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The epidemiology of milk allergy in US children

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ABSTRACT

Background: Milk is one of the most common food allergies in US children, yet little is known about its distribution and diagnosis.

Objective: To better understand current pediatric milk allergy distribution and diagnosis trends in the United States.

Methods: A randomized, cross-sectional survey was administered to parents belonging to a representative sample of US households with children from June 2009 to February 2010. Data from 38,480 parents regarding demographic characteristics, allergic symptoms associated with food ingestion, and methods used to diagnose food allergy were collected and analyzed as weighted proportions. Adjusted models were estimated to examine association of these aspects with odds of milk allergy.

Results: Of the 3,218 children identified with food allergy, 657 (19.9%) were reported to have milk allergy. Asian (odds ratio [OR], 0.5) and black (OR, 0.4) children were half as likely as white children to develop milk allergy. The highest percentage of milk-allergic children (23.8%) were aged 6 to 10 years, and the lowest percentage of milk-allergic children (15.0%) were aged 11 to 15 years. Nearly one-third (31.4%) of children with milk allergy had a history of severe reactions. Compared with children with other food allergies, children with milk allergy had a higher odds of having physician-diagnosed allergy (OR, 1.7) and were twice as likely (OR, 2.1) to outgrow their milk allergy.

Conclusion: Childhood milk allergy, which accounts for one-fifth of US food allergies, is less prevalent among Asian and black children than white children. Although less than half of children with milk allergy received confirmatory testing, it is the most commonly diagnosed food allergy.

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Introduction

Food allergy is a serious and life-threatening condition, now estimated to affect 8% of US children.^{1–4} Of all food allergies, milk is one of the leading causes, affecting between 1% and 5% of children.^{5,6} Milk allergy can be severe enough to cause hospitalizations and has been responsible for numerous food allergy-related fatalities.^{4,7,8} Strict avoidance of this ubiquitous allergen is the only currently approved method of management and entails significant changes in a child's environment. Moreover, previous work has found that food allergy can strain familial relationships, limit social activities, and diminish quality of life among both food-allergic children and their families.^{9,10}

In light of the major effect that milk allergy can have on a child's life, accurate diagnosis is critical. Sackesen et al¹¹ summarized

a recent meeting of global experts in the field of milk allergy, concluding that many knowledge gaps still remain regarding the management of food allergy and that current diagnostic practices in the United States are unsystematic and inconsistent. To this end, the National Institute of Allergy and Infectious Disease (NIAID) released an updated set of *Guidelines for the Diagnosis and Management of Food Allergy in the United States*, which underscore the importance of both obtaining a detailed clinical history and conducting confirmatory testing to accurately diagnose food allergy.¹² However, prior work suggests that guidelines such as these are frequently ignored and can take years to be incorporated into physicians' clinical practice.¹³ Using a population-based sample of 40,000 US households, the current study seeks to gain a more complete understanding of current pediatric milk allergy distribution and diagnosis trends in the United States via a comprehensive epidemiologic study.

Methods

We conducted a randomized, cross-sectional electronic survey of a representative sample of US households with children between

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June 2009 and February 2010. The study protocol was approved by the institutional review boards of Ann & Robert H. Lurie Children's Hospital of Chicago and Northwestern University. Consent to participate was implicit in the completion and return of the survey.

Survey Development and Design

A team of pediatricians, pediatric allergists, and health services researchers developed the survey with support from an expert panel of leaders in the field. Expert panel review and 10 cognitive interviews were conducted using the approach described by Gupta et al.¹⁴ to ensure general understandability and consistency of response. After the survey was reprogrammed for electronic administration, a pretest of 30 interviews was administered to verify survey functionality and understandability. The final survey is available by request and includes items assessing participant report of a child's food allergies. Questions were asked about the date of onset, method of diagnosis, and reaction history for each reported allergen. Detailed demographic items were also included. The article by Gupta et al.¹ provides a detailed description of the survey methods.

