Infant Feeding Practices and Reported Food Allergies at 6 Years of Age

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breastfeeding, children, complementary foods, food allergy, physician diagnosis, prevalence, risk factors

ABBREVIATIONS

aOR—adjusted odds ratio
IFPS II—Infant Feeding Practices Study II
pFA—probable food allergy
Y6FU—Year 6 Follow-Up Study

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abstract

OBJECTIVE: The goal of this study was to identify the frequency of physician-diagnosed food allergies among 6-year-old US children and study the impact of exclusive breastfeeding and complementary food introduction on this frequency.

METHODS: Data were analyzed from children who participated in the Infant Feeding Practices Study II Year 6 Follow-Up Study (Y6FU). Children with probable food allergy (pFA) were defined as children with report of physician-diagnosed food allergy at age 6 years. Subgroups of pFA included children who were not diagnosed before 1 year of age (new pFA) and those with atopic risk factors (high risk).

RESULTS: Prevalence of total pFA in the Y6FU was 6.34%. The majority of these children had new pFA and high-risk factors. Higher maternal education, higher family income, family history of food allergy, and reported eczema before 1 year of age were significantly associated with higher odds of total or new pFA. Exclusive breastfeeding duration and timing of complementary food introduction were not significantly associated with total pFA. However, exclusive breastfeeding of ≥4 months compared with no breastfeeding was marginally associated with lower odds of new pFA (adjusted odds ratio: 0.51; $P = .07$); this effect was not observed with high-risk children.

CONCLUSIONS: Analysis of infant and maternal variables in the Y6FU cohort of US children revealed that socioeconomic and atopic factors were the main predictors of pFA at age 6 years. Exclusive breastfeeding of ≥4 months may have a preventive effect on development of pFA after 1 year of age in non high-risk children. *Pediatrics* 2014;134:S21–S28

Food allergies are a recognized public health problem. Epidemiologic evidence has shown that the prevalence of food allergies in US children has increased over the past decade[1,2] and that development of food sensitization in early life may predispose individuals to later allergic conditions (eg, asthma) in childhood.[3,4] The increased incidence of food allergy cannot be explained by genetic factors alone, and studies linking food allergies to other emerging health conditions in children involving diet (eg, obesity, diabetes)[5,6] suggest that dietary factors may be important. Thus, it is necessary to better understand how and whether certain dietary choices, practices, or related environmental causes early in life are contributing to the development of food allergies in young children.

There have been recent controversies over recommended feeding practices during infancy for the prevention of food allergies and other allergic conditions in later life.[7–9] Although most pediatric organizations continue to promote exclusive breastfeeding for at least the infant's first 6 months of life,[10,11] the optimal timing for introduction of complementary foods has not been well established. There is inconclusive evidence that either early introduction before 4 months of age increases, or delayed introduction after 6 months of age reduces, the risk for subsequent food allergic sensitization, especially for children with atopic risk factors.[9,12–15] The Infant Feeding Practices Study II (IFPS II) and the Year 6 Follow-Up Study (Y6FU), a longitudinal survey of >1500 pregnant women that assessed comprehensive dietary and health histories of their children from birth through 12 months and again at 6 years of age, offer opportunities to study early life practices that contribute to food allergy development by age 6 years.[16,17] Certain characteristics of a probable food allergy (pFA) in infants <1 year old from the IPFS II have previously been reported.[18] The present article expands on the previous article by using the longitudinal data to characterize the development of food allergies in the IFPS II sample when the children are 6 years old. Our main objective was to assess the predictors of pFA in this age group, particularly the impact of feeding practices such as breastfeeding and timing of complementary food introduction at important early life dietary milestones development (ie, at 4 and 6 months, respectively) on food allergies.

METHODS

Study Design

The IFPS II was a mail panel survey conducted in 2005–2007 of US mothers and their newborn infants. Survey data were collected approximately monthly from pregnancy through the infant's first 12 months of life and queried various information on infant feeding and health, including food allergies, maternal diet and health, and demographic and environmental variables.[17] Eligible mothers enrolled in IFPS II were recontacted in 2012 to provide follow-up information for themselves and their 6-year old child. The Y6FU survey queried various information about the child such as current health status, including physician diagnosis of food allergy, food environment, home environment, and other related outcomes. The study was approved by the US Food and Drug Administration's Research Involving Human Subjects Committee. Details on the methods and sample characteristics of participants in Y6FU are described in another article in this supplement.[16]

Sample

The total sample size of the Y6FU study was 1542 children, representing 52% of the original IFPS II population who were eligible for Y6FU.[19] Response by mothers to the Y6FU survey question asking if their child had ever been taken to a physician because of a food allergy was available for 1531 children. If the mother responded affirmatively, she was asked whether the child was diagnosed by a physician as having an allergy to any food. Mothers were also asked whether the 6-year-old had outgrown a food allergy or intolerance that he or she had had when younger. The final analytical sample was further restricted to 1363 children by removing those with missing values for any variables used in the regression model. Analysis of the 179 excluded children showed no significant differences from the final analytical sample with regard to prevalence of pFA at ages 1 and 6 years and variables related to high risk for atopy.

