

Population response to change in infant feeding guidelines for allergy prevention

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Background: It is unknown whether population infant feeding practices have changed since recently revised Australian allergy guidelines removed recommendations to delay allergenic solids. **Objectives:** We sought to determine whether updated 2008 guidelines were associated with changes in feeding practice and to determine whether sociodemographic factors influenced this response.

Methods: In a population-based, cross-sectional study (HealthNuts) of 5276 infants recruited between 2007 and 2011 in Melbourne, Australia, parents reported on infant feeding practices. Multinomial logistic regression was used to investigate the associations between recruitment year and feeding practices and whether these associations were modified by sociodemographic factors.

Results: Compared with participants recruited in 2007-2009, those recruited in 2009-2011 were more likely to introduce solids at age 4 months (adjusted multinomial odds ratio [aMOR], 1.21; 95% CI, 1.02-1.45; $P = .032$) and less likely to introduce solids at age 6 months (aMOR, 0.80; 95% CI,

0.69-0.92; $P = .002$), egg after 6 months (aMOR, 0.82; 95% CI, 0.71-0.94; $P = .004$), and peanut after 12 months (aMOR, 0.70; 95% CI, 0.49-0.98; $P = .037$). Although parents recruited in 2009-2011 were less likely to formula feed (aMOR, 0.84; 95% CI, 0.72-0.98; $P = .023$), formula-fed infants were more likely to be given a partially hydrolyzed formula (aMOR, 1.37; 95% CI, 1.12-1.70; $P = .003$). These changes were significantly stronger among families with a higher socioeconomic status and those without a family history of allergies.

Conclusion: Updated national allergy guidelines are associated with reduced delay in introduction of solids, egg, and peanut and an increase in partially hydrolyzed formula use among formula-fed infants. Higher socioeconomic status and absence of family history of allergies were associated with better uptake of feeding guidelines. (*J Allergy Clin Immunol* 2013;■■■:■■■-■■■.)

Key words: Food allergy, infant feeding, solids, egg, peanut, formula, weaning, family history, guidelines

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With the high prevalence and reportedly increasing rates of IgE-mediated food allergies globally,^{1,2} one of the key hypotheses is that timing of allergenic solids introduction might affect the development of food allergy.³ Du Toit et al⁴ reported that Jewish children in the United Kingdom had higher rates of peanut allergy than Jewish children in Israel (relative risk, 5.8; 95% CI, 2.8-11.8; $P < .001$) and suggested that this was possibly linked to the earlier introduction of dietary peanut in Israeli children. Similarly, we recently reported⁵ that there was an increased risk of challenge-confirmed egg allergy when egg consumption was delayed to age 10 to 12 months (adjusted odds ratio, 1.6; 95% CI, 1.0-2.6) and after age 12 months (adjusted odds ratio, 3.4; 95% CI, 1.8-6.5) in comparison with those who first introduced egg at age 4 to 6 months.

Given this evidence and other similar reports,⁶⁻¹¹ global allergy prevention guidelines^{12,13} have recently been revised to remove previous advice to delay the introduction of potentially allergenic foods. However, despite widespread updating of infant feeding guidelines, there is a paucity of reports on the effect of public health guidelines on changing a population's feeding practices.¹⁴ There is also a lack of understanding as to whether key sociodemographic factors, such as maternal country of birth, socioeconomic status, and family history of allergies, influence the family's uptake of such recommendations.

In Australia the previous recommendations by the National Health and Medical Research Council in 2003 were to introduce solids around the age of 6 months and, where there is a strong family history of allergies, to delay dietary egg, nuts, and shellfish until the age of 1 to 3 years.¹⁵ In September 2008, at the same time as international feeding guidelines were being reviewed, the Australasian Society of Clinical Immunology and Allergy introduced new

Abbreviations used

aMOR: Adjusted multinomial odds ratio
MOR: Multinomial odds ratio

recommendations for all infants, irrespective of family history of allergy, to commence complementary foods between the ages of 4 and 6 months, with express advice that allergenic solids, such as egg and peanut, need not be excluded.¹⁶ Similarly, in 2008, the Australian state of Victoria's Department of Health removed its previous recommendation to delay introduction of allergenic solids (eg, egg and peanut until after age 10 months), whereas mothers were advised to introduce solids at age 6 months (rather than at age 4-6 months, previously).^{17,18} The Australasian Society of Clinical Immunology infant feeding guidelines were otherwise unchanged, including a normal diet for the mother during both pregnancy and lactation and the recommendation to use a partially hydrolyzed formula in place of standard cow's milk formula for infants with a family history of allergic disease if complementary formula feeding was required in the first 4 to 6 months of life.

Objective 1 of our study was to document the effect of changed national guidelines on infant feeding practices in the HealthNuts cohort, a large population-based study of infants, and the development of food allergy over the first year of life. During the 4-year recruitment period from 2007 to 2011, amendment of a key Australian feeding guideline in 2008 provided a unique opportunity for us to study whether actual feeding practices, particularly introduction of potentially allergenic foods, changed in the same period. Objective 2 was to explore whether the effect of guidelines is driven by food allergy or higher sociodemographic status.

METHODS**Design and recruitment**

The HealthNuts study's methods have been previously detailed.¹⁹ In brief, HealthNuts researchers attended 121 council-run immunization sessions across Melbourne, Victoria, Australia, between September 2007 and August 2011, aiming to recruit all 11- to 15-month-old infants attending for their 12-month scheduled immunization. More than 90% of infants in Melbourne receive their 12-month immunizations, with approximately half administered by council-run immunization sessions and the remainder administered either by general practitioners or state/community health agencies.¹⁹

Ethical approval was obtained from the Office for Children HREC (reference no. CDF/07/492), the Department of Human Services HREC (reference no. 10/07) and the Royal Children's Hospital HREC (reference no. 27047). Parents or guardians provided written informed consent.

