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Infant feeding practices and dietary consumption of US infants and toddlers: National Health and Nutrition Examination Survey (NHANES) 2003–2012

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Abstract
Objective: To compare infant and toddler anthropometric measurements, feeding practices and mean nutrient intakes by race/ethnicity and income.
Design: Cross-sectional analysis using general linear modelling. Ten years of survey data (2003–2012) were combined to compare anthropometric measurements, feeding practices and mean nutrient intakes from a nationally representative US sample.
Setting: The 2003–2012 National Health and Nutrition Examination Survey (NHANES).
Subjects: Infants and toddlers (*n* 3669) aged 0–24 months.
Results: Rates of overweight were higher among Mexican-American infants and toddlers ($P = 0{\cdot}002$). There were also several differences in feeding practices among groups based on race/ethnicity. Cessation of breast-feeding occurred earlier for non-Hispanic black and Mexican-American *v.* non-Hispanic white infants (3·6 and 4·2 *v.* 5·3 months; $P < 0{\cdot}0001$; $P = 0{\cdot}001$). Age at first feeding of solids was earlier for white than Mexican-American infants (5·3 *v.* 5·7 months; $P = 0{\cdot}02$). There were differences in almost all feeding practices based on income, including the lowest-income infants stopped breast-feeding earlier than the highest-income infants (3·2 *v.* 5·8 months, $P < 0{\cdot}0001$). Several differences in mean nutrient intakes by both race/ethnicity and income were also identified.
Conclusions: Our study indicates that disparities in overweight, feeding practices and mean nutrient intakes exist among infants and toddlers according to race/ethnicity, which cannot be disentangled from income.

Keywords
Obesity
Paediatric
Child obesity
Feeding behaviours
Infant nutrition
Diet

Childhood overweight and obesity are among the greatest risks to the future health of US children and adults. Early obesity increases risk for dyslipidaemia, pre-diabetes, type 2 diabetes, hypertension, asthma, non-alcoholic fatty liver disease, anxiety and depression in both children and adults[1–11]. Consequently, preventing childhood obesity is a major national health priority[12]. While efforts to combat childhood obesity have expanded, prevalence remains high[13,14].

Obesity is not defined in infants and toddlers, but overweight is defined as weight-for-length greater than or equal to the 95th percentile on the Centers for Disease Control and Prevention growth charts[15]. Obesity in the very next age group (2- to 5-year-olds) is defined in essentially the same way, using BMI ≥ 95th percentile (which is also an indicator of weight-for-length). Using this indicator, the rate of overweight in infants and toddlers for 2011–2012 (8·1 %) was only slightly less than the rate of obesity in 2- to 5-year-olds (8·4 %)[15].

Several studies indicate that rapid weight gain in infancy correlates with obesity in childhood and adulthood[16–22]. The time of onset and causes of early obesity are uncertain, but one study identified a median 'tipping point' of 22 months for the infant transition to overweight, which decreased to 15 months when adjusted for infants who were overweight by the first physician visit[23]. Crossing weight-for-length percentiles in the first 6 months of life is also associated with a significantly higher rate of obesity at age 5 years[24]. Given the potentially severe consequences of early excess weight gain, identifying feeding practices in infancy which could prevent the onset of overweight is essential.

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Infant feeding practices hypothesized to be protective against overweight include breast-feeding, delayed introduction of sugar-sweetened beverages, exposure to a wide range of textures and tastes, responsive feeding and appropriate introduction of solid foods[21,25–27]. However, there are few studies reporting anthropometric measurements and early feeding practices in children from birth to age 24 months, and they are based on samples which are less ethnically diverse and higher income than the US population[28–33]. While Mexican-American infants have higher rates of overweight compared with other groups, data on feeding practices or nutrient intakes stratified according to race/ethnicity or income have not been reported[14].

The National Health and Nutrition Examination Survey (NHANES) is an ongoing programme designed to assess the health and nutrition status of adults and children in the USA. It describes race/ethnicity, income, anthropometric measurements and parental feeding practices of US children, making it useful to identify differences in practices protective against, as well as those associated with, early overweight and obesity[34]. The purpose of the present study was to use data from approximately 10 years of NHANES surveys (2003–2012) to compare infant and toddler anthropometric measurements, feeding practices and mean nutrient intakes by race/ethnicity. Because there are also disparities in income by race/ethnicity in the USA, we also aimed to explore differences in these variables by income.

Participants and methods

Study design

NHANES uses a stratified, multistage probability design to provide cross-sectional health data on a nationally representative sample of all races/ethnicities in the USA. The current study included all infants and toddlers from 0 to 24 months of age in NHANES 2003 to 2012. An approximately 10-year period was chosen to achieve sufficiently large groups by race and ethnicity for comparison. While obesity rates are thought to have changed among 2- to 5-year-old children during 2003–2012, in the 0–24 months age group, the rates were steady[13,14]; thus data from these years were combined.

