The Journal of Nutrition
Community and International Nutrition

# A Summary Index of Feeding Practices Is Positively Associated with Height-for-Age, but Only Marginally with Linear Growth, in Rural Senegalese Infants and Toddlers[1–3]

Kirsten Bork,[4*] Cécile Cames,[4] Sabah Barigou,[4] Amandine Cournil,[4] and Aldiouma Diallo[5]

[4]Institut de Recherche pour le Développement (IRD), UMI 233, IRD/UM1, Montpellier, France, and [5]IRD, UMR198, Centre International de Recherche Université Cheikh Anta Diop–IRD, Dakar, Senegal

## Abstract

Several studies have shown an association between an infant and young child feeding index (ICFI) and height-for-age Z-score (HAZ) in Latin America and Africa. A previous study was unable to reproduce these findings in 500 rural Senegalese 12–42-mo-old children. The relationship of ICFI, dietary diversity index (DDI), food variety index (FVI), meal frequency index (MFI), and breastfeeding (BF) to HAZ and growth in height/length over 6 mo was studied in 1060 6–36-mo-old Senegalese children during 2 visits. List-based food frequencies were recalled for the past 24 h, and height/length and weight measurements were taken. Indicators were transformed into tertiles in age-specific subgroups. DDI, FVI, MFI, and ICFI were poorly concordant across visits at all ages (weighted $\kappa$: 0.02–0.25). In cross-sectional analyses that pooled children from the 2 visits, HAZ was positively associated with DDI and FVI at 6–12, 12–18, and 18–24 mo and with ICFI at 6–12 and 18–24 mo ($P < 0.001$ and $P < 0.05$, respectively) but was negatively associated with BF at 12–18, 18–24, and 24–30 mo. The length increment between visits was positively associated with MFI and ICFI, measured during the first visit in 18–24-mo-olds ($P < 0.001$ and $P < 0.05$, respectively) but not with DDI, FVI, or BF at any age. In conclusion, ICFI, DDI, and FVI were associated with HAZ, particularly during infancy, whereas no indicator was associated with linear growth in this age group. Therefore, the strong association between HAZ and ICFI during infancy may be partly due to maternal adaptation to infant clues, i.e., greater appetite for and interest in non-breast-milk foods among taller infants. J. Nutr. 142: 1116–1122, 2012.



## Introduction

Food intake and feeding patterns are crucial to the nutritional status of infants and young children (1), but reference methods for assessment of energy and nutrient intake are expensive and cumbersome. Ruel and Menon (2) constructed an infant and young child feeding index (ICFI)[6] from 5 indicators collected in demographic and health surveys—i.e., dietary diversity and meal frequency from 24-h recall, breastfeeding (BF), bottle-feeding (scored negatively), and frequency of consumption of food groups over the past 7 d (2). They showed a significant positive association between the ICFI and child height-for-age Z-score (HAZ) in 4 out of 5 Latin American countries.

Sub-Saharan Africa is affected by a high prevalence of preschool stunting (3). In previous work, we found no association between a slightly modified ICFI and HAZ in a sample of 500 rural Senegalese children aged 12–42 mo (4), whereas other authors found a positive association between HAZ and a 24-h recall–based ICFI in 6–12- and 12–24-mo-old children in Northern Burkina Faso (5).

Because HAZ is mainly a function of previous height, the impact of any factor on linear growth would have to be sustained over a longer period of time to make a difference in HAZ. Thus, we hypothesized that 2 prerequisites are necessary for good infant and young child feeding practices to have a positive effect on HAZ: *1*) the quality of feeding tracks over time, i.e., feeding indicators at a given time are predictive of values at later time points, and *2*) the "effect size" (i.e., difference in HAZ between groups of feeding indicators) increases with child age due to cumulative positive effects of good practices.

To test these hypotheses, we conducted a prospective study within the same population as in our previous study. More than 1000 children aged 6–36 mo were investigated during 2 visits (i.e., May–June, the pre-rain season, and November–December, the harvest season). The objectives were as follows: *1*) to assess

[1] Supported by the Institut de Recherche pour le Développement and the Conseil Régional d'Aquitaine (to S.B.).
[2] Author disclosures: K. Bork, C. Cames, S. Barigou, A. Cournil, and A. Diallo, no conflicts of interest.
[3] Supplemental Tables 1-3 are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.
[6] Abbreviations used: BF, breastfeeding; DDI, dietary diversity index; FVI, food variety index; HAZ, height-for-age Z-score; ICFI, infant and young child feeding index; MFI, meal frequency index; WHZ, weight-for-height Z-score.
* To whom correspondence should be addressed. E-mail: kirsten.bork@ird.fr.



Manuscript received January 19, 2012. Initial review completed March 7, 2012. Revision accepted March 28, 2012.
First published online April 25, 2012; doi:10.3945/jn.112.157602.

the concordance of dietary diversity, food variety, meal frequency, and the overall ICFI score for each individual across 2 contrasting seasons; *2*) to test for a cross-sectional association between feeding indicators and HAZ in a large sample by pooling data from the 2 visits and *3*) to test for an association of indicators derived from either the mean of the 2 visits or the first visit alone, with HAZ at the latter visit and height/length velocity between the 2 visits. All analyses were conducted in age-specific subgroups.

## Participants and Methods

Design. This was a prospective open-cohort study in a random cluster sample of 6–36-mo-old children during 2 visits conducted 6 mo apart. Foods and food groups consumed during the preceding day and the number of meals and snacks were investigated through interviews with the primary caregivers, and anthropometric measurements were taken for children and for their mothers.

Study population. The study area was in the Sine region in Senegal. The population is predominantly of the Sereer ethnic group (>97%) and is subject to demographic surveillance. The population size increased from 26,500 to 40,000 between 1990 and 2009. Crops are harvested after the short rainy season (July–September), i.e., from October (groundnuts) to November (millet).