Dependent Variables

The main dependent variable was total pFA (all children with a current physician diagnosis of food allergy at age 6 years). Additional dependent variables included new pFA (subset of children with physician diagnosis of food allergy at age 6 years but with no diagnosis before 1 year of age) to study the potential for effects during the infancy period on later food allergic manifestations and high-risk pFA (subset of children with pFA at age 6 years and report of any of the following atopic risk factors: family history of food allergy, family history of other atopy, or eczema before age 1 year).[9,20]

Independent Variables

Infant feeding variables were derived from IFPS II data. Exclusive breastfeeding duration was calculated as the midpoint between the infant's age when the mother last reported feeding only breast milk and the age when the mother first reported not exclusively breastfeeding.[21] Of note, neonates reportedly given formula in the hospital but exclusively breastfed after discharge were considered exclusively breastfed. The timing of introduction of solid or liquid foods was

estimated by using the midpoint between the age at which the food was not reported as being fed to the infant over the previous 7 days and the age at which food was first reported. Two main food categories were defined: milk allergen–derived foods, including formula (the majority of which [>95%] was milk based), cow's milk, other milk (eg, goat), and dairy (eg, cheese); and complementary foods, comprising mostly solid foods such as any soy, fish/shellfish, peanut, eggs, infant cereals, other cereals, fruit, vegetables, French fries, meats, and sweet foods (eg, pudding).

Background demographic and health information came from the Y6FU and IFPS II databases, with missing Y6FU demographic data imputed from data in IFPS II. Y6FU demographic information included child's gender and mother's education, race, and household income (≤185% vs >185% of the federal poverty level). Y6FU health variables included whether the mother or anyone in the family had a history of food allergy or other atopy (ie, asthma, eczema, environmental allergies). IFPS II data included whether the child was delivered vaginally or by cesarean delivery and whether the child had physician-diagnosed food allergy or reported eczema at any time before age 1 year. The smoking exposure variables were constructed from both Y6FU data on current smoking status of the mother and other household members and IFPS II data on whether mother and others had smoked in the house during pregnancy or the child's first year of life. The number of siblings was constructed from both IFPS II (number of other siblings in household) and Y6FU (number of other siblings born since IFPS II) data.

Statistical Analysis

SAS version 9.3 (SAS Institute, Inc, Cary, NC) was used for all analyses. Because all dependent variables are binary, logistic regression was used. The association between pFA and duration of exclusive breastfeeding or timing of any milk/formula or complementary food introduction was assessed at time periods based on important dietary milestones of either 4 or 6 months. Because only 9 mothers reported exclusive breastfeeding for ≥6 months, 4 months was used as the cutoff point for exclusive breastfeeding duration. Because exclusive breastfeeding and milk/formula introduction were collinear events, logistic regression results were presented for only the exclusive breastfeeding group. Analysis of individual complementary foods produced inconclusive results because the numbers were too small to provide a stable model for the various time points. Thus, we instead counted the earliest time for the introduction of any of the complementary foods in year 1. If the foods were not reported, the individual data were counted as "not reported." Because complementary foods were analyzed as a group, a record was removed from the analysis only if data for the entire group were missing. To understand the relative impact of individual allergenic food groups, cross-tabulations of timing of introduction of these foods in relation to frequency of pFA (ie, percent with pFA) at each respective milestone was constructed. The χ^2 analyses were conducted to compare the differences within each food group.

RESULTS

Prevalence and Characteristics of pFA

From the total population of Y6FU respondents, 97 (6.34%) of 1531 mothers reported a physician diagnosis of food allergy in their child at age 6 years; by comparison, 3.89% of total children in the IFPS II year 1 survey had a reported food allergy diagnosis. Among children with pFA by age 6 years, 78 children developed a newly diagnosed pFA since 1 year of age (ie, had pFA at year 6 but not at year 1). Only 19 had evidence of persistent pFA (ie, had pFA in both years 1 and 6). Among children who had ever been taken to a physician because of a possible food allergy, 37.2% reported that they had outgrown a food allergy or intolerance that they had had when younger.