Procedures

During the 15- to 20-minute compulsory observation period after vaccination, a study nurse administered a skin prick test with single-tine lancets (Stallergenes, Antony, France) to 4 of 5 foods (egg white, peanut, sesame, cow's milk, or shellfish [*Pandalus borealis*]; ALK-Abelló, Madrid, Spain), 10 mg/mL histamine (positive control), and saline (negative control). While waiting for the skin prick test, parents completed a detailed interviewer-administered questionnaire that included information on the age of egg and peanut introduction. A second 8-page self-administered questionnaire collected information on family history of allergies and type of formula used.

Exposure measure

We compared the feeding practices of participants recruited from September 2009 to August 2011 after the implementation of the updated Australasian Society of Clinical Immunology and Allergy infant feeding guidelines in September 2008 against participants recruited from September 2007 to August 2009.

Primary outcome measures: Infant feeding in response to guideline changes

We categorized variables to measure participants' responses to the Australasian Society of Clinical Immunology and Allergy guidelines on infant feeding.¹⁶ Age of solids introduction was categorized into less than 4 months, 4 months, 5 months, 6 months, and greater than 6 months. Age of egg and peanut introduction was initially categorized into less than 4 months, 4 to 6 months, 7 to 12 months, and greater than 12 months. However, because of the low number of participants who introduced egg ($n = 44$ [0.9%]) and peanut before age 4 months ($n = 9$ [0.2%]), the first 2 categories were combined to age 6 months or less for the analysis comparing the first versus the second half of recruitment. The age of introduction of egg and peanut was categorized as greater than 12 months when parents reported that they had not as yet commenced these in their child's diet. Egg introduction was defined as ingestion of either cooked egg (boiled, scrambled, fried, or poached) or baked egg (egg-containing cakes, biscuits, or similar products), whichever was earlier.

Formula feeding was categorized as ever or never formula fed. Among formula-fed participants, formula choice was defined as the first formula used because the majority (78%) of participants used only 1 formula. This was further categorized into 3 groups: regular cow's milk, partially hydrolyzed formula, or other, which included extensively hydrolyzed, amino acid-based, soy, lactose-free, goat/sheep, antireflux, and anticolic formulas. In Australia, during the study period, extensively hydrolyzed formulas and amino acid

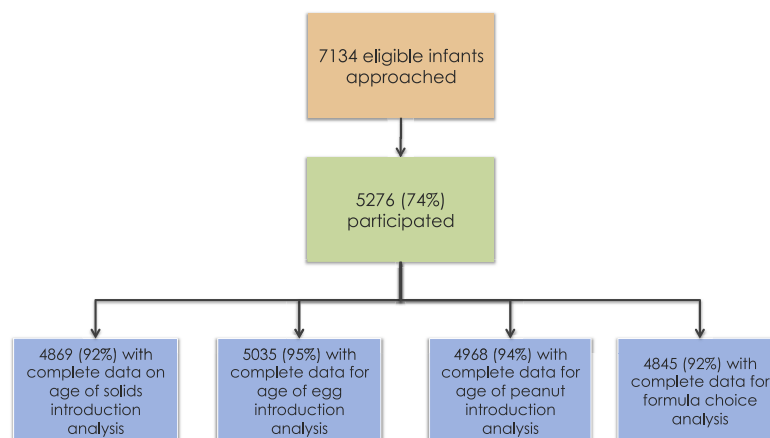


FIG 1. Study participation.

TABLE I. Baseline characteristics of the HealthNuts cohort

Characteristic	n, % (95% CI)
Maternal country of birth	
Australia	3687, 71.8% (70.5% to 73.0%)
Outside Australia	1450, 28.2% (27.0% to 29.5%)
Socioeconomic status*	
Low	2645, 50.1% (48.8% to 51.5%)
High	2631, 49.9% (48.5% to 51.2%)
Current household smoking	
None	4107, 78.5% (77.4% to 79.6%)
Yes	1127, 21.5% (20.4% to 22.6%)
Presence of siblings	
No	2582, 49.5% (48.2% to 50.9%)
≥1	2633, 50.5% (49.1% to 51.8%)
Eczema	
No	3657, 73.4% (72.2% to 74.5%)
Yes	1325, 26.6% (25.4% to 27.8%)
Family history of eczema	
No	3665, 69.5% (68.2% to 70.7%)
Yes	1611, 30.5% (29.3% to 31.8%)
Family history of asthma	
No	3657, 69.3% (68.1% to 70.6%)
Yes	1619, 30.7% (29.4% to 31.9%)
Family history of allergic rhinitis	
No	2636, 50.0% (48.6% to 51.3%)
Yes	2640, 50.0% (48.7% to 51.4%)
Family history of food allergy	
No	4593, 87.1% (86.2% to 88.0%)
Yes	683, 13.0% (12.0% to 13.9%)

*Socioeconomic status was measured by using the Index of Relative Socio-economic Disadvantage (Australian Census, 2006) and categorized as either higher (ie, greater than the median value) or lower (ie, less than the median value).

formulas were only available on restricted prescription for the treatment of established cow's milk and soy allergy.