The NHANES methodology is explained in detail in readily available public reports[35]. Briefly, the methodology is as follows. Respondents were interviewed in their homes and subsequently in mobile examination centres, where the examination component, including obtaining anthropometric measurements and collection of dietary intake data, took place. During a home interview, parents completed the Diet Behavior and Nutrition Questionnaire, which asks questions such as 'Was the child ever breastfed or fed breastmilk?' Dietary data were obtained using the US Department of Agriculture's Automated Multiple-Pass Method with parents acting as proxy reporters. The Automated Multiple-Pass Method is a validated 24 h recall method. Participants self-classified their income into categories at \$US 5000 intervals from \$US 0 to \$US 24 999 and at intervals of \$US 10 000 or more at \$US 25 000 to \$US 74 999 annually. Parents self-classified their race/ethnicity as Mexican-American, non-Hispanic white, non-Hispanic black, other Hispanic, and other race. Anthropometric measurements included reported birth weight, measured weight and measured length.

Data analysis

Participants were categorized as ≥95th percentile (overweight) or <95th percentile for weight-for-length according to the WHO chart. The WHO charts were chosen because, compared with the Centers for Disease Control and Prevention growth charts, they are more representative of how diverse, breast-fed infants and toddlers grow under optimal conditions[36].

Because we sought to compare only nutrient intakes from foods and beverages by race/ethnicity and income without comparing mean intakes with intake standards such as the Dietary Reference Intakes, nutrient intake data presented are based on food and beverage intakes from the first day's recall. This does not include supplement intake, nor does it use statistical methods to estimate usual intakes. NHANES includes data on breast-feeding but does not estimate intakes of nutrients from breast milk; thus for infants whose caregivers reported breast-feeding, the methods of Butte *et al.* and Briefel *et al.* were used to estimate breast-milk intake[37,38] (see online supplementary material, Supplemental Table 1). Nutrient intakes from breast milk were estimated using the Nutrition Data System for Research (NDSR) 2015 dietary analysis program (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, USA).

Family annual income was minimally stratified. The lower income categories were combined into two groups of approximately \$US 10 000 intervals. One lower–middle income group of \$US 20 000–34 999 annually was formed, as well as two middle income and two upper–middle income categories of approximate \$US 10 000 intervals. The upper income (> \$US 75 000) category was left unchanged.

For all analyses, the appropriate complex survey design sample weights were taken into account because of the unequal probabilities for selection as described on the NHANES website. Responses to questions which the participant refused to answer or answered 'don't know' were treated as missing. If a participant had missing data for a particular outcome, the participant was not included in the analysis of that outcome.

The descriptive analyses are reported as survey-weighted mean and 95 % confidence level (CL) for continuous variables, or frequency and percentage for categorical variables. The differences in anthropometric measurements and infant feeding practices among race/ethnicities and income levels and interactions were tested in survey-weighted general linear models. Statistical analysis was conducted using the statistical software package SAS version 9·4. A P value of <0·05 was considered statistically significant.

Results

Data were extracted for 3840 infants and toddlers from 2003 to 2012. Dietary intake data were missing for 171 participants, resulting in n 3669 for dietary analysis. Missing data points were few for variables such as reported birth weight (n 16), weight (n 15) and length (n 10), resulting in n 3628 for the variable weight-for-length ≥95th percentile or <95th percentile. There were similar numbers of males and females (51 % male and 49 % female). Due to intentional oversampling in the recent NHANES surveys, there were large numbers of Mexican-American (33 %) and non-Hispanic black (20 %) participants. There were equal proportions of infants in the age groups 0–5·9 months and 6–11·9 months (30 and 29 %, respectively) and 41 % in the 12–24 months group. Most participants were low income (< $US 35 000; 56 %; Table 1).

Mexican-American and non-Hispanic black infants weighed less at birth than non-Hispanic white infants (P <0·0001 for both). Of 3628 infants and toddlers for whom data were available, 13 % had a weight-for-length ≥95th percentile, indicating overweight. Of these, 26·9 % were non-Hispanic whites, 39·3 % were Mexican-Americans and 19·5 % were non-Hispanic blacks. Mexican-American infants and toddlers were more likely to be classified as overweight compared with non-Hispanic white and black infants and toddlers (P = 0·002; Table 2).

Seventy-one per cent of participants (n 2624) ever received breast milk (74·8 % of non-Hispanic whites, 72·9 % of Mexican-Americans, 55·8 % of non-Hispanic blacks). There were several differences in feeding practices among groups based on race/ethnicity. For age the infant was first fed something other than breast milk, age stopped breast-feeding, age first fed formula and age first fed milk, the feeding practice occurred earlier for both Mexican-American and non-Hispanic black infants compared with non-Hispanic white infants (see Table 3 for mean ages and P values). The age of first feeding of solids was earlier for non-Hispanic white infants compared with Mexican-American infants (5·3 v. 5·7 months; P = 0·02).

