

Original Investigation

The Economic Impact of Childhood Food Allergy in the United States

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IMPORTANCE Describing the economic impact of childhood food allergy in the United States is important to guide public health policies.

OBJECTIVE To determine the economic impact of childhood food allergy in the United States and caregivers' willingness to pay for food allergy treatment.

DESIGN, SETTING, AND PARTICIPANTS A cross-sectional survey was conducted from November 28, 2011, through January 26, 2012. A representative sample of 1643 US caregivers of a child with a current food allergy were recruited for participation.

MAIN OUTCOMES AND MEASURES Caregivers of children with food allergies were asked to quantify the direct medical, out-of-pocket, lost labor productivity, and related opportunity costs. As an alternative valuation approach, caregivers were asked their willingness to pay for an effective food allergy treatment.

RESULTS The overall economic cost of food allergy was estimated at \$24.8 (95% CI, \$20.6-\$29.4) billion annually (\$4184 per year per child). Direct medical costs were \$4.3 (95% CI, \$2.8-\$6.3) billion annually, including clinician visits, emergency department visits, and hospitalizations. Costs borne by the family totaled \$20.5 billion annually, including lost labor productivity, out-of-pocket, and opportunity costs. Lost labor productivity costs totaled \$0.77 (95% CI, \$0.53-\$1.0) billion annually, accounting for caregiver time off work for medical visits. Out-of-pocket costs were \$5.5 (95% CI, \$4.7-\$6.4) billion annually, with 31% stemming from the cost of special foods. Opportunity costs totaled \$14.2 (95% CI, \$10.5-\$18.4) billion annually, relating to a caregiver needing to leave or change jobs. Caregivers reported a willingness to pay of \$20.8 billion annually (\$3504 per year per child) for food allergy treatment.

CONCLUSIONS AND RELEVANCE Childhood food allergy results in significant direct medical costs for the US health care system and even larger costs for families with a food-allergic child.

JAMA Pediatr. 2013;167(11):1026-1031. doi:10.1001/jamapediatrics.2013.2376
Published online September 16, 2013.

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Food allergy is a growing public health concern in the United States that affects 8% of children.¹ Childhood food allergy results in significant direct medical costs to the health care system and imposes substantial costs on families. Direct medical costs to the health care system stem from office visits, rescue medications, emergency department (ED) visits, and hospitalizations. Costs borne by families include medical and nonmedical expenses, specifically out-of-pocket, lost productivity, and opportunity costs.

To our knowledge, no research has offered a comprehensive assessment of the economic burden of food allergies in the United States. A previous study, which examined direct and

indirect costs associated with food-induced allergic events in children and adults, relied primarily on data from federal data sources to identify significant health care costs.² The authors acknowledge that costs were underestimated because not all food allergy cases could be identified using *International Classification of Diseases, Ninth Revision* codes. Moreover, many critical costs to families were not captured from these data.

Indeed, not much data exist about the costs borne by families such as buying special foods or forgoing full-time employment to care for a child with a food allergy. Previous research has articulated how having a child with a food allergy impairs families' overall quality of life through limiting social interac-

tions and adversely affecting family finances.³⁻⁷ However, the total effect of direct medical and nonmedical costs on families has yet to be comprehensively described.

To better allocate resources dedicated to preventing and treating food allergy, policy makers must first understand its economic effect on the health care system and families. To quantify the overall economic impact of food allergy, we conducted a national survey of caregivers of food-allergic children. We hypothesized that the economic impact of food allergy in the United States is significant and has been underestimated.

Methods

Study Design

Caregivers of a child with a current food allergy were surveyed between November 28, 2011, and January 26, 2012, and asked to assess direct medical, out-of-pocket, lost labor productivity, and opportunity costs due to their child's food allergy. Caregivers were also asked about their willingness to pay (WTP) for an effective food allergy treatment as an alternative valuation method. The sample (N = 1643) was weighted to represent the population of US children with current food allergies (Table 1). The institutional review board of Lurie Children's Hospital of Chicago approved the study protocol.

Survey Development

The survey was developed by physicians, health services researchers, and health economists. Cognitive interviews (n = 5) were conducted to ensure general understandability and consistency of response. Quality control testing was carried out to ensure that skip logic and randomization were met. A pretest of 52 surveys was electronically administered to verify the reliability of question responses and to assess respondent burden, which is the effort that is required for caregivers to provide adequate responses to the survey.

The final survey, which incorporated feedback from the cognitive interviews, quality control testing, and pretest, consisted of items assessing child and household demographics, food allergy severity and reaction history, estimates of resource use, lost productivity, health insurance coverage, and WTP. Household information comprised zip code, income, and other demographic descriptors. The survey is available upon request.