Study Participants and Recruitment

Eligible participants included adults (age ≥ 18 years) able to complete the survey in English or Spanish who resided in US households with at least 1 child younger than 18 years. The participants were recruited using a dual-sample approach. A target of 6100 participants was recruited from a Web-enabled panel that is a statistically representative sample of US households with children. This sample included households recruited using probability-based random-digit-dialing sampling that had or were provided Internet connectivity to complete the survey. An additional 33,900 participants were targeted from an online sample of US households with children who had access to the Internet. Responses from the web-enabled panel were used to identify and correct for sampling and nonsampling biases. In households with multiple children, 1 child was randomly selected using a computer algorithm and the participants were required to complete the survey for that particular child. More detailed recruitment and weighting schemes are described in the article by Gupta et al.¹

Outcome Measures

Primary outcome measures were prevalence and severity of milk allergy defined as a convincing or a confirmed allergy to any form of milk. A convincing milk allergy consisted of 1 or more of the following reaction symptoms: anaphylaxis; angioedema of the lips, eyes, or face; other angioedema; coughing; other oropharyngeal symptoms; eczema; flushing; hives; low blood pressure; trouble breathing; pruritus; vomiting; or wheezing. A confirmed milk allergy consisted of these criteria in addition to a physician diagnosis via blood test (serum specific IgE testing), skin test (skin prick testing), or oral food challenge (OFC). History of milk allergy was further described by the age of onset, development of tolerance, severity of reaction symptoms (mild to moderate or severe), and coexistence of other food allergies. A severe reaction consisted of anaphylaxis, difficulty breathing, low blood pressure, wheezing, or a combination of angioedema, coughing, and vomiting; a mild to moderate reaction consisted of symptoms limited to angioedema of the face, lips, or eyes, other angioedema, oropharyngeal symptoms, vomiting, and skin symptoms.

Statistical Analysis

Previously reported data on the other top 8 most common food allergens (peanut, tree nut, fin fish, shellfish, egg, soy, wheat, and sesame) were used as the comparison group (other food allergies group). Analyses were performed at the level of food allergy; for

example, a child with multiple allergies (eg, milk, egg, and peanut) will represent 3 individual cases of food allergy. Data were weighted using both base and poststratification weights to adjust for potential biases from sampling design and survey response. The summary statistics for characteristics of children with food allergies, prevalence of symptoms, and outcome measures were calculated as weighted proportions. Multiple logistic regression models, adjusted for multiple observations per study participant, survey design, and sample weights, were estimated to examine association of child characteristics and reaction history with odds of having a milk allergy compared with the other food allergens. Additional models were also estimated to examine association of child characteristics and reaction history with odds of having a severe compared with a mild to moderate milk allergy, having a physician-diagnosed milk allergy, and having a milk allergy confirmed using OFC. Finally, association of milk allergy vs other allergy diagnosis was compared with the type(s) of confirmatory testing conducted by the child's physician. Each model was adjusted for household income, race/ethnicity, age, sex, severity of allergy, and report of seasonal rhinitis. All analyses were estimated using Stata statistical software, version 11.0 (Stata Corp, Chicago, Illinois).

Results

Data were collected for 40,104 children who were representative of the national population with regards to age, sex, race, and income. Incomplete responses from 1,624 participants were excluded from the analysis. From the final sample of 38,480 children, 657 children were reported by parents to have a milk allergy.

Prevalence and Demographics

Among the 3,218 children with food allergies (8% of analytic sample), milk allergy was present in 19.9% (95% confidence interval [CI], 19.4%–22.8%) and was second only to peanut allergy (24.8%). Milk allergy was evenly distributed within our sample by sex. The highest percentage of milk-allergic children (23.8%) fell within the 6- to 10-year-old age group, and the lowest percentage of milk-allergic children (15.0%) fell within the 11- to 15-year-old age group. Approximately 55.5% of parent-reported milk allergy occurred in white children, 19.8% in Hispanic children, 16.6% in black children, and 4.7% in Asian children. No significant differences were found for children with milk allergy with regard to income. Detailed demographic characteristics of children with milk allergy and other food allergies are listed in Table 1.

Clinical Presentation

Children with milk allergy had their first reaction at a mean age of 2 years. This age was younger than the mean age of first reaction in children with other food allergies (4 years), although this difference was not statistically significant. The occurrence of severe reactions in children with milk allergy was significantly less frequent (31.3%) than in children with other food allergies (47.2%). With regard to symptoms, children with milk allergy most often presented with vomiting (48.7%), diarrhea (46.0%), hives (35.5%), and eczema (35.2%). The most common severe symptoms were wheezing (20.7%) and trouble breathing (16.9%). The mean age at which tolerance was reported to have occurred in children with milk allergy was 4 years as opposed to 6 years for children with other food allergies.

