Complementary feeding in the WHO Multicentre Growth Reference Study

WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP[1,2]

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Abstract

Aim: To describe complementary feeding practices in the Multicentre Growth Reference Study (MGRS) sample. *Methods:* Food frequency questionnaires and 24-h dietary recalls were administered to describe child feeding throughout the first 2 y of life. This information was used to determine complementary feeding initiation, meal frequency and use of fortified foods. Descriptions of foods consumed and dietary diversity were derived from the 24-h recalls. Compliance with the feeding recommendations of the MGRS was determined on the basis of the food frequency reports. Descriptive statistics provide a profile of the complementary feeding patterns among the compliant children. *Results:* Complementary feeding in the compliant group began at a mean age of 5.4 mo (range: 4.8 (Oman)–5.8 mo (Ghana)). Complementary food intake rose from 2 meals/d at 6 mo to 4–5 meals in the second year, in a reverse trend to breastfeeding frequency. Total intake from the two sources was 11 meals/d at 6–12 mo, dropping to 7 meals/d at 24 mo. Inter-site differences in total meal frequency were mainly due to variations in breastfeeding frequency. Grains were the most commonly selected food group compared with other food groups that varied more by site due to cultural factors, for example, infrequent consumption of flesh foods in India. The use of fortified foods and nutrient supplements was also influenced by site-variable practices. Dietary diversity varied minimally between compliance groups and sites.

Conclusion: Complementary diets in the MGRS met global recommendations and were adequate to support physiological growth.

Key Words: *Complementary feeding, dietary diversity index, food frequency, infant feeding, 24-hour dietary recall*

Introduction

The WHO Multicentre Growth Reference Study (MGRS) was designed to collect growth data from an international sample of healthy breastfed infants from widely differing ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman and the USA) [1]. These data have been used to create the new length/height- and weight-based growth standards presented in this supplement [2]. As described elsewhere [3], complementary feeding practices were one of the secondary criteria used for selection of the study sites for the MGRS. The intention was to select populations in which feeding practices were unlikely to pose any constraints on growth. Thus, it is important to document how the children in the MGRS sample were fed in each of the sites.

The period of complementary feeding, when other foods are added to the diet of breastfed children, is a time of particular vulnerability to nutritional deficiencies. This is because children at this age are growing and developing rapidly, yet do not consume large quantities of food. Thus, the foods they eat must be of high nutrient density to provide adequate amounts of essential nutrients. In recent years increasing attention has been paid to the importance of complementary feeding [4,5]. The key limiting nutrients identified for breastfed children between the ages of 6 and 24 mo are iron, zinc, vitamin B_6 and, in some populations, riboflavin, niacin, thiamin, calcium, vitamin A, folate and vitamin C. Vitamin D is also of concern in populations with low exposure to sunshine or at high latitudes. In 2003, global guidelines for complementary feeding of the breastfed child were published [6]. These included recommendations on 1) introducing complementary foods at 6 mo of age, 2) continued breastfeeding to 2 y of age or beyond, 3) responsive feeding practices, 4) safe, hygienic preparation and feeding of complementary

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foods, 5) amounts of complementary foods needed at each age interval, 6) food consistency, 7) meal frequency and energy density, 8) assuring adequate nutrient intake from complementary foods, 9) use of fortified foods or nutrient supplements, and 10) feeding during and after illness. This paper describes the complementary feeding practices of the sample of infants and young children used to construct the WHO Child Growth Standards, and discusses the patterns observed with regard to several of the global guidelines above, such as age of introduction of complementary foods, meal frequency, dietary quality, and use of fortified foods or nutrient supplements.

Methods

Overview of the MGRS

The MGRS was a six-country community-based project designed to develop new growth standards for infants and young children. The design included a longitudinal component that followed children from birth to 24 mo and a cross-sectional component that enrolled children aged 18 to 71 mo. The pooled sample from all six countries included 8440 children. The study subpopulations were selected so that socio-economic conditions would be favourable to growth, and the selection criteria for individuals specified absence of health or environmental constraints on growth, adherence to recommended infant feeding practices, absence of maternal smoking, single term birth, and absence of significant morbidity. This paper describes data from the longitudinal component of the MGRS where mothers and newborns were screened and enrolled at birth and visited in the home at weeks 1, 2, 4 and 6, monthly from 2 to 12 mo, and every 2 mo in the second year of life. Details of the study design and methods can be found elsewhere [3].