Study Participants

Eligible participants included caregivers able to complete the survey in English who resided in US households with at least 1 child with a current food allergy. Caregivers were recruited using a dual-sample approach. The first sample of 629 caregivers was selected by resampling a previous sample of US families with a food-allergic child (N = 3339). The earlier study, which recruited families to estimate the prevalence of childhood food allergy in the United States, is described in depth by Gupta et al.¹ The second sample consisted of 1014 caregivers who were recruited electronically through a food allergy support and advocacy organization. In households with

Table 1. Characteristics of Study Sample Among 1643 Children Surveyed With Childhood Food Allergy

Characteristic	% (95% CI)
Sex	
Male	50.6 (46.4-54.8)
Female	49.4 (45.2-53.6)
Age, y	
≤2	13.4 (10.7-16.5)
3-5	18.2 (15.5-21.3)
6-10	27.0 (23.5-30.7)
11-13	17.0 (14.0-20.6)
14-17	24.5 (20.8-28.5)
Race/ethnicity	
White	75.9 (71.6-79.6)
Black	10.7 (8.0-14.3)
Asian	4.1 (2.7-6.2)
Hispanic	7.6 (5.4-10.6)
Other	1.6 (0.8-3.2)
Annual household income, US\$	
<25 000	14.5 (11.3-18.4)
25 000-49 999	27.1 (23.2-31.4)
50 000-99 999	39.2 (35.2-43.3)
100 000-149 999	12.8 (10.7-15.2)
≥150 000	6.4 (5.3-7.8)
Geographic region	
Midwest	24.4 (21.1-28.1)
Northeast	20.5 (17.4-24.0)
South	33.4 (29.5-37.6)
West	21.7 (18.3-25.4)
Health insurance status	
Insured	88.9 (85.4-91.7)
Not insured	11.1 (8.3-14.6)
Type of food allergy	
Milk	22.3 (19.3-25.6)
Egg	11.1 (9.4-13.1)
Peanut	28.7 (25.7-31.9)
Soy	5.3 (4.1-6.9)
Wheat	5.8 (4.4-7.5)
Tree nut	15.0 (13.1-17.1)
Fin fish	6.2 (4.4-8.7)
Shellfish	18.6 (15.3-22.4)
Pea	3.7 (2.6-5.3)
Sesame	4.6 (3.4-6.0)
Other	37.6 (33.3-42.2)
Severity of food allergy	
Mild reaction in lifetime	91.1 (88.4-93.2)
Severe reaction in lifetime	41.2 (37.3-45.2)
An anaphylactic reaction occurred	10.0 (8.3-12.1)

multiple food-allergic children, 1 child was randomly selected and caregivers were instructed to complete the survey for the selected child. Caregiver recruitment and survey administration were conducted by Knowledge Networks, a survey research firm based in Menlo Park, California.

Table 2. Direct Medical Costs of Childhood Food Allergy^a

Characteristic	Children With Visit, % (SE)	Visits per Child, Mean (SE)	Cost, US\$		
			Visit	Child	Overall Annual (in Millions)
Visits					
Pediatrician	42 (2)	.82 (.05)	112 ^b	92	543
Allergist	41 (2)	.79 (.05)	175 ^b	138	819
Pulmonologist	14 (1)	.07 (.01)	175 ^b	12	71
Nutritionist	17 (1)	.16 (.04)	100 ^b	16	96
Alternative provider	17 (1)	.23 (.05)	100 ^b	23	136
Emergency department	13 (1)	.18 (.02)	711 ^c	129	764
Inpatient hospitalization stays	4 (1)	.05 (.01)	6269 ^c	314	1863
Total direct medical costs				724	4292

^a Direct medical costs are medical costs borne by the health care system associated with the prevention, diagnosis, and treatment of food allergies.

^b Source: Hospital Outpatient Prospective Payment System.⁸

^c Source: Patel et al.²

Measuring Direct Medical Costs

Direct medical costs include the costs to the health care system for the diagnosis, treatment, and prevention of childhood food allergy. Events resulting in resource use were identified by asking caregivers of allergic children about the number of times a child had outpatient visits, ED visits, and inpatient hospitalizations related to a food allergy in the past year. Costs associated for each event were estimated from several sources. Costs for outpatient visits were taken from Medicare cost data.⁸ The mean cost associated with an ED visit was based on prior calculations using the Healthcare Cost and Utilization Project Nationwide Emergency Department Sample for visits due to food allergy and food-induced anaphylaxis.² The mean cost for an inpatient admission was also taken from prior estimates based on the Healthcare Cost and Utilization Project Nationwide Inpatient Sample² and inflated using the inpatient care component of the consumer price index for 2011.⁸ The direct medical costs per child were estimated by multiplying the mean number of each type of visit by the mean cost per visit. This number was then multiplied by the total number of US children with food allergies (5.9 million).¹ The sum of costs for all visits equals the total direct medical costs (Table 2).

