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Original Research

Infant diet quality index predicts nutrients of concern and ultra-processed food intake in low-income children in the United States

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ABSTRACT

Background: Diet quality during infancy can influence nutrient intake and ultra-processed foods (UPFs) consumption throughout later childhood.

Objectives: This study investigated the predictive validity of Infant Diet Quality Index (IDQI) scores from 0 to 1 y of age and consumption of select nutrients and UPFs at different time points in low-income children aged 2–5 y.

Methods: Dietary surveys and 24-h dietary recalls collected between ages 0 and 12 months from 2613 Special Supplemental Women, Infants, and Children Infant Toddler Feeding Practices Study-2 participants were used to assess infant diet quality by final IDQI score ranging from 0 (nonadherence to dietary guidelines) to 1 (complete adherence to guidelines). Single 24-h recalls collected across multiple time points per child aged between 2 and 5 y were used to determine nutrient intakes: vitamin B12 (μg), vitamin D (μg), calcium (mg), iron (mg), zinc (mg), potassium (mg), saturated fat (g), dietary fiber (g), and added sugars (g). Likewise, Nova was used to classify foods (to estimate the percentage of energy from foods) by level of industrial processing at each point in time across ages 2–5 y. Survey-weighted regression analyses estimated associations between total IDQI score and nutrient intake and percentage of energy consumption from each Nova food group at each age between 2–5 y.

Results: IDQI scores based on diet quality from 0–1 y of age were positively associated with children's dietary fiber and potassium intake at ages 2–5 y. Additionally, IDQI was negatively associated with added sugar intake. No associations were observed between IDQI and saturated fat consumption. IDQI scores at age 1 were positively associated with the percentage of energy attributed to unprocessed/minimally processed foods (20%–23%) and negatively associated with UPF consumption at ages 2–5 y (−24% to −29%).

Conclusions: IDQI predicts intake of select nutrients and UPF consumption among low-income US children aged 2–5 y.

This trial was registered at https://clinicaltrials.gov/study/NCT02031978 as "Feeding My Baby – A National WIC Study," NCT02031978.

Keywords: Infant diet, Complementary feeding, Ultra-processed foods, toddlers, children

Introduction

Maintaining a healthful diet during childhood is vital for optimal development [1] as this period has rapid growth and high nutrient requirements [2]. In the United States, preschool-aged children have poor diets [3], which typically worsen into adulthood, increasing their risk of nutrition-related diseases [2]. The 2020–2025 Dietary Guidelines for Americans (DGAs) are the first edition to include dietary recommendations for infants and toddlers [2]. Key recommendations include incorporating nutrient-dense foods, especially those rich in iron and zinc, while avoiding foods high in sodium, saturated fat, and

Abbreviations: UPF, ultra-processed foods; IDQI, Infant Diet Quality Index; WIC, Special Supplemental Women, Infants, and Children; ITFPS-2, Infant Toddler Feeding Practices Study-2; DGA, Dietary Guidelines for Americans; HEI-2015, Healthy Eating Index-2015; BMI-z, Body Mass Index *Z*-score; USDA, United States Department of Agriculture; NH, non-Hispanic.

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added sugars [3,4]. Calcium, vitamin D, dietary fiber, and potassium are identified in the DGAs as nutrients of public health concern [3], and iron and zinc are also often underconsumed by children [5]. Despite these guidelines, currently, children aged 2–5 y are not meeting recommendations for total vegetable, dark green vegetable, red/orange vegetable, seafood, or dairy intake, all of which are important sources of nutrients of concern [3]. In addition, young children are exceeding recommendations for added sugars, saturated fat, and sodium [3]. These trends may reflect the last 2 decades in which young children have increased consumption of ultra-processed foods (UPFs) [6], which are typically energy-dense, rich in salt, added sugars, and fat but low in many other nutrients [7].

UPFs are formulated products made mostly or entirely from foods and additives with little if any, whole natural foods [7]. A high intake of UPFs is associated with a lower intake of healthful foods, which may lead to poorer diet quality [8–10]. Furthermore, diet quality declines with age [3], whereas the consumption of UPFs increases as children grow older [6]. In the United States, UPFs account for more than half of energy consumption in children aged 2–5 [4,6,10]. In 2018, Wang et al. [6] reported industrial grain foods (i.e., breakfast cereals), sweet snacks, and preprepared mixed dishes as foods contributing the highest percentage of energy intake from consumed UPFs in US children's diets. Limiting the consumption of UPFs and implementing recommended feeding practices during infancy can establish a strong foundation to help improve diet quality in later childhood years [4,11].