Complementary feeding guidelines

As described elsewhere [7–12], mothers in each site were given guidelines on complementary feeding. Mothers were advised to introduce complementary foods at 4–6 mo (the WHO recommendation prior to 2001) in Norway and the USA and, in line with individual national policies, at 5–6 mo in Oman and at 6 mo in Brazil, Ghana and India. In all sites, continued breastfeeding was recommended and the guidelines emphasized use of a variety of nutrient-rich foods. Most of the sites also included guidelines regarding meal frequency, food consistency, use of a separate bowl for the infant, use of iron-rich and vitamin A-rich foods, and responsive feeding practices. Half of the sites included advice on nutrient supplements (India, Norway and the USA), limita-

tions on use of sugary beverages such as juice (Norway, Oman and the USA), and avoidance of certain foods if there was a family history of allergy (Norway, Oman and the USA). India and Oman provided guidelines on the amounts of foods to be fed. Ghana and India included recommendations regarding hygiene when preparing and feeding complementary foods. Norway and the USA included advice to use infant formula if a supplement to breast milk was needed. India and Oman advised using only iodized salt, while Norway advised against adding salt to baby food.

Compliance criteria

As described elsewhere [13], the MGRS included three compliance criteria with regard to infant feeding: 1) exclusive or predominant breastfeeding for at least 4 mo (120 d), 2) introduction of complementary foods between 4 and 6 mo (120 to 180 d), and 3) partial breastfeeding to be continued for at least 12 mo (365 d). The operational definition of compliance with the first criterion was that the infant did not consume formula, other milk, or more than one teaspoon of solid or semi-solid food on more than 10% of days during the first 4 mo (i.e. ≤ 12 d). This paper focuses on the complementary feeding practices of subjects who were "compliant" with all three feeding criteria, with brief reference to whether the results for the "non-compliant" subjects differed substantially from those for the compliant subjects. The final sample used to construct the growth standards also excluded children whose mothers smoked and those experiencing morbidity with adverse effects on growth [2].

Definitions of variables and data analysis

Data on feeding practices, including a 24-h dietary recall, were collected at each of the follow-up visits [3]. Before conducting the 24-h recall, the interviewer asked the mother if the child's diet on the preceding day was typical. If not (e.g. because of illness or travelling), then the recall data were collected for the last day when the diet was typical. The mother was asked what the child ate or drank in each of seven time periods during the day (when the child woke up; morning; lunch; afternoon; dinner; evening; during the night).

The results presented here come from several questions in the follow-up questionnaire. Age of introduction of solid or semi-solid foods was derived from a question about whether the child had received certain fluids or foods since the previous visit (which at this age was an interval of 1 mo). If the answer was yes for either of the two non-fluid choices ("fruit" or "solid or semi-solid foods"), the age of the child at the

current visit was taken as the age of introduction. Meal frequency was derived from the 24-h recall. If a child ate twice within 45 min, it was considered a single meal. Water, tea, juice or other beverages consumed on their own were not considered as meals, nor were small snacks (e.g. a small cookie or a spoonful of mashed fruit). The total number of meals included both solid/semi-solid foods and milk-only meals (including breast milk). Milk-only meals included breastfeeds and feedings of formula, milk or yogurt.

Data on the types of foods consumed and dietary diversity were also derived from the 24-h recall. Foods were grouped into 12 categories based on type and nutrient content: grain products, legumes/nuts, tubers, milk products, flesh foods (meat, poultry and fish), eggs, vitamin A-rich fruits and vegetables, other fruits and vegetables, juices, sweetened beverages, soups, and fats/oils (in Brazil, 11 categories were used, without separating vitamin A-rich fruits and vegetables from other fruits and vegetables). To assess dietary diversity, an index developed by other investigators [14] was used, based on the following eight food groups: 1) grain products and tubers, 2) legumes/nuts, 3) milk products, 4) flesh foods, 5) eggs, 6) vitamin-A rich fruits and vegetables, 7) other fruits and vegetables and juices, and 8) fats/oils. This categorization of foods was chosen so that a higher total score would be likely to reflect greater consumption of foods of higher nutrient density, such as animal-source foods (three categories) and fruits and vegetables (two categories). The number of food groups represented in the child's diet (range 0–8, except in Brazil where it was 0–7), regardless of the amount consumed from each food group, was calculated as a measure of dietary diversity. Thus, for example, if the 24-h recall showed that six out of the eight food groups were represented in the diet, then the dietary diversity for that day was 6.