Potential confounders

Potential confounders were factors that have previously been demonstrated to affect infant feeding practice, including eczema, family history of allergic disease, socioeconomic status, smoking, maternal country of birth, and presence of siblings.²⁰⁻²³

Secondary outcome measures: Effect modifiers

We analyzed whether the changes in infant feeding practices were different across the strata of the *a priori* sociodemographic effect modifiers, including socioeconomic status, maternal country of birth, and family history of allergy. Stratified analyses were presented when there was either a statistically significant interaction ($P \leq .05$) or modest evidence of an interaction ($P < .1$).

Eczema was defined by parent report and categorized separately for each analysis according to whether the onset of eczema occurred before the introduction of the food (solids, egg, and peanut) or before the age of 6 months (for the analysis of formula choice) to account for the possible modification of infant feeding by early signs of allergic disease in the child. Family history of allergic disease was categorized as the presence of any eczema, asthma, allergic rhinitis, or food allergy in any of the family members. Socioeconomic status was measured by using the Index of Relative Socio-economic Disadvantage, a general socioeconomic index that summarizes a range of information about the economic and social conditions of households within an area²⁴; these data were obtained from the Australian Census (2006) and matched by postcode. Socioeconomic status was categorized into either quintiles (when analyzed as a potential confounder) or as higher (ie, greater than the median value) or lower (ie, less than the median value, when analyzed as an effect modifier).

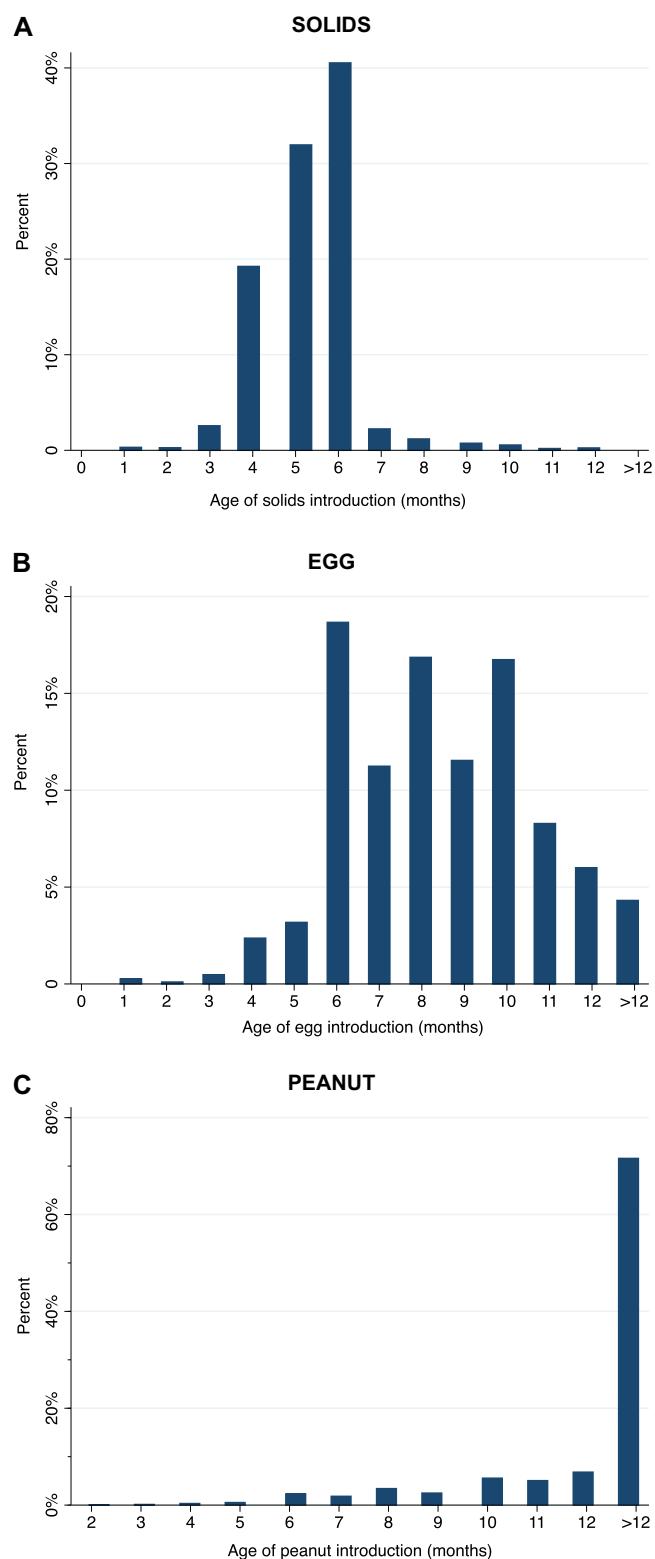


FIG 2. A, Age of solids introduction. B, Age of egg introduction. C, Age of peanut introduction.

Statistical analysis

For our primary aim, we used multinomial logistic regression models for each of the 4 outcomes (age of solids, egg, and peanut introduction and formula choice) to quantify their associations with timing of study recruitment (second

TABLE II. Infant feeding practices in the HealthNuts population: overall and first versus second half of recruitment

