

# Food allergen introduction patterns in the first year of life: A US nationwide survey

Carina Venter<sup>1</sup>  | Christopher Warren<sup>2</sup> | Waheeda Samady<sup>2,3</sup> | Sai R Nimmagadda<sup>2,3</sup> | Eileen Vincent<sup>2</sup> | Justin Zaslavsky<sup>2</sup> | Lucy Bilaver<sup>2</sup> | Ruchi Gupta<sup>2,3</sup>

<sup>1</sup>Children's Hospital Colorado/University of Colorado, Aurora, Colorado, USA

<sup>2</sup>Center for Food Allergy and Asthma Research, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA

<sup>3</sup>Ann and Robert H. Lurie Children's Hospital of Chicago, Chicago, Illinois, USA

## Correspondence

Ruchi Gupta, Center for Food Allergy & Asthma Research, Northwestern University, Feinberg School of Medicine, Rubloff-750 N, Lake Shore Dr. 6th Floor, Chicago, IL, USA.  
Email: [r-gupta@northwestern.edu](mailto:r-gupta@northwestern.edu)

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## Abstract

**Background:** Prevention guidelines have changed over the past decade and now recommend the earlier introduction of peanut and egg without delaying the introduction of other food allergens. This paper explored caregiver practices regarding the introduction of food allergens during infancy.

**Methods:** A survey was administered (2021) to a US population-based sample of 3062 caregivers (children 7 months – 3.5 years). Demographics and feeding practices were collected. Weighted frequencies and proportions were calculated using the svyr package in R 4.1. Survey-weighted chi-square statistics and covariate-adjusted, survey-weighted logistic regression models were used for statistical inference.

**Results:** Cow's milk, wheat, and soy were the top three allergens introduced. Peanut and egg were introduced by 17.2% and 15.5% of caregivers before 7 months and 58.8% and 66.4% before 1 year, respectively. The age of peanut and egg introduction differed significantly by race/ethnicity ( $p < .001$ ) and caregiver age ( $p < .001$ ). Peanut and egg introduction before 7 months was significantly associated with the increased introduction of other allergenic foods before 1 year ( $p = < .001$ ; peanut and  $p = < .001$ ; egg). Caregivers who introduced peanut and egg before 7 months infant age fed an additional mean of 5.4 and 4.5 food allergens, respectively, before 1 year. Few caregivers (0.9%) reported feeding an "early food allergen introduction product"  $\geq 3$  times, which was significantly associated with parental food allergy (OR = 2.2) and previously seen an allergist (OR = 6.7).

**Conclusion:** More than half of the caregivers are not introducing peanut by age of one year and one-third are not introducing egg, though an observed shift toward earlier peanut and egg introduction was seen in the past 5 years. Peanut and egg introduction seem to co-occur and are associated with increased intake of other food allergens.

## KEYWORDS

allergen introduction, egg, food allergy, introduction of solid foods, peanut, prevention

## 1 | INTRODUCTION

It is estimated that roughly 8% of children in the US have IgE-mediated food allergies (FAs) based on multiple, large-scale population-based surveys incorporating detailed symptom-report.<sup>1</sup> Of these, 62% have a physician-diagnosed FA, 40% have multiple FAs, and 42% have experienced a severe reaction.<sup>1</sup> In Europe, 1.4%–3.8% of school-aged children are reported to have a food allergy, either or both IgE- and non-IgE-mediated, based on double-blind placebo-controlled food challenges.<sup>2</sup> Historically, allergy prevention guidelines in the US,<sup>3</sup> Europe,<sup>4</sup> United Kingdom,<sup>5</sup> and elsewhere,<sup>6</sup> recommended delayed introduction of food allergens during childhood. In the US, the American Academy of Pediatrics (AAP) recommended in 2000<sup>3</sup> that infants at high risk of developing allergy, defined as an infant with a family history of allergy may benefit from withholding the introduction of solid foods until 6 months of age. These families were advised to avoid dairy (milk) up to 1 year, eggs until 2 years, and peanuts, nuts, and fish until 3 years of age.<sup>3</sup> In 2008, the AAP updated this guidance<sup>7</sup> to suggest that there was no need to delay the introduction of food allergens beyond 4–6 months.<sup>8</sup>

Following landmark studies,<sup>9,10</sup> guidance has changed. In 2017, The National Institute of Allergy and Infectious Diseases (NIAID)-sponsored addendum guidelines for the Prevention of Peanut Allergy<sup>11</sup> recommend the introduction of peanut-containing foods to “high-risk” (i.e., those with severe eczema or egg allergy) infants beginning at 4–6 months of age and all other infants around 6 months of age or in accordance with family and cultural preferences. More recently, the North American and Canadian allergy societies issued a consensus statement,<sup>12</sup> recommending the introduction of peanut and egg to all infants starting around 6 months but not before 4 months.<sup>12</sup> The most recent European Academy of Allergy and Clinical Immunology (EAACI) guidelines also suggest the introduction of well-cooked egg once solid food introduction commences and suggest that peanut should be introduced as part of complementary feeding in countries where peanut allergy is prevalent.<sup>13</sup> Changes in food allergy prevention guidelines<sup>14</sup> have given rise to the development of numerous “early food allergy introduction products. These are commercial products that are intended to facilitate the earlier introduction of particular allergenic food proteins into the infant diet and are presented mainly as powders or puffs.”<sup>14,15</sup> However, the extent to which these products are currently being used to either complement or supplement the introduction of allergenic solids in their more traditional formats, remains unclear.

The aim of this paper is to describe current practices regarding the reported timing of peanut and egg introduction to US infants, its relationship to the timing of when other common food allergens are first introduced, the most common formats used for peanut and egg introduction, and the extent to which caregivers are reporting use of “early food allergen introduction products.”

### Key Message

This paper shows that the uptake of the early introduction of peanut and egg into the first year of life is still suboptimal.

The introduction of key food allergens during the first 12 months of life appeared infrequent. An important take-away point is that caregivers who introduce peanuts early are also more likely to introduce other food allergens.

## 2 | METHODS

A survey (Appendix S1) was administered between Jan 21, 2021, and February 15, 2021, to a US population-based sample of 3062 US caregivers/caregivers of a child between the ages of 7 months and 3.5 years. Informed consent was obtained from all participants. The Northwestern University and NORC at the University of Chicago's Institutional Review Boards reviewed all study activities. The present caregiver-report survey was developed by a multidisciplinary team of pediatricians, pediatric allergists, and survey methodologists. The instrument was pretested on pilot interviewees and then administered via web and phone in both English and Spanish by trained personnel. Questions relating to the timing of introduction measured the age of introduction of the relevant food allergen and did not measure the frequency of intake or continuation of intake.