In children with milk allergy, shellfish allergy was found to be the most common comorbid food allergen, followed by fin fish and egg (Table 2). Seasonal rhinitis was comorbid with milk allergy in 46.9% of the children, with most frequent occurrence in spring (32.8%). Finally, the odds of tolerance being reported among children with a history of milk allergy were twice those of children with other food allergies (odds ratio [OR], 2.1; 95% CI, 1.7–2.6).

Table 1
Characteristics of the study participants^a

Characteristic	Frequency, % (95% CI)		
	All children (N = 38,480)	Children with milk allergy (n = 657)	Children with other food allergies ^b (n = 2,561)
Prevalence			
Among food allergic children		19.9 (18.3–21.6)	
Among all children		1.6 (1.4–1.7)	
Race/ethnicity			
Non-Hispanic Asian	4.8 (4.6–5.1)	4.7 (3.0–7.3)	8.0 (6.2–10.1)
Non-Hispanic black	14.1 (13.7–14.7)	16.6 (12.7–21.4)	23.8 (20.9–26.9)
Non-Hispanic white	56.4 (55.8–57.1)	55.5 (50.6–60.3)	47.1 (44.0–50.2)
Hispanic	21.6 (20.9–22.2)	19.8 (15.8–24.5)	18.1 (15.5–21.0)
Multiple/other, non-Hispanic	3.0 (2.8–3.2)	3.4 (2.2–5.1)	3.1 (2.3–4.1)
Sex			
Female	49.0 (48.3–49.6)	51.4 (46.7–56.1)	46.9 (43.8–50.1)
Male	51.1 (50.4–51.7)	48.6 (43.9–53.3)	53.1 (50.0–56.2)
Age, y			
0–2	16.8 (16.3–17.3)	20.9 (17.5–24.7)	10.4 (8.8–12.3)
3–5	17.0 (16.5–17.5)	19.5 (16.0–23.5)	20.6 (18.0–23.4)
6–10	26.7 (26.1–27.3)	23.8 (20.1–27.9)	26.3 (23.6–29.2)
11–13	17.2 (16.7–17.7)	15.0 (12.0–18.9)	20.4 (17.9–23.1)
14–17	22.4 (21.9–22.9)	20.8 (17.2–25.1)	22.3 (19.9–25.0)
Household income, \$			
<25,000	20.3 (19.7–20.9)	14.7 (11.6–18.5)	15.0 (12.7–17.6)
25,000–49,999	28.9 (28.3–29.5)	29.6 (25.3–34.3)	25.4 (22.6–28.5)
50,000–99,999	34.6 (34.0–35.1)	38.8 (34.4–43.4)	38.3 (33.4–39.2)
100,000–149,999	11.6 (11.2–12.0)	10.6 (8.1–13.8)	15.0 (12.9–17.3)
≥150,000	4.7 (4.4–4.9)	6.3 (4.5–8.7)	8.3 (6.6–10.5)

Abbreviation: CI, confidence interval.

^aBolded values indicate $P < .05$.^bIncludes the other 8 most common food allergies identified in the sample (shellfish, peanut, tree nut, fin fish, egg, soy, wheat, and sesame), without milk allergy.

Diagnosis

Three-quarters of milk allergies were physician diagnosed (Table 3). The odds of physician diagnosis in children with milk allergy were significantly greater compared with children with other food allergies (OR, 1.7; 95% CI, 1.3–2.3). Among physician-diagnosed milk allergy, 43.5% received some form of diagnostic testing. The most common forms of diagnostic testing among children with milk allergy were skin tests (34.7%) and blood tests (30.2%), with OFCs being performed on 26.0% of children. The odds of receiving an OFC were significantly greater among children with milk allergy than among children with other food allergies (OR, 1.4; 95% CI, 1.1–2.0).