There were also differences in mean macronutrient intakes stratified by race/ethnicity (Table 4). There were no differences in mean intake of protein, saturated fat or fibre according to race/ethnicity; however, non-Hispanic black and white participants had higher energy intake (P < 0·001 and P < 0·01, respectively) compared with Mexican-Americans. Mexican-American participants had lower carbohydrate intake compared with non-Hispanic black participants (117 v. 141 g/d; P < 0·001). Total fat intake was also lower among Mexican-Americans compared with non-Hispanic blacks (39 v. 43 g/d; P < 0·0001; Table 4).

Micronutrient intakes also differed by race/ethnicity. Mexican-American infants and toddlers had lower Na intake compared with non-Hispanic black infants and toddlers (938 v. 1160 mg/d; P < 0·05). Ca intake did not differ, but non-Hispanic black participants consumed more K, Fe, Zn and folate compared with non-Hispanic white and Mexican-American participants (P = 0·03, P < 0·0001, P = 0·04 and P < 0·0001, respectively; Table 4) Differences in feeding practices were also present according to income (Table 5). Most differences by income were between income groups at the very bottom

Table 1 Demographic characteristics of US infants and toddlers aged 0–24 months by race/ethnicity: National Health and Nutrition Examination Survey (NHANES) 2003–2012

	Non-Hispanic white (*n* 1143)		Mexican-American (*n* 1225)		Non-Hispanic black (*n* 720)		All (*n* 3669)	
	n	%	*n*	%	*n*	%	*n*	%
Male	603	52·8	623	50·9	360	50·0	1881	51·3
Female	540	47·2	602	49·1	360	50·0	1778	48·5
Age 0–5·9 months	351	30·7	391	31·9	196	27·2	1107	30·1
Age 6–11·9 months	342	29·9	366	29·9	179	24·9	1063	29·0
Age 12–24 months	450	39·4	468	38·2	345	47·9	1499	40·9
Annual income								
0–$US 9999	107	9·4	120	9·8	158	21·9	451	12·3
$US 10 000–19 999	173	15·1	357	29·1	160	22·2	798	21·7
$US 20 000–34 999	218	19·1	313	25·6	146	20·3	813	22·2
$US 35 000–44 999	75	6·6	112	9·1	53	7·4	284	7·7
$US 45 000–54 999	90	7·9	76	6·2	51	7·1	250	6·8
$US 55 000–64 999	76	6·7	40	3·3	23	3·2	162	4·4
$US 65 000–74 999	58	5·1	37	3·0	27	3·8	143	3·9
≥$US 75 000	306	26·8	99	8·1	69	9·6	582	15·9
Other	40	3·5	71	5·8	33	4·6	186	5·1

Table 2 Anthropometric measurements of US infants and toddlers aged 0–24 months by race/ethnicity: National Health and Nutrition Examination Survey (NHANES) 2003–2012*,†

	Non-Hispanic white		Mexican-American		Non-Hispanic black		All	
	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL
0–2·9 months	*n* 176		*n* 192		*n* 98		*n* 554	
Birth weight (kg)	3·10	2·98, 3·22	3·13	3·04, 3·21	2·96	2·85, 3·08	3·08	3·01, 3·14
Weight (kg)‡	5·39	5·22, 5·57	5·46	5·30, 5·63	5·33	5·11, 5·55	5·42	5·32, 5·52
Overweight (%)§	6·8		14·2		9·2		11·0	
3–5·9 months	*n* 175		*n* 199		*n* 98		*n* 549	
Birth weight (kg)	3·15	3·03, 3·26	3·08	2·97, 3·18	2·85	2·67, 3·02	3·07	2·99, 3·15
Weight (kg)‡	7·39	7·20, 7·57	7·36	7·22, 7·50	7·38	7·11, 7·65	7·37	7·24, 7·50
Overweight (%)§	8·0		7·6		13·3		8·9	
6–8·9 months	*n* 171		*n* 190		*n* 85		*n* 533	
Birth weight (kg)	3·18	3·06, 3·29	3·11	2·99, 3·22	2·92	2·78, 3·05	3·10	3·03, 3·17
Weight (kg)‡	8·54	8·38, 8·70	8·62	8·44, 8·80	8·83	8·57, 9·10	8·55	8·45, 8·66
Overweight (%)§	14·1		14·7		12·9		12·8	
9–11·9 months	*n* 171		*n* 172		*n* 94		*n* 522	
Birth weight (kg)	3·15	3·06, 3·25	3·04	2·91, 3·17	2·82	2·68, 2·96	3·09	3·01, 3·16
Weight (kg)‡	9·62	9·40, 9·84	9·62	9·38, 9·87	9·64	9·38, 9·90	9·59	9·44, 9·74
Overweight (%)§	15·4		18·6		18·1		16·7	
12–17·9 months	*n* 211		*n* 231		*n* 157		*n* 699	
Birth weight (kg)	3·13	3·04, 3·21	3·10	3·00, 3·19	3·01	2·89, 3·13	3·09	3·03, 3·15
Weight (kg)‡	10·66	10·43, 10·89	10·74	10·54, 10·94	10·84	10·57, 11·10	10·70	10·56, 10·84
Overweight (%)§	14·0		20·2		12·8		15·5	
18–24 months	*n* 239		*n* 232		*n* 186		*n* 771	
Birth weight (kg)	3·22	3·14, 3·30	3·11	3·04, 3·19	2·96	2·89, 3·03	3·14	3·10, 3·20
Weight (kg)‡	12·07	11·82, 12·31	12·42	12·17, 12·67	12·19	11·77, 12·61	12·15	11·99, 12·31
Overweight (%)§	9·9		17·0		12·4		13·4	
All ages	*n* 1143		*n* 1244		*n* 718		*n* 3628	
Birth weight (kg)	3·16	3·11, 3·21	3·10	3·06, 3·14	2·92	2·88, 2·99	3·10	3·07, 3·13
Overweight (%)§	11·4		15·4		13·1		13·1	