### 2.1 | Survey sampling, quality control, and weighting

This study leveraged a nationally representative household panel to support population-level inference and utilized a dual-sample methodology that integrates a probability-based sample from NORC at the University of Chicago's, nationally representative *AmeriSpeak*® panel<sup>16</sup> with a nonprobability sample obtained from *Lucid* ( $N = 2425$ ), via *TrueNorth* calibration,<sup>17,18</sup> a hybrid calibration approach based on small area estimation methods that explicitly account for potential bias associated with the nonprobability sample. In this survey, a study design effect of 2.07 was estimated with a margin of error of  $\pm 2.74\%$ .

### 2.2 | Statistical analysis

Weighted frequencies and proportions were calculated using the *svyr* package in R 4.1. Survey-weighted chi-square statistics tested the independence of key study variables across strata of interest. Covariate-adjusted, survey-weighted logistic regression models were used to facilitate statistical inference about specific study

variables of interest adjusting for potential confounding variables. All hypothesis testing utilized a two-sided  $p < .05$  threshold for statistical significance.

### 3 | RESULTS

#### 3.1 | Demographics

Among AmeriSpeak panelists approached for the present study, 36.1% completed a screener administered to determine whether they were a parent/caregiver of a child aged 7 months–3.5 years. Of those completing the screener, 96.5% completed the survey. Respondent demographics are reported in [Tables 1,2](#) are generally representative of the US general population. A history of food allergy was reported by 8% of biological mothers and 5% of biological fathers. Based on maternal biological medical history, the incidence of eczema, asthma, and environmental allergies was 9%, 10%, and 17%, respectively, and that for biological fathers was 6%, 9%, and 19%, respectively. Focusing on breast and formula feeding practices we noticed some differences in the timing of peanut introduction ([Table 1](#)) but not egg introduction ([Table 2](#)) across breastfeeding strata. The greatest differences were reported in the timing of peanut introduction before 7 months and for those who have not introduced peanut. Significantly more infants with “any breastfeeding” had been introduced to peanut compared to those who had “no reported breastfeeding” ( $p < .001$ ). Notably, peanut was introduced before 7 months among 19% of caregivers who reported any breastfeeding, compared with 12% who reported no breastfeeding. Conversely, peanut was never introduced among 8% of caregivers who reported any breastfeeding, compared with 15% who reported no breastfeeding.

#### 3.2 | Allergen introduction

Peanut was introduced by 17.2% of caregivers before 7 months and 58.8% before 1 year. Egg was introduced by 15.5% of caregivers before 7 months and 66.4% before 1 year. Before 7 months of age ([Figure 1](#)), 48.1% of caregivers reported the introduction of one of the top 9 food allergens and 0.4% introduced all allergens. When specific allergens were examined, 26.0% introduced wheat by 7 months, 18.7% introduced cow's milk, 4.3% introduced soy, 4.4% introduced at least one tree nut, 3.7% introduced sesame, 3.1% introduced finned fish, and 2.1% introduced shellfish. Before 13 months of age, 94.1% of caregivers introduced  $\geq 1$  of the aforementioned foods, while 2.5% had introduced all nine. Before 1 year, 62.0% introduced cow's milk-containing foods, 74% wheat, 21.1% soy, 28.1% finned fish, 26.9% sesame, 26.3% introduced  $\geq 1$  tree nut, and 15.8% shellfish.

Of the 3062 caregivers surveyed, 396 had children who were aged under 12 months of age and therefore had fewer person-months for the introduction of allergenic solids during their first “year” of life. However, additional sensitivity analyses ([Figure S1](#)) were conducted, which excluded these participants, and revealed

extremely similar patterns of food introduction to those observed in the full sample. As such, the full sample was retained for analysis throughout the present manuscript.

#### 3.3 | Peanut introduction in relation to other food allergens

Among caregivers who introduced peanut before 7 months ([Figure 2](#)), 50.1% also introduced wheat, 42% egg, 32.3% milk, 13.2% tree nuts, 10.5% finned fish, 7.1% shellfish, 11% sesame seed, and 7.2% soy. Of those who introduced peanuts before 1 year ([Figure 3](#)), 81.9% also introduced wheat, 76.5% egg, 69.5% milk, 36.3% tree nuts, 36.4% finned fish, 21.5% shellfish, 33.4% sesame seed, and 26% soy. Caregivers who introduced peanut before 7 months fed a mean of 4.51 additional Top 9 allergens before 1 year compared with a mean of 2.93 additional Top 9 allergens provided by those who introduced peanut after 6 months ( $t = -11.35$ ;  $p < .001$ ).

#### 3.4 | Egg introduction in relation to other food allergens

Among caregivers who introduced egg before 7 months ([Figure 2](#)), 53.2% also introduced wheat, 46.4% peanut, 37.9% milk, 14% sesame seed, 13.2% tree nuts, 12.2% finned fish, 8.2% shellfish, and 9.8% soy. Of those who introduced egg before 1 year ([Figure 3](#)), 84.2% also introduced wheat, 68.5% milk, 67.8% also introduced peanut, 35.5% finned fish, 33.3% sesame seed, 31.4% tree nuts, 24.6% soy and 19.7% shellfish. Caregivers who introduced egg before 7 months introduced a mean of 4.49 additional allergens before 1 year. Those who did not introduce egg before 7 months, introduced only 2.88 additional food allergens ( $t = -10.49$   $p < .001$ ). When the number of other “Top 9” food allergens introduced before 13 months besides peanut and egg was predicted via two negative binomial regression models (adjusting for eczema status, income, educational attainment, and caregiver age) the expected number of additional allergens introduced was comparable ( $IRR_{\text{egg}} = 1.55$  vs.  $IRR_{\text{peanut}} = 1.50$ ). This suggests that the earlier introduction of peanut and egg was associated with the introduction of a comparable number of other common allergenic solids during the first year of life.

#### 3.5 | Forms of peanut and egg introduction

Forms of peanut and egg consumption are summarized in [Tables S1 and S2](#) and [S2](#). Peanut butter and scrambled egg were the most common types of peanut and egg provided during infancy. The use of thinned peanut butter reduced from 21.0% to 19.0% and then again to 10.8% among caregivers introducing peanut before 7 months, before 1 year, and after 1 year, respectively. The forms of egg introduced or fed to the children did not change over the age range studied.

