6-1-2021

Infant Feeding Practices and Subsequent Dietary Patterns of School-Aged Children in a US Birth Cohort

Alexandra R. Sitarik

Jean M. Kerver

Suzanne L. Havstad

Edward M. Zoratti

Dennis R. Ownby

See next page for additional authors

Authors
Alexandra R. Sitarik, Jean M. Kerver, Suzanne L. Havstad, Edward M. Zoratti, Dennis R. Ownby, Ganesa Wegienka, Christine C. Johnson, and Andrea E. Cassidy-Bushrow

Infant Feeding Practices and Subsequent Dietary Patterns of School-Aged Children in a US Birth Cohort

Alexandra R. Sitarik, MS; Jean M. Kerver, PhD, MSc, RD; Suzanne L. Havstad, MA; Edward M. Zoratti, MD; Dennis R. Ownby, MD; Ganesa Wegienka, PhD; Christine Cole Johnson, PhD; Andrea E. Cassidy-Bushrow, PhD

ARTICLE INFORMATION

Article history:
Submitted 7 August 2019
Accepted 21 August 2020

Keywords:
Breastfeeding
Childhood diet
Birth cohort
Latent class analysis
Causal inference

https://doi.org/10.1016/j.jand.2020.08.083

ABSTRACT

Background Infant feeding practices are thought to shape food acceptance and preferences. However, few studies have evaluated whether these affect child diet later in life.

Objective The study objective was to examine the association between infant feeding practices and dietary patterns (DPs) in school-aged children.

Design A secondary analysis of data from a diverse prospective birth cohort with 10 years of follow-up (WHEALS [Wayne County Health Environment Allergy and Asthma Longitudinal Study]) was conducted.

Participants/setting Children from the WHEALS (Detroit, MI, born 2003 through 2007) who completed a food screener at age 10 years were included (471 of 1,258 original participants).

Main outcome measures The main outcome was DPs at age 10 years, identified using the Block Kids Food Screener.

Statistical analysis performed Latent class analysis was applied for DP identification. Breastfeeding and age at solid food introduction were associated with DPs using a 3-step approach for latent class modeling based on multinomial logistic regression models.

Results The following childhood DPs were identified: processed/energy-dense food (35%), variety plus high intake (41%), and healthy (24%). After weighting for loss to follow-up and covariate adjustment, compared with formula-fed children at 1 month, breastfed children had 0.41 times lower odds of the processed/energy-dense food DP vs the healthy DP (95% CI 0.14 to 1.25) and 0.53 times lower odds of the variety plus high intake DP (95% CI 0.17 to 1.61), neither of which were statistically significant. Results were similar, but more imprecise, for breastfeeding at 6 months. In addition, the association between age at solid food introduction and DP was nonsignificant, with each 1-month increase in age at solid food introduction associated with 0.81 times lower odds of the processed/energy-dense food DP relative to the healthy DP (95% CI 0.64 to 1.02).

Conclusions A significant association between early life feeding practices and dietary patterns at school age was not detected. Large studies with follow-up beyond early childhood that can also adjust for the multitude of potential confounders associated with breastfeeding are needed.
J Acad Nutr Diet. 2021;121(6):1064-1079.

MEETING DIETARY RECOMMENDATIONS DURING childhood is important for appropriate development and healthy weight gain.[1] Unfortunately, most US children fail to meet the 2015-2020 Dietary Guidelines for Americans as described by the US Department of Agriculture and US Department of Health and Human Services.[2] A recent analysis using a representative sample of US children demonstrated that the average Healthy Eating Index 2010 score ranged from 44 to 52 out of 100 and concluded that overall diet quality was poor among all age groups examined (4-8, 9-13, and 14-18 years).[2] Dietary patterns (DPs) track throughout the life course[3-5] and can result in long-term consequences for health and chronic disease risk, emphasizing the importance of establishing healthy eating patterns as early as possible.

Human eating behavior is influenced by both genetic and environmental factors, and begins to take shape *in utero* and continues to develop throughout infancy.[6,7] Previous studies have shown that breastfed children may be more open to trying new foods and accepting them in infancy.[8] This is likely due to the fact that breastfed children are exposed to a complex array of flavors, as maternal diet is reflected in breast milk.[9,10] Indeed, previous studies have shown that flavors such as carrot,[11] vanilla,[10] garlic,[12] and caraway[8] are transmitted through breast milk. In contrast, infant formula does not provide these flavor varieties, and most formula-fed infants are typically given only one type of formula.[13] These differences in experienced flavor diversity may explain why children who are breastfed are less likely to be picky eaters.[14] Some studies have also shown that earlier age at solid food introduction increases food acceptance in infancy.[15-17] However, there is little information regarding whether these effects persist into childhood, and it is unclear whether these associations are due to confounding effects such as that of socioeconomic status.

In this analysis, rather than attempting to isolate individual foods or nutrients, overall DPs are instead identified and participants are grouped based on similarity in these patterns using latent variable modeling. As outlined by Hu,[18] there are several drawbacks to the "single nutrient" approach, including that it fails to consider that people eat a complex mixture of foods that are likely to be interactive or synergistic; the effect of a single nutrient may be too small to detect, whereas cumulative effects of many nutrients within a DP may be substantially larger; and that examining multiple nutrients simultaneously may produce statistically significant associations simply by chance. The objective of this study was to examine the association between early life feeding (breastfeeding and age at solid food introduction) and childhood DPs at age 10 years in a secondary analysis of a longitudinal birth cohort based in Detroit, MI. The hypothesis was that breastfeeding and earlier introduction of solid foods would be associated with a healthier dietary pattern (characterized by a high consumption of whole foods and a low consumption of energy-dense foods) in a cohort of diverse school-aged children.

RESEARCH SNAPSHOT

Research Question: Is breastfeeding or age at solid food introduction associated with dietary patterns in school-aged children?

Key Findings: In a US birth cohort, breastfeeding was initially significantly associated with a healthier dietary pattern in school-aged children. However, the association was no longer detected after covariate adjustment, suggesting that the association is confounded by demographic and maternal characteristics. There were no statistically significant associations between age at solid food introduction and subsequent dietary patterns at school age.

METHODS

Study Population

Data from the WHEALS (Wayne County Health Environment Allergy and Asthma Longitudinal Study), a prospective birth cohort study of 1,258 maternal–child pairs, were analyzed. Cohort details have been published previously.[19-21] Briefly, pregnant women ages 21 to 49 years receiving care at Henry Ford Health System's obstetrics clinics in metropolitan Detroit were recruited from 2003 to 2007. All women resided in a predefined geographic area in Wayne and Oakland counties that included both the city of Detroit, as well as suburban areas, resulting in a racially and socioeconomically diverse population. All participants provided written informed consent, children provided assent, and the study was performed in accordance with protocols approved by the Institutional Review Board at Henry Ford Health System.

Infant Feeding Practices

Feeding practices were maternal-reported during 1-month, 6-month, and 1-year postpartum questionnaires. At each time point, mothers were asked whether they were currently breastfeeding and/or formula feeding their babies. For this analysis, a 3-group variable of current breastfeeding (no formula), formula feeding (no breastfeeding), or mixed feeding was used, at both 1 and 6 months. Breastfeeding at 1 year was not examined due to a small number of babies still being breastfed at that time. Mothers were also asked when they had fed their baby any cereals or other solid foods, which was used to calculate age in months at introduction of first solid food.

Dietary Assessment at Age 10 Years

The Block Kids Food Screener (BKFS)[22] was administered to children at approximately 10 years of age (mean = 10 years; range, 8-12 years). The BKFS is a 41-item food screener developed by NutritionQuest to assess dietary intake by food group in 2- to 17-year-old children. The screener inquired about the frequency and quantity eaten of a variety of foods in the past week. Several variables were calculated by NutritionQuest from the raw responses, including age- and sex-specific mean daily grams of each food, food group estimates (eg, cups per day of fruit), and nutrient estimates (eg, average daily calories). Nutrient estimates should be interpreted with caution, as the screener was not specifically developed for these measurements, except for saturated fat and added sugar. However, previous studies have shown that when compared with 24-hour dietary recall, the BKFS has good relative validity for food groups, with correlations ranging from 0.53 (vegetables) to 0.88 (potatoes).[22] A total of 471 (37%) WHEALS children completed the BKFS and had their questionnaire processed and analyzed by NutritionQuest.