Use of fortified foods was derived from a question that followed the 24-h recall: "Were any of the foods fortified with any of the following nutrients: a) iron, b) vitamin A, c) vitamin C, d) vitamin D, e) other (specify)?" The site-specified fortificants in the "other" category were calcium and zinc (India, Norway, the USA), vitamin E and vitamin B-complex (Ghana), and folic acid (Oman). Use of salt was determined by asking: "Do you add salt to his/her food?" If the mother answered "yes", this was followed by: "Please show me the type of salt you put in your baby's food. I would like to check if it contains iodine, which is important for the baby."

Use of nutrient supplements was determined by asking: "Since the last visit, has your baby received any vitamins or minerals?" If the response was yes, data were recorded on the brand name of the supplement, the dose given and the frequency of supplementation (per day, week or month). The nutrient contents of all supplements used at each site were recorded in order to determine which specific nutrients were taken by each child.

Basic summary statistics such as means, standard deviations, medians, summary ranges and frequency distributions were used in these analyses.

Results

Table I shows the mean and median age of introduction of solid or semi-solid foods for the compliant subjects. The overall mean was 5.4 mo, ranging from 4.8 mo in Oman to 5.8 mo in Ghana. For non-compliant subjects (data not shown), the overall mean was somewhat lower (4.8 mo).

Figure 1 shows the mean number of non-milk meals between 4 and 24 mo for the compliant subjects at each site. Values were close to zero at 4 mo, increasing to an overall average (meals/d) of about 2 at 6 mo, 4 at 9 mo and 4–5 at 12–24 mo. During the first year of life, meal frequency was generally similar across sites, but in the second year the children in Ghana tended to eat somewhat more often and the children in Brazil less often than the children in the other sites. For non-compliant subjects, non-milk meal frequency was slightly higher at 6 mo (∼3 meals/d) compared to compliant subjects, but at the older ages the mean values were similar. Figure 2 shows the mean number of all meals (including milk-only meals) for the compliant subjects. The average decreased with age, from an overall mean of ∼11 meals/d at 6–12 mo to ∼9 at 18 mo and ∼7 at 24 mo. Because of differences in breastfeeding frequency across sites [13], total meal frequency at 4–12 mo tended to be higher in Ghana and Oman and lower in Norway than in the other sites. After 12 mo, total meal frequency remained high in Oman, was lowest in Norway and dropped steadily throughout the second year in

Table I. Mean and median age (in months) of the introduction of solid or semi-solid foods for compliant children.

Site	n	Mean (SD)	Median (min., max.)[a]
Brazil[b]	68	5.5 (0.7)	6.0 (4.0, 7.1)
Ghana	228	5.8 (0.6)	6.0 (1.4, 7.5)
India	173	5.0 (0.6)	5.0 (3.0, 7.0)
Norway	159	5.5 (0.8)	5.1 (3.0, 7.1)
Oman	153	4.8 (0.6)	5.0 (3.2, 7.0)
USA	121	5.4 (0.7)	5.1 (3.9, 7.2)
All	902	5.4 (0.7)	5.1 (1.4, 7.5)