TABLE 1 Demographic characteristics by peanut introduction timing ( $n = 3062$ )

| Characteristics                                          | Entire sample<br>N (%) | Introduced peanut by<br>7 months N (%) | Introduced peanut between<br>7 months and 1 year N (%) | Introduced peanut between<br>13 and 42 months N (%) | Has not introduced<br>peanut N (%) | Survey-adjusted<br>$\chi^2$ ; $p$ value |
|----------------------------------------------------------|------------------------|----------------------------------------|--------------------------------------------------------|-----------------------------------------------------|------------------------------------|-----------------------------------------|
| Race/ethnicity                                           |                        |                                        |                                                        |                                                     |                                    | $F = 3.7$ ; $p < .001$                  |
| Black, Non-hispanic                                      | 425 (14)               | 62 (15)                                | 170 (40)                                               | 146 (34)                                            | 47 (11)                            |                                         |
| Hispanic                                                 | 855 (28)               | 102 (12)                               | 323 (38)                                               | 307 (36)                                            | 124 (14)                           |                                         |
| White, Non-hispanic                                      | 1513 (49)              | 324 (21)                               | 682 (45)                                               | 400 (26)                                            | 107 (7)                            |                                         |
| Asian, Non-hispanic                                      | 128 (4)                | 22 (17)                                | 44 (34)                                                | 53 (41)                                             | 9 (7)                              |                                         |
| Other/multi                                              | 141 (5)                | 17 (12)                                | 56 (40)                                                | 56 (40)                                             | 12 (8)                             |                                         |
| Caregiver age                                            |                        |                                        |                                                        |                                                     |                                    | $F = 4.0$ ; $p < .001$                  |
| 18–29 years                                              | 1019 (33)              | 184 (18)                               | 418 (41)                                               | 275 (27)                                            | 142 (14)                           |                                         |
| 30–44 years                                              | 1824 (60)              | 313 (17)                               | 779 (43)                                               | 591 (32)                                            | 142 (8)                            |                                         |
| 45+ years                                                | 218 (7)                | 30 (14)                                | 76 (35)                                                | 97 (45)                                             | 14 (6)                             |                                         |
| Geography                                                |                        |                                        |                                                        |                                                     |                                    | $F = 1.4$ ; $p = .09$                   |
| New England                                              | 99 (3)                 | 18 (18)                                | 39 (39)                                                | 36 (36)                                             | 6 (6)                              |                                         |
| Mid-Atlantic                                             | 294 (10)               | 53 (18)                                | 115 (39)                                               | 91 (31)                                             | 35 (12)                            |                                         |
| East North central                                       | 341 (11)               | 67 (20)                                | 153 (45)                                               | 94 (28)                                             | 26 (8)                             |                                         |
| West North central                                       | 205 (7)                | 42 (21)                                | 110 (54)                                               | 34 (17)                                             | 19 (9)                             |                                         |
| South Atlantic                                           | 628 (20)               | 132 (21)                               | 249 (40)                                               | 190 (30)                                            | 58 (9)                             |                                         |
| East South central                                       | 231 (8)                | 34 (15)                                | 95 (41)                                                | 72 (31)                                             | 31 (13)                            |                                         |
| West South central                                       | 410 (13)               | 59 (14)                                | 175 (43)                                               | 142 (35)                                            | 33 (8)                             |                                         |
| Mountain                                                 | 289 (9)                | 39 (14)                                | 131 (45)                                               | 89 (31)                                             | 29 (10)                            |                                         |
| Pacific                                                  | 566 (18)               | 82 (14)                                | 208 (37)                                               | 215 (38)                                            | 61 (11)                            |                                         |
| Household income                                         |                        |                                        |                                                        |                                                     |                                    | $F = 7.7$ ; $p < .001$                  |
| <\$30,000                                                | 1006 (33)              | 140 (14)                               | 409 (41)                                               | 292 (29)                                            | 163 (16)                           |                                         |
| \$30,000–\$59,999                                        | 776 (25)               | 107 (14)                               | 312 (40)                                               | 284 (37)                                            | 73 (9)                             |                                         |
| \$60,000–\$99,999                                        | 704 (23)               | 133 (19)                               | 319 (45)                                               | 224 (32)                                            | 28 (4)                             |                                         |
| \$100,000+                                               | 576 (19)               | 146 (25)                               | 233 (40)                                               | 163 (28)                                            | 34 (6)                             |                                         |
| Highest educational attainment                           |                        |                                        |                                                        |                                                     |                                    | $F = 3.4$ ; $p < .001$                  |
| Less than High School                                    | 442 (14)               | 59 (13)                                | 143 (32)                                               | 185 (42)                                            | 56 (13)                            |                                         |
| High school graduate or equivalent                       | 863 (28)               | 110 (13)                               | 379 (44)                                               | 264 (31)                                            | 109 (13)                           |                                         |
| Vocational/tech school/some college/<br>associate degree | 751 (25)               | 140 (19)                               | 304 (40)                                               | 237 (32)                                            | 70 (9)                             |                                         |
| Bachelor's degree                                        | 611 (20)               | 126 (21)                               | 268 (44)                                               | 169 (28)                                            | 46 (8)                             |                                         |
| Postgraduate or professional degree                      | 395 (13)               | 91 (23)                                | 180 (46)                                               | 107 (27)                                            | 17 (4)                             |                                         |

TABLE 1 (Continued)