Total (n = 1363) and high-risk (n = 823) population groups were identified by using logistic regression to analyze and compare frequencies of pFA and other population characteristics or differences in relation to various demographic, environmental, and health variables (Table 1). The subpopulation of children reported to have persistent pFA was too small to provide meaningful results and therefore was not analyzed separately. It was found that 89% (79 of 89) of children with pFA had at least 1 atopic factor. There were no significant differences in characteristics between the high-risk and total populations or with regard to pFA frequency in relation to exclusive breastfeeding duration, timing of complementary food introduction, or other variables.

Predictors of pFA

Relevant demographic, environmental, and health factors were assessed for association with total pFA and among the new pFA or high-risk subgroups by using logistic regression analysis (Table 2). For both total and new pFA samples, controlling for all predictors, the adjusted odds of having pFA at age 6 years were nearly double (adjusted odds ratio [aOR]: 1.86; P = .01) among children who had a family history of food allergy than among those who did not. Children with pFA were more likely to have mothers who had higher education (especially college/bachelor's degree) or were from families with higher income (aOR: 1.70; P = .06) compared with those with incomes <185% of the poverty level. The highest odds associated with total or new pFA were found for children with reported eczema before age 1 year (aOR: 3.69; P < .001). For the high-risk subsample, the main predictor was income >185% of the poverty level (aOR: 3.19; P = .002).

TABLE 1 Descriptive Statistics and Percent Frequency of pFA for Total, New pFA, and High-Risk Groups

Variable	Total Group[a] (n = 1363)			High-Risk Group[c] (n = 823)	
	n (%)	% pFA	% New pFA[b]	n (%)	% pFA
pFA	89	7.0	5.2 (n = 71)	79	9.6
Mother's education					
High school	180 (13.2)	2.7	1.7	101 (12.3)	5.0
Associate degree	174 (12.8)	6.1	4.6	95 (11.5)	9.5
Some college	348 (25.5)	5.4	6.8	204 (24.8)	7.8
Bachelor	470 (34.5)	8.7	6.8	300 (36.4)	12.7
Postgraduate	191 (14.0)	6.8	4.6	123 (15.0)	8.9
Race					
Non-Hispanic white	1177 (86.4)	6.5	5.3	708 (86.0)	9.5
Non-Hispanic Asian	26 (1.9)	7.7	7.7	15 (1.8)	13.3
Non-Hispanic black	53 (3.9)	5.7	3.8	35 (4.2)	8.6
Hispanic	77 (5.6)	7.7	6.5	42 (5.1)	14.3
Non-Hispanic other	30 (2.2)	3.3		23 (2.8)	4.3
Income/percent federal poverty level					
<185%	529 (38.8)	4.3	2.4	319 (38.8)	6.6
≥185%	834 (61.2)	7.9	7.0	504 (61.2)	11.5
Child's gender					
Female	675 (49.5)	5.6	4.6	394 (47.9)	8.1
Male	688 (50.5)	7.4	5.8	429 (52.1)	11.0
Parity					
No sibling	142 (10.4)	9.2	8.4	85 (10.3)	14.1
1 sibling	555 (40.7)	7.0	5.9	325 (39.5)	9.5
≥2 siblings	666 (48.9)	5.6	3.9	413 (50.2)	8.7
Type of delivery					
Vaginal	959 (70.4)	5.8	4.7	592 (71.9)	8.4
Cesarean	404 (29.6)	8.2	6.4	231 (28.1)	12.6
Family history of food allergy					
No	1053 (77.3)	5.6	4.6	513 (62.3)	9.6
Yes	310 (22.7)	10.0	7.4	310 (37.7)	9.7
Family history of other atopy					
No	764 (56.0)	5.2	5.0	224 (27.2)	13.4
Yes	599 (44.0)	8.2	5.5	599 (72.8)	8.2
Reported eczema before age 1 y					
No	1082 (79.4)	4.3	3.6	542 (65.9)	6.8
Yes	281 (20.6)	15.0	11.4	281 (34.1)	15.0
Maternal tobacco smoke exposure					
No	1162 (85.2)	6.4	5.2	700 (85.0)	9.1
Yes	201 (14.8)	7.5	5.0	123 (15.0)	12.2
Other tobacco smoke exposure in home					
No	1189 (87.2)	6.5	5.2	725 (88.1)	9.2
Yes	174 (12.8)	6.9	5.2	98 (11.9)	12.2
Exclusive breastfeeding duration					
0 mo	590 (43.3)	7.4	6.1	345 (41.9)	11.3
1–3 mo	411 (30.2)	5.8	5.1	249 (30.3)	8.4
≥ 4 mo	362 (26.5)	5.8	3.9	229 (27.8)	8.3
Complementary food introduction by age of infant					
1–3 mo	461 (33.8)	7.4	5.6	288 (35.0)	11.1
4–5 mo	542 (39.8)	6.3	5.4	322 (39.1)	8.7
6–12 mo	236 (17.3)	6.8	4.6	141 (17.1)	10.6
Not reported[d]	124 (9.1)	4.0	4.0	72 (8.8)	5.6