Exclusive breastfeeding is recommended for the first 6 mo followed by continued breastfeeding and appropriate complementary foods for at least 1 to 2 y of age [12,13]. Both longer breastfeeding duration and appropriate complementary feeding have been associated with better diet quality in later years and the establishment of healthy eating habits [14–16]. Also, during this time, infants can develop preferences for sweet and salty tastes [17] and should avoid added sugars and sodium [3]. Therefore, it is critical to understand and assess how aspects of the infant diet (i.e., breastfeeding, the timing of solid introduction, and adding cereal to bottles) collectively contribute to later dietary habits.

Previously, studies observing associations between early eating habits and later childhood diet quality were limited in the ability to characterize infant diet [5] or were not generalizable to children in the United States [18]. The Infant Diet Quality Index (IDQI) [19] provides a summary score of feeding practices during the first 12 mo of life. This 16-component index has been adapted specifically for US children to assess the whole diet, diversity, and feeding practices based on alignment with dietary recommendations [3]. In previous studies, IDQI scores from 0–1 y of age was predictive of both Healthy Eating Index-2015 (HEI-2015) scores and BMI-*z* scores in US children aged 2–5 y [20]. Additionally, IDQI partially explains racial and ethnic differences in HEI-2020 scores among low-income children [21]. To our knowledge, there are no studies, however, that have observed the relationship between infant diet quality and its association with nutrient intake and UPFs in young children. Therefore, the objective of this study was to investigate if IDQI score from 0 to 1 y of age is predictive of nutrients of concern and UPF consumption at later ages—2 to 5y—in a longitudinal cohort of low-income children. The hypothesis is that higher infant diet quality will be positively associated with intakes of select nutrients and unprocessed/minimally processed foods at ages 2–5 y. In addition, higher diet quality will be negatively associated with consumption of added sugars, sodium, and UPFs at ages 2–5 y.

Methods

Participants

The WIC Infant and Toddler Feeding Practices Study-2 (ITFPS-2) is one of few national studies to longitudinally capture data on caregivers and their children from low-income families eligible for WIC. WIC ITFPS-2 participants were recruited across 27 states and US territories and enrolled into 1 of 2 samples: the core sample ($n = 3503$) and the supplemental sample ($n = 864$), which oversampled populations of interest, such as African Americans. Together, these 2 samples compose the total longitudinal cohort. All participants received interviews conducted in English or Spanish prenatally and postnatally throughout the first 5 y of the child's life (1, 3, 5, 7, 9, 11, 13, 15, 18, 24, 30, 36, 42, 48, 54, and 60 mo). Interviews collected sociodemographic information, breastfeeding initiation, introduction of complementary foods, and other feeding practices via an interviewer-administered survey.

Participants were included in the parent study if they were enrolling in WIC for the first time either for that pregnancy or infant, and were able to complete interviews in English or Spanish. Exclusion criteria at recruitment consisted of the child being >2.5 mo, being a teenage mother <16 y of age, being a mother in foster care at the time, and being a foster parent enrolling a foster infant. Although the WIC ITFPS-2 will follow children until age 9, this study utilized the data available at the time of this analysis, which included both core and supplemental samples from birth through 5 y of age. The ITFPS-2 was approved by the Westat Institutional Review Board and the US Office of Management and Budget, and the study is registered at www.clinicaltrials.gov as NCT02031978.

Dietary intake

Each postnatal interview (except at 30, 42, and 54 mo) included a 24-h dietary recall administered over the phone using the USDA Automated Multiple-Pass method [22]. Prior to interviews, participants received a package by mail with measuring guides to assist in reporting the study child's portion sizes. Caregivers then reported all foods, beverages (including infant formula and breastfeeding), and dietary supplements for each child's eating event during the 24-h period, which could include the weekend or weekday. In addition, caregivers provided information on foods the child ate at childcare in a separate survey.