| Characteristics                        | Entire sample<br>N (%) | Introduced peanut by<br>7 months N (%) | Introduced peanut between<br>7 months and 1 year N (%) | Introduced peanut between<br>13 and 42 months N (%) | Has not introduced<br>peanut N (%) | Survey-adjusted<br>$\chi^2$ ; p value |
|----------------------------------------|------------------------|----------------------------------------|--------------------------------------------------------|-----------------------------------------------------|------------------------------------|---------------------------------------|
| Biological mother atopy history        |                        |                                        |                                                        |                                                     |                                    |                                       |
| Food allergy                           | 238 (8)                | 52 (22)                                | 106 (45)                                               | 49 (21)                                             | 31 (13)                            | $F = 4.1$ ; $p = .007$                |
| No food allergy                        | 2824 (92)              | 475 (17)                               | 1168 (41)                                              | 913 (32)                                            | 267 (9)                            |                                       |
| Eczema                                 | 278 (9)                | 58 (21)                                | 119 (43)                                               | 71 (26)                                             | 30 (11)                            | $F = 1.2$ ; $p = .32$                 |
| No eczema                              | 2784 (91)              | 469 (17)                               | 1155 (42)                                              | 891 (32)                                            | 267 (10)                           |                                       |
| Asthma                                 | 292 (10)               | 49 (17)                                | 124 (43)                                               | 89 (30)                                             | 30 (10)                            | $F = 0.1$ ; $p = .98$                 |
| No asthma                              | 2770 (90)              | 477 (17)                               | 1149 (42)                                              | 873 (32)                                            | 268 (10)                           |                                       |
| Environmental allergies                | 535 (17)               | 114 (21)                               | 222 (42)                                               | 155 (29)                                            | 44 (8)                             | $F = 2.0$ ; $p = .11$                 |
| No environmental allergies             | 2527 (83)              | 413 (16)                               | 1052 (42)                                              | 808 (32)                                            | 253 (10)                           |                                       |
| Biological father atopy history        |                        |                                        |                                                        |                                                     |                                    |                                       |
| Food allergy                           | 163 (5)                | 39 (24)                                | 67 (41)                                                | 40 (24)                                             | 17 (10)                            | $F = 1.6$ ; $p = .14$                 |
| No food allergy                        | 2899 (95)              | 487 (17)                               | 1206 (42)                                              | 923 (32)                                            | 281 (10)                           |                                       |
| Eczema                                 | 178 (6)                | 46 (26)                                | 75 (42)                                                | 40 (22)                                             | 18 (10)                            | $F = 2.6$ ; $p = .051$                |
| No eczema                              | 2884 (94)              | 481 (17)                               | 1199 (42)                                              | 923 (32)                                            | 280 (10)                           |                                       |
| Asthma                                 | 274 (9)                | 75 (27)                                | 105 (38)                                               | 66 (24)                                             | 30 (11)                            | $F = 4.4$ ; $p = .005$                |
| No asthma                              | 2788 (91)              | 452 (16)                               | 1169 (42)                                              | 897 (32)                                            | 268 (10)                           |                                       |
| Environmental allergies                | 571 (19)               | 129 (23)                               | 242 (42)                                               | 157 (28)                                            | 42 (7)                             | $F = 3.7$ ; $p = .01$                 |
| No environmental allergies             | 2491 (81)              | 397 (16)                               | 1032 (41)                                              | 805 (32)                                            | 255 (10)                           |                                       |
| Breastfeeding and formula feeding      |                        |                                        |                                                        |                                                     |                                    |                                       |
| Breastmilk                             | 815 (27)               | 159 (20)                               | 342 (42)                                               | 256 (31)                                            | 58 (7)                             | $F = 2.2$                             |
| Mostly breast milk and some formula    | 540 (18)               | 102 (19)                               | 227 (42)                                               | 157 (29)                                            | 54 (10)                            | $p = .005$                            |
| Mostly formula and some breast milk    | 580 (19)               | 108 (19)                               | 258 (45)                                               | 180 (31)                                            | 34 (6)                             |                                       |
| Mix of formula and breast milk         | 370 (12)               | 67 (18)                                | 139 (38)                                               | 127 (34)                                            | 37 (10)                            |                                       |
| Only formula                           | 729 (24)               | 80 (11)                                | 302 (42)                                               | 232 (32)                                            | 11 (16)                            |                                       |
| Any breastfeeding vs. no breastfeeding |                        |                                        |                                                        |                                                     |                                    |                                       |
| Any breastfeeding                      | 2305 (75)              | 437 (19)                               | 966 (41)                                               | 721 (31)                                            | 182 (8)                            | $F = 6.7$ ;                           |
| No breastfeeding                       | 748 (25)               | 88 (12)                                | 303 (40)                                               | 241 (32)                                            | 116 (15)                           | $p < .001$                            |

TABLE 2 Demographic characteristics by egg introduction timing ( $n = 3062$ )

| Characteristics                                      | Entire sample<br>N (%) | Introduced egg by<br>7 months N (%) | Introduced egg between<br>7 months and 1 year N (%) | Introduced egg between<br>13 and 42 months N (%) | Has not introduced<br>egg N (%) | Survey-adjusted<br>X <sup>2</sup> ; p value |
|------------------------------------------------------|------------------------|-------------------------------------|-----------------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------------------|
| Race/ethnicity                                       |                        |                                     |                                                     |                                                  |                                 |                                             |
| Asian, Non-hispanic                                  | 128 (4)                | 14 (12)                             | 60 (52)                                             | 30 (26)                                          | 13 (11)                         | F = 2.6; p = .003                           |
| Black, Non-hispanic                                  | 425 (14)               | 52 (13)                             | 196 (49)                                            | 83 (21)                                          | 69 (17)                         |                                             |
| Hispanic                                             | 855 (28)               | 128 (16)                            | 432 (54)                                            | 188 (24)                                         | 48 (6)                          |                                             |
| Multiple/other                                       | 141 (5)                | 21 (16)                             | 60 (46)                                             | 39 (30)                                          | 11 (8)                          |                                             |
| White, NH                                            | 1513 (49)              | 261 (18)                            | 808 (56)                                            | 268 (19)                                         | 99 (7)                          |                                             |
| Caregiver age                                        |                        |                                     |                                                     |                                                  |                                 |                                             |
| 18–29 years                                          | 1019 (33)              | 196 (20)                            | 503 (53)                                            | 181 (19)                                         | 76 (8)                          | F = 2.9; p = .02                            |
| 30–44 years                                          | 1824 (60)              | 250 (15)                            | 977 (57)                                            | 360 (21)                                         | 139 (8)                         |                                             |
| 45+ years                                            | 218 (7)                | 30 (15)                             | 77 (39)                                             | 67 (34)                                          | 24 (12)                         |                                             |
| Geography                                            |                        |                                     |                                                     |                                                  |                                 |                                             |
| New England                                          | 99 (3)                 | 13 (14)                             | 61 (65)                                             | 14 (15)                                          | 6 (7)                           | F = 1.6; p = .03                            |
| Mid-Atlantic                                         | 294 (10)               | 42 (15)                             | 168 (62)                                            | 43 (16)                                          | 18 (7)                          |                                             |
| East North central                                   | 341 (11)               | 54 (17)                             | 169 (52)                                            | 78 (24)                                          | 25 (8)                          |                                             |
| West North central                                   | 205 (7)                | 32 (16)                             | 129 (66)                                            | 25 (13)                                          | 9 (5)                           |                                             |
| South atlantic                                       | 628 (20)               | 108 (18)                            | 298 (50)                                            | 123 (20)                                         | 71 (12)                         |                                             |
| East South central                                   | 231 (8)                | 44 (21)                             | 99 (47)                                             | 51 (24)                                          | 16 (8)                          |                                             |
| West South central                                   | 410 (13)               | 62 (15)                             | 244 (61)                                            | 71 (18)                                          | 24 (6)                          |                                             |
| Mountain                                             | 289 (9)                | 45 (18)                             | 130 (51)                                            | 58 (23)                                          | 20 (8)                          |                                             |
| Pacific                                              | 566 (18)               | 76 (14)                             | 260 (49)                                            | 145 (27)                                         | 48 (9)                          |                                             |
| Household income                                     |                        |                                     |                                                     |                                                  |                                 |                                             |
| <\$30,000                                            | 1006 (33)              | 170 (18)                            | 476 (51)                                            | 197 (21)                                         | 99 (11)                         | F = 1.3; p = .24                            |
| \$30,000–\$59,999                                    | 776 (25)               | 108 (15)                            | 406 (55)                                            | 166 (23)                                         | 59 (8)                          |                                             |
| \$60,000–\$99,999                                    | 704 (23)               | 98 (15)                             | 395 (59)                                            | 133 (20)                                         | 44 (7)                          |                                             |
| \$100,000+                                           | 576 (19)               | 101 (19)                            | 280 (53)                                            | 112 (21)                                         | 38 (7)                          |                                             |
| Highest educational attainment                       |                        |                                     |                                                     |                                                  |                                 |                                             |
| Less than High School                                | 442 (14)               | 76 (19)                             | 210 (52)                                            | 72 (18)                                          | 48 (12)                         | F = .9; p = .56                             |
| High school graduate or equivalent                   | 863 (28)               | 132 (16)                            | 427 (53)                                            | 193 (24)                                         | 54 (7)                          |                                             |
| Vocational/tech school/some college/associate degree | 751 (25)               | 123 (17)                            | 390 (54)                                            | 144 (20)                                         | 61 (9)                          |                                             |
| Bachelor's degree                                    | 611 (20)               | 89 (15)                             | 317 (55)                                            | 119 (21)                                         | 55 (9)                          |                                             |
| Postgraduate or professional degree                  | 395 (13)               | 56 (15)                             | 211 (57)                                            | 80 (22)                                          | 22 (6)                          |                                             |