Measuring Total Costs Borne by the Family

Costs borne by families comprised lost labor productivity, out-of-pocket, and opportunity costs.

Total lost labor productivity costs were estimated by multiplying the mean number of hours reported by caregivers accompanying the child to health visits for food allergy by the mean number of each type of visit and the total number of US children with food allergies. The time spent for each of these visits was then valued using the mean national hourly labor wage from September 2011 (\$30.11/hr).⁸ The sum of caregiver hours spent for all health care visits equals the total lost labor productivity (eTable in the Supplement).

Total direct out-of-pocket costs were estimated by multiplying the percentage of caregivers reporting each type of cost by the mean caregiver-reported cost and the number of US children with food allergies (Table 3).

Total opportunity costs were estimated by multiplying the percentage of caregivers reporting lost opportunity in the labor market by the mean caregiver-reported cost and the number of US children with food allergies (Table 4).

Measuring WTP

The WTP questions were based on established elicitation methods to assess individuals' valuation of health care treatments and outcomes.⁹ Caregivers were asked 2 questions to determine the maximum amount they would be willing to pay per month (out of pocket or through insurance) for a safe and effective treatment that allowed the child to eat all foods. Monthly costs were used since consumers typically pay for prescription drugs and insurance on a monthly basis. For each response, caregivers had to select an expenditure range (eg, \$1000-\$5000) and then report the maximum amount they would be willing to spend within the range. To assess for potential bias due to the predetermined ranges, we randomized caregivers to a second version of the survey with expenditure ranges that were twice as large. Answers from these 2 versions were pooled, and differences in WTP were compared to assess any bias. To reduce the sensitivity of mean estimates of WTP to outliers, we excluded responses of more than \$10 000 per month from the analysis. The total WTP was calculated by multiplying the mean annual amount by the number of food-allergic children in the United States.

Statistical Analysis

Data were weighted using base and poststratification weights to adjust for potential biases from sampling design and survey response. Base and panel demographic poststratification weights were adjusted for known selection deviations in the sampling design used in the study by Gupta et al.¹ Additional poststratification weights were constructed when the study sample was finalized using age, sex, income, type of food allergy, and reaction severity. The study-specific poststratification weights were devised to match benchmark distributions from Gupta et al. Means, proportions, and medians used to calculate costs were computed using the sample weights. All analyses were conducted using Stata 12.0 (StataCorp).

Monte Carlo probabilistic sensitivity analyses were performed to develop 95% CIs around mean cost estimates. A total of 10 000 simulations were run for mean estimates of direct medical costs, direct out-of-pocket costs, lost labor productivity costs, opportunity costs, and all costs combined. Distributions were fit for each input using the means and SEs where appropriate. The method of moments approach was used to estimate α and β parameters for the γ and β distributions. Vari-

Table 3. Out-of-Pocket Costs of Childhood Food Allergy^a

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

^a Out-of-pocket costs: medical costs borne by patient associated with the prevention, diagnosis, and treatment of food allergies. Includes all costs associated with protecting the child from exposure to allergens, including special child care arrangements. The out-of-pocket costs exclude the top 1% of reported costs in each category.

Table 4. Opportunity Cost of Childhood Food Allergy^a

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

^a Opportunity cost is the additional cost associated with activities forgone as a result of a child's allergy. The opportunity costs exclude the top 1% of reported costs in each category.

^b All possible responses were used to calculate job-related opportunity cost.

^c Only the maximum of 4 possible responses was used to calculate job-related opportunity cost.

ance for ED costs and inpatient costs was calculated with the SDs and sample sizes from a previous study.² Outpatient physician costs and the hourly wage rate were varied between $\pm 25\%$ of the base estimate. Nonparametric 95% CIs were constructed using the lower and upper 2.5% of all simulations.

Results

After weighting, the sample of 1643 children with a current food allergy matched the distribution of US children with a food allergy on key characteristics, including race (75.9% white non-Hispanic), sex (50.6% male), and age (68.5% aged 6 years and older) (Table 1). Most families reported an annual household income above \$50 000 (58.4%), and 88.9% reported that their food-allergic child had health insurance. The sample was

evenly distributed across 4 US geographic regions, with a slightly higher concentration in the South (33.4%). The most common food allergies were peanut (28.7%), milk (22.3%), and shellfish (18.6%). Consistent with previous findings, 91.1% reported ever having a mild reaction, and 41.2% reported ever having a severe reaction.