IDQI measured at ages 0 to 1 y

The IDQI is a summary score assessed during the first year of life and consists of the following 16 components which come from information in 24-h dietary recalls and dietary surveys [20,21]: *1*) breastfeeding duration; *2*) exclusive breastfeeding; age of first introduction of: *3*) solids, *4*) iron-rich cereals, *5*) cow milk, *6*) sugar-sweetened beverages, *7*) salty or sweet snacks, *8*) other drinks or liquids (e.g., teas or broths), and *9*) textured foods;

frequency of consuming *10*) fruit or *11*) vegetables; frequency of consuming different *12*) fruit or *13*) vegetables; *14*) non-recommended bottle-feeding practices; *15*) use of commercial baby foods; and *16*) number of meals and snacks. Each component is scored and equally aggregated into a total IDQI score with a potential range of 0 (representing nonadherence to dietary guidelines) to 1 (full adherence to guidelines). Total IDQI score was used as the predictor in all analyses [20].

Dietary outcomes measured at 2–5 y of age

Nutrient intake

Nutrient values were calculated using the USDA Food and Nutrient Database for Dietary Studies, 5.0 (2009–2010) [23], and included the nutrients of public health concern[3]: vitamin D, calcium, potassium, and dietary fiber. Additional nutrients investigated were vitamin B12, iron, zinc, saturated fat, and added sugars. All nutrient intakes were calculated separately at ages 2–5 y using USDA Food and Nutrient Database for Dietary Studies, 5.0 from 24-h dietary recalls reported by caregivers.

Nova Food Classification

Nova is a classification system that considers the physical, biological, and chemical methods used during manufacturing to categorize food and food products by their industrial processing [24]. Using this system, recorded food items obtained from 24-hour dietary recalls were classified into the following 4 Nova groups: *1*) unprocessed/minimally processed (e.g., fresh fruits, vegetables, legumes, and meat); *2*) processed culinary ingredients (oils, animal fat, table sugar, and salt); *3*) processed foods (foods manufactured with the addition of salt or sugar); and *4*) ultra-processed foods (formulations of several ingredients besides salt, sugar, oils, and fats often containing cosmetic additives) [24]. For homemade recipes or mixed dishes, Nova classification was applied to the underlying ingredients (standard reference codes) from the USDA National Nutrient Database for Standard Reference [10,25]. The energy contribution of each of the Nova food groups to daily total energy was calculated for each participant at each age from 2 to 5 y. Two raters independently classified each food item according to Nova, and discordant classifications were solved by discussion [25].

Covariates

Covariates included in regression models were selected based on previously reported associations with infant diet quality and later child diet quality [20,21], which represent potential confounding factors. Maternal sociodemographic variables included race and ethnicity, language preference, age at child's birth, marital status, education level, employment status at the 7-mo visit, BMI, depression score at the 3-mo visit, gestational diabetes status, household size at the 7-mo visit, household income, and household size. Sociodemographic variables specific to the child included sex, age, birth weight, and race and ethnicity. For this analysis, participants were described as Spanish-speaking Hispanic, English-speaking Hispanic, NH Black, NH White, or other, similar to another study using the same population[21].

Statistical analysis

Statistical analyses were performed using Stata version 16 and R version 4.1.1. Analyses were weighted using the provided age-specific survey weights to address nonresponsiveness and to reflect the national study-eligible WIC population. Further estimation incorporated the balanced replicated weights as recommended by the WIC ITFPS-2 study data use guidelines. The WIC ITFPS-2 study enrolled a total of 4367 study participants (core and supplemental), but this analysis excluded 1754 due to the following: premature and very low birth weight (149), long-term medical problems that could affect eating (335), and no dietary intake data at any time point (2–5-y-old) (1270) (Supplemental Figure 1). In this study, all analyses incorporated conditional multiple imputations for participants with partial data [26] (outcomes, IDQI, and/or adjustment variables) using conservative count of 10 imputations.

Survey-weighted linear regression was used to estimate associations between total IDQI score (possible score range 0–1) at age 0–1 and daily intake of nutrients: vitamin B12 (μg), vitamin D (μg), calcium (mg), iron (mg), zinc (mg), potassium (mg), saturated fat (g), dietary fiber (g), and added sugars (g) and also percentage of daily energy consumption from each Nova food group at multiple time points across the 2–5 y age range adjusting for total energy intake as well as the sociodemographic covariates listed above. Nutrient intakes and contribution to total energy intake (% energy) for each Nova category are presented by quintiles of IDQI scores along with the P value for linear trend. Statistical significance was set at a 2-tailed P value <0.05 for all analyses. In addition, to assist in the interpretation of the direction of associations, we estimated the marginal means of the nutrient outcomes for each quintile of IDQI to quantify the magnitude of change in intake as IDQI increases.