TABLE 2 (Continued)

| Characteristics                        | Entire sample<br>N (%) | Introduced egg by<br>7 months N (%) | Introduced egg between<br>7 months and 1 year N (%) | Introduced egg between<br>13 and 42 months N (%) | Has not introduced<br>egg N (%) | Survey-adjusted<br>$\chi^2$ ; p value |
|----------------------------------------|------------------------|-------------------------------------|-----------------------------------------------------|--------------------------------------------------|---------------------------------|---------------------------------------|
| Biological mother atopy history        |                        |                                     |                                                     |                                                  |                                 |                                       |
| Food allergy                           | 238 (8)                | 32 (14)                             | 129 (58)                                            | 36 (16)                                          | 25 (111)                        | $F = 1.5$ ; $p = .20$                 |
| No food allergy                        | 2824 (92)              | 444 (17)                            | 1427 (54)                                           | 572 (22)                                         | 215 (8)                         |                                       |
| Eczema                                 | 278 (9)                | 430 (16)                            | 1409 (54)                                           | 569 (22)                                         | 215 (8)                         | $F = 1.5$ ; $p = .22$                 |
| No Eczema                              | 2784 (91)              | 46 (18)                             | 147 (57)                                            | 39 (15)                                          | 25 (10)                         |                                       |
| Asthma                                 | 292 (10)               | 46 (17)                             | 146 (53)                                            | 54 (20)                                          | 30 (11)                         | $F = 0.6$ ; $p = .63$                 |
| No Asthma                              | 2770 (90)              | 430 (17)                            | 1410 (54)                                           | 554 (21)                                         | 210 (8)                         |                                       |
| Environmental allergies                | 535 (17)               | 96 (19)                             | 290 (56)                                            | 98 (19)                                          | 30 (6)                          | $F = 1.9$ ; $p = .14$                 |
| No environmental allergies             | 2527 (83)              | 380 (16)                            | 1266 (53)                                           | 510 (22)                                         | 210 (9)                         |                                       |
| Biological father atopy history        |                        |                                     |                                                     |                                                  |                                 |                                       |
| Food allergy                           | 163 (5)                | 37 (25)                             | 83 (54)                                             | 22 (14)                                          | 11 (7)                          | $F = 2.4$ ; $p = .07$                 |
| No food allergy                        | 2899 (95)              | 439 (16)                            | 1474 (54)                                           | 586 (21)                                         | 229 (8)                         |                                       |
| Eczema                                 | 178 (6)                | 31 (19)                             | 86 (54)                                             | 25 (16)                                          | 17 (11)                         | $F = 0.9$ ; $p = .45$                 |
| No eczema                              | 2884 (94)              | 445 (16)                            | 1470 (54)                                           | 583 (21)                                         | 223 (8)                         |                                       |
| Asthma                                 | 274 (9)                | 41 (16)                             | 146 (58)                                            | 46 (18)                                          | 20 (8)                          | $F = 0.4$ ; $p = .75$                 |
| No asthma                              | 2788 (91)              | 435 (17)                            | 1410 (54)                                           | 562 (21)                                         | 220 (8)                         |                                       |
| Environmental allergies                | 571 (19)               | 110 (20)                            | 306 (56)                                            | 89 (16)                                          | 39 (7)                          | $F = 2.8$ ; $p = .04$                 |
| No environmental allergies             | 2491 (81)              | 366 (16)                            | 1250 (53)                                           | 519 (22)                                         | 201 (9)                         |                                       |
| Breastfeeding and formula feeding      |                        |                                     |                                                     |                                                  |                                 |                                       |
| Breastmilk                             | 815 (27)               | 124 (16)                            | 429 (55)                                            | 156 (20)                                         | 66 (9)                          | $F = 0.5$<br>$p = .87$                |
| Mostly breast milk and some formula    | 540 (18)               | 87 (18)                             | 263 (54)                                            | 108 (22)                                         | 29 (6)                          |                                       |
| Mostly formula and some breast milk    | 580 (19)               | 83 (15)                             | 316 (58)                                            | 106 (19)                                         | 40 (7)                          |                                       |
| Mix of formula and breast milk         | 370 (12)               | 68 (19)                             | 184 (51)                                            | 79 (22)                                          | 30 (8)                          |                                       |
| Only formula                           | 729 (24)               | 104 (15)                            | 360 (53)                                            | 153 (22)                                         | 68 (10)                         |                                       |
| Any breastfeeding vs. no breastfeeding |                        |                                     |                                                     |                                                  |                                 |                                       |
| Any breastfeeding                      | 2305 (75)              | 362 (17)                            | 1191 (55)                                           | 449 (21)                                         | 165 (8)                         | $F = 1.1$ ; $p = .33$                 |
| No breastfeeding                       | 748 (25)               | 111 (16)                            | 363 (52)                                            | 156 (22)                                         | 73 (10)                         |                                       |