[a] Includes all Y6FU children included in the logistic regression analysis.
[b] Includes children within the total group who had pFA at age 6 years but did not have pFA at age 1 year.
[c] Includes subset of total group children with any of the following: family history of food allergy, family history of other atopy, or reported eczema before 1 year of age.
[d] Includes children not reported to have complementary foods introduced during the IFPS II year 1 survey.

Exclusive Breastfeeding Duration and Timing of Complementary Food Introduction

As shown in Table 1, significant predictors of pFA were similar between total and new pFA except for exclusive breastfeeding variables. Exclusive breastfeeding duration for ≥4 months compared with no exclusive breastfeeding was associated with marginally significant lower odds for new pFA (aOR: 0.51; P = .067) but not for total pFA or pfA in the high-risk population (Table 2). These findings suggest that exclusive breastfeeding for a minimum of 4 months may offer protection from developing food allergies in the postinfancy period but only for children not at high risk for food allergy.

The timing of any complementary food introduction was not independently associated with total, new, or high-risk pFA at defined dietary milestones (Table 2). Table 3 displays the feeding patterns of selected allergenic foods at respective milestones and comparative pFA frequencies for the total and high-risk samples. Milk-based foods and cereals, and to a lesser extent fruits and vegetables, were the foods most commonly introduced before 6 months of age, with <2% of infants introduced to allergenic foods such as egg, peanuts, fish, or soy before 6 months. In both samples, consistently lower pFA were observed in children fed milk, egg, or peanuts by 12 months of age compared with those not reported to be fed these foods; the inverse association was noted for soy, fruits, and infant cereals. However, no statistically significant differences were found.

DISCUSSION

From the nationally distributed IFPS II sample of >1500 children participating in the Y6FU study, we analyzed cases of maternally reported physician diagnoses of food allergy to study the frequency of pFA in 6-year-old US children and to describe present-day and

TABLE 2 aOR Estimates for pFA in Total, New pFA, and High-Risk Groups as a Function of Background Characteristics and Feeding Practices

