through their newsletter and e-bulletin.

Canadian Food Allergy Economic Survey

One adult respondent per household identified all children and adults in the household who self-reported a current FA, and completed the Canadian Food Allergy Economic Survey electronically for each FA-individual. The survey was based on a US economic survey² and incorporated elements from the EuroPrevall Economic Questionnaire.⁶ The Canadian Food Allergy Economic Survey was modified in partnership with Canadian FA advocacy associations to be more applicable to the Canadian healthcare system; it was translated into French and piloted with FA advocacy associations. The survey queried on sociodemographics (age, sex, race and ethnicity [reported as non-White, based on those who responded “White” only], household education, household income, region), atopic history (asthma, eczema, hay fever or allergic rhinitis, hives), self-reported general health in the past year (reported as poor, fair, good, very good or excellent), FA-related healthcare use, associated travel time, out-of-pocket expenditures, and FA-related time lost from paid and unpaid labor and school over the preceding year. Respondents reported current FAs, whether they were physician-diagnosed, age of onset, number of mild or moderate

and severe reactions in the past year, and for the most severe reaction ever, the culprit food, symptoms or signs, mode of contact, interval between ingestion and reaction, and diagnostic testing.

To request the survey, please contact the corresponding author.

Inclusion Criteria

Of respondents self-reporting a current FA, we included only those self-reporting a convincing history of a current immunoglobulin E-mediated FA or a physician diagnosis; respondents not self-reporting a convincing history or physician diagnosis of a current immunoglobulin E-mediated FA were excluded. An individual was considered to have a convincing history if they had 2 mild or 1 moderate or severe sign or symptom^{44–46} (eTable 1) within 2 hours of exposure (eating or touching for all foods; inhalation for fish, shellfish, egg, soy). For milk or wheat allergy, gastrointestinal symptoms alone were not considered a convincing history, and those with lactose or gluten intolerance were not considered to have milk or wheat allergy if reported.

Healthcare Use, Out-of-Pocket Expenses, and Calculating Direct Costs

FA-related healthcare use was reported for each FA-individual and included outpatient visits to physicians (family doctor, pediatrician, allergist, pulmonologist, gastroenterologist, dermatologist), other healthcare practitioners (dietician or nutritionist, mental health professional, alternative health practitioner), and the ED, ambulances, laboratory or diagnostic or therapeutic procedures (chest x-ray examination, breathing test, skin prick test, RAST, ImmunoCap, component testing, oral food challenge, oral immunotherapy), hospitalizations, and medications (antihistamines, inhaled corticosteroids and β_2 -agonists, prednisone, topical medications). Healthcare costs were calculated from the Canadian national health insurance perspective by multiplying each resource by its 2020 Canadian unit cost (eTable 2).

FA-related out-of-pocket expenditures were reported for the household and included nontraditional medicines, special diets and allergen-free foods, additional or modified child care, legal guidance, counseling or mental health services, change in school, and other (eg, vitamins, medical alert bracelets or memberships, cleaning products, etc). In households with multiple FA-individuals, out-of-pocket costs were divided equally among FA-individuals, except additional or modified child care and change in schools, which were divided equally among FA-children. Respondents provided dollar values for each out-of-pocket expense, which were adjusted to 2020 CAD.⁴⁷

Direct costs included healthcare costs, travel costs, and out-of-pocket expenditures.

Time Loss and Calculating Indirect Costs

The caregiver of an FA-child reported time spent doing paid and unpaid labor and time missed from paid labor owing to FA, including accompanying an FA-child to FA-related healthcare visits. Similarly, FA-adults reported time spent doing paid and unpaid labor, FA-related time missed from paid labor, and time another adult missed from paid labor to assist the FA-adult obtain health care. Productivity loss in paid labor was calculated by comparing time the respondent reported working minus FA-related time loss with the average time worked in paid labor by the general Canadian population.⁴⁸

Unpaid labor activities were categorized as related to grocery shopping or food preparation vs other housework or volunteering. Because it is expected that FA requires additional time investment in grocery shopping and food preparation, considering such time as increasing productivity because of FA would misrepresent actual losses; actual losses are better reflected by considering only time loss

in nonfood-related unpaid work (includes nonfood-related housework [eg, taking children to school, cleaning], or volunteering and community activities). Although an increase in food-related unpaid work represents time unavailable for other uses, it is not known whether this time would be used for productive activities vs leisure. Furthermore, because substitution away from nonfood-related to food-related activities is expected in FA-households, the increased time in food-related activities cannot be added to losses in nonfood-related activities because this would likely involve double-counting.

Therefore, we computed 2 estimates of loss productivity in unpaid work:

1. the difference between time the respondent spent in nonfood-related housework or volunteering compared with the average time spent in these activities by the Canadian population,
2. the upper bound of either #1 or additional time spent on food-related unpaid work compared with the Canadian population.⁴⁸

Indirect costs for paid and unpaid labor were valued using average 2020 wages.⁴⁹ A fraction of total indirect costs was derived from time spent accompanying a FA-individual to healthcare services and was calculated at the individual level. However, the remainder of indirect costs was based on the household respondent's lost productivity in paid and unpaid labor, compared with the general population data. In households with multiple FA-individuals, this household-level component was divided equally among FA-individuals, and then combined with the individual-specific portion, to produce indirect cost estimates for each FA-individual.

Statistical Analysis

Those with a convincing history with or without a physician diagnosis were pooled with those with a physician diagnosis only, and sample characteristics, healthcare utilization, and healthcare, out-of-pocket, and indirect costs were compared between

1. those who had ever experienced a severe reaction (≥ 1 severe symptom) (eTable 1) vs those with a mild, moderate or no reaction,
2. children (< 18 years) vs adults.

Results are expressed as means or proportions with differences and corresponding 95% confidence intervals (CIs).

As secondary analyses, healthcare utilization and direct and indirect costs were also compared between those with a convincing history vs physician diagnosis only, and those with a reaction vs no reaction in the past year (eSupplement).

The association between (1) healthcare costs and (2) out-of-pocket expenses and sociodemographics (age, sex, race and ethnicity, household education and income, region), allergic characteristics (reaction in past year, severity of most severe reaction, number of FA, atopic comorbidities), and self-reported good health (good, very good, or excellent) was examined through multivariate linear regression. The regression for indirect costs (ie, based on the conservative estimate of total lost productivity including paid labor and nonfood-related unpaid labor) included the above variables except for region because differences could reflect regional differences in time in paid and unpaid labor, unrelated to FA. We used backward stepwise selection and selected predictor variables for which an association remained statistically significant at the 95% confidence level, after eliminating variables least likely to be associated with the outcome.

The total economic burden of FA in Canada was calculated by multiplying costs weighted to reflect the distribution of the Canadian population with FA by the Canadian prevalence of FA.⁵⁰ To weight and adjust our data for our sample composition to be comparable to the Canadian population of individuals with FA, we used previous

data on the distribution of age, sex, race and ethnicity, geographic region, education, and income of FA-individuals in Canada.⁵⁰ 95% CIs for mean healthcare, out-of-pocket, indirect, and total costs were calculated using robust standard errors.

Analyses were conducted using Stata 15.1. This study was approved by the research ethics board at the University Calgary, and informed consent was obtained for all respondents.

Results

Surveys were completed for 2728 FA-individuals; 2560 were fully and 168 were partially completed. Among these, 2189 reported signs or symptoms compatible with a convincing history, and 503 reported a physician diagnosis only; 36 did not report a convincing history or a physician diagnosis, and were excluded (Fig 1). Of the 2189 reporting signs or symptoms compatible with a convincing history, 96.6% also reported a physician diagnosis. The 2692 FA-individuals (65.1% children) were from 2308 households (eTable 3), with 72.0% reporting 1, 21.5% reporting 2, and 6.5% reporting 3 or more FA-individuals. Among the 2189 FA-individuals with a convincing history, 42.7% experienced 1 or more severe reaction, and 56.2% reported having a reaction in the past year. Of the 503 with a physician diagnosis only, 17.1% experienced a severe reaction (but did not meet the criteria for a convincing history); 43.7% reported symptoms of a mild or moderate reaction, and 39.2% reported no reaction. Of the 306 with a reaction, 56.2% had a reaction in the preceding year.

Sample Characteristics

The mean (SD) age of the sample ($n = 2692$) was 18.7 (16.0) years, and 51.0% were female; 96.8% reported household postsecondary education, and 57.9% reported having a household income of \$100,000 or more (Table 1). Because the groups with a convincing history and physician diagnosis only were demographically similar, they were pooled for subsequent analysis. Healthcare utilization (eTable 4), direct (eTable 5), and indirect costs (eTable 6) were similar between the groups. Healthcare utilization (eTable 4), direct (eTable 5) and indirect costs (eTable 6) were higher among those with a reaction than those with no reaction in the past year. eTable 7 presents the characteristics of those with a reaction versus no reaction in the past year.

Among FA-individuals with a convincing history or physician diagnosis, those with a severe reaction were more likely to be older, female, and reside in lower income households than those with mild, moderate, or no reaction. FA-children were more likely to be male, of non-White race and ethnicity, and to reside in higher income households (Table 2) than adults.