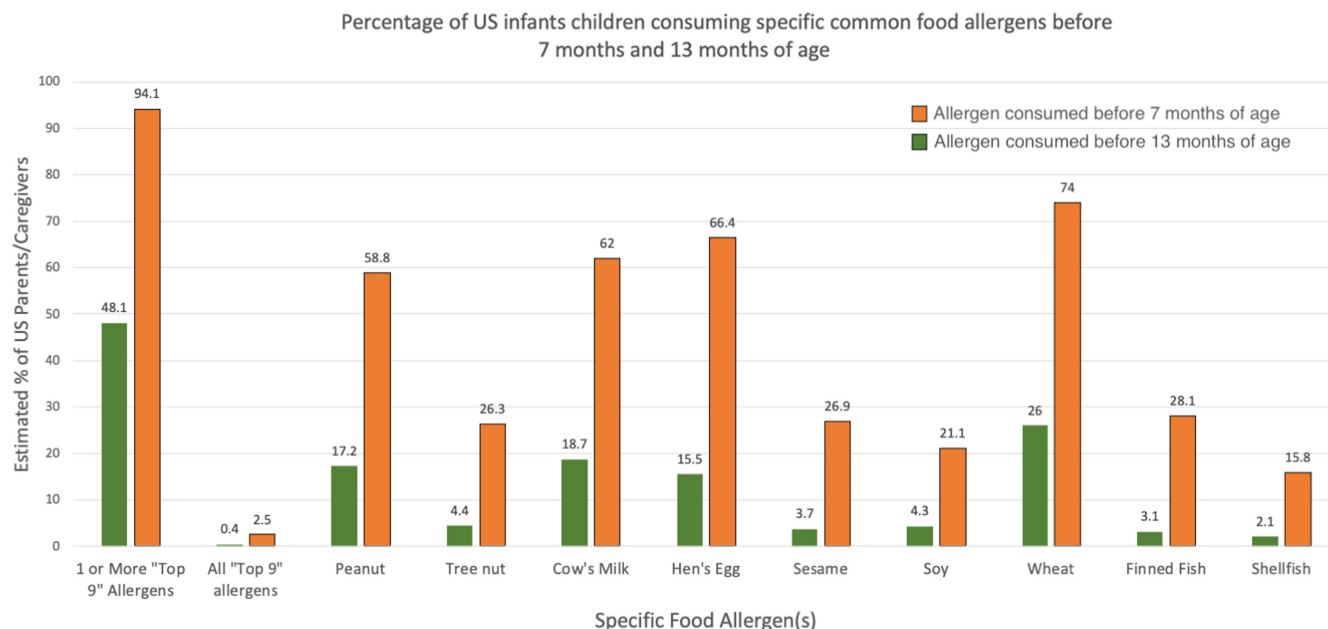


**FIGURE 1** Percentage of children who were fed 9 allergens (peanut, tree nuts, cow's milk, egg, sesame, soy, Wheat, finned fish, and shellfish) before 7 months and 1 year.

Conditional probabilities of introducing specific "Top 9" food allergens before 7 months

|                                            |             | Among children fed column allergen by 6 months |          |      |      |           |             |       |      |        |
|--------------------------------------------|-------------|------------------------------------------------|----------|------|------|-----------|-------------|-------|------|--------|
|                                            |             | Peanut                                         | Tree nut | Milk | Egg  | Shellfish | Finned Fish | Wheat | Soy  | Sesame |
| % of children fed row allergen by 6 months | Peanut      | 100                                            | 51.7     | 29.7 | 46.4 | 57        | 57.7        | 33    | 28.7 | 54.7   |
|                                            | Tree nut    | 13.2                                           | 100      | 12.8 | 13.2 | 42.9      | 33.6        | 9.4   | 17.3 | 29.2   |
|                                            | Milk        | 32.3                                           | 54.8     | 100  | 37.9 | 72.8      | 59.6        | 35.1  | 44.1 | 52.3   |
|                                            | Egg         | 42                                             | 46.7     | 31.4 | 100  | 59.5      | 60.7        | 31.7  | 35.3 | 58.6   |
|                                            | Shellfish   | 7.1                                            | 20.9     | 8.3  | 8.2  | 100       | 54.7        | 6.4   | 15.2 | 31.9   |
|                                            | Finned Fish | 10.5                                           | 24       | 9.9  | 12.2 | 79.7      | 100         | 10.4  | 15.4 | 42.7   |
|                                            | Wheat       | 50.1                                           | 56.2     | 48.9 | 53.2 | 78.1      | 87          | 100   | 59.4 | 85.8   |
|                                            | Soy         | 7.2                                            | 17.1     | 10.2 | 9.8  | 30.6      | 21.4        | 9.8   | 100  | 27.4   |
|                                            | Sesame      | 11.8                                           | 24.7     | 10.4 | 14   | 55.3      | 50.8        | 12.2  | 23.5 | 100    |

**FIGURE 2** Probability of introducing food allergens before 7 months in relation to another allergen.

Conditional probabilities of introducing specific food allergens before 13 months

|                                             |             | Among children fed column allergen by 12 months |          |      |      |           |             |       |      |        |
|---------------------------------------------|-------------|-------------------------------------------------|----------|------|------|-----------|-------------|-------|------|--------|
|                                             |             | Peanut                                          | Tree nut | Milk | Egg  | Shellfish | Finned Fish | Wheat | Soy  | Sesame |
| % of children fed row allergen by 12 months | Peanut      | 100                                             | 81.3     | 76.5 | 67.8 | 80.3      | 76.1        | 65    | 72.4 | 73.3   |
|                                             | Tree nut    | 36.3                                            | 100      | 79.2 | 31.4 | 56        | 45.4        | 29    | 48.5 | 50     |
|                                             | Milk        | 69.6                                            | 78.7     | 100  | 68.5 | 80.7      | 79.8        | 68.3  | 78.5 | 79.5   |
|                                             | Egg         | 76.5                                            | 79.2     | 73.4 | 100  | 82.8      | 83.9        | 75.5  | 77.3 | 82.2   |
|                                             | Shellfish   | 21.5                                            | 33.6     | 20.6 | 19.7 | 100       | 47.9        | 18.9  | 35.7 | 36.2   |
|                                             | Finned Fish | 36.4                                            | 48.6     | 36.2 | 35.5 | 85.4      | 100         | 35    | 56.8 | 55.8   |
|                                             | Wheat       | 81.9                                            | 81.7     | 81.6 | 84.2 | 88.5      | 92.1        | 100   | 93   | 93.5   |
|                                             | Soy         | 26                                              | 39       | 26.8 | 24.6 | 47.8      | 42.7        | 26.5  | 100  | 45.1   |
|                                             | Sesame      | 33.5                                            | 51.1     | 34.4 | 33.3 | 61.7      | 53.4        | 33.9  | 57.4 | 100    |

**FIGURE 3** Probability of introducing food allergens before 1 year in relation to other allergens.

### 3.6 | Use of early introduction products

When asked, "Have you ever used any products intended to help prevent food allergies in your child? These products include but are not limited to, the following brands: 'Hello Peanut'; 'Inspired Start'; 'Lil Mixins'; 'MyPeanut'; 'Ready, Set, Food!'; and 'SpoonfulOne'."

3.1% of caregivers reported the use of an early introduction product at least once and 0.9% reported ever using an early introduction product  $\geq 3$  times. In adjusted models, annual household income, respondent educational attainment, and race/ethnicity were not associated with reported use of early introduction products nor was parental age, child eczema status, or the presence of a food-allergic

**FIGURE 4** Adjusted models for the association between demographic factors and any/every use of early food allergen products.