Variables	Total pFA[a]		New pFA[b]		High-Risk pFA[c]	
	aOR	95% CL	aOR	95% CL	aOR	95% CL
Mother's education						
(High school)[d]	1	—	1	—	1	—
Associate degree	2.1	0.71–7.01	2.15	0.58–10.26	1.74	0.42–8.72
Some college	1.89	0.73–5.86	2.6	0.83–11.43	2.16	0.66–9.77
Bachelor	2.95*	1.16–9.12	3.15†	1.03–13.83	3.18†	1.02–14.08
Postgraduate	1.89	0.63–6.49	2.38	0.67–11.25	2.13	0.58–10.29
Race						
(Non-Hispanic white)	1	—	1	—	1	—
Non-Hispanic Asian	0.99	0.15–3.72	1.08	0.17–4.09	1.48	0.22–6.20
Non-Hispanic black	0.74	0.16–2.25	0.55	0.09–2.03	0.83	0.13–3.08
Hispanic	1.49	0.54–3.48	1.48	0.49–3.68	1.97	0.63–5.19
Non-Hispanic other	0.33	0.02–1.75	NE	—	NE	—
Income/percent of federal poverty level						
(<185%)	1	—	1	—	1	—
≥185%	1.70†	0.99–3.00	2.53**	1.32–5.16	3.19**	1.57–6.99
Child's gender						
(Female)	1	—	1	—	1	—
Male	1.17	0.74–1.86	1.15	0.70–1.92	1.31	0.76–2.29
Parity						
(No sibling)	1	—	1	—	1	—
1 sibling	0.81	0.41–1.68	0.69	0.34–1.48	0.58	0.26–1.32
≥2 siblings	0.78	0.39–1.66	0.56	0.26–1.26	0.56	0.25–1.32
Type of delivery						
(Vaginal)	1	—	1	—	1	—
Cesarean	1.37	0.84–2.21	1.31	0.76–2.21	1.23	0.67–2.21
Family history of food allergy						
(No)	1	—	1	—	—	—
Yes	1.86*	1.12–3.03	1.90*	1.08–3.28	—	—
Family history of other atopy						
(No)	1	—	1	—	—	—
Yes	1.26	0.80–2.01	0.89	0.53–1.50	—	—
Reported eczema before age 1 y						
(No)	1	—	1	—	—	—
Yes	3.69**	2.31–5.91	3.47**	2.05–5.86	—	—
Maternal tobacco smoke exposure						
(No)	1	—	1	—	1	—
Yes	1.26	0.60–2.51	0.96	0.40–2.10	1.1	0.45–2.51
Other tobacco smoke exposure in home						
(No)	1	—	1	—	1	—
Yes	1.42	0.64–2.98	1.5	0.61–3.39	1.81	0.70–4.34
Exclusive breastfeeding duration						
(0 mo)	1	—	1	—	1	—
1–3 mo	0.72	0.42–1.23	0.78	0.43–1.38	0.81	0.42–1.51
≥ 4 mo	0.69	0.36–1.29	0.51†	0.24–1.03	0.58	0.26–1.25
Complementary food introduction by infant age						
(1–3 mo)	1	—	1	—	1	—
4–5 mo	0.83	0.47–1.45	0.98	0.53–1.80	0.91	0.46–1.77
6–12 mo	0.93	0.45–1.86	0.87	0.37–1.89	0.96	0.40–2.20
Not reported[e]	0.64	0.21–1.60	0.84	0.28–2.29	0.69	0.19–1.95

CL, confidence limits; NE, not established due to insufficient numbers. —, denote logistic regression reference variables for background characteristics, feeding practices and high risk group. †$P < .10$, *$P < .05$, **$P < .01$.

[a] Includes all children who had pFA at age 6 years.

[b] Includes children who had pFA at age 6 years but did not have pFA at age 1 year.

[c] Includes children with pFA at age 6 years and any of the following: family history of food allergy, family history of other atopy, or reported eczema before age 1 year.

[d] Reference categories are indicated by parentheses.

[e] Includes children not reported to have complementary foods introduced during the IFPS II year 1 survey.

early life predictors of food allergies in this age group. We found a prevalence of pFA of 6.34% in this sample, which is within the 3.9% to 8% range of national prevalence rates for children estimated by using parental reports of food allergies in North American children.[20,22–24] The majority (89%) of children with pFA had at least 1 atopic risk factor. In this sample, we also observed that pFA reported at age 6 years was diagnosed after age 1 year in at least 75% of children and, in one-third or more of children who had ever been taken to a physician for a possible food allergy, a previous food allergy or intolerance had resolved by age 6 years. Using logistic regression to control for a variety of confounding variables, higher maternal education and family income, family history of food allergy, and reported eczema before age 1 year were the most significant predictors of pFA at age 6 years. These findings support other observations showing the relative importance of socioeconomic and atopic factors in childhood food allergies.[22,25–27] Early life feeding practices, such as exclusive breastfeeding duration and timing of introduction of complementary foods in relation to important dietary milestones at 4 or 6 months of age, were not significantly associated with overall pFA. However, children who were exclusively breastfed for at least 4 months had borderline significantly lower odds of developing a new pFA compared with those who were not exclusively breastfed. This potential benefit was not observed in high-risk atopic children.

The literature has shown inconsistent results regarding the relationship between prolonged exclusive breastfeeding and food allergy in children.[9,15,28] For studies that have shown a preventive benefit, the benefit seems short-lived (up to a few years of age) and limited to atopic children with specific food allergies (ie, cow's milk).[15,28–30] Our results instead seem to show a breastfeeding

TABLE 3 Number of Children Introduced to Milk Allergen–Derived and Allergenic Complementary Foods in Total and High-Risk Samples at Respective Time Points and Percent Frequency of pFA