Outcome	2007-2011		Pre-2009		Post-2009		χ^2 P value
	No.	Percent (95% CI)	No.	Percent (95% CI)	No.	Percent (95% CI)	
Age of solid introduction							
<4 mo	153	3.1 (2.7-3.6)	70	3.6 (2.7-4.4)	83	2.9 (2.3-3.5)	<.001
4 mo	936	19.2 (18.1-20.3)	315	16.0 (14.4-17.7)	621	21.4 (19.9-22.9)	
5 mo	1555	31.9 (30.6-33.3)	612	31.2 (29.1-33.2)	943	32.5 (30.8-34.2)	
6 mo	1974	40.5 (39.1-41.9)	868	44.2 (42.0-46.4)	1106	38.1 (36.3-39.8)	
>6 mo	251	5.2 (4.5-5.8)	99	5.0 (4.1-6.0)	152	5.2 (4.4-6.0)	
Total*	4869	100.0	1964	100.0	2905	100.0	
Age of egg introduction							
<4 mo	44	0.9 (0.6-1.1)	12	0.6 (0.3-0.9)	32	1.1 (0.7-1.5)	.003
4-6 mo	1217	24.2 (23.0-25.4)	460	22.0 (20.3-23.8)	757	25.7 (24.1-27.3)	
7-12 mo	3557	70.6 (69.4-71.9)	1515	72.6 (70.7-74.5)	2042	69.3 (67.6-70.9)	
>12 mo	217	4.3 (3.7-4.9)	100	4.8 (3.9-5.7)	117	4.0 (3.3-4.7)	
Total*	5035	100.0	2087	100.0	2948	100.0	
Age of peanut introduction							
<4 mo	9	0.2 (0.1-0.3)	5	0.2 (0.0-0.4)	4	0.1 (0.0-0.3)	.005
4-6 mo	157	3.2 (2.7-3.7)	54	2.5 (1.9-3.2)	103	3.7 (3.0-4.3)	
7-12 mo	1247	25.1 (23.9-26.3)	502	23.4 (21.6-25.2)	745	26.4 (24.8-28.0)	
>12 mo	3555	71.6 (70.3-72.8)	1586	73.9 (72.0-75.7)	1969	69.8 (68.1-71.5)	
Total*	4968	100.0	2147	100.0	2821	100.0	
Formula use							
Ever formula fed							
No	936	19.3 (18.2-20.4)	349	16.8 (15.2-18.4)	587	21.2 (19.7-22.7)	<.001
Yes	3909	80.7 (79.6-81.8)	1727	83.2 (81.6-84.8)	2182	78.8 (77.3-80.3)	
Total*	4845	100	2076	100	2769	100	
Formula choice							
Cow's milk	2913	79.6 (78.2-80.9)	1209	81.3 (79.3-83.2)	1704	78.4 (76.6-80.1)	<.001
Partially hydrolyzed	479	13.1 (12.0-14.2)	157	10.6 (9.0-12.1)	322	14.8 (13.3-16.3)	
Other†	270	7.4 (6.5-8.2)	122	8.2 (6.8-9.6)	148	6.8 (5.7-7.9)	
Total*	3662	100	1488	100	2174	100	

*Numbers differ because of missing data for age of introduction of solids (n = 407 [7.7%]), egg (n = 241 [4.6%]), and peanut (n = 308 [5.8%]); ever formula fed (n = 431 [8.2%]); and formula choice (n = 399 [10.2%]).

†Other formula: extensively hydrolyzed (n = 17), amino acid-based (n = 22), soy (n = 57), lactose-free (n = 50), goat/sheep (n = 40), antireflux (n = 35), anticolic (n = 5), and other (n = 51) formulas.

half [post-2009] vs first half [pre-2009]). Associations were reported as the multinomial odds ratio (MOR) and adjusted multinomial odds ratio (aMOR) with 95% CIs. Each model was adjusted for all of the above confounders, except for family history of the allergic diseases (eczema, asthma, allergic rhinitis, or food allergies) that were only included in the model if they altered the MORs in the model by greater than 10%. Kaplan-Meier graphs were used to depict the timing of solids, egg, and peanut introduction over the recruitment years, and these were compared between recruitment years by using the log-rank test. Trends in timing of food introduction in relation to recruitment year were compared by using the trend test.

For our second aim, the interaction between potential *a priori* effect modifiers and change in infant feeding practice over the recruitment years were investigated by using likelihood ratio tests. STATA software (release 12.1; StataCorp, College Station, Tex) was used for all analyses.

RESULTS

Sample characteristics

A total of 7134 families were approached, and 5276 (74.0%) participated in the study. Fifty-one percent of participants were male. The complete data set was available for 4421 participants (Fig 1); missing data were not included in the analysis. Baseline characteristics of the cohort are reported (Table I).

Infant feeding practices relevant to food allergy

During the period of the study (2007-2011), almost all participants (91.7%; 95% CI, 90.9% to 92.5%) introduced solids

between the ages of 4 and 6 months (Fig 2 and Table II). Egg was most commonly introduced at 7 to 12 months of age (70.6%; 95% CI, 69.4% to 71.9%), whereas in contrast, peanut was mostly introduced after 12 months (71.6%; 95% CI, 70.3% to 72.8%). Among formula-fed participants, most used a regular cow's milk formula (79.6%; 95% CI, 78.2% to 80.9%), with a sizeable minority using partially hydrolyzed formula (13.1%; 95% CI, 12.0% to 14.2%).

Objective 1: Associations between changes in guidelines and infant feeding practices

Table III shows that after 2009 (ie, after the new national allergy guidelines were introduced), solids were more likely to be introduced earlier at age 4 months (aMOR, 1.21; 95% CI, 1.02-1.45; *P* = .032) and less likely to be introduced later at age 6 months (aMOR, 0.80; 95% CI, 0.69-0.92; *P* = .002) than before 2009. Regarding potentially allergenic foods, after 2009, egg was less likely to be introduced after 6 months (aMOR, 0.82; 95% CI, 0.71-0.94; *P* = .004), and peanut was less likely to be introduced after 12 months (aMOR, 0.70; 95% CI, 0.49-0.98; *P* = .037). After 2009, there was also a modest trend toward reduced likelihood of inappropriate solids introduction before the recommended age of 4 months (aMOR, 0.76; 95% CI, 0.54-1.09; *P* = .135) than before 2009.