*Data are presented as survey-weighted means and 95 % confidence levels (CL), unless indicated otherwise.
†Total *n* 3628. Missing data for forty-one participants, demographics similar to Table 1.
‡Measurement performed when NHANES survey was administered.
§Percentage of group by race/ethnicity plotting ≥95th percentile weight-for-length on WHO birth to 24 months growth charts.

and very top of the spectrum. Cessation of breast-feeding occurred earlier in the lower income groups (< \$US 35 000) compared with the \$US 45 000–54 999 and ≥ \$US 75 000 groups (4·1 *v.* 5·5 and 5·8 months; $P=0·007$ and $P=0·0005$, respectively). The age at which infants were first fed formula was earlier for households with income of < \$US 35 000 compared with the \$US 55 000–64 999 or ≥ \$US 75 000 groups (1·3 *v.* 2·6 and 2·5 months; $P=0·007$ and $P<0·0001$, respectively). The age at which infants stopped receiving formula was also earlier for households with income < US \$35 000 compared with those with incomes of \$US 65 000–74 999 or ≥ \$US 75 000 annually ($P=0·0001$ and $P=0·03$, respectively).

Finally, there were differences in mean nutrient intakes according to income (Table 6). Clear differences according to upper and lower income groups were not universally present; however, the highest income group (≥ \$US 75 000 annual income) had decreased energy intake compared with the lowest income groups (< \$US 35 000 annual income; *P* for trend = 0·002). In addition, the highest income group had decreased saturated fat intake compared with the lowest income groups (*P* for trend = 0·003). Along with higher energy intake, the trend in lower income groups was for higher intake of several micronutrients: Na, Fe, Zn, vitamin E, vitamin A, vitamin C and vitamin B_{12} (*P* for trend = 0·01, 0·001, <0·0001, < 0·0001, 0·002, 0·0001 and 0·0002, respectively). Significant interactions ($P<0·05$) between race/ethnicity and income were found for feeding practices and for intakes of most nutrients with the exceptions of protein, total fat, fibre, K, Ca and vitamin B_{12} (Tables 5 and 6). Of these nutrients, intakes of only total fat and K were different by race/ethnicity, with lower intake of both among Mexican-Americans and non-Hispanic whites.

Discussion

The Feeding Infants and Toddlers Study (FITS 2002 and 2008)[28,29,33] and the Infant Feeding Practices Study II (IFPS II)[30–32] have both provided important insights into feeding practices for children from birth to 24 months. However, FITS used a commercial list of infants and toddlers, which under-represented children from groups of lower socio-economic status and certain race/ethnicities[28,29,33]. IFPS II was also limited by lower participation of minority groups and higher participation of infants of higher socio-economic status. NHANES includes a nationally representative sample, providing important information about how historically under-represented

Table 3 Infant feeding practices of US infants and toddlers aged 0–24 months by race/ethnicity: National Health and Nutrition Examination Survey (NHANES) 2003–2012*