Results

Most mothers identified as Hispanic (48%), preferred English (78%), and were ≥26 y at childbirth (48%) (Table 1). At the time of recruitment, more than a third of mothers had obtained a high school diploma (38%) or more education (39%), nearly half had a normal or underweight BMI (46%), and most were at or <75% of the poverty guideline (62%). Most children in the weighted sample had a normal birthweight (95%) and were male (52%). The median IDQI score for children was 0.36 (range, 0.08–0.79).

A 1-point increase in IDQI score was positively associated with dietary fiber (β = 7.2 g; 95% CI: 5.0, 9.4; $P < 0.01$) and potassium (β = 452.1 mg; 95% CI: 214.8, 689.4; $P < 0.01$) at age 2 y. At age 3 y, IDQI score was positively associated with dietary fiber (β = 7.1 g; 95% CI: 4.3, 9.9; $P < 0.01$), potassium (β = 603.3 mg; 95% CI: 365.8, 840.8; $P < 0.01$), and calcium (β = 389.8 mg; 95% CI: 139.9, 639.6; $P < 0.01$) and (Table 2). At age 4 y, IDQI score was positively associated with dietary fiber (β = 4.8 g; 95% CI: 2.1, 7.6; $P < 0.01$), vitamin B12 (β = 2.3 μg; 95% CI: 0.7, 3.9; $P < 0.01$), vitamin D (β = 3.2 μg; 95% CI: 0.7, 5.6; $P = 0.01$), calcium (β = 342.4 mg; 95% CI: 141.6, 543.3; $P < 0.01$), iron (β = 5.6 mg; 95% CI: -0.2, 11.5; $P < 0.10$), zinc (β = 3.8 mg; 95% CI: 0.9, 6.6; $P = 0.01$), and potassium (β = 586.8 mg; 95% CI: 302.8, 870.8; $P < 0.01$). At age 5, IDQI was positively associated with dietary fiber (β = 5.8 g; 95% CI: 2.6, 8.9; $P < 0.01$), calcium (β = 345.0 mg; 95% CI: 109.6, 580.4; $P <0.01$), sodium (β = 421.3 mg; 95% CI: 81.8, 760.8; $P = 0.02$), and potassium (β = 604.9 mg; 95% CI: 288.2, 921.6; $P < 0.01$). At all ages, IDQI was negatively associated with added sugars: 2 y (β = −3.2 g; 95% CI: −6.0, −0.3; $P = 0.03$), 3 y (β = −5.7 g; 95% CI: −9.3, −2.2; $P < 0.01$), 4 y (β = −6.6 g; 95% CI: −9.6, −3.6; $P < 0.01$), and 5 y (β

TABLE 1
Characteristics for participants in the Special Supplemental Nutrition Program for Women, Infants and Children Infant Toddler Feeding Practices Study-2.

Characteristic[1]	Unweighted $N = 2613$	Weighted $N = 384,698$
Maternal age at childbirth (*n*, %)[2]		
16–19 y	297 (11.4)	45,656 (11.9)
20–25 y	1066 (40.8)	154,861 (40.3)
≥26 y	1250 (47.8)	184,181 (47.9)
Maternal race (*n*, %)		
Hispanic	1037 (39.7)	186,284 (48.4)
Non-Hispanic White	761 (29.1)	101,026 (26.3)
Non-Hispanic Black	673 (25.8)	75,093 (19.5)
Non-Hispanic Other	142 (5.4)	22,295 (5.8)
Language preference (*n*, %)		
Spanish	480 (18.4)	85,435 (22.2)
English	2130 (81.6)	299,263 (77.8)
Marital status (*n*, %)		
Married	797 (30.5)	131,617 (34.2)
Not married[4]	1816 (69.5)	253,081 (65.8)
Maternal education level (*n*, %)		
None through grade 11	621 (23.8)	95,690 (24.9)
High school	982 (37.7)	143,031 (37.2)
More than High school	1002 (38.5)	145,563 (37.9)
Maternal employment status at 6 mo child age (*n*, %)[3]		
Full-time	501 (21.4)	69,022 (19.8)
Part-time	476 (20.3)	67,123 (19.3)
Not working for pay	1359 (58.1)	211,500 (60.8)
Maternal BMI at recruitment (*n*, %)		
Normal or underweight	1164 (44.5)	177,602 (46.2)
Overweight	710 (27.2)	94,956 (24.7)
Obese	739 (28.3)	112,140 (29.2)
Household size at 6 mo child age (*n*, %)[3]		
2 people	213 (9.0)	29,575 (8.5)
3 people	639 (27.1)	93,535 (26.8)
4 people	644 (27.3)	98,662 (28.3)
≥5 people	856 (36.3)	125,102 (35.9)
Household poverty level at enrollment (*n*, %)[3,5]		
≤75% of poverty guideline	1660 (63.5)	238,567 (62.0)
>75% but <130%	698 (26.7)	103,829 (27.0)
>130% of poverty guideline	255 (9.8)	42,302 (11.0)
Child sex, female (*n*, %)	1264 (48.4)	181,941 (47.2)
Child weight at birth (g)		
Low (<2.5 kg)	94 (3.6)	15,378 (4.0)
Normal (2.5 kg to ≤4.5 kg)	2482 (95.0)	364,343 (94.8)
High (>4.5 kg)	37 (1.4)	4677 (1.2)