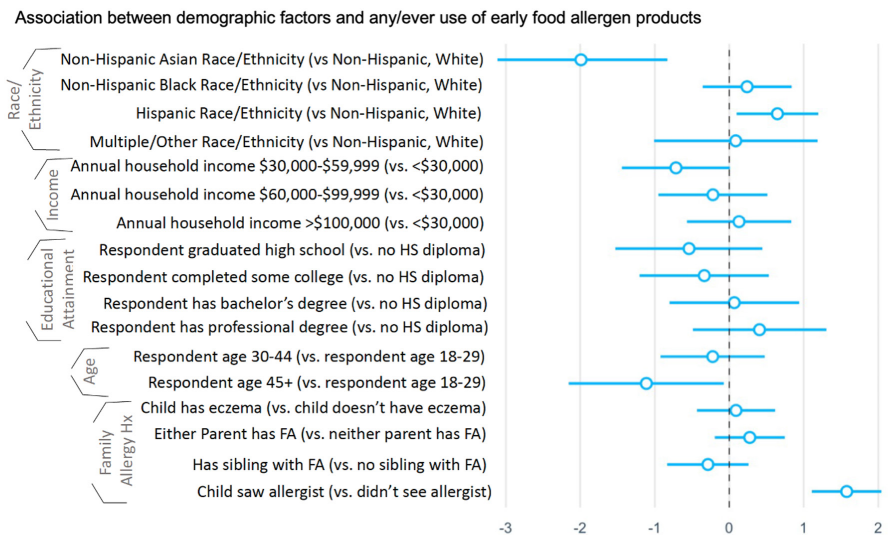
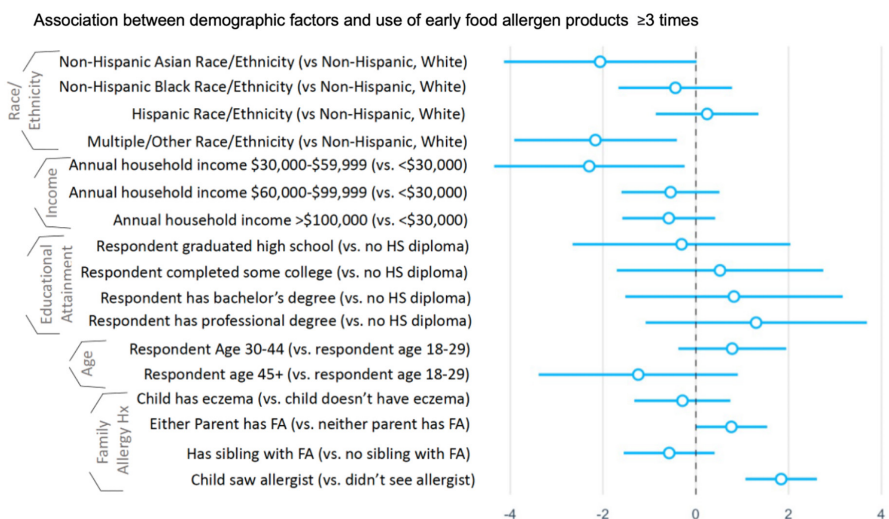


**FIGURE 5** Adjusted models for the association between demographic factors and use of early food allergen products  $\geq 3$  times.



sibling (two-sided  $p > .05$  for all). These predictors were also nonsignificant when the outcome was modeled as any use or use of the product  $\geq 3$  times (Figures 4,5).

Compared with respondents  $<30$  years of age, those  $>44$  years were significantly less likely to report using any food allergen prevention product(s) (OR = 0.32; 95% CI: 0.11–0.90). Respondents whose children had a biological parent with food allergy were more likely to use an early introduction product  $\geq 3$  times (OR = 2.2; 95% CI: 1.00–4.73) but not to report using a product at least once (OR = 1.3; 95% CI: 0.84–2.15). Caregivers who reported that their child had seen an allergist for a food allergy were also significantly more likely to report using an early food allergen introduction product either at least once (OR = 5.4; 95% CI: 3.5–8.4) or  $\geq 3$  times (OR = 6.7; 95% CI: 3.0–15.2).

## 4 | DISCUSSION

This survey of a representative sample of US caregivers of children born since the release of the 2017 NIAID-sponsored addendum

guidelines for the Prevention of Peanut Allergy, suggests that fewer than 1 in 5 parents/caregivers reported introducing peanut to their infant before 7 months of age and fewer than 3 in 5 reported introducing peanut to their infant during the first year of life. Breastfeeding was associated with a greater likelihood of introducing peanut before 7 months of age and a reduced likelihood of not having introduced peanut. It did not show any association with the reported timing of egg introduction. Peanut butter was the most frequently introduced format. Compared with peanut, rates of early introduction of egg were higher with 1 in 8 caregivers introducing egg before 6 months and two-thirds introducing primarily scrambled egg before 1-year infant age. Interestingly, findings in the current study reveal foods containing cow's milk, wheat and soy were the top three allergens introduced during infancy. This may reflect the wide availability of these foods in the US food supply. These data also indicate that earlier introduction of peanut and egg is associated with a higher likelihood of introducing other food allergens during the first year of life. However, very few families reported the use of "early allergen introduction products," and the decision to use these products seems to be associated with having a parent

with a food allergy or having seen an allergist prior to introducing peanut to their child.

While these observed rates of peanut introduction appear low in the context of recently published guidelines recommending that all infants consume peanut during the first year of life, they nevertheless mark a substantial increase from 2016 data collected in the Feeding Infants and Toddlers Study (2016), a US population-based study, surveying caregivers of 3235 infants in the US. In this landmark infant nutrition study,<sup>19</sup> 0.3% of caregivers/caregivers reported introducing peanut to their infant by 4–5.9 months, 0.9% by 6–8.9 months, and 5.5% by 9–11.9 months. In our study 5.5% of caregivers fed infants peanut before 7 months and 44.7% before 13 months. Despite this observed shift toward earlier peanut introduction, it does suggest that many caregivers remain either unamenable or insufficiently aware/convicted of the benefits of introducing peanut to younger infants. It may also indicate that those who are willing to introduce peanut to their young infant, may benefit from practical advice regarding its introduction. In a 2018 study,<sup>20</sup> 31% of caregivers reported willingness to feed infants peanut at or around 6 months of age—higher than the reported rates of introduction of peanut in our survey. This may indicate that a “willingness” to introduce a food to an infant’s diet, does not always translate into actually introducing the food as indicated by Lai et al.,<sup>21</sup> In their 2019 survey, 90% of caregivers indicated that they were comfortable with peanut introduction, yet only 37% reported introducing peanuts into their infants’ diets before 7 months of age.<sup>21</sup> One of the main reasons stated for reluctance or lack of introduction was the fact that written guidance was not provided. In the US, online, written information, with suitable pictures, is publicly available on the NIAID website. This information provides practical guidance regarding safe, developmentally-appropriate forms and fluids to mix peanut foods with household measures to facilitate offering the recommended amounts and guidance on how often peanut should be consumed.<sup>22</sup>

In our survey, 15.5% of caregivers reported introducing egg before 7 months and 66.4% before 13 months, greatly exceeding those reported<sup>19</sup> in 2016. Compared with this survey, rates of introduction of egg increased before 7 months. In fact, egg introduction before 7 months increased 6.5 times between the two study timelines and peanut introduction 18 times. Egg introduction doubled before 13 months between the 2 studies and peanut introduction increased 8 times between the two studies. Increased feeding of egg during the first year of life, may reflect the recommendations on peanut intake by the NIAID-sponsored addendum guidelines indicating both suggested dose and frequency of intake with accompanying practical handouts. The guidance provided by the consensus statement<sup>12</sup> recommends egg and peanut introduction with no further guidance. In addition, the US Dietary Guidelines<sup>23</sup> currently state that “At about 6 months, introduce infants to nutrient-dense complementary foods. Introduce infants to potentially allergenic foods along with other complementary foods,” which may delay uptake of early allergen feeding before 6 months.