Covariate Measurement

A wide range of covariates were included to account for nonresponse bias, potential confounding, and DP description. During the prenatal interview, mothers self-reported race or ethnicity, insurance coverage, household income, education, marital status, previous pregnancies, smoking during pregnancy, household environmental tobacco smoke (ETS), prenatal alcohol use, indoor pets, and history of asthma and allergies. Child race was reported by the mother at the 2-year study visit. Maternal-reported home address during pregnancy was used to define whether the residence was urban (defined as within city of Detroit limits) or suburban. Prenatal and delivery records of mothers were abstracted to obtain body mass index (BMI) at the first prenatal visit, delivery type, gestational age at delivery, and birth weight. Sex- and gestational-age adjusted birth weight *z*-scores were calculated using the US population as a reference.[23] Pubertal development at age 10 years was quantified using the

Pubertal Development Scale[24] as a component of the 10-year questionnaire. Mothers were asked about the number of hours per day their child spends doing common sedentary activities on typical weekdays and weekend days.[25] Child height and weight was measured by trained clinical research assistants during the 10-year study visit, with protocols adapted from the PhenX Toolkit.[26] Briefly, weight was measured in light clothing using an electronic balance. Three measurements of standing height were recorded: if the difference between the first 2 measurements was <0.4 cm, the mean was calculated; otherwise the median of the 3 measures was calculated. Raw BMI was calculated as kg/m^2. BMI *z*-scores and percentiles were calculated using the 2000 Centers for Disease Control and Prevention growth charts,[27] with obesity defined as the $\geq$95th percentile.

Statistical Analysis

Inverse Probability Weighting. Selection bias in cohort studies due to loss to follow-up or nonresponse can affect the internal validity of effect estimates.[28,29] To account for the fact that not all WHEALS children completed the food screener at age 10 years, inverse probability weighting (IPW) was used to attempt to correct for this bias.[28] The following covariates were included in a logistic regression model to obtain predicted probabilities for IPW calculation: maternal race and ethnicity, maternal age, insurance coverage, household income, maternal education, maternal smoking during pregnancy, prenatal ETS exposure, location of residence, marital status, mode of delivery, parity, prenatal alcohol use, child sex, prenatal indoor pets, maternal history of asthma and allergies, breastfeeding status at 1 month, gestational age, and birth weight. To assess balance in the covariates, standardized differences were calculated for each of the covariates before and after weighting; imbalance was defined as absolute value >0.20.[30]

Latent Class Analysis. Dietary patterns were conceptualized as a latent variable, which cannot be observed directly but can be inferred from individual foods. Before analysis, some similar foods with low consumption were collapsed, including specific types of cereal, milk, beans, and beef; all others were left as separate items (37 total foods). The proportion of each food that comprised each child's diet (ie, grams per day of food/total grams per day of all foods) was then calculated. This was done to account for potential underreporting of overall dietary intake, which is a known issue in nutritional studies,[31] but also to detect classes of children who may have different dietary variety, rather than absolute quantities of foods. Because these proportions were highly non-normal, the data were categorized for use in Latent Class Analysis (LCA).[32] Four categories of average daily consumption were created for each food—none, low, medium, and high—which were calculated using tertiles of the non-zero responses. Because consumption of several foods differed by sex, these categories were calculated within sex and subsequently combined.

Including all foods would likely result in an unnecessarily complex LCA model. However, because many foods are highly correlated (redundant), and some might not contribute to clustering (irrelevant), including all foods as model indicators is likely not necessary.[33] To overcome this challenge, a variable selection method described by Dean and Raftery[34] was used, as implemented in the *R package* LCAvarsel.[33] Once the variable selection was completed by LCAvarsel, these foods were used to fit a latent class model in *MPlus*, version 8.2,[35] in order to take advantage of its advanced analytical features for latent variables. Fit statistics were compared across models with differing numbers of classes; quality and interpretability were also considered in selection of the best number of classes.

Once DPs were determined, they were tested for associations with food consumption categories using χ^2 tests, and with consumption by food groups and nutrient intake values using analysis of variance. Differences in the number of foods consumed in the past 7 days by DP was tested using the Kruskal-Wallis test. To inform on potential confounding and describe DPs, maternal and early life characteristics were tested for association with DPs using analysis of variance for numerical covariates and the χ^2 test for categorical covariates. All pairwise comparisons between DPs were Bonferroni-adjusted (ie, raw *P* values were multiplied by the number of comparisons and declared significant if <0.05).

Associating Infant Feeding Practices with Dietary Patterns at Age 10 Years. DP at age 10 years was the dependent variable and infant feeding practices were the independent variables in multinomial logistic regression models. In all models, IPWs were used to account for nonresponse bias, as described previously. During model fitting, IPWs were normalized to sum to the actual sample size. Two different modeling strategies were used for the multinomial logistic regression models: the 3-step approach for latent class modeling with covariates using the R3STEP setting in *MPlus*,[35] in which class assignment uncertainty is considered in model estimation[36]; and the "classify-analyze" approach, whereby participants are assigned to the class in which they had the maximum posterior probability (ie, class assignment uncertainty is ignored). Both approaches are presented for purposes of comparison, but the 3-step approach is considered the primary analysis.

Multivariable models were built to control for several measured confounding covariates (*a priori*—hypothesized as associated with infant feeding practices and DP) simultaneously. The measured confounding covariates evaluated were household income, maternal education, marital status, maternal age, maternal BMI at first prenatal visit, location of residence, prenatal ETS, prenatal indoor pets, maternal asthma, mode of delivery, child race, parity, child sex, gestational age, and birth weight *z*-score. In addition, breastfeeding was considered a potential confounder in age at solid food introduction associations, and vice versa.

Model building steps were as follows: first, each potential confounder was evaluated individually for confounding effects using the "change in estimate" criterion,[37] with a $\geq$20% change in the odds ratio as an indication of confounding and, if met, was included in the multivariable model. Child sex and race were the only covariates automatically included regardless of this criterion. The same set of potential confounders was used for breastfeeding at both 1 and 6 months of age. As a result, the following covariates were included in multivariable breastfeeding models: child race, child sex, marital status, maternal education, prenatal ETS exposure, prenatal indoor pets, and maternal BMI at first prenatal visit. No covariates reached the 20% criteria for age at solid food

Table 1. Differences in WHEALS[a] birth cohort children who did and did not complete the BKFS[b] at age 10 years, before and after inverse probability weighting to account for loss to follow-up

Covariate	Category	Child Completed 10-Year BKFS No (n = 787)	Child Completed 10-Year BKFS Yes (n = 471)	*P* value[c]	Standardized Difference[d] Unweighted	Standardized Difference[d] Weighted
		←n (column %)→				
Race or ethnicity of mother				0.28	0.133	0.034
	White	179 (22.7)	111 (23.6)			
	African American	481 (61.1)	297 (63.1)			
	Hispanic	55 (7)	23 (4.9)			
	Arabic	42 (5.3)	17 (3.6)			
	Other/mixed	30 (3.8)	23 (4.9)			
Annual household income				<**0.001**	0.297	0.045
	<$20,000	130 (16.5)	52 (11)			
	$20,000 to <$40,000	193 (24.5)	102 (21.7)			
	$40,000 to <$80,000	221 (28.1)	126 (26.8)			
	$80,000 to <$100,000	65 (8.3)	70 (14.9)			
	≥$100,000	78 (9.9)	70 (14.9)			
	Refused to answer	100 (12.7)	51 (10.8)			
Maternal education				<**0.001**	0.342	0.045
	Less than high school diploma	60 (7.6)	14 (3)			
	High school diploma	156 (19.8)	72 (15.3)			
	Some college	390 (49.6)	215 (45.6)			
	Bachelor's degree or higher	181 (23)	170 (36.1)			
Mother married				**0.019**	0.138	0.044
	No	323 (41)	162 (34.4)			
	Yes	464 (59)	309 (65.6)			
Insurance coverage				<**0.001**	0.598	0.016
	Health Alliance Plan	252 (32)	250 (53.1)			
	Other insurance	265 (33.7)	166 (35.2)			
	No insurance	12 (1.5)	3 (0.6)			
	Refused/do not know/ other /missing	258 (32.8)	52 (11)			
Location of residence				0.19	-0.077	−0.024
	Suburban	336 (42.7)	219 (46.5)			
	Urban	451 (57.3)	252 (53.5)			
		←n, mean SD[e]→				
Maternal age at birth, y		787, 29.1 ± 5.2	471, 30.3 ± 5.2	<**0.001**	0.217	0.005
		←n (column %)→				
Mom smoked during pregnancy				**0.029**	−0.130	0.004

(*continued on next page*)

Table 1. Differences in WHEALS[a] birth cohort children who did and did not complete the BKFS[b] at age 10 years, before and after inverse probability weighting to account for loss to follow-up (*continued*)