Healthcare and Out-of-Pocket Utilization

Utilization of most healthcare components was higher among those with a severe reaction than those with mild, moderate or no reaction (eTable 8). The differences for proportions using healthcare services were greatest for ED visits, epinephrine autoinjectors, and other medications. Those with a severe reaction were also more likely to report using mental health services and changing schools.

FA-children were more likely to utilize many healthcare and out-of-pocket components (eTable 8) than adults. The differences for the proportions using the service were greatest for laboratory, diagnostic or therapeutic procedures, physician visits, epinephrine autoinjectors, and additional child care (which is not applicable to FA-adults).

Healthcare and Out-of-Pocket Costs

Given those with a severe reaction reported more utilization, their total healthcare (\$1647 vs \$1037; difference, \$610; 95% CI, \$447–\$773) and out-of-pocket expenditures (\$2579 vs \$1867; difference,

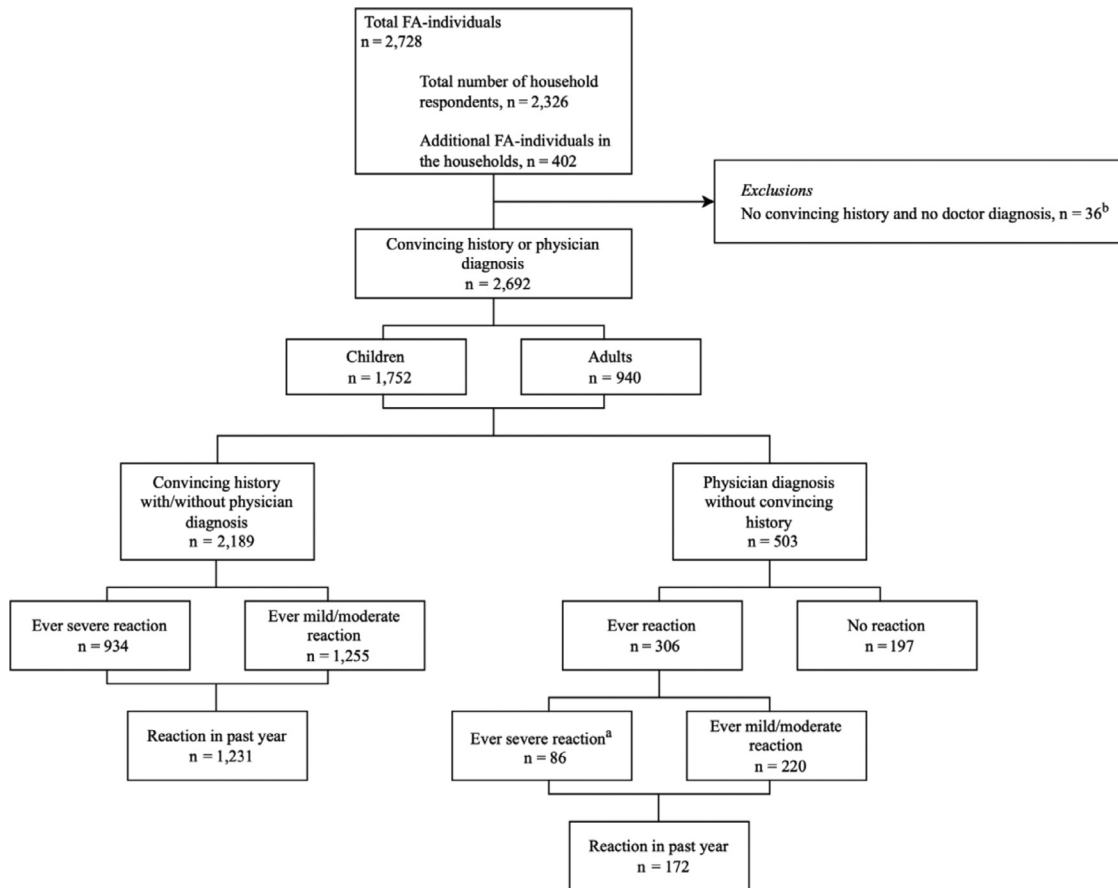


Figure 1. Survey respondent flow diagram. The superscript letter a denotes that although individuals reported a severe symptom, it did not meet criteria for a convincing history because timing or mode of exposure was not specified. The superscript letter b denotes no convincing history or physician diagnosis: either convincing history criteria not met, no reaction, lactose or gluten intolerance, mode or timing missing or unknown, or no or unknown doctor diagnosis.

\$712; 95% CI, \$269–\$1156) were also higher (Table 3). Most component costs were also higher among those with a severe reaction, particularly inpatient admissions (\$226 vs \$56; difference, \$170; 95% CI, \$67–\$273), inpatient admissions for FA-individuals with an admission (\$4556 vs \$2641; difference, \$1915; 95% CI, \$157–\$3672), medications (\$359 vs \$231; difference, \$127; 95% CI, \$88–\$167), and special diets or allergen-free foods (\$1415 vs \$1139; difference, \$276; 95% CI, \$53–\$498).

Total healthcare (\$1393 vs \$1038; difference, \$355; 95% CI, \$200–\$510), out-of-pocket (\$2440 vs \$1579; difference, \$860; 95% CI, \$471–\$1250), and most component costs were also higher among FA-children than in adults (Table 3). The differential was largest for additional child care (\$668 vs N/A; difference, \$668; 95% CI, \$463–\$873), change in school (\$164 vs N/A; difference, \$164; 95% CI, \$85–\$242), epinephrine autoinjectors (\$320 vs \$155; difference, \$165; 95% CI, \$151–\$178), and visits to physicians (\$256 vs \$157; difference, \$99; 95% CI, \$77–\$121).

Indirect Costs

For those with a severe reaction, there was no difference in indirect costs due to lost paid labor or lost unpaid labor in nonfood-related activities (Table 4) compared with those with mild, moderate or no reaction. However, the upper bound of unpaid labor in non-food-related or food-related activities (\$16,175 vs \$15,042; difference, \$1133; 95% CI, \$319–\$1947) and upper bound of total lost productivity (\$18,220 vs \$15,753; difference, \$2467; 95% CI, \$593–\$4340) were higher among those with a severe symptom.

FA-children vs adults incurred lower indirect costs due to lost paid labor (\$259 vs \$2912; difference, –\$2654; 95% CI, –\$4,318 to –\$989) and lost unpaid labor (Estimate # 1: \$3914 vs \$11,820; difference, –\$7905; 95% CI, –\$9054 to –\$6756; Estimate # 2: \$14,728 vs \$16,786; difference, –\$2058; 95% CI, –\$2780 to –\$1336), and both estimates of total lost productivity were lower in FA-children (Estimate # 1: \$4173 vs \$14,732; difference, –\$10,559; 95% CI, –\$12,524 to –\$8594; Estimate # 2: \$14,987 vs \$19,698; difference, –\$4711; 95% CI, –\$6559 to –\$2864) (Table 4).

Respondents with FA-children also reported on missed school days. Children with a severe reaction vs mild, moderate or no reaction missed a mean (SD) of 3 days (22.6) vs 1.2 days (11.4) (difference, 2.2; 95% CI, 0.2–4.1).

Multivariate Results

Higher healthcare costs were associated with lower age (β , \$18; 95% CI, \$14–\$23), non-White race and ethnicity (β , \$181; 95% CI, \$16–\$346), reaction in the past year (β , \$489; 95% CI, \$390–\$587), severe reaction ever (β , \$348; 95% CI, \$230–\$465), multiple FAs (β , \$183; 95% CI, \$128–\$237), atopic comorbidities (β , \$314; 95% CI, \$208–\$420), and fair or poor general health (β , \$1127; 95% CI, \$789–\$1464) (Table 5).

Higher out-of-pocket costs were associated with lower age (β , \$34; 95% CI, \$22–\$47), residing outside Quebec (β , \$1241; 95% CI, \$839–\$1644), severe reaction ever (β , \$471; 95% CI, \$8–\$934), multiple FAs (β , \$414; 95% CI, \$268–\$560), and fair or poor general health (β , \$845; 95% CI, \$141–\$1548).