Sample	Food Introduced		Milk Allergen–Derived Foods	Complementary Foods: Select Individual Allergenic Groups[a]						
				Egg	Peanut	Soy	Fish	Fruit	Vegetable	Cereals[b]
Total group,[c] % pFA = 6.5		*N*	1363	1259	1315	1343	1325	1176	1177	1200
	<4 mo	Yes	899	5	4	3	1	119	82	451
		(% pFA)	(6.7)	(0.0)	(0.0)	(0.0)	(0.0)	(8.4)	(3.6)	(7.3)
	4–5 mo	Yes	59	6	2	7	1	535	585	484
		(% pFA)	(6.8)	(0.0)	(0.0)	(14.0)	(0.0)	(6.2)	(7.4)	(5.8)
	6–12 mo	Yes	300	617	254	96	209	438	423	176
		(% pFA)	(5.3)	(5.5)	(4.7)	(9.4)	(5.7)	(6.6)	(6.4)	(6.8)
	Not reported	Yes	105	631	1055	1237	1114	84	87	89
		(% pFA)	(8.6)	(7.6)	(7.1)	(6.4)	(6.6)	(6.0)	(5.8)	(4.5)
High-risk group,[d] % pFA = 9.6		*n*	823	760	801	815	801	714	715	729
	<4 mo	Yes	530	2	3	2	0	75	55	280
		(% pFA)	(10.0)	(0.0)	(0.0)	(0.0)	(0.0)	(13.3)	(5.4)	(11.0)
	4–5 mo	Yes	42	5	2	3	1	325	350	291
		(% pFA)	(10.0)	(0.0)	(0.0)	(33.3)	(0.0)	(9.2)	(10.8)	(8.2)
	6–12 mo	Yes	180	377	147	61	124	266	261	109
		(% pFA)	(7.8)	(8.2)	(6.1)	(14.8)	(9.0)	(9.8)	(9.6)	(11.0)
	Not reported	Yes	71	376	649	749	676	48	49	49
		(% pFA)	(11.3)	(11.4)	(10.8)	(9.2)	(9.0)	(6.2)	(6.1)	(6.1)

[a] Data do not include frequencies of complementary foods: meats, French fries, and sweet foods.
[b] Data include infant cereals and other cereals.
[c] Includes all children at age 6 years included in the logistic regression analysis.
[d] Includes children with family history of food allergy or other atopy or reported eczema before age 1 year.

benefit for nonatopic children and are consistent with the Tasmanian Asthma Study,[31] which, adjusting for familial risk factors of maternal, paternal, or sibling atopy, found reduced odds of reported physician-diagnosed food allergies in 7-year-old children who were exclusively breastfed for ≥3 months.

With a focus on defined 4- and 6-month dietary milestones, results from the present study concur with findings from a German birth cohort, which found no significant overall effect of complementary/solid food feeding practices on food allergic sensitization at age 6 years.[14] It should be noted, however, that children in the IFPS II study cohort were infants during the years 2005 to 2007, a time period when prevailing advice to US mothers was to delay introduction of food allergens.[32] Indeed, a very small percentage (<2%) of children were reported to have been fed non-milk allergens (nuts, eggs, fish/shellfish, or soy) before 6 months of age. The relative impact of this delayed introduction of allergenic foods on our study's milestone end points cannot be easily dismissed. Moreover, our study focused on children with pFA at age 6 years, not on other current allergic conditions (ie, eczema) for which protective or negative effects of complementary food introduction in infancy have been shown.[33,34] Future analyses of the relationships between breastfeeding, formula feeding, and complementary food type and introduction in relation to children with a combination of allergic conditions may be warranted to fully evaluate the association between infant feeding practices and prevention of food allergies or other allergic diseases.

The present study has some important limitations. First, the criteria for selecting the pFA group were not based on clinically validated methods but from parentally reported cases of physician-diagnosed food allergy. The accuracy of this method in estimating the true prevalence of clinical food allergy is unknown and may be subject to parent or physician biases, especially in cases in which the diagnosis was made without diagnostic testing. Second, although nationally distributed, the IFPS II sample is not nationally representative and therefore is limited in ascribing prevalence estimates to the US population.[19] Third, our prevalence data on the pFA group do not discern whether the reported probable food allergies were immunoglobulin E mediated or could have represented other food allergic disorders in early childhood, such as celiac disease and eosinophilic gastrointestinal diseases.[20] Moreover, analysis of food allergies in this study was not linked to any specific food. Thus, it is not possible to assess the potential impact of early or delayed introduction of respective complementary foods on promoting or preventing individual food allergies. Fourth, the impact on pFA frequency by other potentially relevant and confounding factors tied to the incidence of atopic disorders, such as environment (eg, rural farm versus urban living, infectious exposures)[35] and allergic sensitization between ages 1 and 6 years, is missing from this logistic regression analysis.