[a] The minimum age of introduction is less than 4 mo in several sites because the operational definition for compliance with exclusive or predominant breastfeeding for at least 4 mo allowed for occasional consumption of solid or semi-solid foods, as long as the number of days on which this occurred did not exceed 12.
[b] Excludes one child with missed visits at ages 6 and 7 mo.
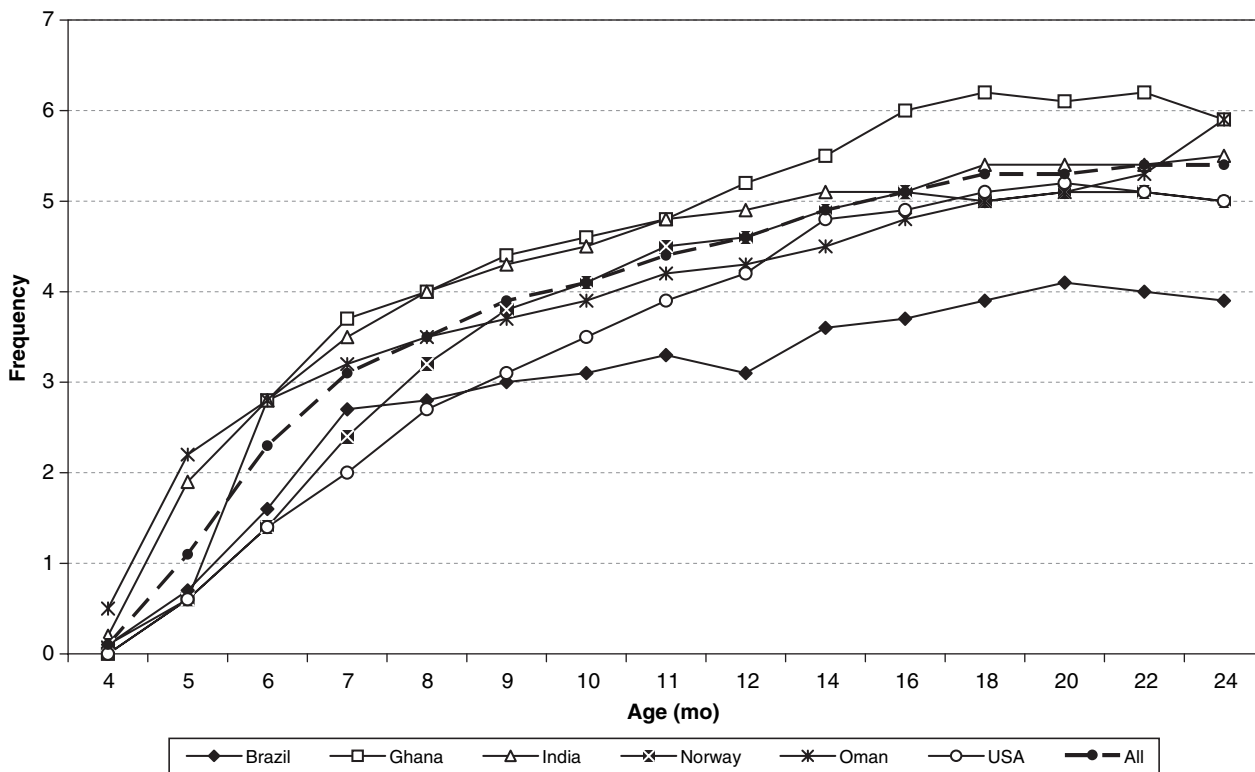
Figure 1. Mean number of non-milk meals (age 4 to 24 mo) per day for compliant children.

Ghana. For non-compliant subjects (data not shown), total meal frequency was lower by about 1–2 meals/d at 6–18 mo in comparison with the values shown for compliant subjects.