TABLE III. Association between feeding practice and recruitment in the second half of the study period

Outcome	Post-2009,* crude MOR (95% CI)	P value	Post-2009,* aMOR† (95% CI)	P value
Age of solids introduction				
<4 mo	0.77 (0.55-1.07)	.124	0.76 (0.54-1.09)	.135
4 mo	1.28 (1.08-1.52)	.004	1.21 (1.02-1.45)	.032
5 mo	1.00		1.00	
6 mo	0.83 (0.72-0.95)	.006	0.80 (0.69-0.92)	.002
>6 mo	1.00 (0.76-1.31)	.980	0.90 (0.68-1.20)	.468
Age of egg introduction‡				
≤6 mo	1.00		1.00	
7-9 mo	0.83 (0.72-0.96)	.013	0.84 (0.72-0.98)	.029
10-12 mo	0.78 (0.67-0.90)	.001	0.80 (0.68-0.94)	.007
>12 mo	0.70 (0.52-0.94)	.016	0.65 (0.48-0.88)	.006
Age of peanut introduction§				
≤6 mo	1.00		1.00	
7-9 mo	0.96 (0.66-1.41)	.850	0.98 (0.66-1.47)	.932
10-12 mo	0.76 (0.54-1.08)	.124	0.80 (0.56-1.15)	.237
>12 mo	0.68 (0.49-0.95)	.022	0.70 (0.49-0.98)	.037
Formula use				
Ever formula fed				
No	1.00		1.00	
Yes	0.75 (0.65-0.87)	<.001	0.84 (0.72-0.98)	.023
Formula choice				
Cow's milk formula	1.00		1.00	
Partially hydrolyzed formula	1.46 (1.19-1.79)	<.001	1.37 (1.12-1.70)	.003
Other formula	0.86 (0.67-1.11)	.241	0.84 (0.65-1.09)	.194

*In comparison with pre-2009 values for each time point.

†Adjusted for socioeconomic status, smoking, maternal country of birth, presence of siblings, and eczema (onset before the introduction of the food [solids, egg, and peanut] or before age 6 months for the analysis of formula choice). Family history of eczema, asthma, allergic rhinitis, or food allergy was included as a confounder if it changed the MOR by 10% or greater.

‡Egg introduction at less than 4 months was merged with the 6-month or less category because of small participant numbers (Table II).

§Peanut introduction at less than 4 months was merged with the 6-month or less category because of small participant numbers (Table II).

||Other formula: extensively hydrolyzed (n = 17), amino acid-based (n = 22), soy (n = 57), lactose-free (n = 50), goat/sheep (n = 40), antireflux (n = 35), anticolic (n = 5), and other (n = 51) formulas.

Participants were less likely to be fed an infant formula after 2009 (aMOR, 0.84; 95% CI, 0.72-0.98; $P = .023$), but among formula-fed participants, there was an increase in partially hydrolyzed formula use relative to use of cow's milk formula (aMOR, 1.37; 95% CI, 1.12-1.70; $P = .003$). These results were concordant when timing of food introduction was compared across all 4 recruitment years (Fig 3), being significant for both trend analysis (solids, $P < .001$; egg, $P < .001$; peanut, $P < .001$; and formula choice, $P = .009$) and log-rank testing (solids, $P = .001$; egg, $P < .001$; and peanut, $P = .001$).

Objective 2: Effect modifiers of change in infant feeding practices over the recruitment years

Change in the introduction of solids according to the revised national allergy guidelines was stronger in mothers born outside Australia, who were less likely to commence their infants on solids before age 4 months when recruited after 2009 compared with those recruited before 2009 (aMOR, 0.37; 95% CI, 0.17-0.78; $P = .009$), but this association was not statistically significant among mothers born in Australia (Table IV).

Participants from a higher socioeconomic status category were more likely to respond to changed guidelines by introducing dietary egg and peanut earlier (Table V). Families with higher socioeconomic status were less likely to delay dietary egg after age 7 months (aMOR, 0.70; 95% CI, 0.57-0.86; $P = .001$) and peanut after age 7 months (aMOR, 0.44; 95% CI, 0.25-0.78; $P = .005$) when recruited after 2009 compared with before 2009. However, this association was not statistically significant among those from a lower socioeconomic status category.

Participants with and without a family history of allergic disease differed in their responses to feeding guidelines (Table VI). Families without a history of food allergy were less likely to delay introduction of peanut beyond age 7 months when recruited after 2009 compared with those recruited before 2009 (aMOR, 0.68; 95% CI, 0.47-0.96; $P = .030$), but this association was not observed in families with a history of food allergy. Similarly, families without a history of allergic rhinitis were less likely to delay introduction of egg beyond age 7 months when recruited after 2009 compared with before 2009 (aMOR, 0.72; 95% CI, 0.59-0.87; $P = .001$), but this association was not observed among those with a family history of allergic rhinitis. Furthermore, among families without a history of eczema, those recruited after 2009 were less likely to formula feed compared with those recruited before 2009 (aMOR, 0.74; 95% CI, 0.61-0.90; $P = .002$), but this association was not observed among those with a family history of eczema. In contrast, when analysis was restricted to participants who were formula fed, those families with a history of food allergy were more likely to use a partially hydrolyzed formula when recruited in 2009-2011 compared with those recruited in 2007-2009 (aMOR, 2.29; 95% CI, 1.20-4.37; $P = .012$) in comparison with those without a family history of food allergy (aMOR, 1.29; 95% CI, 1.03-1.61; $P = .026$).