While not suggesting the active introduction of other food allergens, international food allergy prevention guidelines<sup>6,12,13,24</sup> also recommend not to delay the introduction of these allergens. In our survey

wheat, milk (which included cow’s milk formula), and soy were consistently shown as the food allergens most often introduced before 7 months and 1 year of age. Our data indicate that fewer caregivers introduced soy, finned fish, and shellfish to infants before 13 months of age than peanut and egg. This could either indicate less emphasis on the introduction of these allergens, lower intake of these foods by the US population, or uncertainty in the allergy community about a suitable age of introduction for these foods in particular. Soy and shellfish have not been studied in the most recent allergy prevention trials. In the Enquiring About Tolerance (EAT) study, fish allergy was more prevalent in the intervention group than the control group, though cases were rare and this difference was not statistically significant.<sup>14</sup>

It has also been shown that diet diversity, with particular reference to food allergen diversity before 1 year of age, is associated with reduced food allergy outcomes.<sup>25</sup> In a large, well-characterized European birth cohort with minimal participant attrition, Venter et al.<sup>26</sup> showed that for each additional food allergen given before 1 year of age, the odds of developing food allergy by 10 years of age were reduced by 33%. Consequently, we were interested to see whether families who introduce peanuts and egg earlier (before 6 months of age) are more likely to also introduce other food allergens. In our survey, among caregivers who introduced peanuts before 7 months, 42% also introduced egg before 7 months.

In our study, of those who introduced peanuts before 13 months, 76.5% also introduced egg. Groetch et al.<sup>19</sup> noted that only 60.5% of children consuming peanut by 12 months, also consumed egg-containing foods by 12 months. In our survey, the converse was also true: among caregivers who introduced egg before 7 months and before 1 year, 46.4% and 67.8% also introduced peanut, respectively. However, this was much lower in the study by Groetch et al.,<sup>19</sup> These authors noted that only 2.3% of children consuming egg by 6 months and 9.3% of children consuming egg by 12 months, also consumed peanut-containing foods by 6 months.

In our study, the introduction of peanuts and egg before 7 months of age was significantly associated with the introduction of other food allergens before 1 year of age ( $p = <.001$ ). The incidence rate ratio was similar for egg (1.56) and peanut (1.5) introduction before 7 months, indicating that such introduction of peanut and egg was similarly associated with the introduction of other food allergens during the first year of life.

Peanut butter was caregivers’ preferred form of peanut fed to infants in our study, consistent with findings from the LEAP trial.<sup>9</sup> However, caregivers’ approach to introducing peanut safely to their children is questionable considering most did not report thinning peanut butter with water before feeding to avoid infant choking as advised by the AAP.<sup>27</sup> It remains unclear which forms of peanut young children in the US regularly consume as peanut intake measured by questionnaire is often described in a combined category of “nuts, seeds, and legumes” in federal surveys<sup>27</sup> and infant feeding studies.<sup>19,28</sup> Currently most validated food recall measures in the US such as the ASA-24<sup>29</sup> and the Diet History Questionnaire (DHQ)<sup>30</sup> do not clearly distinguish between different forms of nuts and seeds eaten, which poses a practical

challenge for food allergy research, where understanding the quantity, frequency and format in which specific allergenic solids are consumed are crucial.

Perhaps unsurprisingly, given their relative novelty, fewer than 1 in 20 families reported ever using early food allergen introduction products: and fewer than 1 in 100 reported using such products more than twice. We did not enquire about the brand names of the products used. Factors associated with using these products  $\geq 3$  times were a family history of allergy and that the infant was seen by an allergist. However, it is unclear whether and to what extent these products were actually recommended by an allergist. It is important to note that these products vary widely in their allergenic protein content, and the presence of adjuvants (e.g., Vitamin D) and their efficacy for food allergy prevention have not been clinically evaluated.

Finally, and important to note, in our study, similar to findings from Australia, earlier introduction of peanut did not appear to shorten breastfeeding duration.<sup>31</sup>

A strength of our study is that it leverages recent data from a large, nationally representative sample of infant caregivers. The study was designed to assess current trends in allergenic solid food intake, particularly peanut and egg, in the context of food allergy prevention. This is in contrast with most other nutritional studies, which focus on assessing nutritional intake with no targeted questions on the consumption of allergenic solids.<sup>19,28</sup> Due to our reliance on caregiver-reported dietary recall measures, assessed cross-sectionally, our study is subject to their inherent limitations, most notably recall bias. We also note one possible limitation. Our study was conducted during the COVID-19 period, during which reduced access to healthcare or other issues might have impacted allergenic food introduction practice.<sup>32</sup> It is also important to consider that the survey reports on food allergen introduction practices and how this impacts allergy outcomes in future remain to be studied.

Recent data from Australia<sup>33</sup> indicate that earlier introduction of food allergens, may not be directly related to reduced food allergies outside of a randomized controlled trial setting. The findings of the Australian study may be limited due to a lack of information on dose and frequency of intake, similar to the limitation of our study.

## 5 | CONCLUSION

Less than half of caregivers in the US are introducing peanut products to their infants before 13 months of age, though an observed shift toward earlier peanut and egg introduction was seen in the past 5 years. An important take-away point is that caregivers who introduce peanut and egg earlier, are also more likely to introduce other allergens. It is therefore possible that information on the active and early introduction of peanuts and egg, may pave the way for the introduction of other food allergens.

### AUTHOR CONTRIBUTIONS

CV, CW, and RG conceptualize the paper. CW developed methodology. RG is overseeing data curation. CW and LB conducted and

reviewed the analysis. RG provided study and paper supervision. SN, WS, and JZ were involved in the visualization of data and final paper. RG provided administrative support and resources. CV wrote the first draft. All authors were involved in the review and editing of the paper.

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### CONFLICT OF INTEREST

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### PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/pai.13896>.

### DATA AVAILABILITY STATEMENT

Data are available upon request by contacting [cfaar@northwestern.edu](mailto:cfaar@northwestern.edu)

### ORCID

Carina Venter  <https://orcid.org/0000-0002-7473-5355>

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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