Subjects' food consumption patterns were evaluated by categorizing the foods reported in the 24-h recall into 12 food groups. The percentages of compliant children fed foods from these food groups
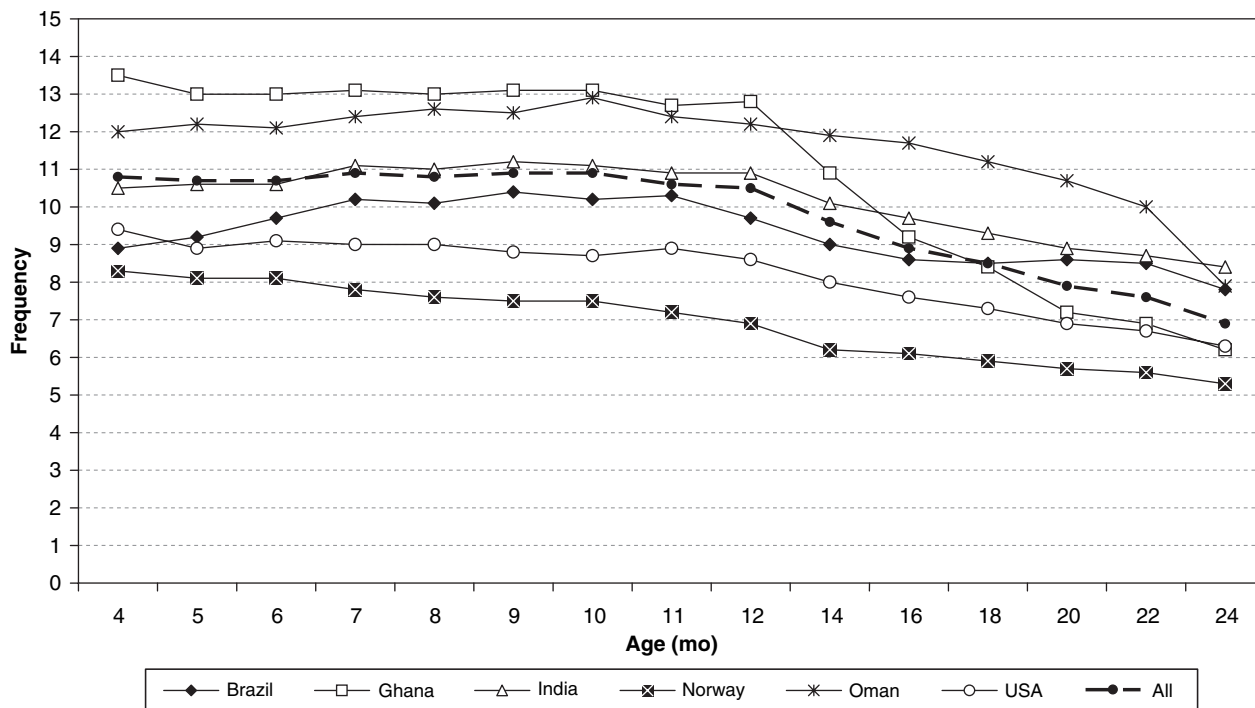

Figure 2. Mean number of all meals (age 4 to 24 mo) per day for compliant children.

by the stated ages are reported in Table II. Grain products were consumed by the vast majority of subjects at all ages (except in Brazil at 6 mo). There was wide variability in the percentage of children who consumed legumes or nuts after 6 mo: <6% in Norway, 12–21% in Oman, 9–43% in the USA, 36–47% in Ghana, 39–60% in Brazil, and 71–91% in India. Consumption of tubers was uncommon at 6 mo (except in Oman), but increased thereafter to 33–51% overall, with the highest percentages in Ghana, India and Oman. Consumption of milk products varied by site at 6–9 mo (high in Ghana, India and Oman, lower in Norway and the USA), but at 12–24 mo >75% of children in all sites consumed milk products. Flesh foods were rarely consumed at 6 mo (except in Oman), but intake rose thereafter. In all sites except India, the percentage of children consuming flesh foods on the day of the recall was >50% at 12 mo, >66% at 18 mo, and >75% at 24 mo; in India ≤11% of children consumed flesh foods on the day of the recall. Egg consumption varied by age and by site, with the overall percentage being 3–10% at 6–9 mo and ∼20–30% thereafter. Eggs were rarely consumed in Norway (at all ages) and in the USA at 6–9 mo, whereas they were consumed by almost half the children in Oman at 24 mo. Consumption of vitamin A-rich fruits and vegetables was relatively low at 6 mo (except in Oman and the USA), but increased thereafter to 43–48% overall, with the highest percentages reported for Ghana and the USA. Other fruits and vegetables were consumed by 35% of children at 6 mo, with intake rising thereafter to 70–87% overall. At 6 mo, juice was infrequently consumed by infants in Ghana, Norway and the USA, but consumed by 20–45% of infants in Brazil, India and Oman; thereafter, juice consumption rose in all sites, with the highest percentages at 24 mo reported for Oman and the USA. Sweet beverages were rarely consumed at 6–9 mo (except in Brazil), with intake rising to 15–34% overall from 12 to 24 mo. Consumption of soup was highly variable across sites: it was common in Brazil, Oman and Ghana but uncommon in India, Norway and the USA. Consumption of fats and oils after 6 mo was also highly variable across sites, being very common in Ghana and Norway, less common in India and the USA, and rare in Brazil and Oman.