Table 1

Sample Characteristics: Convincing History (Hx) vs Physician (Dr) Diagnosis Only

Characteristic	Total sample (n = 2692)	Convincing Hx with/without Dr diagnosis (n = 2189)	Dr diagnosis without convincing Hx (n = 503)	Difference (95% CI)
Age (y), mean (SD)	18.7 (16.0)	19.0 (16.3)	17.7 (14.8)	1.3 (−0.2, 2.7)
Children (<18 y), %	65.1%	64.6%	67.2%	−2.6% (−7.2%, 2.0%)
Female, % (n)	51.0% (n = 2,679)	52.0% (n = 2,177)	46.2% (n = 502)	5.8% (1.0%, 10.7%)
Non-White race and ethnicity, % (n)	21.0% (n = 2,653)	21.3% (n = 2,162)	19.6% (n = 491)	1.8% (−2.2%, 5.7%)
Household with any postsecondary education, % (n)	96.8%, (n = 2,494)	96.9%, (n = 2,030)	95.9%, (n = 464)	1.0% (−0.8%, 2.9%)
Household income ≥100K, % (n)	57.9% (n = 1,978)	58.4% (n = 1,629)	55.9%, (n = 349)	2.5% (−3.3%, 8.4%)
Region of residence, %				
Atlantic Canada	4.8%	4.8%	4.4%	0.4% (−1.7%, 2.5%)
Ontario	34.2%	34.6%	32.6%	2.0% (−2.8%, 6.8%)
Quebec	34.8%	33.6%	39.7%	−6.1% (−11.1%, −1.1%)
Western Canada	26.0%	26.7%	23.3%	3.4% (−0.9%, 7.8%)
Territories	0.2%	0.3%	0.0%	0.3% (−0.04%, 0.6%)
Current food allergies reported, %				
Peanut	65.6%	65.1%	67.4%	−2.3% (−6.8%, 2.3%)
Tree nut	49.4%	51.0%	42.5%	8.5% (3.6%, 13.3%)
Sesame	13.2%	14.1%	8.9%	5.2% (2.3%, 8.1%)
Milk/dairy	21.1%	22.8%	13.9%	8.9% (5.4%, 12.4%)
Egg	21.8%	23.4%	14.7%	8.7% (5.1%, 12.3%)
Fish	10.7%	11.3%	8.3%	2.9% (0.2%, 5.7%)
Crustaceans or molluscs	15.5%	16.4%	11.7%	4.7% (1.5%, 7.9%)
Soy	9.3%	9.4%	8.7%	0.7% (−2.1%, 3.4%)
Wheat/Triticale	8.9%	7.8%	13.5%	−5.7% (−9.0%, −2.4%)
Mustard	3.5%	3.7%	2.6%	1.1% (−0.5%, 2.7%)
Number of food allergies reported, mean (SD)	2.6 (1.8)	2.7 (1.9)	2.2 (1.6)	0.5 (0.3, 0.6)
Atopic comorbidities, %				
Asthma	49.5%	50.5%	45.1%	5.4% (0.5%, 10.3%)
Eczema	59.9%	60.4%	57.5%	3.0% (−1.8%, 7.8%)
Hay fever or allergic rhinitis	46.2%	47.2%	41.7%	5.4% (0.5%, 10.3%)
Hives	44.8%	46.5%	37.6%	8.9% (4.1%, 13.7%)
General good health (self-reported good/very good/excellent), %	89.5%	89.1%	91.3%	−2.2% (−5.1%, 0.7%)
Reaction in past year, %	52.1%	56.2%	34.2%	22.0% (17.3%, 26.8%)

Abbreviation: CI, confidence interval.

NOTE. Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.

Higher indirect costs were associated with higher age (β , \$203; 95% CI, \$141–\$265), lower education (β , \$10,503; 95% CI, \$4440–\$16,566), lower household income (β , \$6661; 95% CI, \$4466–\$8856), and fair or poor general health (β , \$3852; 95% CI, \$680–\$7024).

Total Costs per Food Allergy-Individual

Total mean annual costs per FA-individual are \$11,259, comprised of healthcare (including transportation) of \$1267, out-of-pocket of \$2136, and indirect costs of \$7950 (note: sum of component costs does not equal total mean cost because the *n*'s for the components differ; healthcare and out-of-pocket costs [*n* = 2596], indirect costs [*n* = 2474]). Per FA-individual, indirect costs are responsible for 71% of total costs (\$7950 of \$11,259), and costs from unpaid labor account for 85% of total indirect costs (\$6742 of \$7950). Out-of-pocket expenditures make up 63% of direct costs (\$2136 of \$3403), and special diets and allergen-free foods account for 58% of out-of-pocket expenditures (\$1243 of \$2136) (Fig 2).

Economic Burden of Food Allergy in Canada

When our sample was weighted to reflect the distribution of the population of FA-individuals in Canada, it had a higher proportion of adults (78.8% vs 34.9%), and lower proportion of households with postsecondary education (85.6% vs 96.8%) and annual income of \$100,000 or more (35.5% vs 57.9%). After weighting, the healthcare (\$1225) and out-of-pocket costs (\$2104) per FA-individual changed little, whereas the indirect costs increased 2-fold (\$14,817). When weighted costs are multiplied by the Canadian FA prevalence of 6.1%⁵⁰ (FA defined as self-report of convincing history or a physician diagnosis), the total annual economic burden of FA is approximately \$41.9 billion, comprised of healthcare costs of \$2.8 billion, out-of-

pocket costs of \$4.9 billion, and indirect costs of \$34.4 billion (Table 6). If the additional 3.2% of Canadians self-reporting FA but without a convincing history or a physician diagnosis are included,⁵⁰ the total annual economic burden increases to \$63.9 billion (healthcare costs \$4.3 billion, out-of-pocket costs \$7.4 billion, indirect costs \$52.4 billion).

Discussion

The costs of FA are substantial, particularly indirect costs related to lost time in unpaid labor, which accounted for 60% of the total costs (\$6742 of \$11,259). Costs not directly related to health care (ie, out-of-pocket and indirect costs) substantially exceeded healthcare costs (\$10,086 vs \$1267). FA-related healthcare costs (\$1267) and indirect costs from paid labor (\$1208) were reasonably similar to Canadian estimates for asthma (\$1208 and \$807).⁵² FA-related costs impose a considerable burden on the Canadian healthcare system and affected families, with the total economic burden ranging from \$41.9–\$63.9 billion, depending on whether those self-reporting FA without a convincing history or physician diagnosis are included. Although this latter amount is likely an overestimate because these individuals likely utilize fewer healthcare services, it provides an upper bound because they likely incur expenses related to allergen-avoidance behaviors. This estimate also underscores the potential cost savings if individuals suspecting they have FA received an accurate diagnosis.

To the best of our knowledge, our study is unique in its comparison of direct and indirect cost components stratified by reaction severity and age. We demonstrated that many healthcare and out-of-pocket costs are higher among those with severe FA and FA-children. For indirect costs, total lost productivity in paid labor and nonfood-related unpaid labor is higher in FA-adults than in FA-children.

Table 2

Sample Characteristics: Convincing History or Physician Diagnosis Stratified by

1) ≥1 severe symptom vs mild and/or moderate symptoms or no reaction

2) children vs adults

Characteristic	≥ 1 Severe Symptom (n = 1020)	Mild/Moderate Symptoms or No Reaction (n = 1672)	Difference (95% CI)	Children (n = 1752)	Adults (n = 940)	Difference (95% CI)
Age (y), mean (SD)	21.6 (17.4)	16.9 (14.9)	4.7 (3.4, 6.0)	9.3 (4.8)	36.4 (14.7)	−27.1 (−28.1, −26.1)
Children (<18 y), %	57.8%	69.5%	−11.7% (−15.5%, −7.9%)	100%	0%	
Female, % (n)	55.3% (n = 1015)	48.3% (n = 1664)	7.0% (3.1%, 10.8%)	40.3% (n = 1743)	70.8% (n = 936)	−30.6% (−34.3%, −26.8%)
Non-White race and ethnicity, % (n)	21.7% (n = 1008)	20.5% (n = 1645)	1.2% (−2.1%, 4.4%)	24.1% (n = 1722)	15.3% (n = 931)	8.8% (5.8%, 11.9%)
Household with any postsecondary education, % (n)	95.9% (n = 936)	97.2% (n = 1558)	−1.3% (−2.8%, 0.2%)	97.6% (n = 1609)	95.1% (n = 885)	2.5% (0.8%, 4.1%)
Household income ≥\$100K, % (n)	53.8% (n = 757)	60.5% (n = 1221)	−6.8% (−11.4%, −2.1%)	65.0% (n = 1292)	44.6% (n = 686)	20.4% (15.9%, 24.9%)
Region of residence, %						
Atlantic Canada	4.4%	5.0%	−0.5% (−2.2%, 1.1%)	5.0%	4.3%	0.8% (−0.9%, 2.5%)
Ontario	38.6%	31.5%	7.0% (3.1%, 11.0%)	33.1%	36.2%	−3.1% (−7.1%, 0.8%)
Quebec	29.5%	38.0%	−8.5% (−12.3%, −4.6%)	35.1%	34.2%	0.9% (−2.9%, 4.7%)
Western Canada	27.4%	25.2%	2.2% (−1.5%, 5.8%)	26.7%	24.9%	1.8% (−1.7%, 5.3%)
Territories	0.1%	0.3%	−0.2% (−0.7%, 0.2%)	0.1%	0.4%	−0.3% (−1.0%, 0.4%)
Current food allergies reported, %						
Peanut	66.1%	65.3%	0.8% (−2.9%, 4.5%)	73.5%	50.7%	22.8% (18.9%, 26.6%)
Tree nut	54.8%	46.2%	8.6% (4.7%, 12.6%)	51.4%	45.9%	5.5% (1.5%, 9.5%)
Sesame	14.7%	12.2%	2.5% (−0.2%, 5.2%)	15.4%	9.0%	6.3% (3.8%, 8.9%)
Milk/dairy	27.3%	17.4%	9.9% (6.5%, 13.2%)	24.3%	15.3%	8.9% (5.9%, 12.0%)
Egg	23.7%	20.6%	3.1% (−0.2%, 6.4%)	27.2%	11.7%	15.5% (12.6%, 18.5%)
Fish	12.7%	9.5%	3.2% (0.8%, 5.7%)	9.2%	13.6%	−4.4% (−7.0%, −1.9%)
Crustaceans or molluscs	18.5%	13.7%	4.8% (1.9%, 7.8%)	10.6%	24.7%	−14.1% (−17.2%, −10.9%)
Soy	12.9%	7.1%	5.9% (3.5%, 8.3%)	7.4%	12.9%	−5.5% (−8.0%, −3.0%)
Wheat/Triticale	11.2%	7.5%	3.7% (1.4%, 6.0%)	7.8%	11.0%	−3.2% (−5.5%, −0.9%)
Mustard	5.0%	2.6%	2.4% (0.9%, 4.0%)	3.4%	3.6%	−0.2% (−1.7%, 1.3%)
Number of food allergies reported, mean (SD)	3.0 (2.0)	2.3 (1.7)	0.6 (0.5, 0.8)	2.6 (1.8)	2.6 (1.9)	0.0 (−0.1, 0.2)
Atopic comorbidities, %						
Asthma	62.6%	41.5%	21.1% (17.3%, 25.0%)	47.3%	53.6%	−6.3% (−10.3%, −2.3%)
Eczema	60.6%	59.4%	1.1% (−2.7%, 5.0%)	67.2%	46.2%	21.1% (17.1%, 25.0%)
Hay fever or allergic rhinitis	54.4%	41.1%	13.3% (9.4%, 17.1%)	39.4%	58.8%	−19.4% (−23.3%, −15.6%)
Hives	53.7%	39.4%	14.4% (10.5%, 18.2%)	45.6%	43.3%	2.3% (−1.6%, 6.2%)
General good health (self-reported good/very good/excellent), %	85.0%	92.2%	−7.2% (−9.8%, −4.7%)	91.6%	85.5%	6.1% (3.5%, 8.7%)
Reaction in past year, %	63.8%	45.0%	18.8% (15.0%, 22.7%)	50.6%	54.9%	−4.3% (−8.2%, −0.3%)