Children. A sample of 615 extended families (compounds), which included 1126 children aged 6–36 mo in May 2009 (for a target sample size of 1000), was randomly selected from the database. The probability of selection of compounds was adjusted for the number of preschool children. Personal identification number, name, address, and birth date were extracted prior to the first visit. Infants younger than the age of 6 mo could not be identified from the database (due to a delay in updating).

Approximately 6 mo later, a second visit was conducted. All children 6–36 mo of age residing in the selected compounds were eligible, including those who had been absent and those for whom consent has not been obtained.

In the first visit, 1061 out of 1126 eligible children were included (52 absences, 13 refusals), compared with 1058 out of 1130 during the second visit (38 absences, 13 refusals, 4 deaths, 17 who had moved out of the area). Altogether, 1329 children born to 1189 different mothers were included. A total of 879 children aged 6–30 mo at the first visit were included in the 2 visits (i.e., 90% of those eligible for both visits.

Ethics. The study was reviewed by the ethical review committee of the Senegalese Ministry of Health. It was conducted in accordance with the Helsinki Declaration of 1975, as revised in 1983. Mothers or other primary caregivers provided oral informed consent.

Infant and young child feeding. The first visit was conducted from May 9 to June 21, 2009, and the second visit was conducted from November 7 to December 10, 2009. At both visits recalls of feeding during the preceding day were conducted by the same highly experienced female fieldworker native from the area. The occurrence of BF and of consumption of a list of 20 locally relevant foods or food groups was recalled, together with the numbers of meals and snacks. A "meal" was defined as a feeding given at the time of the 3 family meals. During the first visit, it became clear that, for the mothers, the "snacks" covered only the 2 extra meals eaten in midmorning and midafternoon, i.e., "snack meals." Thus, during the second visit, the number of additional "free" snacks was also assessed.

Anthropometric measurements. Recumbent length was measured up until 2 y of age, and standing height thereafter, by using a locally made wooden measuring board precise to the nearest millimeter. Maternal height was measured by using a Harpenden anthropometer (Siber Hegner) that was precise to the nearest millimeter. Two independent height/length measurements were taken, and the mean was used for analysis. Weight measurements were taken by using battery-powered electronic Seca infant scales (Seca) that were precise to the nearest 10 g for children weighing <13 kg. For women and heavier children, we used battery-powered electronic scales that were precise to the nearest 0.1 kg (Seca). Children were naked or wore light clothing during measurements and mothers removed jackets, sandals, and head-cloths. One of the authors (S.B.) performed all measurements during the first visit and was assisted by the above-mentioned field worker who performed all measurements during the second visit. During a formal reliability assessment conducted prior to the first visit in 15 children aged 6–36 mo, the length/height intrameasurer technical errors (6) were 1.1 and 1.5 mm for S.B. and the fieldworker, respectively, whereas their intermeasurer technical error was 2.1 mm. The mean of within-subject differences of measurements between them was 1 mm.

Socioeconomic status. Socioeconomic data collected by interview included maternal education and occupation and indicators of quality of housing and of maternal use of health services. Data on selected possessions in the compound were taken from the database.

Indicators of infant and young child feeding. The ICFI proposed by Ruel and Menon (2) was adapted to the data. We did not include any indicator for bottle-feeding, which is rare in this area, nor did we collect information on the frequency of consumption of foods during the past 7 d. Instead, we constructed a food variety index (FVI), as suggested by Sawadogo et al. (5). Thus, the ICFI was constructed as the sum of scores from 4 indicators: BF, meal frequency (i.e., number of meals and snack meals), dietary diversity, and food variety, which were all recalled from the preceding 24 h (**Table 1**).

The dietary diversity index (DDI) included 7 food groups: animal milk products, animal-based foods (meat including poultry and organ meats, fresh fish, dried fish, eggs), cereals and tubers (all millet-based recipes, rice, bread and biscuits, tubers), pulses and nuts (groundnuts and other legumes), fruit and vegetables (any), vitamin A–rich foods (e.g., mangos, tomatoes, red palm oil), and food with fat added (oil or butter). Each component scored 1 point for a total of 0 to 7.

The FVI included 20 individual foods or food groups (fresh milk, powered milk, sour milk, fresh fish, dried or smoked fish, eggs, meat/organ meats/chicken, groundnuts, other legumes, vegetables/leaves, fruit, vitamin A–containing food, tubers/roots, millet gruel, milk-based millet gruel, millet couscous, millet porridge, rice, fat-containing foods, and bread/ biscuits), together with a category "other foods," for a total of 21 items. The FVI was constructed as the sum of all components (1 for "yes," 0 for "no"; i.e., from 0 to 21).

The meal frequency index (MFI) score ranged from 0 to 5. The number of additional snacks was collected during the last visit only and was therefore not included in the MFI.

For the MFI, DDI, and FVI, children were allocated to tertiles, and these indicators scored from 0 to 2 each. BF scored 1 point if present.

The ICFI score was constructed as the sum of scores of each component (possible values: 0–7) and, as described previously, children were divided into 3 groups of similar size using age-specific cutoffs (6–11.9, 12–17.9, 18–23.9, 24–29.9, and 30–36 mo). The same cutoffs were used for both visits for a given indicator (Table 1). Analyses using different cutoffs for the 2 visits provided very similar results with respect to the association with HAZ and linear growth (data not shown).

"Average" indicators computed from the 2 visits were constructed by summing tertile scores of each indicator at the 2 visits for DDI, FVI, and MFI (i.e., values from 0 to 6), which were divided into tertiles. BF scores from the 2 visits were also summed (i.e., values from 0 to 2). "Average" ICFI was constructed by summing tertile scores for each of its 4 components (i.e., values from 0 to 8) and then dividing the sum into tertiles.

Three children were excluded from the analysis because of missing data for some food items.