DISCUSSION

This is the first large-scale epidemiologic study to investigate changes in the population's infant feeding practices during a time when revised national allergy feeding guidelines were introduced. We report that infants recruited to the study after introduction of revised guidelines were more likely to introduce solids at age 4 months and less likely to introduce solids at age 6 months, less likely to delay dietary egg beyond age 6 months, and less likely to delay peanut beyond age 12 months. Participants were also less likely to use infant formula after guidelines; however, among those who were formula fed, there was increased use of a partially hydrolyzed formula. Maternal country of birth, socioeconomic status, and family history of allergies were significant effect modifiers of the observed change in feeding practice.

In comparison with published reports on infant feeding practices (Table VII),^{4,8,21,23,25-29} the HealthNuts population in Victoria, Australia, had the highest rate of solids introduction between the ages of 4 and 6 months (91.7%; 95% CI, 90.9% to 92.5% in HealthNuts vs 86.5% to 89.4% in other published reports),^{8,25} introduction of egg by age 6 months (25.1%; 95% CI, 23.9% to 26.3 in HealthNuts vs 1.7% to 27.1% by age 6 to 8 months in other published reports),^{21,23,26} and introduction of peanut comparatively later (10.4%; 95% CI, 9.5% to 11.3% in HealthNuts vs 10% to 69% by age 9 months in other published reports).^{4,21} In stark contrast to astonishingly high rates of inappropriate introduction of solids before age 4 months in the United Kingdom (27.3%; 95% CI, 24.5% to 30.3%)²⁷ and the United States (40.5%;

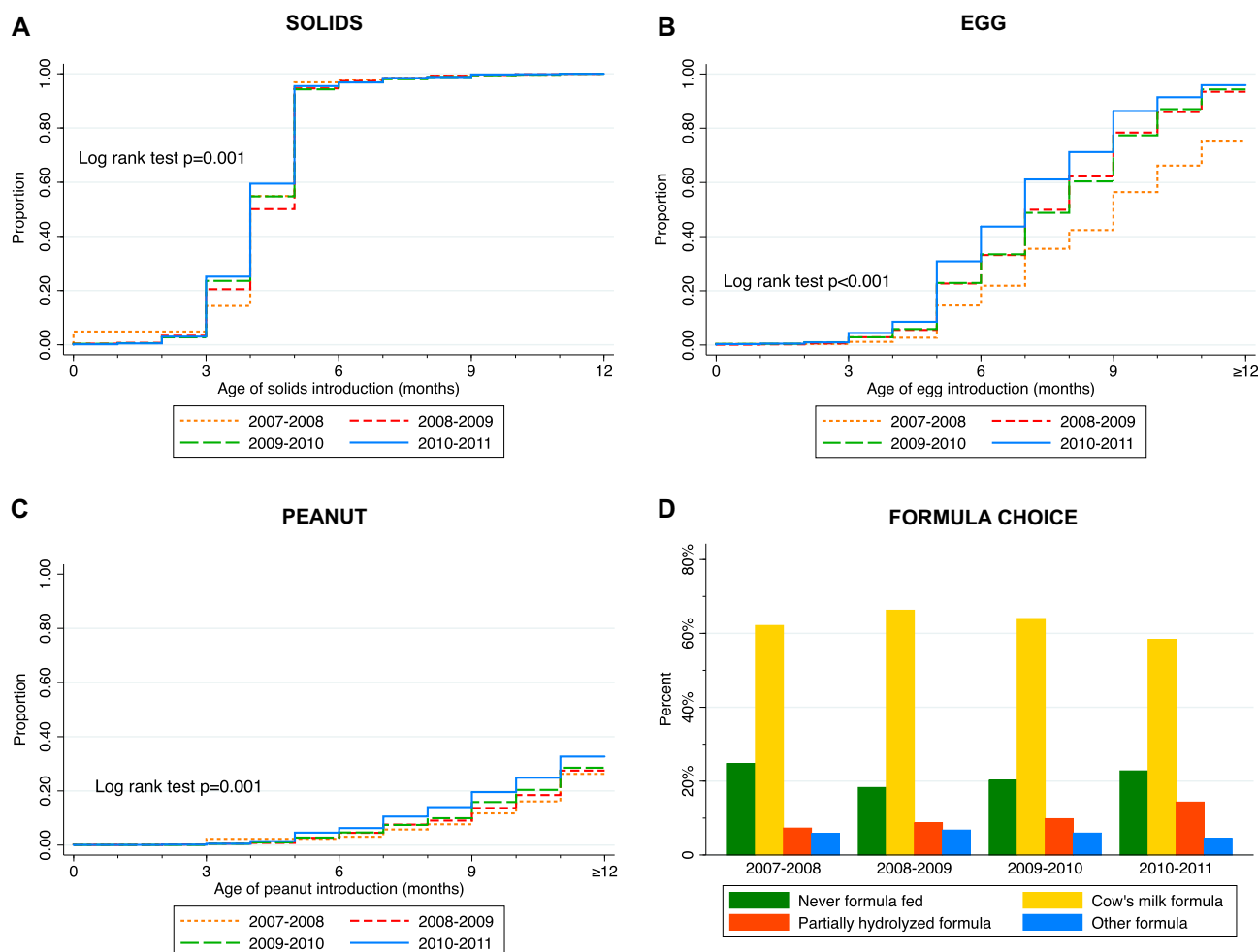


FIG 3. A, Kaplan-Meier graphs for recruitment year and solids introduction. B, Kaplan-Meier graphs for recruitment year and egg introduction. C, Kaplan-Meier graphs for recruitment year and peanut introduction. D, Multiple bar graphs for recruitment year and formula choice. *The y-axis represents the proportion of participants who have consumed food by age (in months).