	Non-Hispanic white			Mexican-American			Non-Hispanic black				All		
	n†	Mean	95 % CL	*n*†	Mean	95 % CL	*n*†	Mean	95 % CL	*P* value	*n*†	Mean	95 % CL
Age first fed something other than breast milk or water	480	3·0	2·6, 3·3	619	2·3	2·0, 2·6	238	2·1	1·8, 2·5	0·0009	1545	2·8	2·6, 3·0
Age stopped breast-feeding	563	5·3	4·8, 5·8	638	4·2	3·7, 4·6	298	3·6	3·2, 4·1	<0·0001	1812	4·9	4·6, 5·2
Age first fed formula	893	2·1	1·8, 2·3	1064	1·3	1·1, 1·5	670	1·1	0·9, 1·3	<0·0001	3127	1·7	1·6, 1·9
Age stopped getting formula	364	11·6	11·3, 11·8	414	11·1	10·8, 11·3	339	11·0	10·8, 11·2	0·002	1324	11·3	11·1, 11·5
Age first fed milk	472	11·5	11·3, 11·6	514	11·1	10·9, 11·3	360	11·0	10·8, 11·3	0·003	1590	11·4	11·3, 11·5
Age first fed solids	582	5·3	5·1, 5·6	627	5·7	5·5, 6·0	385	5·6	5·3, 5·9	0·05	1824	5·5	5·3, 5·7

*Data are presented as survey-weighted means and 95 % confidence limits (CL) in months.
†Number of participants within each category responding to each question.

groups and low-income groups differ in overweight, feeding practices and mean nutrient intake levels.

The present study identified a few differences in feeding practices compared with FITS and IFPS. A lower proportion of women in the NHANES sample (which is lower education level, younger age, lower socio-economic status, and more diverse) initiated breast-feeding compared with the IFPS II and FITS samples (71·5 *v.* 83 and 80 %, respectively). The median age of initiation of solids or complementary foods in NHANES was higher compared with IFPS II and FITS (~5 months compared with 4 months for both IFPS and FITS)[28–31].

When comparing feeding practices in NHANES with those recommended by the American Academy of Pediatrics and Academy of Nutrition and Dietetics[39,40], the mean age of introduction of something other than breast-feeding or water was about 3–4 months earlier than the recommended time for exclusive breast-feeding of 6 months. The total mean duration of breast-feeding (5 months) was about 1 month less than the recommended time for exclusive breast-feeding (6 months) and more than 6 months less than the recommended time for beginning of weaning from the breast (12 months)[39,40]. The present study reaffirms that infant feeding practices fall short of what is recommended. Breast-feeding initiation rates remain low (71 %) and many infants receive infant formula at an early age.

Rates of overweight in the present study are higher than those reported in other investigations using similar data[13] (13 *v.* 8 %), in part because the 95th percentile on the WHO chart was chosen as the comparative standard rather than the 95th percentile on the Centers for Disease Control and Prevention chart. In addition, disparities by race/ethnicity and income existed, with lower birth weight among non-Hispanic blacks and Mexican-Americans. However, it is unusual to note that despite similar feeding practices among both Mexican-American and non-Hispanic black parents, only Mexican-American infants and toddlers had higher rates of early overweight. Among non-white infants and toddlers, rates of breast-feeding were lower, breast-feeding cessation occurred earlier, and introduction of water, formula and milk all occurred earlier compared with non-Hispanic whites. Differences in mean nutrient intakes according to both race/ethnicity and income also existed. Mexican-Americans had the lowest reported energy, carbohydrate and fat intakes. Non-Hispanic blacks had the highest reported energy, carbohydrate and fat intakes. In general, reported energy intake was higher in lower income groups, with protein intake being similar among groups but with higher intakes of total fat and total carbohydrate in lower income groups. There was no difference in fibre intake among groups; however, there were higher intakes of many nutrients, including vitamin C, Fe and energy, in the lowest income groups and non-Hispanic black infants. This may be indicative of higher intakes of cheaper, processed but fortified foods and juices[41].

Table 4 Mean daily macronutrient and micronutrient intakes of US infants and toddlers aged 0–24 months by race/ethnicity: National Health and Nutrition Examination Survey (NHANES) 2003–2012*