Anthropometric variables. Child nutritional indicators, HAZ and weight-for-height Z-score (WHZ), were calculated according to the WHO 2006 growth standard by using Anthro (version 3.2.2.; WHO). Stunting and wasting were defined as HAZ and WHZ below −2 Z-scores,

**TABLE 1** Construction of an ICFI among 1060 rural Senegalese infants (6–12 mo old) and children (12–36 mo old) cutoffs for the definition of low, medium, and high scores by child age[1]

| | Score | Child age | | | | |
|---|---|---|---|---|---|---|
| | | 6–9 mo | 9–12 mo | 12–18 mo | 18–24 mo | 24–36 mo |
| MFI[2] | | | | | | |
| Low | 0 | 0 | 0–1 | 0–2 | 0–2 | 0–3 |
| Medium | 1 | 1 | 2 | 3 | 3 | 4 |
| High | 2 | 2–5 | 3–5 | 4–5 | 4–5 | 5 |
| DDI[3] | | | | | | |
| Low | 0 | 0–1 | | 0–2 | 0–3 | 0–3 |
| Medium | 1 | 2–3 | | 3–4 | 4 | 4 |
| High | 2 | 4–7 | | 5–7 | 5–7 | 5–7 |
| FVI[4] | | | | | | |
| Low | 0 | 0–2 | | 0–4 | 0–6 | 0–6 |
| Medium | 1 | 3–5 | | 5–6 | 7–8 | 7–8 |
| High | 2 | 6–21 | | 7–21 | 9–21 | 9–21 |
| ICFI[5] | | | | | | |
| Low | 1 | 0–3 | | 0–2 | 0–2 | 0–2 |
| Medium | 2 | 4–5 | | 3–4 | 3–4 | 3–4 |
| High | 3 | 6–7 | | 5–7 | 5–7 | 5–7 |

[1] Values are index scores divided into 3 groups of similar size. DDI, dietary diversity index; FVI, food variety index; ICFI, infant and young child feeding index; MFI, meal frequency index.
[2] Three possible family meals and 2 snack meals, for a maximum of 5.
[3] Food groups: cereals/tubers, milk products, meat/fish/eggs, nuts/legumes, vegetables/fruit, vitamin A–rich foods, and fat-based foods, for a maximum of 7.
[4] Foods and food groups (range of 0 to 21): rice, millet porridge, millet couscous, infant millet gruel, milk-enriched millet gruel, tubers/roots, fermented milk, fresh milk, powdered milk, meat/organ meats/chicken, fresh fish, dried/smoked fish, eggs, groundnuts, other legumes (peas), fruit, vegetables/leaves, vitamin A–rich foods (fruit, vegetables, tubers, red palm oil), bread/biscuit/fritters, fat (oil, butter), and others.
[5] ICFI: sum of tertile scores (range of 0 to 7) for MFI, DDI, FVI, and breastfeeding (1 for yes, 0 for no).

respectively. Length/height increments were computed as the difference between measurements in the second and first visits and were standardized to exact 6-mo intervals (i.e., the mean duration of the interval) by dividing by the exact duration of the interval and multiplying by 6. No adjustment in the increment was made for children measured in the lying position in the first visit and in the upright position at the second, because virtually all children were affected similarly by this bias (i.e., those aged 18–24 mo at inclusion). Maternal BMI was computed as current weight divided by squared height after the exclusion of pregnant women.

Two children with unreliable length/height measurements (length/height increment below −1 or >12 cm/6 mo) were excluded from the analysis.

**Potential confounding factors.** A wealth index was constructed as the first axis of principal components analysis by using the following characteristics of the child's compound: possession of a bicycle, moped, cell phone, refrigerator, gas cooker, or generating unit, and quality of materials used for construction of the mother's hut (walls and roof). The first axis explained 33.4% of variability among children, and values were separated into tertiles for analysis. Maternal height and BMI were separated into quintiles and quartiles, respectively.

**Statistical analysis.** Trends in the prevalence of malnutrition of children and women across the 2 visits were tested by using McNemar's test applied to repeated data. Cronbach's $\alpha$ coefficient was used to assess the internal consistency of the ICFI on the basis of data from the first visit. Concordances of DDI, FVI, MFI, and ICFI across the 2 visits and between DDI, FVI, and MFI for a given visit were assessed by using the weighted $\kappa$ coefficient (within-individual analyses).

The association of HAZ and length increments with feeding indicators was assessed by using mixed models with adjustment for child age as a continuous variable (in all models) and either with or without adjustment for other potential confounding factors (wealth index, maternal height, school education, and professional activity). Because none of the potential confounding factors were associated with both HAZ and feeding, adjusted models did not provide results that were different from those of unadjusted models. Indeed, maternal height was strongly associated with HAZ but not with feeding indicators in any age group ($P > 0.20$). Conversely, the wealth index was not associated with HAZ in any age group, but it was positively associated with dietary diversity in 18–24- and 24–30-mo-old children ($P < 0.05$ for both; results not shown). Maternal BMI was not included in the final models due to lack of an association with either set of variables. Due to missing background data for some children, results presented for HAZ were adjusted for child age only.

HAZ was tested for an association with feeding indicators: first, by using pooled data from the 2 visits (cross-sectional analysis), and second, by using "average" indicators computed from both visits in relation to HAZ at the last visit (longitudinal analysis). Similar analyses were conducted by using WHZ or length/height instead of HAZ. Some children ($n$ = 26) were in the same age group at both visits. For them, only data from the first visit were retained in the "pooled" analysis.

Linear growth between visits was tested for an association with feeding indicators from the first visit and with "average" indicators, computed from both visits. Due to minor differences between adjusted and unadjusted results, data presented were adjusted for precise child age, wealth index, and maternal education and occupation.

Statistical power was estimated for the "pooled" analysis of HAZ, with consideration of only the 2 extreme tertiles (high vs. low) and observed SD and sample sizes with an $\alpha$ value of 0.05 for 2-sided tests. The power to detect an effect size of 0.4 Z-scores was 0.57, 0.79, 0.84, 0.87, and 0.88 at 6–12, 12–18, 18–24, 24–30, and 30–36 mo, respectively. For linear growth, the statistical power for detection of a difference of 1.0 cm/6 mo between these 2 groups was 0.79, 0.86, 0.93, and 0.98 at 6–12, 12–18, 18–24 and 24–30 mo, respectively.