TABLE IV. Effect of maternal country of birth on the association between recruitment year and feeding practice

TABLE 11. Effect of maternal country of birth on the association between breastfeeding year and feeding practices					
Outcome	Post-2009* aMOR† (95% CI), P value				Interaction term P value
	Mother born in Australia		Mother born outside Australia		
Age of solids introduction					
<4 mo	0.96 (0.64-1.45)	.857	0.37 (0.17-0.78)	.009	.022
4 mo	1.25 (1.01-1.53)	.036	1.14 (0.80-1.63)	.210	.723
5 mo	1.00		1.00		
6 mo	0.78 (0.67-0.92)	.003	0.83 (0.63-1.11)	.455	.632
>6 mo	0.83 (0.58-1.19)	.307	1.04 (0.64-1.68)	.881	.458

*In comparison with pre-2009 values.

†Adjusted for socioeconomic status, smoking, maternal country of birth, presence of siblings, and eczema (onset before the introduction of the food [solids, egg, and peanut] or before age 6 months for the analysis of formula choice). Family history of eczema, asthma, allergic rhinitis, or food allergy was included as a confounder if it changed the MOR by 10% or greater.

95% CI, 37.8% to 43.2%),²⁸ this was a problem in only a minority of our cohort (2.9%; 95% CI, 2.4% to 3.4%).

Our findings that the introduction of solids, egg, and peanut was less likely to be delayed after the change in infant feeding recommendations suggest that the population has responded favorably to revised national allergy guidelines. Furthermore, there was no increase in the likelihood of inappropriate earlier introduction of solids; conversely, there was a modest trend

toward a reduced likelihood of dietary solids introduction before age 4 months. In contrast, although the updated guidelines were unchanged in their advice regarding formula use, there was an increase in use of partially hydrolyzed formula after the guidelines. This might have been a consequence of the general increased community awareness of the feeding guidelines because of the significant national and global media spotlight on these recommendations during the

TABLE V. Socioeconomic status modifying the association between recruitment year and feeding practice

	Post-2009* aMOR† (95% CI), <i>P</i> value				
Outcome	Low socioeconomic status		High socioeconomic status		Interaction term <i>P</i> value
Age of egg introduction					
≤6 mo	1.00		1.00		
>7 mo	0.89 (0.74-1.07)	.209	0.70 (0.57-0.86)	.001	.076
Age of peanut introduction					
≤6 mo	1.00		1.00		
>7 mo	0.97 (0.64-1.49)	.907	0.44 (0.25-0.78)	.005	.034

*In comparison with pre-2009 values.

†Adjusted for socioeconomic status, smoking, maternal country of birth, presence of siblings, and eczema (onset before the introduction of the food [solids, egg, and peanut] or before age 6 months for the analysis of formula choice). Family history of eczema, asthma, allergic rhinitis, or food allergy was included as a confounder if it changed the MOR by 10% or greater.

TABLE VI. Family history of allergies modifying the association between recruitment year and feeding practice

Post-2009* aMOR† (95% CI), P value					
Family history of allergic disease					
Outcome	Fhx: allergic rhinitis negative		Fhx: allergic rhinitis positive		Interaction term P value
Age of egg introduction					
≤6 mo	1.00		1.00		
>7 mo	0.72 (0.59-0.87)	.001	0.90 (0.74-1.10)	.297	.099
Fhx: food allergy negativeFhx: food allergy positive					
Age of peanut introduction					
≤6 mo	1.00		1.00		
>7 mo	0.68 (0.47-0.96)	.030	2.08 (0.56-7.76)	.276	.083
Fhx: eczema negativeFhx: eczema positive					
Ever formula fed					
No	1.00		1.0		
Yes	0.74 (0.61-0.90)	.002	1.05 (0.81-1.36)	.699	.003
Fhx: food allergy negativeFhx: food allergy positive					
Formula choice					
Cow's milk	1.00		1.00		
Partially hydrolyzed	1.29 (1.03-1.61)	.026	2.29 (1.20-4.37)	.012	.092
Other‡	0.86 (0.65-1.13)	.282	0.70 (0.34-1.43)	.325	.649

Fhx, Family history.

*In comparison with pre-2009 values.

†Adjusted for socioeconomic status, smoking, maternal country of birth, presence of siblings, and eczema (onset before the introduction of the food [solids, egg, and peanut] or before age 6 months for the analysis of formula choice). Family history of eczema, asthma, allergic rhinitis, or food allergy was included as a confounder if it changed the MOR by 10% or greater.

‡Other formulas: soy (n = 57), extensively hydrolyzed (n = 17), amino acid-based (n = 22), lactose-free (n = 50), goat/sheep (n = 40), antireflux (n = 35), anticolic (n = 5), and other (n = 51) formulas.

study period, or alternatively, it might have been secondary to market forces and commercial activities during that time period. The Kaplan-Meier survival curves demonstrated that the change in infant feeding practices over the 4-year recruitment period was steady and gradual, possibly indicating that the community was cautious in embracing the rollout of these new recommendations. In contrast to our findings that the population in Melbourne responded favorably to changes in the national feeding guidelines, Hourihane et al¹⁴ reported that although 61% of women recalled hearing about the 1998 United Kingdom Government advice to withhold peanut consumption during pregnancy, only 4% adhered to this recommendation.