Characteristics were collected at recruitment unless noted otherwise (e.g., maternal age at birth).
[1] Values are means ± SDs or frequency (percentage)
[2] Maternal includes other primary caregiver if not mother (<1% of respondents are caregivers other than the baby's biological mother at the time of enrollment).
[3] Because of missing values, the total n is not the same for all variables.
[4] Not married includes divorced, widowed, or separated.
[5] Income at 100 percent of the Federal Poverty Level was $23,550 for family of 4 in 2013.

= −8.9 g; 95% CI: −12.4, −5.4; P <0.01). Nutrient intake values trended across IDQI quintiles (scores ranging from 0.08–0.79) at all ages, with higher IDQI scores associated with higher dietary fiber and potassium intake (Supplemental Table 1).

Across quintiles at all ages, higher IDQI scores were associated with consuming a higher percentage of energy from unprocessed/minimally processed foods and a lower percentage of energy attributed to UPFs (Supplemental Table 1). A 1-point increase in IDQI score was positively associated with the percentage of energy attributed to unprocessed/minimally processed foods at all ages: 2 y (β = 20%; 95% CI: 11, 28; $P < 0.01$), 3 y (β = 16%; 95% CI: 5, 27; $P < 0.01$), 4 y (β = 16%; 95% CI: 7, 25; $P < 0.01$), and 5 y (β = 23%; 95% CI: 13, 33; $P < 0.01$). IDQI scores were positively associated with processed foods at age 5 y (β = 5%; 95% CI: 1, 9; $P < 0.01$). In addition, IDQI scores were negatively associated with the percentage of energy attributed to UPFs (expressed as proportions) at all ages: 2 y (β = −24%; 95% CI: −32, −15; $P < 0.01$), 3 y (β = −20%; 95% CI: −31, −10; $P < 0.01$), 4 y (β = −20%, 95% CI: −30, −10; $P < 0.01$), and 5 y (β = −29%; 95% CI: −40, −18; $P < 0.01$).

Discussion

In this longitudinal, national sample, US infants with higher diet quality had higher intake of several nutrients of public health concern according to the DGAs [3] and a lower intake of UPFs in later childhood years. Nearly half of energy intake was attributed to UPFs in this sample of young children across all levels of IDQI scores. This is consistent as recent literature shows over the past 2 decades, US children are consuming more UPFs such as industrial grains (e.g., pancakes or waffles), sweet bakery products, and ready-to-heat mixed dishes (e.g., pizza or sandwiches) [6]. Given that children with better infant diet quality consumed less UPFs later in childhood, improving infant diet quality may help counteract the trend of increasing UPF consumption by children.

Although early nutrition can impact diet quality in later years [4,11,27], most studies have only investigated associations with HEI scores [20] or the consumption of certain food groups as outcomes [28]. This study differs by distinguishing diet associations by intake of nutrients across multiple ages. Similar to this study, Golley et al. [18] analyzed the predictive validity of a complementary feeding utility index tailored to a United Kingdom population and found infant diet scores positively associated with select nutrients. This study differs from Golley et al. [18] in that additional associations were observed among nutrients of public health concern, such as dietary fiber and potassium. Additionally, this study examined the relationship between infant diet quality and UPF intake in early childhood, which, to our knowledge, has not been explored in a sample of low-income children.