Associations

The odds of milk allergy were significantly lower among Asian (OR, 0.6; 95% CI, 0.4–0.8) and black children (OR, 0.5; 95% CI, 0.3–0.8) compared with white children. The ORs (95% CIs) for milk allergy vs other food allergies were 1.7 (1.3–2.3) in those with physician-diagnosed allergy, 0.8 (0.6–1.1) in those with allergy confirmed by skin testing, 0.9 (0.6–1.2) in those with allergy confirmed by blood tests, and 1.4 (1.1–2.0) in those with allergy confirmed by an OFC.

Table 2
Children with milk allergy or other food allergies who have comorbid food allergies^a

Variable	Frequency, % (95% CI)	
	Milk allergy	Other food allergy
Comorbid food allergies		
Peanut	3.8 (2.4–5.9)	6.3 (4.9–8.0)
Fin fish	13.6 (10.5–17.4)	22.1 (19.2–25.4)
Tree nut	6.2 (4.2–9.0)	15.1 (12.7–17.9)
Shellfish	15.4 (12.8–18.4)	6.2 (4.3–9.0)
Egg	11.5 (8.7–14.9)	8.4 (6.6–10.7)
Soy	4.7 (3.1–6.9)	5.5 (4.1–7.4)
Wheat	6.9 (4.9–9.7)	5.8 (4.3–7.7)
Sesame	2.1 (0.9–4.8)	3.4 (2.4–4.6)
Seasonal allergy	46.9 (42.3–51.7)	53.0 (49.8–56.1)

Abbreviation: CI, confidence interval.

^aBolded values indicate $P < .05$.

Milk allergy was significantly more prevalent among children younger than 2 years than among children of any other age group. However, milk allergy with a severe reaction history was significantly more prevalent in the age groups of 3 to 5 years (OR, 2.2; 95% CI, 1.1–4.4) and 14 to 17 years (OR, 2.3; 95% CI, 1.1–4.6) compared with children younger than 2 years. Household income was not associated with the presence or severity of milk allergy.

Children with milk allergy and comorbid seasonal rhinitis had significantly greater odds of having their milk allergy diagnosed by a physician (OR, 1.7; 95% CI, 1.1–2.7). Milk-allergic children with one additional food allergy had greater odds of having had an OFC than those with only a milk allergy (OR, 1.7; 95% CI, 1.0–2.9). Also, children with two or more food allergies had significantly increased odds of having a milk allergy with a severe reaction history (OR, 2.3; 95% CI, 1.2–4.6) (Table 4).

Discussion

To our knowledge, this study is the first to comprehensively describe the prevalence, distribution, symptoms, severity, and

Table 3
Children with milk allergy or other food allergies whose conditions were diagnosed by a physician and type of test performed^a

Variable	Frequency, % (95% CI)	
	Milk allergy	All food allergies ^b
Physician diagnosis?		
Yes	75.6 (71.3–79.4)	69.1 (66.4–71.7)
With testing	43.5 (38.9–48.2)	48.4 (45.4–51.4)
Without testing	32.1 (27.9–36.7)	20.7 (18.4–23.3)
No	24.4 (20.6–28.7)	30.9 (28.3–33.6)
Tests performed ^c		
Skin test	34.7 (29.8–40.0)	50.6 (47.1–54.1)
Blood test	30.2 (25.4–35.5)	42.4 (39.0–45.9)
Oral food challenge	26.0 (21.6–31.0)	18.7 (16.0–21.7)

Abbreviation: CI, confidence interval.

^aBolded values indicate $P < .05$.^bIncludes the other 8 most common food allergies identified in the sample (shellfish, peanut, tree nut, fin fish, egg, soy, wheat, and sesame), without milk allergy.^cAmong physician-diagnosed allergy only.

Table 4Multiple logistic regression models: adjusted ORs (95% CIs) for milk allergy, severe milk allergy, physician diagnosis, and confirmation using oral food challenge^a