Despite these limitations, the main strengths of the Y6FU study are the large

sample size of >1500 children, the inclusion of questions that address many different pFA-associated factors likely to affect outcomes, and the ability to examine the association between information on infant factors, including feeding before age 1 year and reported physician-diagnosed pFA by age 6 years in more than one-half of the original participants from the IFPS II study. The longitudinal study design with a short time frame over which mothers were asked to recall information in early infancy, as well as the additional detailed questions relative to most population surveys in this age group, are particularly relevant to ascertain how factors in early life relate to development of pFA later in life.

CONCLUSIONS

In this cohort of 6-year-old US children, socioeconomic (higher maternal education and income) and atopic (family history of food allergy and infant eczema) factors were significant predictors of pFA. Our analysis did not find a significant association between pFA and feeding practices at established dietary milestones in infancy. However, among children who did not have pFA by age 1 year, exclusive breastfeeding of ≥4 months was marginally associated with lower odds of developing pFA at age 6 years. This potential benefit was not observed among the high-risk atopic children, which suggests the need to separate children according to atopic risk when studying preventive benefits of exclusive breastfeeding on food allergy.

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REFERENCES

1. Branum AM, Lukacs SL. Food allergy among U.S. children: trends in prevalence and hospitalizations. *NCHS Data Brief*. 2008;10:1–8
2. Sicherer SH, Muñoz-Furlong A, Godbold JH, Sampson HA. US prevalence of self-reported peanut, tree nut, and sesame allergy: 11-year follow-up. *J Allergy Clin Immunol*. 2010;125(6):1322–1326
3. Schroeder A, Kumar R, Pongracic JA, et al. Food allergy is associated with an increased risk of asthma. *Clin Exp Allergy*. 2009;39(2):261–270
4. Brockow I, Zutavern A, Hoffmann U, et al; GINIplus Study Group. Early allergic sensitizations and their relevance to atopic diseases in children aged 6 years: results of the GINI study. *J Investig Allergol Clin Immunol*. 2009;19(3):180–187
5. Caffarelli C, Cavagni G, Pierdomenico R, Chiari G, Spattini A, Vanelli M. Coexistence of IgE-mediated allergy and type 1 diabetes in childhood. *Int Arch Allergy Immunol*. 2004;134(4):288–294
6. Visness CM, London SJ, Daniels JL, et al. Association of obesity with IgE levels and allergy symptoms in children and adolescents: results from the National Health and Nutrition Examination Survey 2005-2006. *J Allergy Clin Immunol*. 2009;123(5):1163–1169, e1–e4
7. Cattaneo A, Williams C, Pallás-Alonso CR, et al. ESPGHAN's 2008 recommendation for early introduction of complementary foods: how good is the evidence? *Matern Child Nutr*. 2011;7(4):335–343
8. Fewtrell M, Wilson DC, Booth I, Lucas A. Six months of exclusive breast feeding: how good is the evidence? *BMJ*. 2011;342:c5955
9. Greer FR, Sicherer SH, Burks AW; American Academy of Pediatrics Committee on Nutrition; American Academy of Pediatrics Section on Allergy and Immunology. Effects of early nutritional interventions on the development of atopic disease in infants and children: the role of maternal dietary restriction, breastfeeding, timing of introduction of complementary foods, and hydrolyzed formulas. *Pediatrics*. 2008;121(1):183–191
10. Section on Breastfeeding. Breastfeeding and the use of human milk. *Pediatrics*. 2012;129(3). Available at: www.pediatrics.org/cgi/content/full/129/3/e827
11. Agostoni C, Decsi T, Fewtrell M, et al; ESPGHAN Committee on Nutrition. Complementary feeding: a commentary by the ESPGHAN Committee on Nutrition. *J Pediatr Gastroenterol Nutr*. 2008;46(1):99–110
12. Nwaru BI, Takkinen HM, Niemelä O, et al. Introduction of complementary foods in infancy and atopic sensitization at the age of 5 years: timing and food diversity in a Finnish birth cohort. *Allergy*. 2013;68(4):507–516
13. Poole JA, Barriga K, Leung DY, et al. Timing of initial exposure to cereal grains and the risk of wheat allergy. *Pediatrics*. 2006;117(6):2175–2182
14. Zutavern A, Brockow I, Schaaf B, et al; LISA Study Group. Timing of solid food introduction in relation to eczema, asthma, allergic rhinitis, and food and inhalant sensitization at the age of 6 years: results from the prospective birth cohort study LISA. *Pediatrics*. 2008;121(1). Available at: www.pediatrics.org/cgi/content/full/121/1/e44
15. Muraro A, Dreborg S, Halken S, et al. Dietary prevention of allergic diseases in infants and small children. Part III: critical review of published peer-reviewed observational and interventional studies and final recommendations. *Pediatr Allergy Immunol*. 2004;15(4):291–307
16. Fein SB, Li R, Chen J, Scanlon KS, Grummer-Strawn LM. Methods for the year 6 follow-up study of children in the Infant Feeding Practices Study II. *Pediatrics*. 2014;134(suppl 1):S4–S12
17. Fein SB, Grummer-Strawn LM, Raju TN. Infant feeding and care practices in the United States: results from the Infant Feeding Practices Study II. *Pediatrics*. 2008;122(suppl 2):S25–S27
18. Luccioli S, Ross M, Labiner-Wolfe J, Fein SB. Maternally reported food allergies and other food-related health problems in infants: characteristics and associated factors. *Pediatrics*. 2008;122(suppl 2):S105–S112
19. Fein SB, Labiner-Wolfe J, Shealy KR, Li R, Chen J, Grummer-Strawn LM. Infant Feeding Practices Study II: study methods. *Pediatrics*. 2008;122(suppl 2):S28–S35
20. Boyce JA, Assa'ad A, Burks AW, et al; NIAID-Sponsored Expert Panel. Guidelines for the diagnosis and management of food allergy in the United States: report of the NIAID-sponsored expert panel. *J Allergy Clin Immunol*. 2010;126(suppl 6):S1–S58
21. Zhang Y, Carlton E, Fein SB. The association of prenatal media marketing exposure recall with breastfeeding intentions, initiation, and duration. *J Hum Lact*. 2013;29(4):500–509