Abbreviation: CI, confidence interval.

NOTE. Significant differences in bold. Difference (95% CI) based on *t* statistics adjusted for household clusters.

Table 3

Healthcare and Out-of-Pocket Costs (2020 CAD): Convincing History or Physician Diagnosis Stratified By

1) ≥ 1 severe symptom vs mild and/or moderate symptoms or no reaction

2) children vs adults

Component	≥ 1 severe symptom (n = 979)		Mild and/or moderate symptoms or no reaction (n = 1617)		Difference (95% CI)	Children (n = 1677)		Adults (n = 919)		Difference (95% CI)
	Mean cost	% of total	Mean cost	% of total		Mean cost	% of total	Mean cost	% of total	
Total healthcare costs + out-of-pocket expenditures	\$4227		\$2904		\$1323 (\$823, \$1822)	\$3833		\$2617		\$1216 (\$770, \$1662)
Total healthcare costs	\$1647	39.0%	\$1037	35.7%	\$610 (\$447, \$773)	\$1393	36.3%	\$1038	39.7%	\$355 (\$200, \$510)
Total out-of-pocket expenditures	\$2579	61.0%	\$1867	64.3%	\$712 (\$269, \$1156)	\$2440	63.7%	\$1579	60.3%	\$860 (\$471, \$1250)
Healthcare component										
Visits to physicians	\$264	16.0%	\$195	18.8%	\$69 (\$46, \$92)	\$256	18.4%	\$157	15.1%	\$99 (\$77, \$121)
Visits to other health practitioners	\$103	6.3%	\$61	5.9%	\$42 (\$23, \$62)	\$67	4.8%	\$94	9.1%	-\$27 (-\$48, -\$6)
Laboratory, diagnostic, or therapeutic procedures	\$118	7.2%	\$92	8.8%	\$27 (\$12, \$42)	\$129	9.3%	\$52	5.0%	\$77 (\$64, \$91)
Oral immunotherapy/ desensitization	\$110	6.7%	\$82	7.9%	\$28 (-\$0.005, \$55)	\$118	8.5%	\$46	4.4%	\$72 (\$48, \$96)
Emergency department visits	\$152	9.3%	\$53	5.1%	\$99 (\$78, \$121)	\$89	6.4%	\$94	9.0%	-\$5 (-\$26, \$16)
Inpatient admissions	\$226	13.7%	\$56	5.4%	\$170 (\$67, \$273)	\$99	7.1%	\$160	15.4%	-\$61 (-\$158, \$35)
Inpatient admissions for patients with an admission (n)	\$4556 (n = 48)		\$2641 (n = 34)		\$1915 (\$157, \$3672)	\$3312 (n = 50)		\$4464 (n = 32)		-\$1152 (-\$3434, \$1131)
Epinephrine autoinjectors obtained	\$284	17.3%	\$248	23.9%	\$37 (\$21, \$53)	\$320	23.0%	\$155	14.9%	\$165 (\$151, \$178)
Medications (excluding epinephrine autoinjectors)	\$359	21.8%	\$231	22.3%	\$127 (\$88, \$167)	\$291	20.9%	\$259	24.9%	\$32 (-\$5, \$69)
Transportation for healthcare services, excluding ambulance	\$31	1.9%	\$20	1.9%	\$11 (\$8, \$14)	\$25	1.8%	\$21	2.0%	\$4 (\$1, \$7)
Out-of-pocket component										
Nontraditional medicines	\$71	2.7%	\$42	2.3%	\$28 (-\$4, \$60)	\$49	2.0%	\$61	3.8%	-\$12 (-\$43, \$19)
Special diets and allergen-free foods	\$1415	54.9%	\$1139	61.0%	\$276 (\$53, \$498)	\$1265	51.8%	\$1203	76.2%	\$62 (-\$170, \$294)
Additional child care	\$478	18.5%	\$403	21.6%	\$75 (-\$194, \$344)	\$668	27.4%	\$N/A	N/A%	\$668 (\$463, \$873)
Legal guidance	\$12	0.5%	\$4	0.2%	\$7 (-\$7, \$22)	\$11	0.5%	\$0.1	0.0%	\$11 (\$2, \$20)
Mental health services	\$99	3.8%	\$51	2.7%	\$48 (\$11, \$85)	\$67	2.7%	\$72	4.6%	-\$5 (-\$41, \$31)
Change in school	\$180	7.0%	\$61	3.3%	\$119 (\$9, \$228)	\$164	6.7%	\$N/A	N/A%	\$164 (\$85, \$242)
Other out-of-pocket expenditures	\$325	12.6%	\$166	8.9%	\$160 (\$18, \$301)	\$216	8.9%	\$243	15.4%	-\$26 (-\$164, \$111)

Abbreviation: CI, confidence interval.

NOTE. Significant differences in bold. Difference (95% CI) between groups based on t statistics adjusted for household clusters.

Table 4

Indirect Costs (2020 CAD): Convincing History or Physician Diagnosis Stratified By

1) ≥1 severe symptom vs mild or moderate symptoms or no reaction

2) children vs adults

Component	≥1 Severe symptom (n = 922)		Mild or moderate symptoms or no reaction (n = 1552)		Difference (95% CI)	Children (n = 1589)		Adults (n = 885)		Difference (95% CI)
	Mean cost	% of total	Mean cost	% of total		Mean cost	% of total	Mean cost	% of total	
Estimate # 1										
Total lost productivity - paid labor and nonfood –related unpaid labor, mean	\$8647		\$7536		\$1111 (–\$867, \$3090)	\$4173		\$14,732		–\$10,559 (–\$12,524, –\$8594)
Lost paid labor, mean	\$2045	24%	\$711	9%	\$1334 (–\$313, \$2980)	\$259	6%	\$2912	20%	–\$2654 (–\$4318, –\$989)
Lost unpaid labor - restricted to nonfood –related activities, mean	\$6603	76%	\$6825	91%	–\$222 (–\$1488, \$1044)	\$3914	94%	\$11,820	80%	–\$7905 (–\$9054, –\$6756)
Estimate # 2										
Total lost productivity - paid labor and upper bound of nonfood–related or food-related activities, mean	\$18,220		\$15,753		\$2467 (\$593, \$4340)	\$14,987		\$19,698		–\$4711 (–\$6559, –\$2864)
Lost paid labor, mean	\$2045	11%	\$711	5%	\$1334 (–\$313, \$2980)	\$259	2%	\$2912	15%	–\$2654 (–\$4318, –\$989)
Lost unpaid labor - upper bound of nonfood –related or food-related activities, mean	\$16,175	89%	\$15,042	95%	\$1133 (\$319, \$1947)	\$14,728	98%	\$16,786	85%	–\$2058 (–\$2780, –\$1336)

Abbreviation: CI, confidence interval.

NOTE. Significant differences in bold. Difference (95% CI) between groups based on t statistics adjusted for household clusters.