Data entry was performed by using Epidata (EpiData Association), whereas SAS version 9.2 (SAS Institute) was used for the analysis. The relationship of feeding indicators with HAZ, WHZ, and linear growth was carried out by using the MIXED procedure to account for the cluster-based sampling design. Tests were considered significant at $P < 0.05$. Values for HAZ, WHZ, and length/height increment are reported as means ± SD.

## Results

**Background characteristics.** The numbers of children included in the analysis were 1060 and 1054 for the first and second visits, respectively, and age ranges were 6–36 and 9–36 mo, respectively. (Due to the sampling design, no 6–8-mo-olds were included in the second visit.) The cross-sectional "pooled" analysis included 2088 child-visits.

Background factors showed low proportions of parents with any schooling (13.7 and 22.0% for mothers and fathers, respectively), few mothers with income-generating activities (17.1%), relatively few households with latrines (33.5%) and none with a flush toilet, and virtually no access to electricity (3.3%), which contrasts with a fairly satisfactory use of basic preventive health services (**Supplemental Table 1**).

**Nutritional status.** HAZ was −1.20 ± 1.2 during the first visit and −1.17 ± 1.1 during the second visit compared with −0.29 ± 1.0 during the first visit and −0.26 ± 0.9 during the second visit for WHZ. The prevalence of stunting was 23.3% and that of wasting was 4.6%, and these did not differ across visits whereas that of maternal underweight doubled between the first and second visit (from 6.3 to 11.4%, $P < 0.001$).

Compared with girls, boys had significantly lower HAZ during infancy (−0.79 ± 1.3 vs. −0.48 ± 1.2, $P$ = 0.032) and beyond [−1.33 ± 1.2 vs. −0.93 ± 1.2 at 12–18 mo ($P < 0.001$), −1.44 ± 1.1 vs. −1.22 ± 1.1 at 18–24 mo ($P$ = 0.066), and −1.40 ± 1.1 vs. −1.18 ± 1.0 at 24–30 mo of age, respectively ($P$ = 0.025)].

**Feeding practices.** Ninety-six percent of 9–12-mo-old children had eaten at least one meal during the preceding day, with no differences across seasons, compared with >99% of those beyond infancy and 83% of 6–8-mo-olds (during the first visit). During the second visit, occasional nibbling (mainly of groundnuts) during the preceding day was reported in 88% of the sample (72, 82, and 92% at 9–11, 12–17, and 18–36 mo of age, respectively; $P < 0.001$), for a median of 2 (IQR: 1–2), 2.5 (2–3), and 3 (2–4) times at 9–18, 18–24, and 24–36 mo of age, respectively.

Compared with the first visit the second visit showed significantly lower rates of consumption during the previous 24 h for fruit, rice, fresh fish, and vitaminA–rich and fat-containing foods, whereas consumption of milk, bread and biscuits, groundnuts, and vegetables/leaves increased (**Supplemental Table 2**). The proportion of breast-fed children did not differ across visits. The DDI was lower in the second visit compared with the first at 18–24 and 24–36 mo of age, whereas the FVI and MFI were remarkably similar across the 2 visits (**Table 2**).

**Internal consistency of the ICFI.** Cronbach's $\alpha$ coefficient of the ICFI was 0.75 for 6–12-mo-olds compared with 0.67, and 0.55 for 12–24-, and 24–36- mo-old children, respectively. BF was negatively correlated with the index at 12–24 mo ($r$ = −0.26, $P < 0.001$)—thereby increasing the $\alpha$ value to 0.82 when omitted—and was not correlated with the ICFI for any other age group. The MFI contributed to the index up to age 2 y (when omitted, $\alpha$ coefficients decreased to 0.51 and 0.35 for 6–12 and 12–24-mo-old children, respectively), but not beyond that age.

The DDI and FVI were closely concordant, from a maximum $\kappa$ of 0.71 (95% CI: 0.65, 0.77) for infants to a minimum of 0.57 (95% CI: 0.53, 0.63) for 24–30-mo-old children, and both contributed greatly to the ICFI. The MFI was not significantly correlated with either DDI or FVI.

**Correlation within indicators over time.** The within-individual concordance of indicator tertiles across visits was assessed. Overall, point estimates of the $\kappa$ coefficient were low for all indicators and in all age groups, and several were not significantly greater than 0. Those for ICFI ranged from 0.09 (95% CI: −0.03, 0.20) at 12–18 mo to 0.25 (95% CI: 0.14, 0.36) at 18–24 mo of age.

**Cross-sectional analysis of HAZ in relation to feeding indicators.** In cross-sectional analyses pooling data from both visits DDI and FVI were significantly and positively associated with HAZ at 6–12, 12–18, and 18–24 mo of age (**Table 3**). The difference in HAZ between children with the lowest vs. highest score was much greater for infants (+1.25 for DDI) than during the second year of life (+0.57 and +0.45 for DDI at 12–18 and 18–24 mo, respectively). The differences in length between children with high vs. low DDI were +3.0, +1.2, and +1.1 cm for these 3 age groups, respectively (results not shown). Higher MFI scores were associated with greater HAZ among infants and at 24–30 mo of age only, whereas BF was associated with a significantly lower HAZ at 12–18, 18–24, and 24–30 mo (Table 3).

The ICFI was strongly and positively associated with HAZ among infants, but less strongly during the second year of life and no longer associated during the third year. These results remained unchanged in analyses that were adjusted for wealth index and maternal height, education, and occupation (results not shown). The differences in means between those with low vs. high values of the index were +0.97, +0.36, and +0.37 Z-scores at 6–12, 12–18, and 18–24 mo, respectively (i.e., +2.3, +1.4, and +0.9 cm, respectively; results not shown).