Covariate	Category	Child Completed 10-Year BKFS		*P* value[c]	Standardized Difference[d]	
		No (n = 787)	Yes (n = 471)		Unweighted	Weighted
	No	681 (86.5)	427 (90.7)			
	Yes	106 (13.5)	44 (9.3)			
Prenatal ETS[f] exposure				**0.038**	−0.122	−0.010
	No	554 (70.4)	357 (75.8)			
	Yes	233 (29.6)	114 (24.2)			
Prenatal alcohol use				0.16	0.080	0.019
	No	759 (96.7)	447 (95.1)			
	Yes	26 (3.3)	23 (4.9)			
Maternal doctor diagnosed hay fever or allergic rhinitis				0.67	−0.029	−0.016
	No	659 (84.6)	395 (85.5)			
	Yes	120 (15.4)	67 (14.5)			
Maternal doctor diagnosed asthma				0.40	0.048	0.015
	No	635 (80.7)	370 (78.7)			
	Yes	152 (19.3)	100 (21.3)			
Prenatal indoor dogs				0.19	0.076	0.045
	No	607 (77.1)	348 (73.9)			
	Yes	180 (22.9)	123 (26.1)			
Prenatal indoor cats				0.75	0.018	0.019
	No	662 (84.1)	393 (83.4)			
	Yes	125 (15.9)	78 (16.6)			
Mode of delivery				0.64	−0.024	0.031
	Vaginal	486 (62.2)	298 (63.5)			
	Cesarean section	295 (37.8)	171 (36.5)			
Parity				0.24	0.069	0.034
	Multiparous (≥1 previous birth)	509 (64.7)	289 (61.4)			
	Nulliparous (no previous births)	278 (35.3)	182 (38.6)			
Child sex				0.73	−0.021	0.023
	Male	386 (49.1)	236 (50.1)			
	Female	400 (50.9)	235 (49.9)			
		←*n, mean ± SD*→				
Gestational age at delivery (wk)		768, 38.7 ± 1.8	464, 38.8 ± 1.6	0.23	0.070	−0.011
Birth weight (g)		734, 3273 ± 561	448, 3356 ± 591	**0.016**	0.140	−0.015

(*continued on next page*)

Table 1. Differences in WHEALS[a] birth cohort children who did and did not complete the BKFS[b] at age 10 years, before and after inverse probability weighting to account for loss to follow-up (*continued*)

Covariate	Category	Child Completed 10-Year BKFS: No (n = 787)	Child Completed 10-Year BKFS: Yes (n = 471)	P value[c]	Standardized Difference[d]: Unweighted	Standardized Difference[d]: Weighted
		←n (column %)→				
Breastfeeding status at 1 mo				**0.021**	0.656	0.020
	Formula fed	303 (53)	198 (44.3)			
	Mixed feeding	196 (34.3)	185 (41.4)			
	Breastfed	73 (12.8)	64 (14.3)			

[a]WHEALS = Wayne County Health Environment Allergy and Asthma Longitudinal Study.
[b]BKFS = Block Kids Food Screener.
[c]Calculated by the χ^2 test or analysis of variance (bold type indicates $P < 0.05$).
[d]Imbalance in covariates defined as absolute value of standardized difference >0.20.
[e]SD = standard deviation.
[f]ETS = environmental tobacco smoke.

introduction, so only child sex and race were included in the final multivariable model. Complete-case analysis was used, but covariate missingness was generally low (5% to 10%). For all analyses, statistical significance was set at 0.05.

RESULTS

The 471 children who completed the BKFS at age 10 years were first described and compared with those who did not (Table 1). Children who completed the BKFS were dissimilar from children who did not; notably, they had mothers with higher household incomes, higher levels of education, were more likely to be married, were more likely to report insurance coverage, were older, and were more likely to breastfeed at 1-month postpartum (all, $P < 0.05$). In addition, they were less like to smoke prenatally and be exposed to household smoke. Standardized differences were often large ($\geq$0.20), indicating imbalance between groups. However, after weighting participants by their IPW, these imbalances were no longer present.

Four foods were retained through variable selection as being the most relevant to latent class clustering: fried potatoes, hamburgers/cheeseburgers, pizza, and snack chips. Model fit statistics are shown in Table 2. Three DPs were the best fit by Bayesian Information Criterion and the Lo–Mendell–Rubin test, which suggested that 3 classes fit better than 2 ($P = 0.025$), but 4 did not fit better than 3 ($P = 0.36$). Although the Akaike information criterion and sample size–adjusted Bayesian Information Criterion preferred the 4-class solution, the Bayesian Information Criterion is generally the best performing information criteria.[38] The bootstrap likelihood ratio test also preferred the 4-class solution; however, this model had the lowest entropy (ie, class assignment accuracy) and the interpretability of the classes was imprecise due to low homogeneity. Weighing each of these pieces of evidence, the 3-class model was selected.

A total of 28 of the 37 foods were significantly associated with DP (Figure 1). Children assigned to DP_1 (35%) were characterized by a high consumption of fried potatoes, hamburgers/cheeseburgers, hotdogs/sausages, pizza, snack chips, ice cream, and cake. Conversely, children assigned to DP_3 (24%) had low consumption of these foods and a higher consumption of unprocessed/whole foods, including milk, cooked cereal (like oatmeal), "other" vegetables (like corn, carrots, greens, and broccoli), beans, and vegetable soup. Compared with DP_1 and DP_3, DP_2 children (41%) were more likely to consume a "moderate" frequency of foods (low and medium categories) of nearly all significant foods. This led to the hypothesis that they eat a variety of foods, regardless of type or quality. To confirm this, the number of the 37 foods consumed in the past week was calculated. This significantly differed by DP ($P < 0.001$), which was driven by the distinction of DP_2 (DP_1 vs DP_2; $P < 0.001$; DP_1 vs DP_3; $P = 0.23$; and DP_2 vs DP_3; $P < 0.001$); specifically, these children reported consuming more foods than DP_1 and DP_3 children (median = 25 vs 21 vs 21, respectively).

When examining overall consumption of food groups and nutritional intake values by DP (Table 3), DP_1 children were characterized by a low consumption of dairy, legumes, and vegetables. DP_2 children were characterized by the highest consumption of fruit/fruit juice, meat/poultry/fish, added sugars, as well as naturally occurring sugars, saturated fat, total carbohydrates, total fiber, and total protein. In addition, they, on average, consumed the highest number of daily calories compared with DP_1 and DP_3. These results support the notion that DP_2 children eat a variety of foods (both healthy and unhealthy), but also indicate that they generally eat a larger amount of food than DP_1 and DP_3 children. On the other hand, DP_3 children had the lowest consumption of potatoes (including french fries), sugary beverages, total fat, and saturated fat, and the highest consumption of legumes. Compared with DP_1 children, DP_3 children consumed a similar (and nonsignificantly different) amount of total daily calories, suggesting that they are not consuming less food overall, but seemingly more healthful foods. The following

Table 2. Latent class model fit statistics, descriptives, and quality among the 471 WHEALS[a] birth cohort children who completed the BKFS[b] at age 10 years

Fit statistic	1 Class	2 Classes	3 Classes	4 Classes
Log-likelihood	−2564.058	−2503.377	−2458.496	−2438.616
AIC[c]	5152.116	5056.753	4992.993	4979.232
BIC[d]	5201.974	5160.625	5150.878	5191.129
SSA-BIC[e]	5163.888	5081.279	5030.273	5029.265
LMR[f] P value	NA[g]	0.017	0.025	0.36
BLRT[h] P value	NA	$<$0.001	$<$0.001	$<$0.001
Entropy	NA	0.86	0.83	0.81
Error messages?	No	No	No	No
% per class	100	42, 58	35, 41, 24	18, 38, 21, 23

[a]WHEALS = Wayne County Health Environment Allergy and Asthma Longitudinal Study.
[b]BKFS = Block Kids Food Screener.
[c]AIC = Akaike Information Criterion.
[d]BIC = Bayesian Information Criterion.
[e]SSA-BIC = sample size–adjusted BIC.
[f]LMR = Lo–Mendell–Rubin Test.
[g]NA = not applicable.
[h]BLRT = bootstrap likelihood ratio test.