Food consumption patterns of the non-compliant subjects (data not shown) did not differ dramatically from those of compliant subjects with the following exceptions. Because they were less likely to be breastfeeding, non-compliant children were more likely to consume milk products. Compared to compliant subjects, they tended to have a lower consumption of vitamin A-rich fruits and vegetables and fats and oils (at all ages), and a higher consumption of soups at 6–9 mo.

Mean and median dietary diversity are shown in Table III for compliant subjects. The median number of food groups consumed, out of a maximum of eight (seven in Brazil), was two at 6 mo, four at 9 mo, and five at 12–24 mo. Values for Brazil were lower than for the other sites because the dietary diversity index included seven rather than eight food groups. For the other sites, dietary diversity at 6 mo was lower in Norway and higher in India and Oman compared to the overall median; by 18–24 mo dietary diversity was similar among sites except for Ghana, where it was higher. Dietary diversity was similar between compliant and non-compliant subjects (data not shown).

Use of fortified foods varied by age and by site. For simplicity, only data for foods fortified with iron or vitamin A are shown. Figure 3 shows the percentage of compliant subjects consuming iron-fortified foods at each age. The majority of infants consumed such foods at 6 mo in all sites, ranging from ∼60% in Oman to 75–90% in Ghana and the USA. Thereafter, the percentage remained very high in the USA and rose from ∼60% to ∼85% in Oman, but declined in the other sites to ∼40% in Ghana and ∼20% in India and Norway by 24 mo (data were unavailable for Brazil). Figure 4 shows the percentage of compliant subjects consuming vitamin A-fortified foods. In Norway and Ghana, the percentage was ∼80–100% at all ages, whereas in Oman it was 50–60%, in India it decreased from ∼65% at 6 mo to ∼20% at 24 mo, and in the USA it increased from ∼20% at 6 mo to >90% at 24 mo. Use of iron- or vitamin A-fortified foods was generally somewhat lower among compliant than among non-compliant subjects (data not shown).

Salt was commonly used in the foods provided to the children, particularly after 6–9 mo. The percentage using salt between 6 and 24 mo increased from 71% to 99% in Brazil, 48% to 100% in Ghana, 82% to 100% in India, 2% to 80% in Norway, 40% to 100% in Oman, and 0% to 36% in the USA. Of those using salt in food, over 93% used iodized salt, except in Norway where 8–17% used non-iodized salt at 12–24 mo.

Use of nutrient supplements varied greatly by site. Table IV shows the percentage of children in the compliant group who received supplements that contained one or more of the specified nutrients. The fat-soluble vitamins A, D and E are often combined in one supplement for infants, and this combination was commonly used in Norway throughout the age range 6–24 mo (73–80% of children). Vitamins A and D were taken by 30–35% of children in Ghana and 12–40% of children in India. Between 12 and 44% of children in Norway, Ghana and India also used supplements containing vitamins C, B$_1$, B$_2$ and B$_6$. In Norway folate was taken by 15–22% of children, in Ghana niacin was taken by 23–29% of

Table II. Twenty-four-hour dietary intake (prevalence and median) from selected food subgroups by compliant children at 6–24 mo.