Table 5

Characteristics Associated With Healthcare, Out-of-Pocket, and Indirect Costs

Characteristic	Healthcare costs		Out-of-pocket expenses		Indirect costs	
	Coefficient	95% Confidence Interval	Coefficient	95% Confidence Interval	Coefficient	95% Confidence Interval
Sociodemographics						
Age (y)	–18	(–23, –14)	–34	(–47, –22)	203	(141, 265)
Female	83	(–31, 196)	–71	(–513, 372)	492	(–1436, 2420)
Non-White race and ethnicity	181	(16, 346)	—	—	—	—
Postsecondary education ^a	—	—	—	—	–10,503	(–16,566, –4440)
Income ≥\$100K ^a	—	—	—	—	–6661	(–8856, –4466)
Region of residence						
Atlantic Canada and territories ^b	—	—	—	—	—	—
Ontario	—	—	—	—	—	—
Quebec	—	—	–1241	(–1644, –839)	—	—
Western Canada	—	—	—	—	—	—
Allergic characteristics						
Reaction in past year	489	(390, 587)	—	—	—	—
Severe reaction ever	348	(230, 465)	471	(8, 934)	—	—
Number of food allergies reported	183	(128, 237)	414	(268, 560)	—	—
Atopic comorbidity ^c	314	(208, 420)	—	—	—	—
General health status						
General good health (self-reported good/very good/excellent)	–1127	(–1464, –789)	–845	(–1548, –141)	–3852	(–7024, –680)

NOTE. Empty cells indicate variable was not included in the model.

Significant variables in bold.

Abbreviation: CI, confidence interval.

^aMissing value indicator was used for those who did not provide education or household income.^bThese regions were combined because of fewer respondents.^cDiagnosed comorbidity ever.

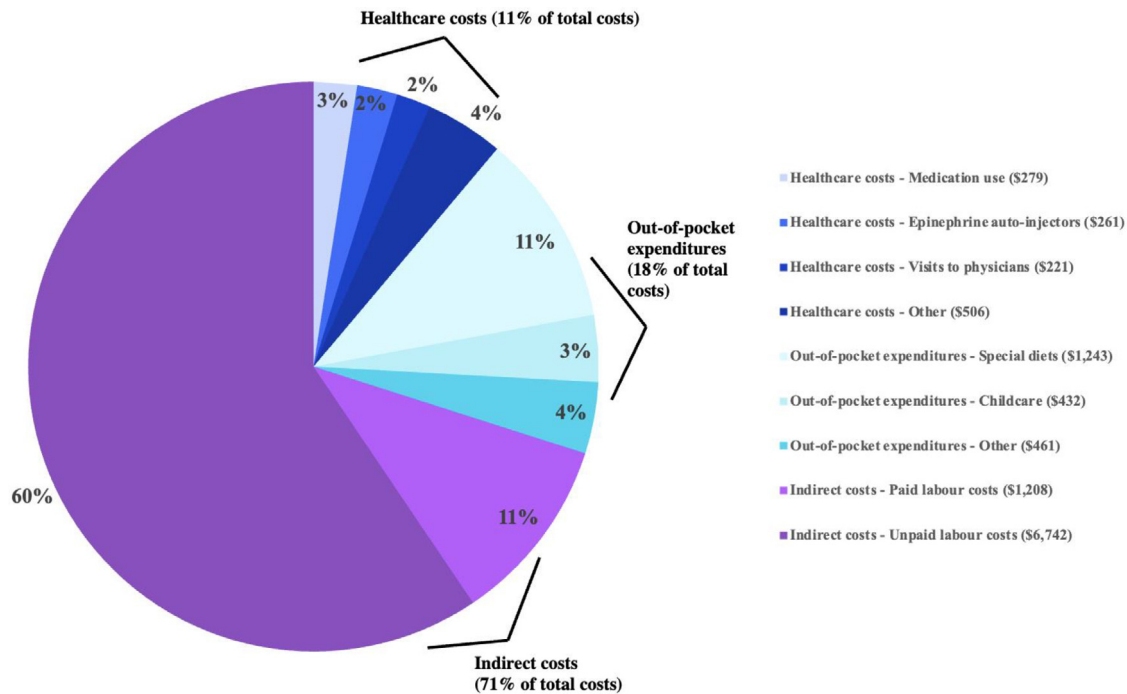


Figure 2. Breakdown of total mean annual costs (\$11,259^a 2020 CAD) per FA-Individual by Healthcare Costs (\$1267), Out-of-Pocket Expenditures (\$2136), and Indirect Costs (\$7950). Note: the sum of the component costs does not equal the total cost, because the n's for the components differ; healthcare and out-of-pocket costs (n = 2596), indirect costs (n = 2474).

However, for lost unpaid labor related to food-related activities, caregivers of FA-children spend more time on food preparation and grocery shopping than FA-adults (data not shown); hence, the difference between the upper bound for indirect costs due to unpaid labor from nonfood-related or food-related activities for adults compared with children is much smaller, although still significant (difference, −\$2058; 95% CI, −\$2780 to −\$1336).

Our findings in multivariable analysis that having a reaction in the past year, severe reaction ever, multiple FAs, and atopic comorbidities were associated with higher healthcare costs and a severe reaction ever and multiple FAs with higher out-of-pocket costs corroborate clinical experience. It is possible that higher healthcare costs in those with atopic comorbidities are partially related to the respondent misattributing costs that are related to an atopic condition to FA. Our findings are consistent with previous studies demonstrating an association between FA severity and higher healthcare⁷ and out-of-pocket costs.^{8,9} Although previous studies report both positive¹⁴ and negative⁴ associations between income and healthcare⁴ and out-of-pocket costs,^{4,14} we found no association between income and healthcare or out-of-pocket costs. This is unsurprising, given most Canadian healthcare services are publicly funded.

No FA-related clinical variables were associated with indirect costs, although self-reported fair or poor health was associated with higher direct, out-of-pocket, and indirect costs. Although postsecondary education and income of \$100,000 or more were associated with lower indirect costs, these variables are likely predictors of respondents' ability to participate in paid and unpaid labor generally, and may be independent of their FA status. Those in Quebec were more likely to incur lower out-of-pocket expenses because overall cost-of-living is lower in Quebec than in other Canadian regions.^{53–55} This was observed particularly for childcare expenses (approximately 20% of out-of-pocket expenditures) in Quebec vs other Canadian regions (\$153 vs \$573; difference, −\$419; 95% CI, −\$626 to −\$212).

Our data add to a growing body of work describing the economic burden of FA^{1–15} and allergic disease more broadly.^{5,52,56–59} Our methodology is similar to most previous cost-of-illness studies, which developed estimates through surveying affected individuals or families.^{2,4,6–9,11,13,14} Although administrative databases generally allow for inclusion of larger numbers of affected individuals and validation of healthcare utilization,^{3,5,10} they are limited by potential diagnostic inaccuracies and do not allow for inclusion of indirect costs. Although several studies provide estimates that include only

Table 6
Unweighted and Weighted Healthcare, Out-of-Pocket and Indirect Costs, and Total Economic Burden of FA in Canada (2020 CAD)

Cost component	Unweighted cost per FA-individual		Weighted cost per FA-individual		Weighted Economic Burden (FA prevalence of 6.1%) ^{a,47}		Weighted Economic Burden – upper Bound (FA prevalence of 9.3%) ^{a,47}	
	Mean	95% CI ^b	Mean	95% CI ^b	Mean	95% CI ^b	Mean	95% CI ^b
Healthcare costs	\$1267	\$1197, \$1338	\$1225	\$1018, \$1432	\$2.8	\$2.4, \$3.3	\$4.3	\$3.6, \$5.1
Out-of-pocket costs	\$2136	\$1914, \$2357	\$2104	\$1616, \$2592	\$4.9	\$3.8, \$6.0	\$7.4	\$5.7, \$9.2
Indirect costs	\$7950	\$6981, \$8920	\$14,817	\$12,391, \$17,243	\$34.4	\$28.8, \$40.0	\$52.4	\$43.8, \$61.0
Total costs	\$11,259	\$10,254, \$12,264	\$18,066	\$15,492, \$20,640	\$41.9	\$35.9, \$47.9	\$63.9	\$54.8, \$73.0

Abbreviation: CI, confidence interval.

^an = 38,037,204, July 1, 2020.⁵¹

^b95% CI were calculated using robust standard errors.

healthcare^{3,5,7,10} or out-of-pocket^{8,9,11,14} costs, there are few that provide comprehensive direct-cost estimates.² Several studies estimate indirect costs,^{2,3,8–11,14} but many fail to include lost productivity in unpaid labor.^{2,3,10} Our study addresses these limitations by recruiting a large national sample of children and adults with FA from clinics, research registries, and FA advocacy associations to provide a comprehensive estimate of economic burden, including healthcare, out-of-pocket, and paid and unpaid labor costs.