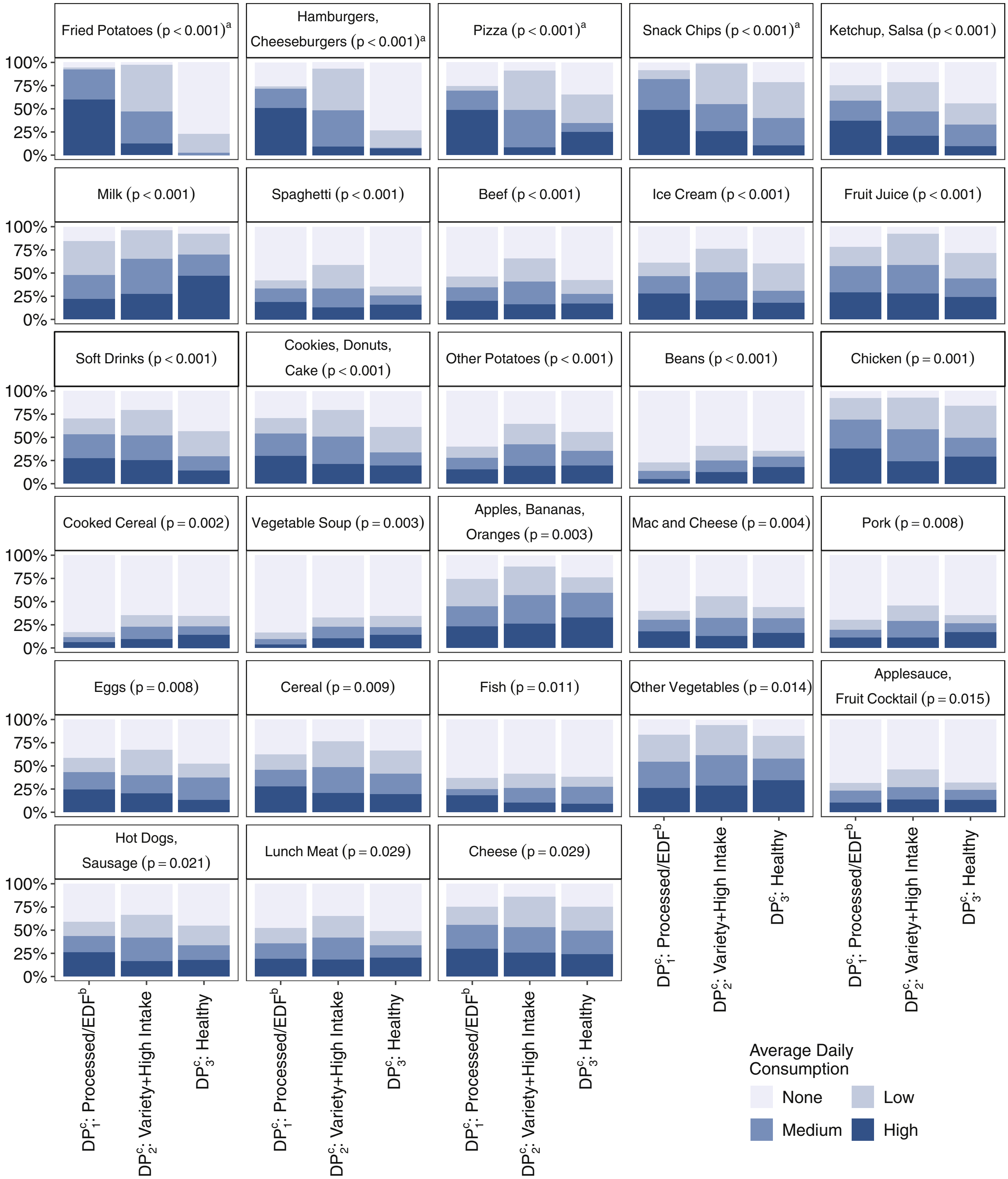
class labels were chosen: processed/energy-dense food (EDF) (DP_1), variety + high intake (DP_2), and healthy (DP_3).

In order to further describe the identified DPs, associations with maternal, early life, and child characteristics were examined next (Table 4). Suburban children, children from higher-income households, white children, children with prenatal pets, children born vaginally, and breastfed children were all significantly ($P < 0.05$) more likely to be assigned to DP_3 (healthy). DP_3 (healthy) children also had significantly fewer hours of sedentary activity on both the weekends and weekdays, compared with DP_1 (processed/EDF) and DP_2 (variety + high intake) children. Although BMI z-scores and the proportion with obesity was lowest in DP_3 (healthy) children, these were not significantly different ($P = 0.51$ and $P = 0.11$, respectively). In addition, children with prenatal ETS exposure were more likely to be assigned to DP_2 (variety + high intake), and African American children were more likely to be assigned to DP_1 (processed/EDF). Several notable factors were also not significantly associated with DP, including child sex, child age, or season at the 10-year visit, and pubertal development score, indicating that the identified DPs are not simply a product of these variables.

Crude analyses identified an association between breastfeeding at 1 and 6 months and DP at age 10 years ($P = 0.012$ and $P < 0.001$, respectively; Table 4). In unadjusted models using the 3-step approach, significant associations were found between breastfeeding at 1 month and DP (Figure 2). Specifically, significance appeared to be primarily driven by the distinction of breastfed children compared with formula-fed children, where children who were breastfed at 1 month had 0.23 (95% CI 0.09 to 0.61) times lower odds of being DP_1 (processed/EDF) and 0.32 (95% CI 0.12 to 0.81) times lower odds of being in DP_2 (variety + high intake) compared with DP_3 (healthy). Results were similar for breastfeeding at 6 months, although effect sizes were larger: children who were breastfed at 6 months had 0.05 (95% CI 0.004 to 0.66) times lower odds of being DP_1 (processed/EDF) and 0.17 (95% CI 0.05, 0.63) times lower odds of being in DP_2 (variety + high intake) compared with DP_3 (healthy).

When multivariable models using the 3-step approach were fit to adjust for potential confounders, these associations were no longer statistically significant. Namely, comparing breastfed with formula-fed children, children who were breastfed at 1 month had 0.41 (95% CI 0.14 to 1.25) times lower odds of being DP_1 (processed/EDF) and 0.53 (95% CI 0.17 to 1.61) times lower odds of being in DP_2 (variety + high intake) compared with DP_3 (healthy), both of which contain the null value of 1. Similarly, although with extremely imprecise estimates, children who were breastfed at 6 months had 0.06 (95% CI 0.001 to 5.23) times lower odds of being DP_1 (processed/EDF) and 0.46 (95% CI 0.12 to 1.72) times lower odds of being in DP_2 (variety + high intake) compared with DP_3 (healthy). In contrast, significance was obtained in the multivariable models using the classify-analyze approach (Figure 2)—comparing breastfed children with those formula- or mixed-fed, breastfed children had lower odds of DP_1 (processed/EDF) relative to DP_3 (healthy).

Crude analyses did not find a significant association between age at solid food introduction and DP category ($P = 0.14$; Table 4). In the unadjusted 3-step model (Figure 3), each 1-month increase in age at solid food introduction was associated with 0.83 (95% CI 0.64 to 1.08) times lower odds of DP_1 (processed/EDF) and 0.89 (95% CI 0.67 to 1.17) times lower odds of DP_2 (variety + high intake) relative to DP_3 (healthy), both of which failed to reach statistical significance. Results were similar in the adjusted 3-step model (DP_1 vs DP_3: odds ratio 0.81, 95% CI 0.64 to 1.02; DP_2 vs DP_3: odds ratio 0.88, 95% CI 0.70 to 1.11). They were also similar and nonsignificant using the classify-analyze approach (Figure 3). Whether the association between timing of solid food



[a]Foods retained through variable selection; [b]EDF, energy dense food; [c]DP, dietary pattern.

Figure 1. Distribution of foods across the 3 DPs identified using latent class analysis, among the 471 WHEALS (Wayne County Health Environment Allergy and Asthma Longitudinal Study) birth cohort children who completed the Block Kids Food Screener at age 10 years. All significant foods are shown and are ordered by significance (χ^2 *P* values).

Table 3. Characterization of the DPs,[a] among the 471 WHEALS[b] birth cohort children who completed the BKFS[c] at age 10 years

Variable	DP_1: Processed/ EDF[d] (n = 165)	DP_2: Variety + high intake (n = 193)	DP_3: Healthy (n = 113)	Overall *P* value[e]	Pairwise Comparison *P* Values[f] DP_1 vs DP_2	DP_1 vs DP_3	DP_2 vs DP_3
	←median (IQR[g])→						
Foods (per day), only those retained through variable selection							
Fried potatoes (%)	2.3 (1.9)	1.1 (1.1)	0.0 (0.0)	**<0.001**[h]	**<0.001**[i]	**<0.001**[i]	**<0.001**[i]
Hamburgers, cheeseburgers (%)	3.4 (5.2)	2.0 (1.3)	0.0 (1.0)	**<0.001**[h]	**<0.001**[i]	**<0.001**[i]	**<0.001**[i]
Pizza (%)	3.6 (5.4)	2.0 (1.7)	1.3 (3.4)	**<0.001**[h]	**<0.001**[i]	**<0.001**[i]	**0.013**[i]
Snack chips (%)	1.4 (1.2)	0.9 (0.9)	0.5 (0.9)	**<0.001**[h]	**<0.001**[i]	**<0.001**[i]	**<0.001**[i]
	←mean ± SD[j]→						
Food group estimates (per day)							
Dairy (cups)	1.2 ± 0.8	1.7 ± 0.9	1.6 ± 1.0	**<0.001**	**0.003**	**0.003**	1.00
Fruit/fruit juice (cups)	1.2 ± 0.9	1.8 ± 0.9	1.5 ± 1.0	**<0.001**	**0.003**	0.135	**0.009**
Vegetables excluding potatoes and legumes (cups)	0.6 ± 0.4	0.8 ± 0.5	0.7 ± 0.4	**<0.001**	**0.003**	0.912	0.081
Legumes (cups)	0.02 ± 0.05	0.05 ± 0.09	0.06 ± 0.13	**0.001**	**0.003**	**0.003**	1.00
Potatoes, including french fries (cups)	0.3 ± 0.2	0.4 ± 0.3	0.2 ± 0.2	**<0.001**	0.759	**0.003**	**0.003**
Whole grains (oz)	0.6 ± 0.5	0.7 ± 0.6	0.6 ± 0.4	**0.017**	**0.027**	1.00	0.183
Meat, poultry, fish (oz)	2.6 ± 1.8	3.1 ± 1.9	2.3 ± 1.7	**0.001**	**0.048**	0.591	**0.003**
Nutrient estimates (per day)							
Sugar added during processing/ preparation (tsp)	7.9 ± 5.2	10.1 ± 5.9	7.2 ± 6.1	**<0.001**	**0.003**	0.87	**0.003**
Glycemic index (glucose scale)	52.5 ± 3.5	50.8 ± 3.0	49.6 ± 4.1	**<0.001**	**0.003**	**0.003**	**0.015**
Glycemic load (glucose scale)	72.5 ± 36.8	90.1 ± 37.2	69.2 ± 30.4	**<0.001**	**0.003**	1.00	**0.003**
Daily calories from sugary beverages[k]	45.9 ± 61.3	60.7 ± 69.3	38.7 ± 72.6	**0.014**	0.102	1.00	**0.027**
Total sugars naturally occurring in foods, juices (g)[k]	75.0 ± 40.8	104.1 ± 41.7	83.1 ± 39.2	**<0.001**	**0.003**	0.30	**0.003**
Daily calories[k]	1277 ± 622	1537 ± 621	1183 ± 471	**<0.001**	**0.003**	0.525	**0.003**
Saturated fat (g)	18.6 ± 9.7	22.0 ± 9.8	16.7 ± 7.3	**<0.001**	**0.003**	0.228	**0.003**
Total carbohydrate (g)[k]	148.5 ± 75.3	189.5 ± 74.5	149.8 ± 62.2	**<0.001**	**0.003**	1.00	**0.003**
Total fiber (g)[k]	9.8 ± 5.1	12.7 ± 5.7	10.6 ± 5.0	**<0.001**	**0.003**	0.555	**0.003**
Total protein (g)[k]	51.4 ± 26.3	61.6 ± 27.7	48.8 ± 21.1	**<0.001**	**0.003**	1.00	**0.003**
Total fat (g)[k]	54.8 ± 28.3	61.7 ± 27.7	45.3 ± 19.8	**<0.001**	0.060	**0.006**	**0.003**