Variable	Milk allergy	Milk allergy with severe reaction history	Milk allergy with physician diagnosis	Milk allergy with oral food challenge
Race/ethnicity (vs non-Hispanic white)				
Non-Hispanic Asian	0.5 (0.3–0.8)	1.9 (0.7–5.0)	0.6 (0.2–1.6)	0.8 (0.2–2.5)
Non-Hispanic black	0.6 (0.4–0.8)	1.0 (0.5–2.1)	0.6 (0.3–1.3)	0.9 (0.4–1.8)
Hispanic	0.9 (0.6–1.1)	0.9 (0.5–1.8)	1.1 (0.6–2.0)	0.8 (0.4–1.5)
Multiple/other, non-Hispanic	0.8 (0.5–1.3)	0.6 (0.2–1.9)	1.8 (0.6–5.9)	1.2 (0.4–3.8)
Sex				
Male (vs female)	0.8 (0.7–1.0)	1.3 (0.8–1.9)	0.9 (0.6–1.4)	1.4 (0.8–2.2)
Age, y (vs 0–2 years)				
3–5	0.5 (0.3–0.7)	2.2 (1.1–4.4)	1.3 (0.7–2.7)	1.1 (0.5–2.3)
6–10	0.5 (0.3–0.6)	1.9 (0.9–3.7)	0.8 (0.4–1.6)	1.4 (0.7–2.7)
11–13	0.4 (0.3–0.5)	1.9 (0.9–4.0)	0.7 (0.3–1.5)	1.6 (0.7–3.6)
14–17	0.5 (0.3–0.6)	2.3 (1.1–4.6)	0.9 (0.4–1.7)	1.6 (0.7–3.3)
Household income, \$				
<50,000 (vs ≥50,000)	1.2 (0.9–1.4)	0.8 (0.5–1.3)	0.9 (0.6–1.4)	1.2 (0.7–1.9)
Comorbid food allergies (vs milk only)				
1 Additional food allergy		1.1 (0.7–1.8)	0.9 (0.5–1.4)	1.7 (1.0–2.9)
≥2 Additional food allergies		2.3 (1.2–4.6)	1.3 (0.6–2.9)	0.8 (0.4–1.7)
Comorbid seasonal rhinitis (vs none)	0.9 (0.7–1.1)	0.8 (0.5–1.3)	1.7 (1.1–2.7)	1.4 (0.9–2.1)

Abbreviations: CI, confidence interval; OR, odds ratio.

^aAdjusted for all categorical covariates and referents listed in table in addition to physician diagnosis and diagnostic testing. Bolded values indicate $P < 0.05$.

diagnosis of milk allergy among US children. In the present study, we found that one-fifth (19.9%) of food-allergic children were reported to have milk allergy. Compared with other food allergies, milk allergy had significantly increased odds of being diagnosed by a physician and to be confirmed by an OFC. Approximately one-third of children with milk allergy had a history of severe reactions. Children with milk allergies had twice the odds of reporting tolerance compared with children with other food allergies.

The most recent food allergy guidelines published by the NIAID state that clinical history must be combined with testing (food-specific IgE and/or an OFC)¹⁵ for the accurate diagnosis of food allergy. Both the NIAID and World Allergy Organization's Diagnosis and Rationale for Action Against Cow's Milk Allergy guidelines are also in agreement that diagnosis of milk allergy begins with clinical history and ends with an OFC.^{12,16} However, only 43.5% of children with milk allergy in our study underwent a diagnostic test—skin, blood, or OFC. Verifying the presence of milk allergy with testing is critical because milk allergy adversely influences a child's quality of life and participation in social activities more than other allergens.^{9,10,17,18} Therefore, it is imperative to confirm the presence of milk allergy before subjecting children to unnecessary avoidance measures, which may also affect nutritional status.

Despite the recommendations of major US and international allergy organizations supporting OFC as the criterion standard of food allergy diagnosis,^{12,16} concerns regarding inadequate use of the OFC have been raised by Sackensen et al.¹¹ Indeed, a recent study reported that only one-fifth of physicians caring for food-allergic children regularly used OFC to confirm a food allergy diagnosis.¹⁹ Consistent with these past findings, our study found that a mere 26% of children with a physician-diagnosed milk allergy received an OFC. The underuse of OFC has been attributed to safety concerns of parents and lack of availability of OFC in allergists' offices because of time constraints, poor reimbursement, risk of adverse events, and the lack of dedicated resources.²⁰