Although direct comparisons with previous FA studies are difficult due to differences in healthcare delivery and financing, social systems and cost-of-living¹⁴, varying methodological approaches, and inconsistent inclusion of cost components and populations, we believe our study may be most directly comparable to a US study by Gupta et al,² because we modeled our economic survey after theirs. They surveyed 1643 caregivers of FA-children and estimated total annual costs of \$6595 (2020 CAD), comprised of healthcare costs (including co-pays and medications) of \$1593, out-of-pocket expenditures of \$1024, and indirect costs from lost paid labor and opportunity costs of \$3978.⁶⁰ We estimated total costs among children of \$8615, comprised of healthcare costs of \$1599, out-of-pocket expenditures of \$2589, and indirect costs from lost paid labor of \$1504 and unpaid labor of \$3031. Although our total estimate of FA among children (\$8615) is higher than that of Gupta et al (\$6595), we also included indirect costs from unpaid labor. Our healthcare costs are comparable because although our utilization rate for services reported by Gupta et al (eg, physicians, ED visits, inpatient admissions) is higher, our prices for these healthcare services are lower.² Our higher estimate of out-of-pocket costs may reflect the greater availability of FA resources since the study by Gupta et al, and the subjective nature of reporting out-of-pocket costs. Our lower estimate for indirect costs from lost paid labor likely reflects differing methods of ascertaining opportunity costs.

Our study has several limitations. First, our FA diagnosis is based on self-report of a convincing history or physician diagnosis. Although patients were not diagnosed on the basis of a food challenge, their behavior is likely related to their perception of having FA, and costs are unlikely to be higher than those with a confirmed diagnosis. Second, self-reporting healthcare use and out-of-pocket expenditures is subject to misattribution and recall bias and may result in inclusion of costs unrelated to FA. Third, reliably measuring time lost in paid and unpaid labor directly attributable to FA is challenging. We have estimated indirect costs by comparing time in paid and unpaid labor between FA-individuals and the general population. Our indirect cost methodology is limited by the assumption that the FA-population has the same distribution of demographics and comorbidities as the general population. Furthermore, we used national estimates of time spent in paid and unpaid labor for the Canadian population although they may vary by region. Nevertheless, this approach likely provides a more reliable estimate than comparing self-reported productivity with the respondent's expectations of productivity if they were unaffected by FA. Moreover, assigning an accurate fraction of out-of-pocket expenditures and of the respondent's productivity losses to multiple FA-individuals within the same household can be challenging. Assuming equal distribution like we did may be imperfect, but is likely the best approach in the absence of further information, which would have been difficult to obtain.

An additional limitation is that our population may not be representative of the general population of Canadians with FA. Individuals recruited from advocacy associations may utilize more healthcare resources and supports than the general population, which may result in overestimation of costs. Unfortunately, we could not identify which individuals were recruited through advocacy associations because respondents may have been recruited through multiple sources, and therefore, we could not compare the costs of individuals recruited through FA associations with the rest of our sample. Furthermore, we could not accurately estimate a response rate. Certain

out-of-pocket expenditures (eg, legal guidance, mental health services) may also not be utilized by the general population with FA, and hence may represent an upper bound. Although our sample may not represent the Canadian population with FA, we adjusted partly for this by weighting our data so our sample composition was comparable to the Canadian population of FA-individuals in terms of demographics.⁵⁰ Weighting alters our sample characteristics, increasing the age and lowering the proportion with postsecondary education and higher income. Therefore, indirect costs increased 2-fold because, as shown in the regression, higher age and lower household education and income were associated with higher indirect costs.

Our findings show that FA in Canada places a substantial economic burden on individuals and society. Ensuring that those most adversely affected by FA are allocated resources to best support disease management is critical to reducing the burden of FA.

Supplementary Data

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.anai.2022.05.014>.

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Supplementary Data

eTable 1

Signs or Symptoms Associated With Mild, Moderate, and Severe Food Allergy Reactions

Severity of reaction	Signs or symptoms
Mild	Hives, itching, rash, redness and/or flushing, perioral redness, oral pruritus/tingling, nasal congestion, feeling of impending doom, sneezing
Moderate	Swelling (eg, lip and/or tongue), difficulty swallowing, hoarseness, throat tightening, drooling/phlegm, chest tightening, repetitive cough, trouble breathing, abdominal pain, cramps, diarrhea, nausea, vomiting, chest pain, tachycardia
Severe	Wheezing, fainting and/or dizziness, hypotension, cyanosis

eTable 2

Direct Costs Calculations

Healthcare component	Source of unit cost
Visits to physicians	Ontario ¹ and Quebec ² physician fee schedules ^a
Visits to other health practitioners	Review of relevant Canadian websites
Emergency department visits, including ambulance	CIHI
Laboratory, diagnostic, or therapeutic procedures (including food challenge)	Ontario and Quebec fee schedules for physician reimbursement; CIHI's Comprehensive Ambulatory Classification System for hospital expenses ³
Oral immunotherapy and/or desensitization	Survey of Canadian allergists ⁴
Inpatient admissions	Length of stay multiplied by the cost per inpatient day, with adjustments based on CIHI Case-Mix Group method ^b ; Ontario and Quebec fee schedules for physician reimbursement
Medications	Quebec ² List of medications, generic prices were used when possible (average Canadian medication prices were derived by multiplying Quebec-based costs by the ratio of a combined Canadian 15-city average price index for health care to the corresponding Montréal price index ⁵)

Abbreviation: CIHI, Canadian Institute for Health Information.

^aProvinces were chosen because they are the 2 most populous and represent high- and low-cost regions.^bAdjusting for complexity through resource intensity weights linked with admission diagnosis.**eTable 3**

Breakdown of Household Respondent Categories

Household respondent category	% of household respondents (n = 2308)
Caregiver of a child with food allergy only	54.5
Adult reporting their own food allergy only	23.6
Caregiver of a child with food allergy also reporting their own allergy	9.6
Adult reporting for another adult with food allergy only	5.8
Caregiver of a child with food allergy also reporting for another adult with food allergy	3.6
Caregiver of a child with food allergy also reporting for their own allergy and another adult with food allergy	1.5
Adult with food allergy also reporting for another adult with food allergy	1.4

eTable 4

Healthcare Utilization Stratified by
 1) convincing history or physician diagnosis
 2) reaction vs no reaction in past year

Component	Convincing Hx with/without Dr diagnosis (n = 2111)	Dr diagnosis without convincing Hx (n = 485)	Difference (95% CI)	Reaction in past year (n = 1340)	No reaction in past year (n = 1256)	Difference (95% CI)
Healthcare component						
Visits to physician per patient, mean (SD)	2.4 (3.4)	2.1 (3.0)	0.3 (−0.05, 0.6)	3.1 (3.9)	1.4 (2.2)	1.7 (1.5, 2.0)
Patients with a visit to physician, %	70.3%	70.9%	−0.7% (−5.2%, 3.9%)	77.5%	62.8%	14.6% (11.0%, 18.2%)
Visits per patient using service, mean (SD)	3.4 (3.6)	3.0 (3.2)	0.4 (0.01, 0.8)	4.1 (4.0)	2.3 (2.4)	1.8 (1.5, 2.1)
Visits to other healthcare practitioner per patient, mean (SD)	0.7 (2.2)	0.7 (2.4)	0.0 (−0.2, 0.3)	1.0 (2.6)	0.5 (1.7)	0.5 (0.3, 0.7)
Patients with a visit to other healthcare practitioner, %	18.3%	16.9%	1.4% (−2.4%, 5.1%)	23.2%	12.5%	10.7% (7.7%, 13.7%)
Visits per patient using service, mean (SD)	4.0 (3.6)	4.1 (4.5)	−0.2 (−1.2, 0.9)	4.2 (3.9)	3.7 (3.5)	0.5 (−0.2, 1.2)
Laboratory, diagnostic, or therapeutic procedure per patient, mean (SD)	1.6 (2.3)	1.6 (2.4)	0.0 (−0.2, 0.2)	2.0 (2.6)	1.2 (1.9)	0.8 (0.6, 1.0)
Patients with a laboratory, diagnostic, or therapeutic procedure, %	56.7%	59.0%	−2.3% (−7.2%, 2.6%)	64.3%	49.4%	14.9% (11.0%, 18.8%)
Procedures per patient using service, mean (SD)	2.8 (2.4)	2.7 (2.7)	0.1 (−0.2, 0.5)	3.1 (2.6)	2.3 (2.1)	0.7 (0.5, 1.0)
Patients with oral immunotherapy/desensitization, %	7.5%	4.5%	3.0% (0.9%, 5.1%)	9.5%	4.3%	5.2% (3.2%, 7.1%)
Visits to ED per patient, mean (SD)	0.3 (0.9)	0.2 (0.6)	0.1 (0.1, 0.2)	0.6 (1.1)	0.0 (0.3)	0.6 (0.5, 0.6)
Patients with an ED visit, %	20.8%	13.6%	7.2% (3.7%, 10.7%)	34.9%	2.9%	32.0% (29.2%, 34.7%)
Visits per patient using service, mean (SD)	1.7 (1.2)	1.6 (0.9)	0.1 (−0.2, 0.3)	1.7 (1.2)	1.3 (1.0)	0.4 (0.04, 0.7)
Inpatient admissions per patient, mean (SD)	0.04 (0.3)	0.04 (0.2)	0.01 (−0.01, 0.03)	0.08 (0.37)	0.00 (0.03)	0.08 (0.06, 0.1)
Patients with an inpatient admission, %	3.2%	2.9%	0.3% (−1.3%, 2.0%)	6.0%	0.1%	6.0% (4.7%, 7.3%)
Admissions per hospitalized patient, mean (SD)	1.4 (0.8)	1.2 (0.6)	0.1 (−0.2, 0.5)	1.3 (0.8)	1.0 (0.0)	0.3 (0.2, 0.5)
Length of stay per admission, ^a mean (SD)	2.1 (2.7)	2.6 (2.4)	−0.5 (−1.9, 0.8)	2.2 (2.7)	1.0 (0.0)	1.2 (0.6, 1.9)
Epinephrine autoinjectors per patient, mean (SD)	2.8 (2.1)	2.6 (2.1)	0.3 (0.1, 0.5)	2.7 (2.2)	2.9 (2.0)	−0.2 (−0.3, −0.003)
Patients with an epinephrine autoinjector, %	84.1%	77.1%	7.0% (2.9%, 11.1%)	80.4%	85.4%	−4.9% (−7.9%, −1.9%)
Epinephrine autoinjectors per patient obtaining autoinjector, mean (SD)	3.4 (1.9)	3.3 (1.9)	0.1 (−0.1, 0.3)	3.4 (1.9)	3.4 (1.8)	−0.004 (−0.2, 0.2)
Patients using medications (excluding epinephrine autoinjectors), %	71.3%	61.2%	10.1% (5.3%, 14.8%)	88.3%	49.3%	39.0% (35.7%, 42.3%)
Out-of-pocket component						
Patients using nontraditional medicines, %	11.2%	9.5%	1.7% (−1.4%, 4.8%)	14.5%	7.0%	7.5% (5.0%, 9.9%)
Patients using special diets and allergen, free foods, %	76.8%	76.3%	0.5% (−3.8%, 4.8%)	80.3%	72.9%	7.4% (4.1%, 10.8%)
Patients using additional child care, %	10.1%	7.8%	2.3% (−0.4%, 5.0%)	13.0%	6.2%	6.8% (4.5%, 9.1%)
Patients using legal guidance, %	0.5%	0.4%	0.1% (−0.6%, 0.7%)	0.5%	0.4%	0.1% (−0.4%, 0.7%)
Patients using mental health services, %	8.0%	7.8%	0.1% (−2.6%, 2.9%)	9.3%	6.4%	2.9% (0.8%, 5.0%)
Patients changing schools, %	1.8%	1.2%	0.6% (−0.6%, 1.7%)	1.9%	1.4%	0.5% (−0.5%, 1.5%)
Patients using other out-of-pocket expenditures, %	24.5%	21.9%	2.7% (−1.5%, 6.9%)	26.8%	21.1%	5.7% (2.3%, 9.1%)