We have demonstrated key sociodemographic characteristics that are important effect modifiers in the population's response

to the recently revised feeding guidelines. Notwithstanding the low proportion of participants who inappropriately commenced solids before the recommended age of 4 months before the revised feeding guidelines (3.6%; 95% CI, 2.7% to 4.4%), mothers born outside Australia from a different culture and background were more likely to adopt the new guidelines, with a reduced likelihood of earlier solids introduction before age 4 months compared with mothers born in Australia. Families of higher socioeconomic status were less likely to delay introduction of dietary egg and peanut after guidelines, likely reflecting a demographic who have superior access to health care advice and hence are more likely to undertake better-informed health care decisions in a more timely manner compared with those who are socioeconomically disadvantaged.

TABLE VII. Comparison of age of introduction of allergenic foods and any solids between studies

Study	Age of introduction, proportion (95% CI), no. of participants		
	Peanut	Egg	Solids
Zutavern, Germany (1997-1999) ²³		≤6 mo: 6.6% (5.7% to 7.6%)* n = 2543	≤4 mo: 34.0% (32.1% to 35.9%)* 5-6 mo: 48.1% (46.1% to 50.1%)* >6 mo: 18.0% (14.5% to 21.9%)* n = 2474
Giovannini, Italy (1999) ²⁹			≤4 mo: 34.2% (32.4% to 36.0%)* ≤6 mo: 85.5% (84.1% to 86.8%)* n = 2771
Snijders, The Netherlands (2000-2005) ⁸			<4 mo: 7.6% (6.6% to 8.7%)* 4-6 mo: 89.4 (88.1% to 90.6%)* >6 mo: 1.8% (1.3% to 2.4%)* n = 2510
Venter, United Kingdom (2001-2002) ²⁷			≤3 mo: 27.3% (24.5% to 30.3%)* ≤4 mo: 82.1% (79.5% to 84.5%)* n = 969
Nwaru, Finland (1998-2000) ²⁶		<8.1 mo: 27.1% (24.3% to 30.0%)* n = 994	Median age, 3.5 mo (range, 0.7-10.0 mo) n = 994
Du Toit, Israel and United Kingdom (2004-2005) ⁴	≤9 mo Israel: 69% (59% to 78%)*, n = 99 United Kingdom: 10% (5% to 20%)*, n = 77		
Grummer-Strawn, United States (2005-2007) ²¹	≤12 mo: 25.1% (23.1% to 27.2%) n = 1782	≤6 mo: 1.7% (1.2% to 2.4%)*, n = 2046	
Clayton, United States (2005-2007) ²⁸			<4 mo: 40.5% (37.8% to 43.2%)* n = 1334
Chuang, Taiwan (2005-2007) ²⁵			<4 mo: 4.5% (4.2% to 4.8%)* 4-6 mo: 85.5 (85.0% to 86.0%)* >6 mo: 10.0% (9.6% to 10.4%)* n = 18,773
HealthNuts, Australia (2007-2011)	≤9 mo: 10.4% (9.5% to 11.3%) n = 4971	≤6 mo: 25.1% (23.9% to 26.3%) n = 5038	<4 mo: 2.9% (2.4% to 3.4%) 4-6 mo: 84.7% (83.7% to 85.7%) >6 mo: 12.4% (11.5% to 13.3%) n = 5276

*95% CIs were calculated from available data by using STATA software.

Although the effect of family history of allergies on infant feeding practice has been well described by previous investigators,^{27,30} we are the first to report that it is a crucial driver in a family's response to new feeding guidelines. Infants with a family history of food allergy after guidelines were more likely to have been fed partially hydrolyzed formula, a feeding decision that, apart from economic cost, has low perceived risk to the infant. Conversely, it was the participants without a family history of food allergy who were more receptive to the new guidelines by not delaying the introduction dietary peanut, a feeding decision that carries a higher perceived risk by parents. These contrasting effects highlight that families with a history of allergy are selective in their adoption of revised guidelines, with the degree of perceived risk of each recommendation being the most likely driving factor for parental action.

The strengths of this study include its population-based sampling frame, large sample size, high recruitment rate, and ability to control for a wide range of potential confounders. One limitation is that the retrospective collection of data at age 12 months could have led to parental recall error; however, we expect this to have been nondifferential by the recruitment year. We minimized the possibility of parental recall bias affecting these results by adjusting for early-onset eczema and ensuring the

questionnaire on food introduction was collected before parental knowledge of skin prick test outcomes. Development of the 2008 revised national infant feeding guidelines might have also resulted in recall bias secondary to parental intentions to adhere to these guidelines. Finally, these changes were observable within 3 years of revised national guidelines, and follow-up studies might reveal further significant modification of the population's behavior.

In conclusion, this is the largest population cohort study investigating the change in infant feeding practices after updated national allergy guidelines. We report that the Victorian population in Australia has responded encouragingly to these recommendations, with a reduction in the delayed introduction of dietary solids, egg, and peanut. The changes in these feeding practices were modified by the mother's country of birth, the family's socioeconomic status, and the presence of a family history of allergies. Addressing the challenges raised by these key modifiers of the population's response to feeding recommendations is a prerequisite for the successful delivery and implementation of future national and global infant feeding guidelines.

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Key messages

- Revised national allergy guidelines in 2008 have been associated with a reduction in the delayed introduction of dietary solids, egg, and peanut and an increase in partially hydrolyzed formula use among formula-fed infants.
- Maternal country of birth outside Australia, higher socioeconomic status, and the absence of a family history of allergies are key drivers to the population's acceptance of new feeding recommendations.

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