[a]DP = dietary pattern.
[b]WHEALS = Wayne County Health Environment Allergy and Asthma Longitudinal Study.
[c]BKFS = Block Kids Food Screener.
[d]EDF = energy-dense food.
[e]Calculated by analysis of variance unless specified otherwise (bold type indicates *P* <0.05).
[f]Calculated by analysis of variance unless specified otherwise, with Bonferroni adjustment (bold type indicates *P* < 0.05).
[g]IQR = interquartile range.
[h]Calculated by the Kruskal-Wallis test (bold type indicates *P* < 0.05).
[i]Calculated by the Kruskal-Wallis test, with Bonferroni adjustment (bold type indicates Bonferroni *P* < 0.05).
[j]SD = standard deviation.
[k]Interpret with caution; screener was not specifically developed for these measurements.

Table 4. Association between maternal and child factors and DP[a] among the 471 WHEALS[b] birth cohort children who completed the BKFS[c] at age 10 years

Characteristics	DP_1: Processed/EDF[d] (n = 165)	DP_2: Variety + high intake (n = 193)	DP_3: Healthy (n = 113)	*P* Value[e]
	←——*n (column %)*——→			
Maternal and prenatal characteristics				
Maternal education				0.135
Less than high school diploma	4 (2.4)	9 (4.7)	1 (0.9)	
High school diploma	22 (13.3)	37 (19.2)	13 (11.5)	
Some college	82 (49.7)	82 (42.5)	51 (45.1)	
Bachelor's degree or higher	57 (34.5)	65 (33.7)	48 (42.5)	
Mother married				0.202
No	60 (36.4)	71 (36.8)	31 (27.4)	
Yes	105 (63.6)	122 (63.2)	82 (72.6)	
Annual household income				**0.025**
<$20,000	19 (11.5)	24 (12.4)	9 (8)	
$20,000 to <$40,000	37 (22.4)	39 (20.2)	26 (23)	
$40,000 to <$80,000	35 (21.2)	61 (31.6)	30 (26.5)	
$80,000 to <$100,000	26 (15.8)	29 (15)	15 (13.3)	
≥$100,000	23 (13.9)	20 (10.4)	27 (23.9)	
Refused to answer	25 (15.2)	20 (10.4)	6 (5.3)	
Location of residence				**0.040**
Suburban	69 (41.8)	86 (44.6)	64 (56.6)	
Urban	96 (58.2)	107 (55.4)	49 (43.4)	
	←——*n, mean ± SD*[f]——→			
Maternal age at birth (y)	165, 30.2 ± 5.1	193, 30.4 ± 5.4	113, 30.2 ± 4.9	0.905
	←——*n (column %)*——→			
Mom smoked during pregnancy				0.206
No	149 (90.3)	171 (88.6)	107 (94.7)	
Yes	16 (9.7)	22 (11.4)	6 (5.3)	
Prenatal ETS[g] exposure				**0.022**
No	130 (78.8)	134 (69.4)	93 (82.3)	
Yes	35 (21.2)	59 (30.6)	20 (17.7)	
Prenatal indoor dogs				0.052
No	131 (79.4)	142 (73.6)	75 (66.4)	
Yes	34 (20.6)	51 (26.4)	38 (33.6)	
Prenatal indoor cats				**0.001**
No	147 (89.1)	164 (85)	82 (72.6)	
Yes	18 (10.9)	29 (15)	31 (27.4)	
	←——*n, mean ± SD*——→			
Maternal BMI[h] at first prenatal visit	136, 31.3 ± 7.8	160, 30.7 ± 8.6	97, 29.9 ± 7.2	0.406
Birth and early life characteristics				
Gestational age at delivery (wk)	164, 38.8 ± 1.6	188, 38.8 ± 1.7	112, 38.8 ± 1.5	0.927

(*continued on next page*)

Table 4. Association between maternal and child factors and DP[a] among the 471 WHEALS[b] birth cohort children who completed the BKFS[c] at age 10 years (*continued*)

Characteristics	DP_1: Processed/EDF[d] (n = 165)	DP_2: Variety + high intake (n = 193)	DP_3: Healthy (n = 113)	*P* Value[e]
Birth weight *z*-score	161, −0.11 ± 0.99	175, −0.08 ± 1.07	108, 0.11 ± 1.04	0.179
	←———	*n (column %)*	———→	
Mode of delivery				**0.048**
Vaginal	96 (58.2)	120 (62.8)	82 (72.6)	
Cesarean section	69 (41.8)	71 (37.2)	31 (27.4)	
Parity				0.806
Multiparous (≥1 previous birth)	98 (59.4)	121 (62.7)	70 (61.9)	
Nulliparous (no previous births)	67 (40.6)	72 (37.3)	43 (38.1)	
Child sex				0.937
Male	83 (50.3)	98 (50.8)	55 (48.7)	
Female	82 (49.7)	95 (49.2)	58 (51.3)	
Child race				<**0.001**
White	18 (10.9)	40 (20.7)	39 (34.5)	
African American	128 (77.6)	127 (65.8)	50 (44.2)	
Other/mixed	19 (11.5)	26 (13.5)	24 (21.2)	
Breastfeeding at 1 mo				**0.012**
Formula fed	76 (48.1)	83 (45.1)	39 (37.1)	
Mixed feeding	69 (43.7)	75 (40.8)	41 (39)	
Breastfed	13 (8.2)	26 (14.1)	25 (23.8)	
Breastfeeding at 6 m				<**0.001**
Formula fed	125 (80.6)	144 (77.8)	65 (63.1)	
Mixed feeding	28 (18.1)	31 (16.8)	24 (23.3)	
Breastfed	2 (1.3)	10 (5.4)	14 (13.6)	
	←———	*n, mean ± SD*	———→	
Age at solid food introduction (mo)	157, 4.3 ± 1.6	185, 4.4 ± 1.5	110, 4.7 ± 1.8	0.142
Child age at 10-y visit (y)				
Age at solid food introduction (mo)	165, 10.3 ± 0.8	193, 10.2 ± 0.9	113, 10.4 ± 0.8	0.391
	←———	*n (column %)*	———→	
Season of 10-y visit				0.598
Winter	41 (24.8)	47 (24.4)	29 (25.9)	
Spring	31 (18.8)	42 (21.8)	32 (28.6)	
Summer	57 (34.5)	65 (33.7)	31 (27.7)	
Fall	36 (21.8)	39 (20.2)	20 (17.9)	
	←———	*n, mean ± SD*	———→	
Pubertal development score	163, 2.0 ± 0.5	186, 2.0 ± 0.5	108, 1.9 ± 0.6	0.407
BMI[f] *z*-score	165, 0.48 ± 1.28	193, 0.44 ± 1.23	113, 0.31 ± 1.17	0.514
	←———	*n (column %)*	———→	
Has obesity				0.107
No	127 (77)	151 (78.2)	98 (86.7)	
Yes	38 (23)	42 (21.8)	15 (13.3)	

(*continued on next page*)

Table 4. Association between maternal and child factors and DP[a] among the 471 WHEALS[b] birth cohort children who completed the BKFS[c] at age 10 years (*continued*)

Characteristics	DP_1: Processed/EDF[d] (n = 165)	DP_2: Variety + high intake (n = 193)	DP_3: Healthy (n = 113)	*P* Value[e]
	←——— *n, mean* ± *SD* ———→			
Hours of sedentary activities on typical weekend day	164, 9.3 ± 5.2	191, 8.2 ± 5.1	112, 6.8 ± 4.2	**<0.001**
Hours of sedentary activities on typical weekday	165, 7.1 ± 4.8	192, 7.3 ± 4.4	112, 5.6 ± 4.0	**0.004**

[a]DP = dietary pattern.
[b]WHEALS = Wayne County Health Environment Allergy and Asthma Longitudinal Study.
[c]BKFS = Block Kids Food Screener.
[d]EDF = energy-dense food.
[e]*P* value is calculated by analysis of variance for numerical covariates and χ^2 test for categorical covariates (bold type indicates $P < 0.05$).
[f]SD = standard deviation.
[g]ETS = environmental tobacco smoke.
[h]BMI = body mass index; calculated as kg/m^2.

introduction and DP differed by breastfeeding status was also evaluated using interaction terms; these effects were nonsignificant for breastfeeding at both 1 and 6 months (interaction $P = 0.88$ and $P = 0.94$, respectively).