WHZ was negatively associated with BF at 24–30 and 30–36 mo ($P < 0.05$ and $P$ = 0.001, respectively). It was also negatively associated with DDI and FVI at 30–36 mo ($P < 0.01$ and $P < 0.05$, respectively), whereas no associations were found at younger ages (results not shown).

**HAZ at the second visit in relation to feeding indicators.** When HAZ at the second visit was analyzed in relation to "average" feeding indicators, computed from both visits differences in HAZ across children in the 3 groups of DDI were very similar to those found in the cross-sectional analysis presented previously, but levels of significance were generally lower due to the lower sample size (**Supplemental Table 3**). The same was true for FVI, MFI, and BF. Differences in HAZ across groups of ICFI were significant for infants only ($P < 0.001$).

The number of times the child had nibbled groundnuts (divided into tertiles) was positively associated with HAZ in 12–18-mo-olds (−1.35 ± 1.2, −1.29 ± 1.0, and −0.82 ± 1.3 for the 3 tertiles, respectively; $P < 0.01$) and 18–24-mo-olds (−1.52 ± 1.1, −1.68 ± 1.1, and −1.18 ± 1.0 for the 3 tertiles, respectively; $P < 0.01$). As a consequence, the total number of daily feedings (meals + snack meals + informal snacks) was also positively associated with HAZ in 12–18-mo-olds (−1.35 ± 1.1, −0.99 ± 1.2, and −0.83 ± 1.3 for the 3 tertiles, respectively; $P < 0.05$) and in 18–24-mo-olds (−1.68 ± 1.2, −1.44 ± 1.1, and −1.15 ± 0.9 for the 3 tertiles, respectively; $P < 0.05$).

**Linear growth in relation to feeding indicators.** The mean length/height increment between visits was 4.6 ± 1.7 cm/6 mo and was significantly associated with age group: 5.2 cm at 6–12 mo, 4.7 cm at 12–18 mo, 4.1 cm at 18–24 mo, and 4.4 cm at 24–30 mo ($P < 0.001$). Girls tended to have greater increases in length/height than boys at all ages, and the difference was significant in infants (5.8 ± 1.8 vs. 5.3 ± 1.6 cm/6 mo; $P < 0.05$).

There was no significant association between the length/height increment and DDI, FVI, or BF at any age. By using feeding indicators measured at the first visit, a positive association with MFI was borderline significant for infants and highly significant at 18–24 mo of age (**Table 4**). The IFCI was also positively associated with linear growth in 18–24-mo-old toddlers. By using feeding indicators averaged over the 2 visits, MFI and ICFI remained positively associated with linear growth at 18–24 mo ($P < 0.05$ for both; results not shown).

The age-adjusted tertile score of additional snacks eaten at the second visit was not significantly associated with linear growth in any age group (results not shown).

## Discussion

We analyzed the relationship of an ICFI with HAZ and linear growth in rural Senegalese 6–36-mo-old infants and young children. ICFI was strongly and positively related to HAZ at 6–12 mo of age and less strongly associated at 18–24 mo. Among its components, 24-h dietary diversity and food variety were both strongly and positively associated with HAZ at 6–12, 12–18, and 18–24 mo of age.

**TABLE 2** Distribution of infant and young child feeding indicators—DDI, FVI, MFI, BF, and ICFI—by season/visit in 1060 infants (6–12 mo old ) and children (12–36 mo old) in rural Senegal in May–June and November–December 2009 (i.e., during the pre-rain and harvest seasons, respectively)[1]

| | Child age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6–9 mo | 9–12 mo | | 12–18 mo | | 18–24 mo | | 24–36 mo | |
| Indicator | Pre-rain[2] ($n$ = 118) | Pre-rain ($n$ = 102) | Harvest ($n$ = 78) | Pre-rain ($n$ = 201) | Harvest ($n$ = 255) | Pre-rain ($n$ = 219) | Harvest ($n$ = 237) | Pre-rain ($n$ = 420) | Harvest ($n$ = 484) |
| | *n (%)* | | | | | | | | |
| DDI | | | | | | | | | |
| Low | 40 (33.9) | 17 (16.7) | 7 (9.0) | 38 (18.9) | 54 (21.2) | 67 (30.6) | 89 (37.6) | 100 (23.8) | 122 (25.2) |
| Medium | 44 (37.3) | 56 (54.9) | 45 (58.0) | 99 (49.3) | 144 (56.5) | 36 (16.4) | 75 (31.7) | 84 (20.0) | 180 (37.2) |
| High | 34 (28.8) | 29 (28.4) | 25 (35.5) | 64 (31.8) | 57 (27.4) | 116 (53.0) | 73 (30.8)*** | 236 (56.2) | 182 (37.6)*** |
| FVI | | | | | | | | | |
| Low | 49 (41.5) | 24 (23.5) | 12 (15.6) | 52 (25.9) | 61 (23.9) | 81 (37.0) | 110 (46.4) | 133 (31.7) | 147 (30.4) |
| Medium | 36 (30.5) | 45 (44.1) | 31 (40.3) | 59 (29.4) | 88 (34.5) | 84 (38.4) | 75 (31.7) | 153 (36.4) | 199 (41.1) |
| High | 33 (28.0) | 33 (32.4) | 34 (44.2) | 90 (44.8) | 106 (41.6) | 54 (24.7) | 52 (21.9) | 134 (31.9) | 138 (28.5) |
| MFI | | | | | | | | | |
| Low | 21 (17.8) | 34 (33.3) | 15 (19.5) | 77 (38.3) | 111 (43.5) | 49 (22.4) | 59 (24.9) | 153 (36.4) | 187 (38.6) |
| Medium | 43 (36.4) | 39 (38.2) | 27 (35.1) | 66 (32.8) | 87 (34.1) | 74 (33.8) | 78 (32.9) | 152 (36.2) | 186 (38.4) |
| High | 54 (45.8) | 29 (28.4) | 35 (45.5)* | 58 (28.9) | 57 (22.4) | 96 (43.8) | 100 (42.2) | 115 (27.4) | 111 (22.9) |
| BF | | | | | | | | | |
| None | 0 | 1 (1) | 1 (1) | 4 (2.0) | 12 (4.7) | 75 (34.2) | 77 (32.5) | 399 (95.0) | 454 (93.8) |
| Any | 118 (100) | 101 (99) | 77 (99) | 197 (98.0) | 243 (95.3) | 144 (65.8) | 160 (67.5) | 21 (5.0) | 30 (6.2) |
| ICFI | | | | | | | | | |
| Low | 50 (42.4) | 35 (34.3) | 15 (19.5) | 65 (32.3) | 103 (40.4) | 59 (26.9) | 71 (30.0) | 135 (32.1) | 190 (39.3) |
| Medium | 34 (28.8) | 39 (38.2) | 32 (41.6) | 79 (39.3) | 90 (35.3) | 65 (29.7) | 93 (39.2) | 162 (38.6) | 188 (38.8) |
| High | 34 (28.8) | 38 (27.5) | 30 (39.0) | 57 (28.4) | 62 (24.3) | 95 (43.4) | 73 (30.8)* | 123 (29.3) | 106 (21.9)* |