	Non-Hispanic white (*n* 1143)		Mexican-American (*n* 1225)		Non-Hispanic black (*n* 720)			All (*n* 3669)	
	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	*P* value	Mean	95 % CL
Energy (kJ/d)	4058	3883, 4230	3899	3749, 4050	4515	4330, 4694	<0·0001	4092	3979, 4201
Energy (kcal/d)	970	928, 1011	932	896, 968	1079	1035, 1122	<0·0001	978	951, 1004
Protein (g/d)	31·6	29·7, 33·4	31·4	29·8, 33·1	34·1	32·2, 36·0	0·06	32·0	30·8, 33·1
Carbohydrate (g/d)	124·3	118·7, 130·0	116·8	111·7, 121·8	141·0	134·8, 147·3	<0·0001	125·4	121·6, 129·2
Fibre (g/d)	5·5	5·2, 5·9	4·9	4·6, 5·3	5·4	5·0, 5·8	0·06	5·3	5·1, 5·6
Total fat (g/d)	39·7	38·1, 41·3	38·6	37·2, 40·0	43·0	41·1, 45·0	0·001	39·8	38·8, 40·8
Saturated fat (g/d)	16·5	15·8, 17·2	15·9	15·3, 16·5	16·8	16·1, 17·6	0·16	16·4	16·0, 16·8
Na (mg/d)	1007	935, 1079	938	871, 1004	1160	1080, 1241	0·0002	1016	972, 1060
K (mg/d)	1371	1302, 1441	1375	1311, 1439	1486	1408, 1563	0·04	1389	1343, 1435
Fe (mg/d)	10·0	9·4, 10·6	9·2	8·6, 9·7	12·8	12·0, 13·7	<0·0001	10·2	9·8, 10·6
Ca (mg/d)	771	729, 812	754	716, 791	785	746, 823	0·45	773	746, 800
Zn (mg/d)	5·8	5·6, 6·1	5·7	5·5, 5·9	6·5	6·2, 6·8	<0·0001	5·9	5·7, 6·1
Folate (µg/d)	164	155, 173	157	149, 165	177	169, 185	0·004	164	158, 170
Vitamin E, α-tocopherol (mg/d)	4·4	4·1, 4·6	4·4	4·2, 4·7	5·6	5·3, 6·0	<0·0001	4·5	4·4, 4·7
Vitamin A (RAE/d)	559	537, 581	520	496, 544	565	530, 599	0·06	550	535, 565
Vitamin C (mg/d)	73	68, 78	73	69, 78	99	90, 108	<0·0001	78	74, 82
Vitamin B_{12} (µg/d)	2·8	2·6, 3·0	2·9	2·8, 3·1	3·0	2·7, 3·3	0·39	2·9	2·7, 3·0

RAE, retinol activity equivalents.
*Data are presented as survey-weighted means and 95 % confidence limits (CL).

Why reported intakes were lowest in Mexican-Americans, the group with the highest overweight rate, is unclear. It is possible that Mexican-American parents under-report intake consistently, but this diverges from the higher reported intake levels in lower income groups, who are also at increased risk for overweight.

Any conclusions related to nutrient intakes are limited by the absence of using statistical methods to estimate usual intakes of nutrients. However, since this deficit was present across all groups, and the intention was to simply compare groups, not to compare intakes with desirable standards, this approach was unlikely to invalidate the comparison. In addition, one recent analysis indicated that in a group of Mexican infants, toddlers and pre-school children, there was no difference in estimated intakes determined using one-day analyses *v.* usual intake methods for most nutrients except for fat and Fe[42]. Trends in differences according to income were clear but not consistent across all income levels. It should be noted that it is difficult to disentangle race/ethnicity from income since Mexican-American and black families are more likely to suffer low income compared with white families. Thus, the effect of income appears to be greater in non-Hispanic whites.

It is interesting that the group with the highest rates of early overweight (Mexican-Americans) had similar rates of breast-feeding initiation and duration, later introduction of solids, and lower energy and carbohydrate intakes compared with non-Hispanic blacks, who did not have rates of overweight disproportionate to their sample size. However, there is a significant, emerging body of literature that indicates early feeding practices may be less influential than previously thought. For example, Daniels *et al.*[43] reviewed twenty papers related to feeding practices and later obesity and found that there was only slight evidence for introduction of solids at earlier than 4 months of age being associated with obesity. They identified methodological problems with the studies that have been done in this area. A recent paper which found increased risk for obesity with both early and late introduction of solids had only nine participants in the 'early' group and just ten in the 'late' group[44]. In a much more nuanced study of early feeding patterns by Rose *et al.,* only early feeding of sugary and fatty foods such as cookies and fries was associated with early obesity[45]. Likewise, Barrera *et al.*[46] and Leary *et al.*[47] both found an increased risk of obesity for early feeding disappeared after adjusting for covariates. Finally, Kerr *et al.*[48] also found that baseline information such as child and maternal BMI, maternal age and education, and child health were the strongest predictors of onset and resolution of obesity in the school years with perinatal, breast-feeding and lifestyle exposures not being predictive. It is possible that early obesity in Mexican-American infants and toddlers, which is correlated to higher later obesity[16–22], relates more to genetic or parental factors or simply that Mexican-American parents are more prone to under-reporting offering high-energy

Table 5 Infant feeding practices of US infants and toddlers aged 0–24 months by annual income: National Health and Nutrition Examination Survey (NHANES) 2003–2012*