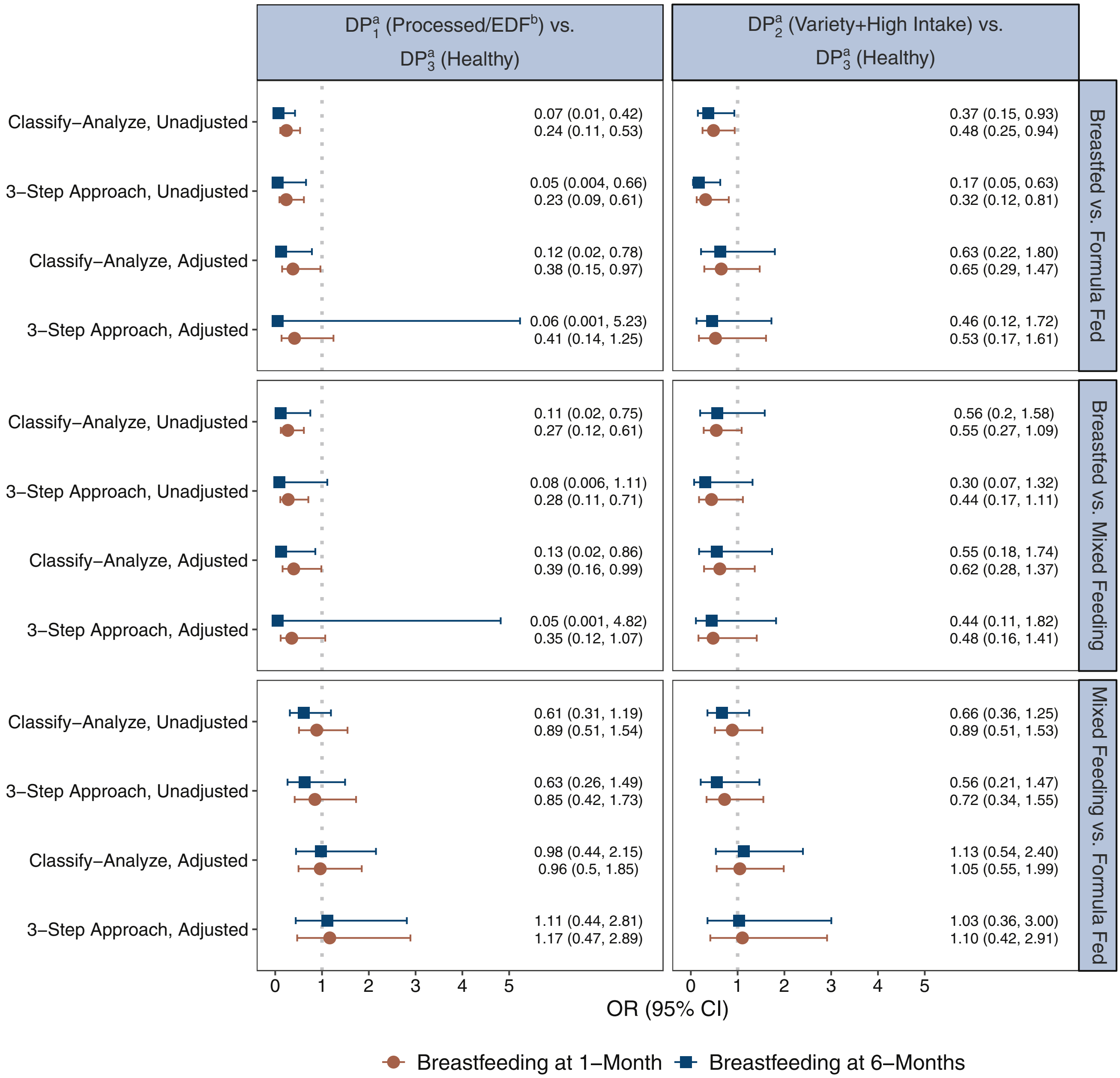
DISCUSSION

The study hypothesis was that children who were breastfed were less likely to have a diet characterized by a high consumption of processed and energy dense foods at 10 years of age, and more likely to have a diet characterized by a high consumption of foods generally considered healthy (eg, milk, cooked cereal, vegetables, and beans). Although this was the direction of association observed, after performing bias corrections due to loss to follow-up and classification error and adjusting for a large set of confounders (child race, child sex, marital status, maternal education, prenatal ETS exposure, prenatal indoor pets, and maternal BMI at first prenatal visit), estimates were not statistically significant. An additional hypothesis included that earlier introduction of solid foods would be associated with a healthier childhood diet; in fact, it was observed that later introduction of solid foods was associated with a healthier DP, but this association was also not statistically significant.

Breastfeeding is widely considered to be nutritionally optimal for infants, as it has been shown to have major long-term effects on health and development.[39] Although it has been shown to impact infant dietary choices,[8,40] less is known about its impact on dietary choices in school-aged children. The direction of association in previous studies has generally been consistent and suggests a protective effect of breastfeeding on dietary outcomes. For example, one study of approximately 1,500 children demonstrated that breastfeeding was associated with child diet at age 6 years, with increased fruit and vegetable intake and decreased intake of sugar-sweetened beverages in breastfed children.[41] A study examining the DPs (based on factor analysis) of approximately 2,300 Australian children at 2 to 8 years of age showed that breastfeeding was associated with a healthier DP characterized by high meat, vegetable, fruit, and whole-grain intake.[42] In a Brazilian birth cohort study of roughly 3,400 children, DPs were identified using principal components analysis; a high intake of snacks and treats and a low intake of fruits and vegetables at age 6 years was associated with short duration of exclusively breastfeeding.[43] Each of these studies performed extensive covariate adjustment with large sample sizes, but concern remains regarding the effect of residual confounding and confounding due to maternal diet. Future studies that identify significant associations should consider methods that quantify how strong unmeasured confounders would have to be to negate associations, such as the E-value.[44] Regarding maternal diet, a previous study found that fruit and vegetable intake in preschool-aged children was higher if they were breastfed, even after adjusting for maternal fruit and vegetable intake.[45]

Although an effect of breastfeeding on DP was initially detected in unadjusted models, both the effect size and precision of these estimates were diminished upon covariate adjustment. Therefore, given that breastfeeding is closely intertwined with social, economic, and cultural determinants and that studies are typically observational in nature, considerably larger sample sizes may be required to detect a significant, unconfounded effect. This is particularly true in socioeconomically diverse populations, such as the one here, in which the rates of breastfeeding are especially low (in the analysis subset, only 14% were breastfed without the use of formula at 1 month of age and only 6% were by 6 months). These low rates, coupled with the large number of confounders, often made estimates imprecise, particularly for breastfeeding at 6 months. Performing latent class analysis on a larger sample size may reveal more precise DPs; utilizing more comprehensive food frequency questionnaires and more sensitive statistical methods may also better reveal these associations.