[1] Asterisks indicate different from Pre-rain: $*P < 0.05$, $***P < 0.001$. BF, breastfeeding; DDI, dietary diversity index; FVI, food variety index; ICFI, infant and young child feeding index; MFI, meal frequency index.
[2] No data were available for 6–9-mo-old infants during the harvest.

The main strengths of this study lie in the large sample size, the inclusion of infants, and the longitudinal approach, which—coupled with the high quality of length/height measurements and the low attrition rates—enabled us to study the association of the ICFI with linear growth. The large sample size made it possible to carry out age-specific analyses.

The study's limitations included the absence of 6–9-mo-old infants at the second visit due to delayed updating of the population database. The collection of feeding data was limited to the preceding 24 h and did not include assessment of foods meal by meal (i.e., 24-h recalls). Finally, DDI and FVI were very closely correlated, both conceptually and statistically. It would probably have been more rigorous to use only the former, but the inclusion of both indicators enabled us to compare our results with those of a previous study from West Africa (5).

Overall, feeding patterns were quite satisfactory in this population. Complementary food was introduced on time for most children. Among 6–8-mo-olds, only 18% had not eaten any complementary food during the preceding 24 h, compared with 57, 28, and 57% of children during the preceding week in Mali, Benin, and Ethiopia, respectively (7). In addition, most children were fed an adequate number of daily meals [as per 2004 recommendations (8)], and many also had access to additional high-energy food (groundnuts) between meals, at least during the months after the harvest.

In northern Burkina Faso, the ICFI was positively associated with HAZ in 6–12- and 12–24-mo-old children, whereas a negative association emerged among 24–36-mo-olds, probably due to a negative association of HAZ with BF in older children (5). In this rural Senegalese population, we also found a strong negative relationship between BF and HAZ at 12–18, 18–24, and 24–30 mo of age. This association has previously been shown to result from reverse causality in this population—i.e., mothers deciding to prolong BF for malnourished children and to cease earlier for tall, strong healthy children (9–11).

In contrast to our first hypothesis, we found weak concordance between the 2 visits for the ICFI and its components, suggesting that these indicators track poorly over 6 mo in infants and young children, at least for contrasting seasons such as those compared here. One earlier study reported concordance over time with use of a slightly different ICFI in Madagascan 6–18-mo-old children, who were measured 3 times during a period of 6 mo (12). Unfortunately, the measurement of stability of the ICFI across visits used in that study was not comparable to the $\kappa$ coefficient used here.

With regard to our second hypothesis, the "effect size" of the ICFI (i.e., the difference in means between those with high vs. low values of the index) did not increase; rather, it tended to decrease with increasing child age (i.e., +0.97, +0.36, and +0.37 Z-scores at 6–12, 12–18, and 18–24 mo, respectively). In other words, we found no evidence of a cumulative effect of good feeding practices on HAZ over time.

We found no association between linear growth and either DDI or FVI measured at the onset of the growth interval, although the technical quality of measurements was high and the statistical power strong. A higher meal frequency at 18–24 mo was associated with faster linear growth, suggesting a positive effect of greater meal frequency on linear growth during the critical period of BF cessation. Girls had faster linear growth than did boys from 6–12 mo of age, in accordance with sex differences in HAZ at 6–24 mo of age.

**TABLE 3** HAZ in relation to DDI, FVI, MFI, BF, and ICFI scores, assessed during 2 visits in May–June and November–December 2009 in 1060 rural Senegalese infants (6–12 mo old) and children (12–36 mo old)[1]