	0–$US 9999			$US 10 000–19 999			$US 20 000–34 999			$US 35 000–44 999		
	n†	Mean	95 % CL	*n*†	Mean	95 % CL	*n*†	Mean	95 % CL	*n*†	Mean	95 % CL
Age first fed something other than breast milk or water	161	1·9	1·5, 2·4	326	2·4	2·1, 2·7	338	2·6	2·2, 3·1	73	2·8	2·1, 3·0
Age stopped breast-feeding	181	3·2	2·6, 3·8	369	3·8	3·3, 4·3	395	4·8	4·1, 5·4	78	4·7	3·6, 6·0
Age first fed formula	407	0·9	0·7, 1·1	714	1·3	1·1, 1·5	704	1·5	1·1, 1·9	115	1·8	0·8, 1·5
Age stopped getting formula	182	10·8	10·4, 11·2	305	11·4	11·1, 11·7	281	11·0	10·4, 11·5	50	11·7	10·9, 11·8
Age first fed milk	207	11·1	10·8, 11·3	353	11·1	10·9, 11·4	330	11·4	11·0, 11·8	62	11·4	11·1, 12·0
Age first fed solids	248	5·4	4·8, 5·9	423	5·5	5·3, 5·8	390	5·4	5·0, 5·8	71	5·8	5·2, 6·2

	$US 45 000–54 999			$US 55 000–64 999			$US 65 000–74 999			≥ $US 75 000			
	n†	Mean	95 % CL	*n*†	Mean	95 % CL	*n*†	Mean	95 % CL	*n*†	Mean	95 % CL	*P* value for trend
Age first fed something other than breast milk or water	122	2·8	2·3, 3·4	82	2·7	1·9, 3·5	73	2·8	2·0, 3·6	244	3·3	2·7, 3·9	0·0001
Age stopped breast-feeding	144	5·5	4·5, 6·4	92	4·6	3·5, 5·7	78	4·7	3·5, 5·8	319	5·8	5·0, 6·6	<0·0001
Age first fed formula	204	1·7	1·2, 2·2	134	2·6	1·7, 3·4	115	1·8	1·1, 2·6	457	2·5	2·1, 3·0	<0·0001
Age stopped getting formula	94	11·2	10·5, 11·9	57	11·7	10·7, 12·7	50	11·7	11·5, 11·9	191	11·7	11·3, 12·0	0·001
Age first fed milk	119	11·4	11·2, 11·7	70	11·5	10·7, 12·4	62	11·4	11·1, 11·8	247	11·6	11·4, 11·8	0·01
Age first fed solids	134	5·4	4·7, 6·1	83	5·3	4·8, 5·8	71	5·8	5·0, 6·5	254	5·4	5·1, 5·8	0·77

*Data are presented as survey-weighted means and 95 % confidence limits (CL) in months.
†Number of participants within each category responding to each question.

Table 6 Mean daily macronutrient and micronutrient intakes of US infants and toddlers aged 0–24 months by annual income: National Health and Nutrition Examination Survey (NHANES) 2003–2012*,†