In our study, we found that children with a history of milk allergy had double the odds of tolerance compared with children with other food allergies. However, marked variability exists within the literature regarding the age of development of tolerance. A prospective study of a Danish cohort born in 1985 found that a high percentage (75%–87%) of children developed tolerance to milk by 3

to 4 years of age.^{6,21} However, a study conducted by Skripak et al²² using retrospective medical record reviews starting from 1993 found that a substantially lower rate (1%–26%) of children developed tolerance at 4 years of age, with 79% achieving tolerance by 16 years of age. The authors suggested that fewer children may be developing tolerance and at later ages than previously reported. Our findings, although limited by the cross-sectional nature of the study, indicated that 50% of children with a history of milk allergy were reported as tolerant to milk by 4 years of age. In addition, we found that nearly one-third (35%) of milk-allergic children in our sample were older than 11 years. The disparate results from these studies may be explained by differences in study designs (prospective, retrospective, and cross-sectional), differences in race/ethnicity (more homogenous vs multiracial/ethnic populations), and potential selection bias (the population in the study by Skripak et al included an academic center that may have managed children with more severe or persistent food allergies). Given the current lack of consensus within the field, large prospective studies are needed to understand the natural history of milk allergy.

Our study found unique differences in the racial/ethnic distribution of milk allergy compared with other food allergies. Prior work has argued that black children have increased odds of being diagnosed as having conditions such as asthma, allergies, and food-induced anaphylaxis.^{23,24} This racial disparity in food-induced anaphylaxis may arise as early as 2 years of age and exist for numerous food allergens.²⁴ Our study demonstrated that although reactions to the other 8 allergens followed a similar pattern, the distribution of milk allergy in particular differed significantly with regard to race/ethnicity. We found that Asian and black children had half the odds of having a milk allergy than did white children. Although Kumar et al reported that black children had increased odds of being sensitized to egg and peanut, no significant associations were identified for milk.²⁵ Such a racial discrepancy in milk allergy distribution has not been reported in the past and may be secondary to cultural practices or specific dietary habits of these groups. For example, there are racial and ethnic differences in breastfeeding, with non-Hispanic blacks having the lowest levels of initiation and continuation of nursing.²⁶ Although data on nursing and allergy development are mixed,^{27,28} it is conceivable that early and consistent use of a cow's milk–based formula could decrease

the risk for development of milk allergy. Indeed, the incidence of peanut allergy is relatively low in countries where peanut is introduced into the diet in infancy.²⁹ Studies have also shown that genetic and environmental factors may influence sensitization to food allergens and clinical food allergy, yielding another potential explanation for these racial differences.^{30,31} Clearly, additional studies are needed to further elucidate these associations.

Nearly 1 in 3 children with milk allergy presented with severe symptoms. Children falling within the 3- to 5-year and 14- to 17-year age groups had twice the odds of having milk allergy with a severe reaction history compared with children younger than 2 years. Increased severe reaction history in 3- to 5-year-olds may reflect increased exposure to food allergens as children leave home to begin preschool and increase social interactions outside their home. With risk-taking behaviors and denial of symptoms more common in 14- to 17-year-olds,³² it follows that they would have an increased severe reaction history. In light of recent milk allergy–related fatalities and hospitalizations described in the literature,⁷ the seriousness of milk allergy should not be underestimated.

It is important to acknowledge the limitations of our study. Although the large, opt-in online sample was augmented by using a probability-based sample representative of US households in our dual-sample approach, the possibility of selection bias remains a limitation. Because the data were mainly parent reported, they are susceptible to recall bias and subjective perceptions. However, we attempted to minimize this risk of false report through the establishment of strict and specific criteria for milk allergy by our expert panel. Further, data were not collected on suspected milk allergy ruled out by a physician, which may have underestimated the use of food challenges. Finally, because of the survey-based nature of the study, biological samples were not collected from respondents, and as such, we were unable to assess immunologic mechanisms.

Milk allergy is highly prevalent among the US pediatric population, accounting for one-fifth of all food allergies. Nearly one-third of these children present with severe symptoms. Our findings suggest that less than half of children with milk allergy are having their conditions diagnosed by confirmatory testing; nevertheless, milk allergy is diagnosed by physicians more frequently than any other food allergy. However, in the absence of confirmatory diagnoses, children without a true milk allergy could potentially be subjected to unnecessary avoidance measures that may significantly affect a child's quality of life. Efforts are needed to increase awareness about the importance of physician diagnoses and confirmatory testing of suspected milk allergy. This is particularly important in light of the recent evidence suggesting that fewer children are outgrowing their milk allergies than in the past.

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