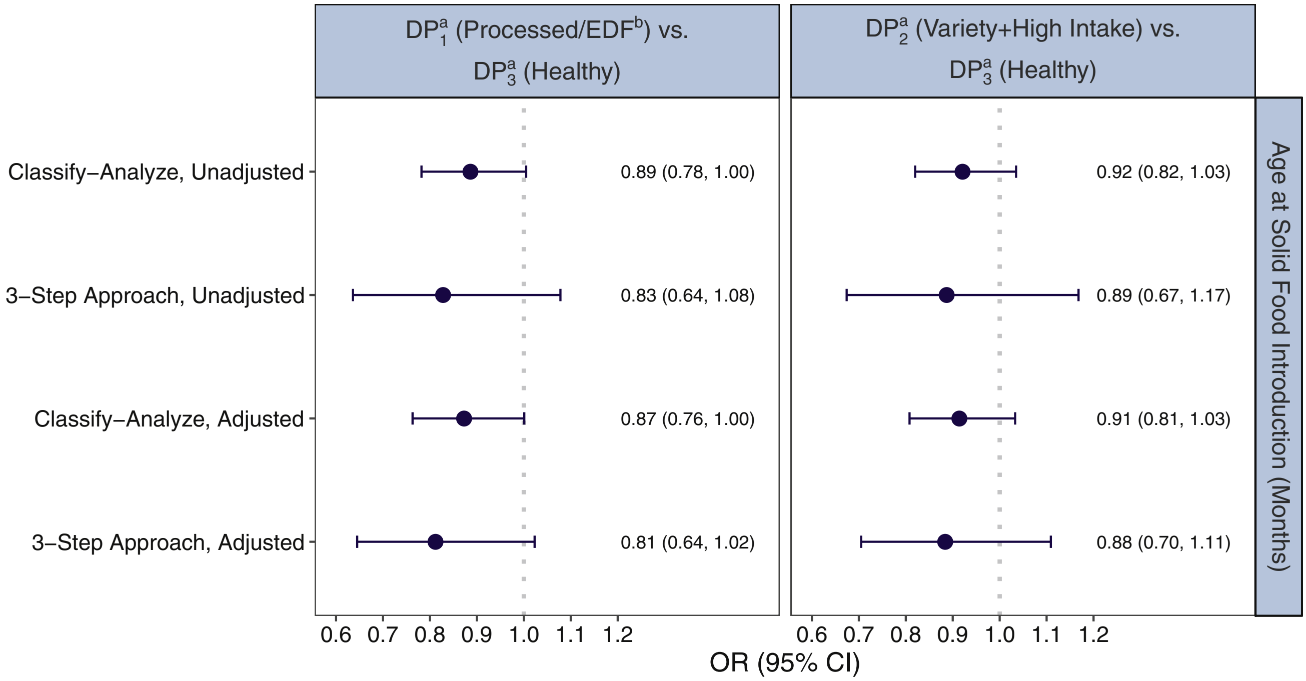
Older age at solid food introduction was associated with lower odds of a diet high in processed and EDFs (relative to a healthier diet), but this failed to achieve statistical signifi-



[a]DP, dietary pattern; [b]EDF, energy dense food.

Figure 2. Association between breastfeeding and DPs at age 10 years, among the 471 WHEALS (Wayne County Health Environment Allergy and Asthma Longitudinal Study) birth cohort children who completed the Block Kids Food Screener at age 10 years. Adjusted models include child race, child sex, marital status, maternal education, prenatal environmental tobacco smoke exposure, prenatal indoor pets, and maternal body mass index at first prenatal visit. Inverse probability weights are used to account for loss to follow-up. OR = odds ratio.

cance. Given the small size of this effect, the study may have been underpowered to detect it. To date, there has been conflicting evidence regarding the association between timing of solid food introduction and dietary preferences throughout infancy and childhood and, to the best of our knowledge, no studies have followed children to 10 years of age, making hypothesis generation difficult. A previous study found that earlier introduction of fruits and vegetables was associated with higher intake of both in 2- to 6-year-old children[46]; another found that early introduction of solid foods is associated with a greater willingness to try a novel fruit in preschool-aged children.[47] Conversely, others have found that early introduction of solid food is associated with eating fatty and sugary foods at 1 year of age,[48] a higher risk



[a]DP, dietary pattern; [b]EDF, energy dense food.

Figure 3. Association between age at solid food introduction and DP at age 10 years, among the 471 WHEALS (Wayne County Health Environment Allergy and Asthma Longitudinal Study) birth cohort children who completed the Block Kids Food Screener at age 10 years. Adjusted models include child race and sex. Inverse probability weights are used to account for loss to follow-up. Odds ratios (ORs) reflect a 1-month increase in age at solid food introduction.

of feeding difficulties at age 3 years,[49] and a high intake of snacks and treats plus a low intake of fruits and vegetables at age 6 years.[43] Given these contradictory findings, additional studies with detailed longitudinal follow-up are needed. Alternatively, the timing of solid food introduction may be less critical compared with the variety and frequency of foods given at introduction; for example, an experimental study demonstrated that a higher variety of foods introduced resulted in greater food acceptance.[40] In addition, the various reasons that mothers introduce solid foods early[50] may be relevant to these associations, although this information was not collected.

This study is not without limitations. Although correction for loss to follow-up using IPW was performed, some residual bias may remain. The generalizability of the results may be limited, given the racial and ethnic diversity of the study population (approximately 60% African American); however, the diversity of this cohort is a strength, as the consistency of findings should be examined in different populations, despite the previously mentioned challenges. In addition, the questions used to assess infant feeding practices were not validated, and the DPs were based on responses to a food screener rather than 24-hour dietary recall. However, the BKFS has been shown to have good relative validity when compared with 24-hour recall.[22] In addition, 24-hour recall would not be the preferred dietary assessment method in the context of these study aims (to identify overall dietary patterns), as atypical eating habits rather than usual intake may be captured with such a small timeframe.[51] Although a more comprehensive food frequency questionnaire was not used, the BKFS had low participant burden, which was important, given that a time-intensive clinical examination was performed at the same time. Correction for any overall dietary underreporting or overreporting was done by analyzing the proportion of foods consumed; however, this approach is unable to correct for underreporting or overreporting of specific foods, which is a known issue in nutritional studies[31] and a limitation of these data.

A major strength of this analysis was the rigorous approach taken to latent variable modeling, using variable selection to handle high-dimensional covariates and identify those most relevant to class distinction, followed by 3-step modeling to associate early life feeding practices with DPs, which appropriately treats DP as an unobserved variable rather than a fixed, observed one. Comparing the results of the classify-analyze approach to that of the 3-step approach, although effect sizes were very similar, the CIs of the 3-step approach were much wider than that of the classify-analyze approach and lead to nonsignificance. This result was surprising, as most studies on simulated and real data suggest that the classify-analyze approach generally attenuates estimates.[36] Nonetheless, because the inherent uncertainty in DP assignment is modeled in the 3-step approach but effectively ignored in the classify-analyze approach, these results should be favored and the classify-analyze approach should be used with caution. Additional studies are needed that capture a wide range of confounders as was done here, while also properly modeling the latent variable of dietary pattern.

CONCLUSIONS

In a racially diverse US birth cohort, breastfeeding and age at solid food introduction were not significantly associated with consumption of a healthier DP in children at 10 years of age. However, this study may have been underpowered to detect these effects, as the effect size of solid food introduction was small, and the effect size of breastfeeding was large, but was a relatively rare exposure in this racially and socioeconomically diverse population, and required substantial covariate adjustment to reduce confounding bias. Additional longitudinal studies that carefully evaluate what early life factors are determinants of healthy eating habits later in childhood are needed.