Findings from this study also suggest that IDQI is associated with additional nutrients recommended for this age group. For example, at age 4, higher IDQI scores (representing a change from no adherence to complete adherence) were associated with higher vitamin D and iron, which are important for bone growth and prevention of iron deficiency anemia in this age group [4]. Furthermore, IDQI was negatively associated with added sugars, which is a major concern for children as it is associated with an increased risk of cardiovascular disease [29], weight gain [30], and prediabetes [31]. Further, these findings are consistent with higher IDQI being associated with lower BMI-*z* scores in young children [20].

Not all of the associations with IDQI and subsequent dietary intakes were in the direction that was expected. For example, at age 5 a positive association between IDQI score and sodium intake was observed. This could be related to an increased consumption of processed foods, which was also positively

TABLE 2
Associations between US-adjusted Infant Diet Quality Index scores at age 0–1 and intake outcomes at age 2–5 y for children in the Special Supplemental Nutrition Program for Women, Infants, and Children Infant Toddler Feeding Practices Study-2 (n = 2613).

	Age at dietary recall							
	2 y		3 y		4 y		5 y	
	β (95%CI)	*P* value	β (95%CI)	*P* value	β (95%CI)	*P* value	β (95%CI)	*P* value
Nutrient intake outcomes								
Dietary Fiber (g)	7.16 (4.98, 9.35)	<0.01	7.12 (4.33, 9.91)	<0.01	4.84 (2.07, 7.61)	<0.01	5.78 (2.64, 8.93)	<0.01
Vitamin D (μg)	0.86 (−2.14, 3.86)	0.58	1.97 (−0.79, 4.74)	0.16	3.17 (0.70, 5.64)	0.01	−0.48 (−7.13,6.17)	0.89
Potassium (mg)	452.09 (214.82, 689.36)	<0.01	603.30 (365.84, 840.76)	<0.01	586.80 (302.82, 870.77)	<0.01	604.89 (288.18, 921.60)	<0.01
Calcium (mg)	156.89 (−3.27, 317.05)	0.06	389.78 (139.92, 639.63)	<0.01	342.44 (141.60, 543.28)	<0.01	345.02 (109.61, 580.43)	<0.01
Vitamin B12 (μg)	0.37 (−1.15, 1.90)	0.63	0.69 (−0.88, 2.27)	0.39	2.29 (0.70, 3.89)	<0.01	3.43 (−5.59, 12.45)	0.46
Iron (mg)	(2.45 (−1.99, 6.89)	0.28	0.99 (−3.45,5.42)	0.66	5.64 (−0.22, 11.51)	0.06	1.73 (−3.58, 7.04)	0.52
Zinc (mg)	0.93 (−1.25, 3.11)	0.40	1.97 (−0.98, 4.92)	0.19	3.76 (0.90, 6.62)	0.01	2.22 (−0.80, 5.23)	0.15
Sodium (mg)	−39.38 (−291.01, 212.25)	0.76	181.39 (−53.32, 416.11)	0.13	−11.12 (−348.55, 326.32)	0.95	421.30 (81.76, 760.83)	0.02
Saturated Fat (g)	−1.24 (−4.24, 1.77)	0.42	−2.23 (−5.60,1.15)	0.20	−0.17 (−3.84, 3.49)	0.92	0.23 (−4.05, 4.51)	0.92
Added Sugars (g)	−3.18 (−6.04, −0.31)	0.03	−5.74 (−9.28, −2.20)	<0.01	−6.56 (−9.55, −3.57)	<0.01	−8.93 (−12.44, −5.41)	<0.01
Nova[2] category intake outcomes (% of energy)								
Unprocessed/Minimally Processed	20% (11, 28)	<0.01	16% (5, 27)	<0.01	16% (7, 25)	<0.01	23% (13,33)	<0.01
Processed culinary ingredients	1% (−1, 2)	0.29	1% (−0, 2)	0.25	1% (−0, 2)	0.22	0% (−1, 2)	0.67
Processed foods	3% (−0, 7)	0.06	4% (−0, 8)	0.07	3% (−2, 8)	0.19	5% (1, 9)	<0.01
Ultra-processed foods	−24% (−32, −15)	<0.01	−20% (−31, −10)	<0.01	−20% (−30, −10)	<0.01	−29% (−40, −18)	<0.01

[1] Adjusted for child age, energy intake, child sex, childbirth weight, child race/ethnicity, maternal age, maternal race/ethnicity, marital status, maternal education level, maternal depression score, maternal weight, maternal employment status, household size, household income, and gestational diabetes.