22. Gupta RS, Springston EE, Warrier MR, et al. The prevalence, severity, and distribution of childhood food allergy in the United States. *Pediatrics*. 2011;128(1). Available at: www.pediatrics.org/cgi/content/full/128/1/e9
23. Soller L, Ben-Shoshan M, Harrington DW, et al. Overall prevalence of self-reported food allergy in Canada. *J Allergy Clin Immunol*. 2012;130(4):986–988
24. Branum AM, Lukacs SL. Food allergy among children in the United States. *Pediatrics*. 2009;124(6):1549–1555
25. Ben-Shoshan M, Harrington DW, Soller L, et al. Demographic predictors of peanut, tree nut, fish, shellfish, and sesame allergy in Canada. *J Allergy (Cairo)*. 2012;2012:858306
26. Schnabel E, Sausenthaler S, Schaaf B, et al; LISA Study Group. Prospective association between food sensitization and food allergy: results of the LISA birth cohort study. *Clin Exp Allergy*. 2010;40(3):450–457
27. Tan RA, Corren J. The relationship of rhinitis and asthma, sinusitis, food allergy, and eczema. *Immunol Allergy Clin North Am*. 2011;31(3):481–491
28. van Odijk J, Kull I, Borres MP, et al. Breastfeeding and allergic disease: a multidisciplinary review of the literature (1966–2001) on the mode of early feeding in infancy and its impact on later atopic manifestations. *Allergy*. 2003;58(9):833–843
29. Lucas A, Brooke OG, Morley R, Cole TJ, Bamford MF. Early diet of preterm infants and development of allergic or atopic disease: randomised prospective study. *BMJ*. 1990;300(6728):837–840
30. Saarinen UM, Kajosaari M. Breastfeeding as prophylaxis against atopic disease: prospective follow-up study until 17 years old. *Lancet*. 1995;346(8982):1065–1069
31. Matheson MC, Erbas B, Balasuriya A, et al. Breast-feeding and atopic disease: a cohort study from childhood to middle age. *J Allergy Clin Immunol*. 2007;120(5):1051–1057
32. American Academy of Pediatrics. Committee on Nutrition. Hypoallergenic infant formulas. *Pediatrics*. 2000;106(2 pt 1):346–349
33. Kumar R, Caruso DM, Arguelles L, et al. Early life eczema, food introduction, and risk of food allergy in children. *Pediatr Allergy Immunol Pulmonol*. 2010;23(3):175–182
34. Zutavern A, Brockow I, Schaaf B, et al; LISA Study Group. Timing of solid food introduction in relation to atopic dermatitis and atopic sensitization: results from a prospective birth cohort study. *Pediatrics*. 2006;117(2):401–411
35. von Mutius E. Allergies, infections and the hygiene hypothesis—the epidemiological evidence. *Immunobiology*. 2007;212(6):433–439

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