References

1. US Department of Health and Human Services and US Department of Agriculture. 2015–2020 Dietary Guidelines for Americans. 8th edition. Published December 2015. Accessed September 23, 2020. https://health.gov/our-work/food-and-nutrition/2015-2020-dietary-guidelines/
2. Banfield EC, Liu Y, Davis JS, Chang S, Frazier-Wood AC. Poor adherence to US dietary guidelines for children and adolescents in the national health and nutrition examination survey population. *J Acad Nutr Diet*. 2016;116(1):21-27.
3. Mikkilä V, Räsänen L, Raitakari O, Pietinen P, Viikari J. Consistent dietary patterns identified from childhood to adulthood: The cardiovascular risk in Young Finns Study. *Br J Nutr*. 2005;93(6):923-931.
4. Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. *Maturitas*. 2011;70(3):266-284.
5. Movassagh EZ, Baxter-Jones AD, Kontulainen S, Whiting SJ, Vatanparast H. Tracking dietary patterns over 20 years from childhood through adolescence into young adulthood: The Saskatchewan Pediatric Bone Mineral Accrual Study. *Nutrients*. 2017;9(9):990.
6. Harris G, Coulthard H. Early eating behaviours and food acceptance revisited: Breastfeeding and introduction of complementary foods as predictive of food acceptance. *Curr Obes Rep*. 2016;5(1):113-120.
7. Schaal B, Marlier L, Soussignan R. Human foetuses learn odours from their pregnant mother's diet. *Chem Senses*. 2000;25(6):729-737.
8. Hausner H, Nicklaus S, Issanchou S, Mølgaard C, Møller P. Breastfeeding facilitates acceptance of a novel dietary flavour compound. *Clin Nutr*. 2010;29(1):141-148.
9. Ventura AK, Worobey J. Early influences on the development of food preferences. *Curr Biol*. 2013;23(9):R401-R408.
10. Mennella JA, Beauchamp GK. The human infants' response to vanilla flavors in mother's milk and formula. *Infant Behav Dev*. 1996;19:13-19.
11. Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. *Pediatrics*. 2001;107(6):e88.
12. Mennella JA, Beauchamp GK. Maternal diet alters the sensory qualities of human milk and the nursling's behavior. *Pediatrics*. 1991;88(4):737-744.
13. Nevo N, Rubin L, Tamir A, Levine A, Shaoul R. Infant feeding patterns in the first 6 months: An assessment in full-term infants. *J Pediatr Gastroenterol Nutr*. 2007;45(2):234-239.
14. Maier-Nöth A, Schaal B, Leathwood P, Issanchou S. The lasting influences of early food-related variety experience: A longitudinal study of vegetable acceptance from 5 months to 6 years in two populations. *PLoS One*. 2016;11(3). 2016;e0151356.
15. Harris G, Thomas A, Booth DA. Development of salt taste in infancy. *Dev Psychol*. 1990;26:534.
16. Northstone K, Emmett P, Nethersole F, Team AS. The effect of age of introduction to lumpy solids on foods eaten and reported feeding difficulties at 6 and 15 months. *J Hum Nutr Diet*. 2001;14(1):43-54.
17. Coulthard H, Harris G, Fogel A. Exposure to vegetable variety in infants weaned at different ages. *Appetite*. 2014;78:89-94.
18. Hu FB. Dietary pattern analysis: A new direction in nutritional epidemiology. *Curr Opin Lipidol*. 2002;13(1):3-9.
19. Aichbhaumik N, Zoratti EM, Strickler R, et al. Prenatal exposure to household pets influences fetal immunoglobulin E production. *Clin Exp Allergy*. 2008;38(11):1787-1794.
20. Wegienka G, Havstad S, Joseph CL, et al. Racial disparities in allergic outcomes in African Americans emerge as early as age 2 years. *Clin Exp Allergy*. 2012;42(6):909-917.
21. Havstad S, Johnson CC, Kim H, et al. Atopic phenotypes identified with latent class analyses at age 2 years. *J Allergy Clin Immunol*. 2014;134(3):722-727.e722.
22. Hunsberger M, O'Malley J, Block T, Norris JC. Relative validation of Block Kids Food Screener for dietary assessment in children and adolescents. *Matern Child Nutr*. 2015;11(2):260-270.
23. Oken E, Kleinman KP, Rich-Edwards J, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. *BMC Pediatr*. 2003;3:6.
24. Petersen AC, Crockett L, Richards M, Boxer A. A self-report measure of pubertal status: Reliability, validity, and initial norms. *J Youth Adolesc*. 1988;17(2):117-133.
25. Verloigne M, Van Lippevelde W, Maes L, et al. Self-reported TV and computer time do not represent accelerometer-derived total sedentary time in 10 to 12-year-olds. *Eur. J. Public Health*. 2013;23(1):30-32.
26. Hamilton CM, Strader LC, Pratt JG, et al. The PhenX Toolkit: Get the most from your measures. *Am J Epidemiol*. 2011;174(3):253-260.
27. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: Methods and development. *Vital Health Stat*. 2002 May;11(246):1-190.
28. Hernán MA, Hernández-Díaz S, Robins JM. A structural approach to selection bias. *Epidemiology*. 2004;15(5):615-625.
29. Howe CJ, Cole SR, Lau B, Napravnik S, Eron JJ Jr. Selection bias due to loss to follow up in cohort studies. *Epidemiology*. 2016;27(1):91-97.
30. Yang D, Dalton JE. A unified approach to measuring the effect size between two groups using SAS®. *SAS Global Forum*. 2012;3352012:1-6.
31. Macdiarmid J, Blundell J. Assessing dietary intake: Who, what and why of under-reporting. *Nutr Res Rev*. 1998;11(2):231-253.
32. Lazarsfeld P, Henry N. *Latent Structure Analysis*. Boston, MA: Houghton Mifflin Company; 1968.
33. Fop M, Smart KM, Murphy TB. Variable selection for latent class analysis with application to low back pain diagnosis. *Ann Appl Stat*. 2017;11(4):2080-2110.
34. Dean N, Raftery AE. Latent class analysis variable selection. *Ann Inst Stat Math*. 2010;62(1):11-35.
35. Muthén LK, Muthén BO. *Mplus User's Guide*. 8th ed. Los Angeles, CA: Muthén & Muthén; 1998-2017.
36. Vermunt JK. Latent class modeling with covariates: Two improved three-step approaches. *Politic Anal*. 2010;18(4):450-469.
37. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. *Am J Epidemiol*. 1989;129(1):125-137.
38. Nylund KL, Asparouhov T, Muthén BO. Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Struct Equat Model*. 2007;14(4):535-569.
39. Victora CG, Bahl R, Barros AJ, et al. Breastfeeding in the 21st century: Epidemiology, mechanisms, and lifelong effect. *Lancet*. 2016;387(10017):475-490.
40. Maier AS, Chabanet C, Schaal B, Leathwood PD, Issanchou SN. Breastfeeding and experience with variety early in weaning increase infants' acceptance of new foods for up to two months. *Clin Nutr*. 2008;27(6):849-857.
41. Perrine CG, Galuska DA, Thompson FE, Scanlon KS. Breastfeeding duration is associated with child diet at 6 years. *Pediatrics*. 2014;134(suppl 1):S50-S55.
42. Grieger JA, Scott J, Cobiac L. Dietary patterns and breast-feeding in Australian children. *Public Health Nutr*. 2011;14(11):1939-1947.
43. Santos LP, Assunção MCF, Matijasevich A, Santos IS, Barros AJ. Dietary intake patterns of children aged 6 years and their association with socioeconomic and demographic characteristics, early feeding practices and body mass index. *BMC Public Health*. 2016;16(1):1055.

44. VanderWeele TJ, Ding P. Sensitivity analysis in observational research: Introducing the E-value. *Ann Intern Med*. 2017;167(4):268-274.
45. de Lauzon-Guillain B, Jones L, Oliveira A, et al. The influence of early feeding practices on fruit and vegetable intake among preschool children in 4 European birth cohorts. *Am J Clin Nutr*. 2013;98(3):804-812.
46. Cooke L, Wardle J, Gibson E, Sapochnik M, Sheiham A, Lawson M. Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutr*. 2004;7(2): 295-302.
47. Blissett J, Bennett C, Donohoe J, Rogers S, Higgs S. Predicting successful introduction of novel fruit to preschool children. *J Acad Nutr Diet*. 2012;112(12):1959-1967.
48. Grummer-Strawn LM, Scanlon KS, Fein SB. Infant feeding and feeding transitions during the first year of life. *Pediatrics*. 2008;122(suppl 2):S36-S42.
49. Hollis J, Crozier S, Inskip H, et al. Age at introduction of solid foods and feeding difficulties in childhood: Findings from the Southampton Women's Survey. *Br J Nutr*. 2016;116(4):743-750.
50. Clayton HB, Li R, Perrine CG, Scanlon KS. Prevalence and reasons for introducing infants early to solid foods: Variations by milk feeding type. *Pediatrics*. 2013;131(4):e1108-e1114.
51. Shim JS, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. *Epidemiol Health*. 2014;36:e2014009.

AUTHOR INFORMATION

A. R. Sitarik is a biostatistician, Department of Public Health Sciences, Henry Ford Health System, Detroit, MI. J. M. Kerver is an assistant professor, Department of Epidemiology and Biostatistics, Michigan State University, Traverse City, MI. S. L. Havstad is a biostatistician, Department of Public Health Sciences, Henry Ford Health System, Detroit, MI. E. M. Zoratti is an allergist/immunologist, Division of Allergy and Immunology, Henry Ford Health System, Detroit, MI. D. R. Ownby is an allergist, immunologist, and pediatrician, Augusta, GA. G. Wegienka is an epidemiologist, Department of Public Health Sciences, Henry Ford Health System, Detroit, MI. C. Cole Johnson is an epidemiologist, Department of Public Health Sciences, Henry Ford Health System, Detroit, MI. A. E. Cassidy-Bushrow is an epidemiologist, Department of Public Health Sciences, Henry Ford Health System, Detroit, MI.

Address correspondence to: Alexandra R. Sitarik, MS, Department of Public Health Sciences, Henry Ford Health System, 1 Ford Pl, 3E, Detroit, MI 48202. E-mail: asitari1@hfhs.org

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING/SUPPORT

The Wayne County Health Environment Allergy and Asthma Longitudinal Study was supported by the National Institutes of Health (R01 AI050681; R01 HD082147; R01 HL-113010; P01 AI089473). This work was also supported by the Fund for Henry Ford Hospital.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the continued dedicated participation of the Wayne County Health Environment Allergy and Asthma Longitudinal Study families in this long-standing birth cohort study.

AUTHOR CONTRIBUTIONS

A. R. Sitarik conceptualized and designed the study, performed the statistical analysis, and drafted the initial manuscript. J. M. Kerver conceptualized and designed the study and provided feedback throughout the course of the analysis. S. L. Havstad, D. R. Ownby, and G. Wegienka contributed to the conduct and design of the parent study and provided feedback throughout the course of the analysis. E. M. Zoratti contributed to the conduct and design of the parent study. C. Cole Johnson and A. E. Cassidy-Bushrow contributed to the conduct and design of the parent study, conceptualized and designed the study, and provided feedback throughout the course of the analysis. All authors critically reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.