| Indicator and child age | *n* | Feeding indicator score: Low | Medium | High | *P* |
|---|---|---|---|---|---|
| DDI | | | | | |
| 6–12 mo | 294 | −1.18 (64) | −0.74 (145) | +0.09 (89) | <0.001 |
| 12–18 mo | 450 | −1.41 (92) | −1.19 (243) | −0.84 (121) | <0.01 |
| 18–24 mo | 448 | −1.54 (156) | −1.37 (111) | −1.09 (189) | <0.001 |
| 24–30 mo | 442 | −1.27 (112) | −1.35 (128) | −1.30 (206) | >0.20 |
| 30–36 mo | 454 | −1.57 (110) | −1.35 (136) | −1.31 (212) | >0.10 |
| FVI | | | | | |
| 6–12 mo | 294 | −1.22 (85) | −0.52 (113) | −0.15 (100) | <0.001 |
| 12–18 mo | 450 | −1.30 (113) | −1.24 (147) | −0.95 (196) | <0.05 |
| 18–24 mo | 448 | −1.48 (191) | −1.30 (159) | −1.03 (106) | <0.01 |
| 24–30 mo | 442 | −1.20 (143) | −1.36 (176) | −1.33 (127) | >0.20 |
| 30–36 mo | 454 | −1.52 (137) | −1.40 (176) | −1.24 (145) | 0.062 |
| MFI | | | | | |
| 6–12 mo | 294 | −0.89 (70) | −0.62 (109) | −0.41 (119) | <0.05 |
| 12–18 mo | 450 | −1.22 (188) | −1.03 (153) | −1.14 (115) | >0.20 |
| 18–24 mo | 448 | −1.45 (108) | −1.34 (152) | −1.22 (196) | >0.20 |
| 24–30 mo | 442 | −1.47 (181) | −1.18 (163) | −1.21 (102) | <0.05 |
| 30–36 mo | 454 | −1.39 (159) | −1.42 (175) | −1.33 (124) | >0.20 |
| BF[2] | | | | | |
| 6–12 mo | 294 | +2.18 (2) | −0.60 (292) | — | <0.01 |
| 12–18 mo | 450 | −0.35 (16) | −1.16 (434) | — | 0.011 |
| 18–24 mo | 448 | −0.97 (150) | −1.48 (298) | — | <0.001 |
| 24–30 mo | 442 | −1.27 (399) | −1.62 (43) | — | <0.05 |
| 30–36 mo | 454 | −1.39 (447) | −1.17 (7) | — | >0.20 |
| ICFI | | | | | |
| 6–12 mo | 294 | −1.04 (100) | −0.66 (105) | −0.07 (93) | <0.001 |
| 12–18 mo | 450 | −1.29 (168) | −1.13 (168) | −0.93 (119) | 0.057 |
| 18–24 mo | 448 | −1.51 (130) | −1.33 (158) | −1.14 (168) | 0.015 |
| 24–30 mo | 442 | −1.25 (170) | −1.45 (167) | −1.17 (109) | 0.074 |
| 30–36 mo | 454 | −1.50 (155) | −1.35 (183) | −1.28 (120) | >0.20 |

[1] Values are means (*n*), adjusted for child age and visit (SD: 0.8–1.3). Data from both visits were pooled, *n* = 2088. *P* values indicate differences across feeding indicator scores. BF, breastfeeding; DDI, dietary diversity index; FVI, food variety index; HAZ, height-for-age Z-score; ICFI, infant and young child feeding index; MFI, meal frequency index.
[2] Low, no BF; medium, any BF.

The particularly strong relationship of HAZ with DDI and FVI during late infancy might be due to the fact that infant growth is particularly rapid and sensitive to dietary intake (13). Indeed, several studies have shown that greater dietary diversity is associated with greater intake of various micronutrients among infants and young children in less-developed countries (14–16). However, this interpretation is challenged by the absence of an association of these indicators with linear growth, despite a strong power in detection of such differences. These findings could also be partly explained by reverse causality—i.e., mothers tend to provide a more diverse diet to taller infants with more rapid motor development who are likely to have more "proactive" behavior during feeding.

The fact that the number of times 12–24-mo-old children nibbled groundnuts was associated with HAZ, whereas the number of meals was not, suggests a similar mechanism: taller and more independent toddlers may have been more prone to eating these nuts, which are freely available in a pile on the ground in the compound yard and are consumed by all family members on a "help yourself" basis. Indeed, height status is positively associated with a child's motor skills and activity level, including the exploration of her or his environment (17,18). Further studies are necessary to test this hypothesis.

In summary, the ICFI was positively associated with HAZ at 6–12 and 18–24 mo of age, and the association was particularly strong among infants. This relationship was mainly due to positive associations with DDI and FVI, whereas its association with MFI was weak and that with BF was negative. Linear growth over a 6-mo period was positively associated with female gender (in infancy) and MFI (at 18–24 mo of age) but not with DDI, FVI, or BF.

In conclusion, we found a positive association between feeding indicators and HAZ among infants and toddlers, but no evidence of a direct causal relationship. Therefore, reverse causality and other factors (e.g., unmeasured confounding factors) may account for part of this association. These observations do not preclude the ICFI and its core components (BF, DDI, and MFI) from being valuable indicators of infant and young child feeding practices.

**TABLE 4** Adjusted length/height increments between May–June and November–December 2009 in relation to DDI, FVI, MFI, BF, and ICFI scores assessed in May–June 2009 in 683 rural Senegalese infants and young children aged 6–30 mo in May–June 2009[1]