[2] Nova is a food classification system that uses processes and ingredients to classify foods as (1) unprocessed/minimally processed, (2) processed culinary ingredients, (3) processed foods, and (4) ultra-processed foods.

associated with IDQI at age 5. These findings may be reflective of children in the United States who may be consuming more meals outside of the home at this age and, therefore, have greater exposure to processed foods [6], which are often higher in sodium and added sugar [7]. Additionally, many US toddlers attend some form of early childcare program, which may influence their consumption patterns based on the practices and policies in place [32–34]. Future research should investigate how infant diet quality is associated with differences in later childhood diet quality as influenced by environments outside the family home (i.e., early childcare, family childcare programs, and Head Start).

Similar to this study, Golley et al. [18] found that a higher complementary feeding utility index score was associated with a lower processed dietary pattern score (characterized by a lower intake of high-fat and/or high-sugar foods such as chips and soda) at 3 y of age. The present study differs by using Nova classification to determine the degree of exposure to a UPF diet and investigate its association with previous infant diet quality. In addition, previous literature shows that such products, including sweet baked goods, soft drinks, and candy, are contributing high amounts of solid fats and added sugars to the diet of young US children [35]. Results from this study suggest that improving infant diet may potentially reduce added sugar, saturated fat, and sodium intake in young children, a key recommendation of the DGAs [3].

This study used the ITFPS-2, which sampled caregivers and children in a low-income population. The study did not include infants who were born prematurely or had a very low birth weight. Therefore, the findings may not be generalizable to all US low-income populations. Dietary intakes were assessed by a single 24-h dietary recall at each time point completed by parents, who may not have provided accurate estimates of usual intakes [36,37]. However, diet recalls did occur repeatedly at multiple time points allowing the opportunity to longitudinally assess diet quality. In addition, because Nova's classification of UPFs is based on industrial food processing rather than nutrient profiles [6], some nutritious foods that study participants may have received in the WIC food package, such as whole grain packaged bread, would be classified as a UPF, thus increasing UPF consumption. However, the greatest increase in UPF consumption in recent years is among unhealthier foods like pre-prepared mixed dishes [6] and salty snacks [38], which are advised to be consumed in moderation [3]. Further, although this study collected some information indicative of food processing (i.e., product brands), these data were not consistently determined for all food items, which could lead to modest overestimation or underestimation of UPF intake. Lastly, social desirability bias could have led to the overestimation of IDQI and inaccuracy of reported nutrient intakes but will less likely affect the association between IDQI and nutrient or Nova intakes.

In conclusion, this study found that IDQI score is predictive of select nutrient and UPF consumption among low-income US children ages 2–5 y. Such tools can highlight infant feeding practices that can be improved, and those that can be the focus of future research and interventions. Evaluating infant diet quality is critical because introducing healthful eating habits during the complementary feeding period can establish a strong foundation to help mitigate a poor dietary decline in later childhood years.

Author contributions

The authors' responsibilities were as follows – AMC: assisted in the investigation, drafted the manuscript, and revised the manuscript; LEA: conceptualized, designed the study, supervised the investigation, critically reviewed, and revised the manuscript; EAF: conceptualized, designed the study, critically reviewed, and revised the manuscript; CDA: conceptualized, designed the study, carried out the analyses, critically reviewed, and revised the manuscript; LDR: conceptualized, designed the study, critically reviewed, and revised the manuscript; EMS: critically reviewed and revised the manuscript; and all authors: read and approved the final manuscript as submitted and agreed to be accountable for all aspects of work.

Conflict of interest

The authors report no conflicts of interest.

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Data share statement

Data described in the manuscript, code book, and analytic code will be made publicly and freely available without restriction at https://agdatacommons.nal.usda.gov/articles/dataset/WIC_Infant_and_Toddler_Feeding_Practices_Study-2_WIC_ITFPS-2_Prenatal_Infant_Year_5_Year_Datasets/24668343.

De-identified individual participant data from the WIC ITFPS-2 study is publicly available through USDA Ag Data Commons.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cdnut.2024.104483.

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