Abbreviation: CI, confidence interval; ED, emergency department.

NOTE. Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.

^aCalculated as a weighted average.

eTable 5

Healthcare and Out-of-Pocket Costs (2,020 CAD) Stratified by

1) convincing history or physician diagnosis

2) reaction vs no reaction in past year

Component	Convincing Hx with/without Dr diagnosis (n = 2111)		Dr diagnosis without convincing Hx (n = 485)		Difference (95% CI)	Reaction in past year (n = 1340)		No reaction in past year (n = 1256)		Difference (95% CI)
	Mean cost	% of total	Mean cost	% of total		Mean cost	% of total	Mean cost	% of total	
Total healthcare costs + out-of-pocket expenditures	\$3440		\$3241		\$199 (−\$465, \$862)	\$4195		\$2557		\$1638 (\$1159, \$2117)
Total healthcare costs	\$1303	37.9%	\$1112	34.3%	\$191 (\$22, \$361)	\$1706	40.7%	\$800	31.3%	\$906 (\$774, \$1037)
Total out-of-pocket expenditures	\$2137	62.1%	\$2130	65.7%	\$7 (−\$585, \$599)	\$2490	59.3%	\$1758	68.7%	\$732 (\$296, \$1168)
Healthcare component										
Visits to physicians	\$225	17.2%	\$204	18.4%	\$20 (−\$5, \$46)	\$286	16.8%	\$151	18.9%	\$135 (\$115, \$156)
Visits to other health practitioners	\$78	6.0%	\$73	6.6%	\$4 (−\$20, \$28)	\$102	6.0%	\$50	6.3%	\$51 (\$34, \$69)
Laboratory, diagnostic, therapeutic procedures	\$102	7.8%	\$101	9.0%	\$1 (−\$18, \$21)	\$131	7.7%	\$71	8.9%	\$60 (\$45, \$75)
Oral immunotherapy/desensitization	\$100	7.7%	\$60	5.4%	\$40 (\$11, \$68)	\$126	7.4%	\$57	7.1%	\$69 (\$43, \$95)
Emergency department visits	\$98	7.5%	\$57	5.1%	\$42 (\$22, \$61)	\$167	9.8%	\$9	1.2%	\$157 (\$140, \$175)
Inpatient admissions	\$120	9.2%	\$121	10.9%	−\$1 (−\$96, \$94)	\$232	13.6%	1 \$	0.1%	\$231 (\$153, \$309)
Inpatient admissions for patients with an admission (n)	\$3670 (n = 68)		\$4208 (n = 14)		−\$538 (−\$2790, \$1715)	\$3791 (n = 81)		\$1412 (n = 1)		\$2379 (\$1347, \$3410)
Epinephrine autoinjectors obtained	\$266	20.4%	\$240	21.6%	\$27 (\$7, \$46)	\$254	14.9%	\$270	33.7%	−\$16 (−\$31, −\$0.3)
Medications (excluding epinephrine autoinjectors)	\$290	22.2%	\$235	21.3%	\$55 (\$10, \$100)	\$376	22.0%	\$177	22.1%	\$199 (\$164, \$234)
Transportation for healthcare services, excluding ambulance	\$24	1.9%	\$21	1.9%	\$3 (−\$0.3, \$7)	\$33	2.0%	\$14	1.7%	\$20 (\$17, \$22)
Out-of-pocket component										
Nontraditional medicines	\$56	2.6%	\$39	1.8%	\$17 (−\$9, \$44)	\$77	3.1%	\$28	1.6%	\$49 (\$22, \$77)
Special diets and allergen-free foods	\$1250	58.5%	\$1214	57.0%	\$36 (−\$246, \$317)	\$1440	57.8%	\$1033	58.8%	\$407 (\$182, \$632)
Additional child care	\$435	20.4%	\$416	19.5%	\$20 (−\$298, \$338)	\$492	19.8%	\$367	20.9%	\$124 (−\$144, \$392)
Legal guidance	\$8	0.4%	\$2	0.1%	\$6 (−\$2, \$14)	\$6	0.2%	\$9	0.5%	−\$3 (−\$15, \$9)
Mental health services	\$68	3.2%	\$74	3.5%	−\$7 (−\$44, \$31)	\$83	3.3%	\$54	3.1%	\$28 (−\$3, \$60)
Change in school	\$101	4.7%	\$124	5.8%	−\$23 (−\$205, \$160)	\$98	3.9%	\$114	6.5%	−\$15 (−\$117, \$86)
Other out-of-pocket expenditures	\$218	10.2%	\$260	12.2%	−\$42 (−\$197, \$113)	\$294	11.8%	\$153	8.7%	\$141 (\$27, \$255)

Abbreviation: CI, confidence interval.

Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.**eTable 6**

Indirect Costs (2020 CAD) Stratified by

1) convincing history or physician diagnosis

2) reaction vs no reaction in past year

Component	Convincing history with or without physician diagnosis (n = 2013)		Physician diagnosis without convincing history (n = 461)		Difference (95% CI)	Reaction in past year (n = 1264)		No reaction in past year (n = 1210)		Difference (95% CI)
	Mean cost	% of total	Mean cost	% of total		Mean cost	% of total	Mean cost	% of total	
Estimate # 1										
Total lost productivity - paid labor and nonfood-related unpaid labor, mean	\$7805		\$8582		−\$777 (−\$3253, \$1699)	\$9019		\$6833		\$2186 (\$278, \$4095)
Lost paid labor, mean	\$1260	16%	\$981	11%	\$279 (−\$1763, \$2322)	\$2190	24%	\$182	3%	\$2008 (\$413, \$3604)
Lost unpaid labor - restricted to nonfood-related activities, mean	\$6545	84%	\$7602	89%	−\$1056 (−\$2544, \$431)	\$6829	76%	\$6651	97%	\$178 (−\$1016, \$1372)
Estimate # 2										
Total lost productivity - paid labor and upper bound of nonfood-related or food-related activities, mean	\$16,669		\$16,689		−\$20 (−\$2277, \$2237)	\$17,582		\$15,722		\$1860 (\$62, \$3657)
Lost paid labor, mean	\$1260	8%	\$981	6%	\$279 (−\$1763, \$2322)	\$2190	12%	\$182	1%	\$2008 (\$413, \$3604)
Lost unpaid labor - upper bound of nonfood-related or food-related activities, mean	\$15,409	92%	\$15,708	94%	−\$300 (−\$1268, \$668)	\$15,392	88%	\$15,540	99%	−\$149 (−\$905, \$607)

Abbreviation: CI, confidence interval.

Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.

eTable 7

Sample Characteristics: Convincing History or Physician Diagnosis Stratified by Reaction vs No Reaction in the Past Year

Characteristic	Reaction in past year (n = 1403)	No reaction in past year (n = 1289)	Difference (95% CI)
Age (y), mean (SD)	19.2 (17.5)	18.2 (14.2)	1.1 (−0.1, 2.3)
Children (<18 y), %	63.2%	67.1%	−3.9% (−7.5%, −0.3%)
Female, % (n)	54.1% (n = 1394)	47.5% (n = 1285)	6.5% (2.8%, 10.3%)
Non-White race and ethnicity, % (n)	24.0% (n = 1380)	17.8% (n = 1273)	6.2% (3.0%, 9.4%)
Household with any postsecondary education, % (n)	96.3% (n = 1281)	97.3% (n = 1213)	−1.0% (−2.5%, 0.4%)
Household income ≥\$100K, % (n)	54.0% (n = 1066)	62.5% (n = 912)	−8.5% (−12.9%, −4.0%)
Region of residence, %			
Atlantic Canada	4.6%	4.9%	−0.3% (−1.9%, 1.4%)
Ontario	34.2%	34.1%	0.1% (−3.7%, 3.9%)
Quebec	31.9%	37.8%	−5.9% (−9.7%, −2.0%)
Western Canada	29.0%	22.9%	6.0% (2.5%, 9.6%)
Territories	0.2%	0.2%	0.0% (−0.3%, 0.3%)
Current food allergies reported, %			
Peanut	59.8%	71.8%	−12.0% (−15.6%, −8.4%)
Tree nut	50.7%	48.0%	2.7% (−1.1%, 6.5%)
Sesame	17.1%	8.8%	8.3% (5.7%, 10.8%)
Milk/dairy	31.4%	10.0%	21.4% (18.3%, 24.4%)
Egg	29.9%	13.0%	17.0% (13.9%, 20.1%)
Fish	14.0%	7.1%	6.9% (4.6%, 9.2%)
Crustaceans or molluscs	18.1%	12.7%	5.4% (2.7%, 8.1%)
Soy	13.4%	4.8%	8.6% (6.4%, 10.8%)
Wheat/Triticale	13.7%	3.6%	10.0% (7.9%, 12.2%)
Mustard	5.3%	1.6%	3.7% (2.4%, 5.1%)
Number of food allergies reported, mean (SD)	3.1 (2.1)	2.0 (1.4)	1.1 (0.9–1.2)
Atopic comorbidities, %			
Asthma	51.0%	47.9%	3.2% (−0.7%, 7.0%)
Eczema	61.7%	58.0%	3.7% (−0.03%, 7.4%)
Hay fever or allergic rhinitis	47.7%	44.5%	3.2% (−0.7%, 7.0%)
Hives	53.8%	35.0%	18.8% (15.1%, 22.6%)
General good health (self-reported good/very good/excellent), %	84.4%	95.0%	−10.6% (−13.0%, −8.3%)
Reaction in past year, %	100.0%	0.0%	

Abbreviation: CI, confidence interval.

Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.

eTable 8

Healthcare Utilization: Convincing History or Physician Diagnosis Stratified by:

1) ≥1 severe symptom vs mild/moderate symptoms or no reaction

2) children vs adults

Component	≥ 1 severe symptom (n = 979)	Mild/moderate symptoms or no reaction (n = 1617)	Difference (95% CI)	Children (n = 1677)	Adults (n = 919)	Difference (95% CI)
Healthcare component						
Visits to physician per patient, mean (SD)	2.8 (3.9)	2.0 (2.8)	0.8 (0.6, 1.1)	2.6 (3.1)	1.8 (3.6)	0.8 (0.6, 1.1)
Patients with a visit to physician, %	73.4%	68.5%	4.9% (1.3%, 8.5%)	80.7%	51.5%	29.3% (25.5%, 33.0%)
Visits per patient using service, mean (SD)	3.9 (4.1)	2.9 (3.0)	1.0 (0.6, 1.3)	3.2 (3.2)	3.5 (4.3)	−0.2 (−0.7, 0.2)
Visits to other healthcare practitioner per patient, mean (SD)	1.0 (2.6)	0.6 (1.9)	0.4 (0.2, 0.6)	0.6 (1.8)	0.9 (2.7)	−0.3 (−0.5, −0.1)
Patients with a visit to other healthcare practitioner, %	22.9%	15.1%	7.8% (4.7%, 10.9%)	17.9%	18.2%	−0.2% (−3.3%, 2.9%)
Visits per patient using service, mean (SD)	4.2 (3.9)	3.8 (3.6)	0.4 (−0.3, 1.1)	3.5 (3.0)	5.0 (4.6)	−1.5 (−2.3, −0.7)
Laboratory, diagnostic, or therapeutic procedure per patient, mean (SD)	1.7 (2.4)	1.5 (2.2)	0.3 (0.1, 0.5)	2.0 (2.5)	0.8 (1.7)	1.2 (1.0, 1.3)
Patients with a laboratory, diagnostic, or therapeutic procedure, %	58.5%	56.3%	2.3% (−1.7%, 6.2%)	70.7%	32.4%	38.2% (34.4%, 42.0%)
Procedures per patient using service, mean (SD)	3.0 (2.5)	2.6 (2.4)	0.4 (0.1, 0.6)	2.8 (2.5)	2.5 (2.1)	0.3 (0.04, 0.6)
Patients with oral immunotherapy/desensitization, %	8.3%	6.2%	2.1% (−0.0%, 4.2%)	8.9%	3.5%	5.4% (3.6%, 7.2%)
Visits to ED per patient, mean (SD)	0.5 (1.1)	0.2 (0.6)	0.3 (0.3, 0.4)	0.3 (0.8)	0.3 (0.9)	0.0 (−0.1, 0.1)
Patients with an ED visit, %	29.4%	13.4%	16.0% (12.7%, 19.3%)	20.6%	17.3%	3.3% (0.2%, 6.4%)
Visits per patient using service, mean (SD)	1.8 (1.3)	1.5 (1.0)	0.4 (0.2, 0.6)	1.6 (1.1)	1.9 (1.4)	−0.3 (−0.5, −0.1)
Inpatient admissions per patient, mean (SD)	0.1 (0.4)	0.0 (0.2)	0.05 (0.02, 0.1)	0.0 (0.2)	0.1 (0.3)	−0.0 (−0.04, 0.01)
Patients with an inpatient admission, %	4.9%	2.1%	2.8% (1.3%, 4.3%)	3.0%	3.5%	−0.5% (−1.9%, 0.9%)
Admissions per hospitalized patient, mean (SD)	1.4 (0.8)	1.2 (0.6)	0.3 (−0.05, 0.6)	1.2 (0.7)	1.5 (0.9)	−0.2 (−0.6, 0.1)
Length of stay per admission ^a , mean (SD)	2.5 (3.1)	1.7 (1.3)	0.9 (−0.2, 1.9)	2.1 (2.5)	2.4 (2.8)	−0.3 (−1.7, 1.1)
Epinephrine autoinjectors per patient, mean (SD)	3.0 (2.2)	2.6 (2.1)	0.4 (0.2, 0.6)	3.4 (2.1)	1.7 (1.6)	1.8 (1.6, 1.9)
Patients with an epinephrine autoinjector, %	87.9%	79.7%	8.2% (5.3%, 11.1%)	90.6%	68.7%	21.9% (18.6%, 25.3%)
Epinephrine autoinjectors per patient obtaining autoinjector, mean (SD)	3.4 (2.0)	3.3 (1.8)	0.1 (−0.03, 0.3)	3.8 (1.9)	2.4 (1.4)	1.4 (1.2, 1.5)
Patients using medications (excluding epinephrine autoinjectors), %	78.2%	64.1%	14.2% (10.7%, 17.7%)	69.6%	69.0%	0.7% (−3.1%, 4.4%)
Out-of-pocket component						
Patients using nontraditional medicines, %	11.6%	10.4%	1.3% (−1.3%, 3.8%)	11.3%	10.0%	1.3% (−1.1%, 3.8%)
Patients using special diets and allergen-free foods, %	78.4%	75.6%	2.8% (−0.6%, 6.2%)	79.8%	71.1%	8.7% (5.2%, 12.2%)
Patients using additional child care, %	10.9%	9.0%	2.0% (−0.5%, 4.5%)	15.0%	N/A%	15.0% (13.2%, 16.9%)
Patients using legal guidance, %	0.5%	0.4%	0.1% (−0.4%, 0.6%)	0.7%	0.1%	0.5% (0.2%, 0.9%)
Patients using mental health services, %	10.0%	6.7%	3.3% (1.1%, 5.6%)	8.7%	6.5%	2.2% (0.1%, 4.2%)
Patients changing schools, %	2.7%	1.1%	1.5% (0.4%, 2.6%)	2.6%	N/A%	2.6% (1.8%, 3.4%)
Patients using other out-of-pocket expenditures, %	28.3%	21.5%	6.8% (3.3%, 10.4%)	23.9%	24.4%	−0.5% (−3.9%, 2.9%)

Abbreviation: CI, confidence interval; ED, emergency department.

Significant differences in bold. Difference (95% CI) between groups based on *t* statistics adjusted for household clusters.^aCalculated as a weighted average.

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