Total annual direct medical costs due to food allergy were estimated at \$4.3 billion or \$724 per child (Table 2). Hospitalizations accounted for the largest proportion of direct medical cost (\$1.9 billion), followed by outpatient visits to allergists (\$819 million), ED visits (\$764 million), and pediatrician visits (\$543 million).

Annual lost labor productivity costs associated with caregivers accompanying their child to medical visits totaled \$773 million or \$130 per child (eTable in the Supplement). Lost labor productivity due to caregiver time attending allergist vis-

Table 5. Comparison of WTP and Total Reported Costs

Characteristic	Annual Costs, US\$			
	Total (in Billions)	Per Child	95% CI	
			Total (in Billions)	Per Child
WTP ^a	20.8	3504	15.7-25.7	2652-4344
Total costs borne by families	20.5	3457	16.7-24.9	2816-4208
Out-of-pocket costs for treatment ^b	5.5	931	4.7-6.4	793-1080
Lost labor productivity	0.77	130	0.53-1.00	89-175
Opportunity costs ^{b,c}	14.2	2399	10.5-18.4	1771-3104
Total direct medical costs	4.3	724	2.8-6.3	472-1063
Total reported costs	24.8	4184	20.6-29.4	3475-4960

Abbreviation: WTP, willingness to pay.

^a The 95% CIs for WTP estimates were computed using linearized SEs while all other 95% CIs were computed with the probabilistic method. Monthly WTP responses greater than \$10 000 have been excluded.

^b Top 1% of responses from each question in these categories has been excluded.

^c Only the maximum of 4 possible responses was used to calculate any job-related opportunity cost.

its accounted for the largest proportion of costs (\$318 million), followed by pediatrician visits (\$165 million) and ED visits (\$148 million).

Annual out-of-pocket costs borne by the caregivers of children with food allergy totaled \$5.5 billion or \$931 per child (Table 3). The highest proportion of direct out-of-pocket costs stemmed from caregiver estimates of the cost of special diets and allergen-free foods (\$1.7 billion). The second largest driver of costs was due to additional or changes in child care due to food allergy (\$857 million), followed by changes in schools (\$650 million).

Annual opportunity costs due to forgone labor market activities were estimated at \$14 billion or \$2399 per child (Table 4). A job-related opportunity cost was reported by 9.1% of caregivers. The largest proportion of caregivers reported restriction of career choice (5.7%), followed by giving up a job (4.9%), needing to change jobs (2.5%), and losing a job (1.9%).

Annual medical, out-of-pocket, lost labor productivity, and lost opportunity costs in the United States totaled \$24.8 billion or \$4184 per child (Table 5). Caregivers' WTP for an effective treatment totaled \$20.8 billion or \$3504 per child. After excluding direct medical costs, which are typically covered by insurance, the total \$20.8 billion WTP for treatment almost equaled the \$20.5 billion for reported costs borne by caregivers.

A probabilistic sensitivity analysis was performed to account for the uncertainty relating to all costs. Simulations of each type of cost yielded 95% CIs presented in Table 5. Total reported costs spanned a 95% CI from \$20.6 billion to \$29.4 billion annually.

The results of the probabilistic sensitivity analysis reflect uncertainty surrounding the model parameters, including each event associated with resource use, the number of adults accompanying the child for prevention and care, the time involved in accessing health care services, and the costs assigned to allergic events.

The 95% CI around WTP spanned \$15.7 billion to \$25.7 billion (Table 5). By comparing responses across randomly assigned expenditure ranges, we assessed the sensitivity of the WTP estimates. We found insignificant differences in mean WTP by expenditure range.

Discussion

To our knowledge, this is the first study to comprehensively quantify the economic impact of childhood food allergy in the United States. Overall, food allergy costs \$24.8 billion annually or \$4184 per child. The total cost comprises significant direct medical costs for food allergy (\$4.3 billion) and even larger costs borne by families (\$20.5 billion). The cost borne by families is remarkably similar to caregivers' WTP for a food allergy treatment (\$20.8 billion).

Few studies describe the economic impact of food allergy on children and their families. One study by Patel et al² estimated that the annual cost of food-induced allergic reactions in a combined child and adult population was \$500 million. The authors acknowledge they underestimated the prevalence of childhood food allergy and excluded many other costs, including those borne by families. In addition, a recent European study found that food-allergic children had 4 more annual visits to health care professionals than children without food allergies, which resulted in an additional annual direct medical cost of \$1334 per child.¹⁰ Similar to the Patel et al study, the European study did not report other costs, especially those borne by families.