	0–$US 9999 (*n* 451)		$US 10 000–19 999 (*n* 798)		$US 20 000–34 999 (*n* 813)		$US 35 000–44 999 (*n* 284)		$US 45 000–54 999 (*n* 250)		$US 55 000–64 999 (*n* 162)		$US 65 000–74 999 (*n* 143)		≥ $US 75 000 (*n* 582)		*P* value for trend
	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	Mean	95 % CL	
Energy (kJ/d)	4469	4234, 4707	4410	4176, 4644	4280	4050, 4510	4151	3833, 4469	3841	3552, 4130	3452	3059, 3845	4084	3561, 4611	3887	3669, 4100	0·002
Energy (kcal/d)	1068	1012, 1125	1054	998, 1110	1023	968, 1078	992	916, 1068	918	849, 987	825	731, 919	976	851, 1102	929	877, 980	0·002
Protein (g/d)	33·9	31·4, 36·3	33·7	31·3, 36·1	33·6	31·0, 36·2	32·9	29·3, 36·5	31·3	27·7, 34·9	24·9	20·6, 29·3	32·2	27·2, 37·2	31·1	28·9, 33·4	0·02
Carbohydrate (g/d)	137·2	129·2, 145·1	137·4	128, 146	131	123, 139	125·0	114, 136	115·3	105, 125	107·0	93·8, 120·3	128·6	108, 149	118·2	111, 126	0·0009
Fibre (g/d)	5·1	4·5, 5·7	5·5	4·9, 6·1	5·3	4·8, 5·8	5·3	4·6, 6·0	4·9	4·3, 5·5	4·2	3·3, 5·0	6·0	4·7, 7·4	5·7	5·1, 6·3	0·5
Total fat (g/d)	43·7	41·3, 46·1	42·1	40·0, 44·3	41·6	39·5, 43·7	41·0	38·0, 44·1	37·9	34·8, 41·0	33·9	30·8, 37·1	38·3	34·1, 42·5	38·1	36·1, 40·1	< 0·0001
Saturated fat (g/d)	18·1	17·1, 19·1	17·0	16·1, 17·9	17·0	16·1, 17·9	16·7	15·3, 18·0	16·3	14·7, 17·8	13·8	12·5, 15·1	16·1	14·2, 17·9	15·7	14·9, 16·5	0·0002
Na (mg/d)	1083	977, 1189	1127	1033, 1220	1040	937, 1144	1077	939, 1214	1006	802, 1210	752	600, 905	1018	813, 1223	978	884, 1072	0·01
K (mg/d)	1493	1397, 1589	1509	1415, 1602	1450	1351, 1550	1388	1250, 1525	1356	1224, 1488	1114	938, 1290	1366	1169, 1563	1322	1232, 1412	0·006
Fe (mg/d)	12·1	11·0, 13·2	11·3	10·4, 12·1	10·8	10·2, 11·6	10·1	8·8, 11·4	9·0	7·8, 10·2	9·1	7·5, 10·6	10·4	8·6, 12·1	9·3	8·4, 10·2	0·0001
Ca (mg/d)	823	763, 884	814	763, 865	815	760, 871	762	684, 839	756	671, 841	638	539, 737	816	704, 929	748	697, 798	0·05
Zn (mg/d)	6·8	6·4, 7·2	6·4	6·0, 6·7	6·1	5·8, 6·4	6·0	5·5, 6·4	5·6	5·1, 6·0	5·0	4·2, 5·8	6·0	5·2, 6·7	5·4	5·1, 5·7	< 0·0001
Folate (μg/d)	182	168, 196	180	165, 195	162	152, 172	161	145, 176	153	137, 169	130	108, 151	190	153, 227	157	144, 171	0·08
Vitamin E, α-tocopherol (mg/d)	5·4	5·0, 5·9	5·1	4·8, 5·5	4·9	4·5, 5·2	4·7	4·2, 5·3	4·0	3·5, 4·6	3·9	3·3, 4·6	3·8	3·3, 4·4	4·0	3·7, 4·4	< 0·0001
Vitamin A (RAE/d)	595	539, 650	556	526, 585	562	531, 593	526	490, 562	538	487, 589	486	432, 541	553	489, 616	545	516, 575	0·02
Vitamin C (mg/d)	96	87·3, 105·1	91·4	83·1, 99·7	82·9	74·2, 91·5	91	75·3, 106·2	69	59·0, 78·0	65	52·0, 77·4	71	56·2, 85·5	63	57·7, 68·7	<0·0001
Vitamin B_{12} (μg/d)	3·4	3·0, 3·8	3·0	2·8, 3·3	3·0	2·8, 3·2	2·9	2·5, 3·2	2·9	2·6, 3·3	2·4	1·8, 2·9	2·9	2·4, 3·4	2·6	2·4, 2·8	0·002

RAE, retinol activity equivalents.
*Data are presented as survey-weighted means and 95 % confidence limits (CL).
†Total *n* 3483; 186 participants reported income as 'other'.

foods, a common occurrence in parents of overweight and obese children.

The present study of NHANES data is unique because it compares feeding practices and nutrient intakes of infants and toddlers by race/ethnicity and income. It is not surprising that we found differences in feeding practices according to race/ethnicity given well-known cultural differences in eating patterns and health disparities[49,50]. However, the present study had several limitations in addition to those already mentioned. The racial groups 'other Hispanic' and 'other race/ethnicity' were too small to allow for comparisons. In addition, racial/ethnic categories are largely cultural rather than biological designations, and not all individuals who identify with a particular culture may have the feeding practices or food intake considered common to that culture. As stated before, differences in intakes and feeding practices according to race/ethnicity and income are correlated and impossible to fully disentangle. Finally, the questions asked in the NHANES questionnaire are broad and do not allow for insight into the reasoning behind parental feeding decisions.

Conclusion

The present study showed consistent disparities in feeding practices among lower income parents and parents of Mexican-American infants and toddlers compared with higher income and white, non-Hispanic parents. In addition, nutrient intake disparities were also identified. These disparities provide support for the Special Supplemental Nutrition Program for Women, Infants, and Children, which provides nutrition education in addition to supplemental foods because although low-income children and children of certain races/ethnicities often had higher nutrient intakes, they also had less optimal feeding practices. In addition, the study supports the notion that low-income parents and parents of colour should be the focus of interventions to improve early feeding practices and actual food intake to potentially mediate early obesity.

To reduce early obesity, future research should evaluate patterns of food intake, not only nutrients, to gain better insight into how to best educate parents to improve the diet of young children. Longitudinal research to follow offspring of parents who get more intensive or targeted anticipatory guidance regarding infant feeding would also be desirable to determine if intensive efforts result in improved outcomes in adolescent and adult obesity. In addition, more qualitative research is needed with parents, especially lower-income parents and parents of colour, to determine what factors most affect feeding decisions and how best to intervene with parents to improve feeding practices and reduce infant overweight.

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Supplementary material

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