| Indicator and age | Feeding indicator score: Low | Medium | High | *P* |
|---|---|---|---|---|
| | | *cm/6 mo* (*n*) | | |
| DDI | | | | |
| 6–12 mo | 5.7 ± 1.8 (35) | 6.3 ± 1.8 (64) | 5.9 ± 1.8 (51) | 0.071 |
| 12–18 mo | 4.8 ± 2.0 (33) | 4.5 ± 1.5 (79) | 4.6 ± 1.5 (47) | >0.20 |
| 18–24 mo | 4.0 ± 1.6 (60) | 3.8 ± 1.6 (26) | 4.2 ± 1.4 (97) | >0.20 |
| 24–30 mo | 4.1 ± 1.1 (50) | 4.1 ± 1.3 (35) | 3.9 ± 1.6 (106) | >0.20 |
| FVI | | | | |
| 6–12 mo | 5.9 ± 1.9 (46) | 6.1 ± 2.0 (55) | 6.0 ± 1.5 (49) | >0.20 |
| 12–18 mo | 4.8 ± 1.7 (45) | 4.8 ± 1.8 (47) | 4.4 ± 1.3 (67) | >0.20 |
| 18–24 mo | 3.8 ± 1.7 (72) | 4.2 ± 1.4 (63) | 4.2 ± 1.3 (48) | >0.20 |
| 24–30 mo | 4.0 ± 1.3 (66) | 4.0 ± 1.7 (73) | 3.9 ± 1.3 (52) | >0.20 |
| MFI | | | | |
| 6–12 mo | 5.5 ± 1.8 (37) | 6.0 ± 1.8 (57) | 6.4 ± 1.7 (57) | 0.075 |
| 12–18 mo | 4.6 ± 1.7 (65) | 4.5 ± 1.5 (49) | 4.7 ± 1.5 (45) | >0.20 |
| 18–24 mo | 3.3 ± 1.3 (43) | 4.1 ± 1.6 (62) | 4.4 ± 1.4 (78) | <0.001 |
| 24–30 mo | 3.9 ± 1.6 (75) | 4.1 ± 1.5 (73) | 3.9 ± 1.1 (63) | >0.20 |
| BF[2] | | | | |
| 6–12 mo | 5.4 (1) | 6.1 ± 1.8 (149) | — | — |
| 12–18 mo | 2.9 ± 0.2 (2) | 4.6 ± 1.6 (157) | — | — |
| 18–24 mo | 3.9 ± 1.3 (60) | 4.2 ± 1.6 (123) | — | >0.20 |
| 24–30 mo | 4.0 ± 1.5 (174) | 3.8 ± 1.1 (17) | — | >0.20 |
| ICFI | | | | |
| 6–12 mo | 5.9 ± 1.9 (56) | 6.2 ± 1.9 (49) | 6.1 ± 1.6 (45) | >0.20 |
| 12–18 mo | 4.7 ± 1.8 (55) | 4.6 ± 1.6 (62) | 4.5 ± 1.4 (42) | >0.20 |
| 18–24 mo | 3.6 ± 1.7 (52) | 4.1 ± 1.5 (54) | 4.4 ± 1.4 (77) | 0.03 |
| 24–30 mo | 4.1 ± 1.3 (66) | 3.7 ± 1.7 (73) | 4.1 ± 1.2 (52) | 0.17 |

[1] Values are means ± SD (*n*), adjusted for child age, wealth index, and maternal education and occupation. *P* values indicate differences across feeding indicator scores. BF, breastfeeding; DDI, dietary diversity index; FVI, food variety index; ICFI, infant and young child feeding index; MFI, meal frequency index.
[2] Low, no BF; medium, any BF.

## Acknowledgments

The authors thank Amady Ndiaye-Sarr for skilled data collection. This article is dedicated to the memory of Adama Marra, database manager at the Niakhar Project from 1989 to 2009. K.B., C.C., S.B., and A.D. designed the research; C.C. and S.B. conducted the research; K.B., S.B., and A.C. analyzed the data; and K.B. wrote the manuscript and had primary responsibility for final content. All authors read and approved the final version of the manuscript.

## Literature Cited

1. Brown KH, Dewey KG, Allen LH. Complementary feeding of infants and young children. Geneva: WHO; 1998.
2. Ruel MT, Menon P. Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the Demographic and Health Surveys. J Nutr. 2002;132:1180–7.
3. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371:243–60.
4. Ntab B, Simondon KB, Milet J, Cissé B, Sokhna CS, Boulanger D, Simondon F. A composite young child feeding index is not associated with either height-for-age or with height velocity in rural Senegal, West Africa. J Nutr. 2005;135:457–64.
5. Sawadogo PS, Martin-Prevel Y, Savy M, Kameli Y, Traissac P, Traore AS, Delpeuch F. An infant and child feeding index is associated with the nutritional status of 6- to 23-month-old children in rural Burkina Faso. J Nutr. 2006;136:656–63.
6. Cameron N. The methods of auxological anthropometry. In: Falkner F, Tanner JM, editors. Human growth A comprehensive treatise. 2nd ed. New York: Plenum Press; 1986. p. 3–46.
7. Arimond M, Ruel MT. Dietary diversity is associated with child nutritional status: evidence from 11 Demographic and Health Surveys. J Nutr. 2004; 134:2579–85.
8. Pan American Health Organization. Guiding principles for complementary feeding of the breastfed child. Washington: PAHO; 2004.
9. Simondon KB, Simondon F. Mothers prolong breastfeeding of undernourished children in rural Senegal. Int J Epidemiol. 1998;27:490–4.
10. Simondon KB, Simondon F, Costes R, Delaunay V, Diallo A. Breastfeeding is associated with improved growth in length, but not weight, in rural Senegalese toddlers. Am J Clin Nutr. 2001;73:959–67.
11. Simondon KB, Costes R, Delaunay V, Diallo A, Simondon F. Children's height, health and appetite influence mothers' weaning decisions in rural Senegal. Int J Epidemiol. 2001;30:476–81.
12. Moursi MM, Martin-Prevel Y, Eymard-Duvernay S, Capon G, Treche S, Maire B, Delpeuch F. Assessment of child feeding practices using a summary index: stability over time and association with child growth in urban Madagascar. Am J Clin Nutr. 2008;87:1472–9.
13. Schroeder DG, Martorell R, Rivera J, Ruel MT, Habicht JP. Age difference in the impact of supplement on growth. J Nutr. 1995;125: 1051S–9S.
14. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr. 2006;9:644–50.
15. Moursi MM, Arimond M, Dewey KG, Treche S, Ruel MT, Delpeuch F. Dietary diversity is a good predictor of the micronutrient density of the diet of 6- to 23-month-old children in Madagascar. J Nutr. 2008; 138:2448–53.
16. Moursi MM, Treche S, Martin-Prevel Y, Maire B, Delpeuch F. Association of a summary index of child feeding with diet quality and growth of 6–23 months children in urban Madagascar. Eur J Clin Nutr. 2009;63:718–24.
17. Cheung YB, Yip PS, Karlberg JP. Fetal growth, early postnatal growth and motor development in Pakistani infants. Int J Epidemiol. 2001; 30:66–72.
18. Olney DK, Pollitt E, Kariger PK, Khalfan SS, Ali NS, Tielsch JM, Sazawal S, Black R, Mast D, Allen LH, et al. Young Zanzibari children with iron deficiency, iron deficiency anemia, stunting, or malaria have lower motor activity scores and spend less time in locomotion. J Nutr. 2007;137:2756–62.