To put food allergy costs in context, we compare them with asthma costs as asthma affects a similar number of US children.¹⁰ Direct medical costs for asthma have been estimated at \$3259 per person (child or adult), which is about 5 times the cost per food-allergic child (\$724 per child).¹¹ Prescription medications account for more than 50% of direct medical costs associated with asthma.¹⁰ In contrast, few prescription medication options exist for treating food allergies. Overall costs for outpatient visits for persons with asthma are also considerably higher.¹⁰ In contrast, costs for ED and inpatient visits are similar for asthma and food allergy.¹⁰

This study found that direct medical costs were a small portion of the total economic burden of childhood food allergy. For example, out-of-pocket costs due to copayments, medications, special diets, and special child care arrangements amounted to \$5.5 billion (\$931 per child). Food allergy places unique out-of-pocket cost burdens on families such as pur-

chasing allergen-free foods (\$1.7 billion). Other unique out-of-pocket costs are incurred to avoid unintentional exposure to food allergens, including special child care arrangements (\$857 million), changing schools (\$650 million), and attending special summer camps (\$125 million).

Lost opportunities, including a change or loss of a job, had the highest associated cost at \$14.2 billion. This cost was higher than all other food allergy-related costs combined. Although assessing lost opportunities is complex, evidence now suggests that childhood food allergy has a profound effect on families' finances by altering caregivers' careers. Previous studies have clearly articulated how food allergy affects daily life for the food-allergic child and his or her caregiver(s).³⁻⁷ The constant threat of an accidental exposure of the allergen throughout a child's environment, including school, extracurricular, and social activities, may limit social interactions for the child or require a caregiver to be present more frequently.⁷ Moreover, caregivers often need to be at school, social events, or camp to educate and affirm the seriousness of their child's condition.^{6,7,12,13} In case of an emergency, caregivers may not be able or willing to take a job that requires travel or many hours away from their child.

Caregivers reported they would pay \$3504 per year per child for food allergy treatment. These WTP estimates are remarkably similar to estimates of total food allergy costs minus direct medical costs (\$3457 per family). The human capital method used alongside WTP has estimated costs of other disease states.¹⁴ The fact that parents were willing to pay a similar amount for treatment that they currently incur due to food allergy seems to confirm the consistency and validity of the 2 analytical approaches.

This study has several limitations common to survey research since it relies on self-reporting by caregivers of events and costs during 1 year. Poor recall and misunderstanding of the question may influence the results. Another potential limitation is that the sample of families used in this study may not be representative of the population of families with food-allergic children in the United States. For example, the second sample of caregivers was recruited from a food allergy support and advocacy organization. To address this issue, we weighted and adjusted the data for known selection deviations in the sampling design and finalized them using age, sex, income, type of food, and reaction severity. Another limitation is that the cost estimates did not include childhood mortality or missed school days due to food allergy.

In summary, childhood food allergy in the United States places a considerable economic burden on families and society. Results from this study reveal significant direct medical costs to the US health care system and even larger costs to families with a food-allergic child. Furthermore, we found that caregivers' WTP for food allergy treatment is similar to the total costs borne by families associated with out-of-pocket expenses, lost labor productivity, and lost opportunity. Given these findings, research to develop an effective food allergy treatment and cure is critically needed. Moreover, unlike other common childhood diseases in which most costs are borne by the health care system, childhood food allergy disproportionately burdens family finances. Ultimately, to reduce the economic effect on families due to lost opportunity, additional policies to ensure safe environments and to provide health insurance coverage of special needs for food-allergic children are essential.

ARTICLE INFORMATION

Accepted for Publication: March 18, 2013.

Published Online: September 16, 2013.
doi:10.1001/jamapediatrics.2013.2376.

Author Contributions: *Study concept and design:* Gupta, Holdford, Dyer, Meltzer.

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Statistical analysis: Bilaver, Meltzer.

Obtained funding: Gupta, Holdford, Dyer.

Administrative, technical, or material support: Gupta, Dyer, Holl, Meltzer.

Study supervision: Gupta, Holl, Meltzer.

Conflict of Interest Disclosures: None reported.

Funding/Support: This study was supported by Food Allergy Research Education (FARE; www.foodallergy.org/).

Additional Contributions: Timothy Inocencio, PharmD, PhD, provided assistance with the sensitivity analysis, and Claudia Lau interpreted out-of-pocket cost data.

Correction: This article was corrected on October 9, 2013, to fix Tables 3 and 5.

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