Food subgroups	Age (mo)	Sites						
		Brazil (n =69)	Ghana (n =228)	India (n =173)	Norway (n =159)	Oman (n =153)	USA (n =121)	All (n =903)
Grains	6	24.6 (1)	88.6 (3)	86.1 (2)	79.2 (1)	85.6 (2)	73.6 (1)	79.1 (2)
	9	59.4 (2)	94.3 (4)	97.7 (3)	97.5 (3)	94.8 (2)	93.4 (2)	92.8 (3)
	12	85.5 (3)	97.4 (4)	100.0 (4)	100.0 (3)	97.4 (3)	97.5 (3)	97.5 (3)
	18	95.7 (4)	98.7 (4)	97.1 (4)	98.1 (4)	98.7 (3)	99.2 (4)	98.1 (4)
	24	97.1 (3)	97.8 (4)	99.4 (4)	98.7 (3)	100.0 (4)	97.5 (4)	98.6 (4)
Legumes & nuts	6	5.8 (1)	20.2 (2)	35.3 (1)	0.0 (0)	10.5 (1)	0.8 (1)	14.2 (1)
	9	39.1 (1)	36.4 (2)	70.5 (1)	1.3 (1)	11.8 (1)	9.1 (1)	29.1 (1)
	12	43.5 (2)	38.6 (1)	87.3 (1)	3.8 (1)	15.7 (1)	33.9 (1)	37.7 (1)
	18	60.0 (2)	45.2 (1)	87.9 (2)	2.5 (1)	17.6 (1)	43.0 (1)	42.0 (1)
	24	56.5 (1)	47.4 (1)	90.8 (2)	5.7 (1)	20.9 (1)	43.0 (1)	44.0 (1)
Tubers	6	5.8 (1)	9.2 (1)	12.1 (1)	10.7 (1)	47.7 (1)	3.3 (1)	15.5 (1)
	9	18.8 (1)	39.0 (1)	38.2 (1)	30.2 (1)	45.8 (1)	11.6 (1)	33.2 (1)
	12	23.2 (1)	49.6 (1)	50.9 (1)	33.3 (1)	45.8 (1)	21.5 (1)	40.5 (1)
	18	38.6 (1)	55.7 (1)	59.0 (1)	44.0 (1)	51.0 (1)	21.5 (1)	47.6 (1)
	24	37.7 (1)	64.5 (1)	59.5 (1)	46.5 (1)	55.6 (1)	22.3 (1)	51.2 (1)
Milk (dairy) products	6	20.3 (1)	59.2 (2)	64.2 (2)	13.2 (1)	49.7 (1)	9.1 (2)	40.8 (2)
	9	75.4 (1)	73.2 (2)	82.7 (2)	33.3 (1)	73.2 (2)	43.0 (2)	64.1 (2)
	12	75.4 (2)	76.3 (2)	89.6 (3)	82.4 (2)	83.0 (2)	86.0 (2)	82.3 (2)
	18	91.4 (4)	89.9 (2)	92.5 (4)	95.6 (4)	94.1 (3)	97.5 (4)	93.3 (3)
	24	88.4 (4)	93.0 (2)	96.0 (4)	95.6 (4)	94.1 (4)	97.5 (3)	94.5 (3)
Flesh foods	6	2.9 (1)	11.4 (1)	0.0 (0)	3.1 (1)	26.8 (1)	1.7 (1)	8.4 (1)
	9	10.1 (1)	70.6 (2)	2.3 (1)	42.1 (1)	63.4 (1)	26.4 (1)	40.8 (1)
	12	50.7 (2)	81.1 (2)	6.4 (1)	66.7 (1)	77.8 (1)	59.5 (1)	58.5 (1)
	18	65.7 (2)	91.2 (2)	9.2 (1)	79.9 (2)	84.3 (1)	69.4 (1)	67.5 (2)
	24	81.2 (1)	93.9 (2)	11.0 (1)	80.5 (2)	77.8 (1)	76.9 (1)	69.7 (2)
Eggs	6	2.9 (1)	4.4 (1)	3.5 (1)	0.0 (0)	7.8 (1)	0.0 (0)	3.3 (1)
	9	7.2 (1)	13.2 (1)	8.1 (1)	1.9 (1)	22.2 (1)	5.8 (1)	10.3 (1)
	12	8.7 (1)	27.2 (1)	13.9 (1)	3.1 (1)	31.4 (1)	18.2 (1)	18.5 (1)
	18	27.1 (1)	35.5 (1)	26.0 (1)	5.7 (1)	42.5 (1)	21.5 (1)	27.1 (1)
	24	26.1 (1)	39.0 (1)	33.5 (1)	8.8 (1)	47.1 (1)	19.0 (1)	30.3 (1)
Vitamin A-rich fruits and vegetables[a]	6	–	7.5 (1)	15.0 (1)	7.5 (1)	38.6 (1)	34.7 (1)	17.3 (1)
	9	–	46.9 (1)	32.4 (1)	32.7 (1)	56.9 (1)	69.4 (1)	42.7 (1)
	12	–	53.9 (1)	31.8 (1)	29.6 (1)	46.4 (1)	78.5 (2)	43.3 (1)
	18	–	69.7 (2)	38.7 (1)	35.8 (1)	36.6 (1)	79.3 (2)	48.1 (1)
	24	–	73.2 (2)	38.7 (1)	34.6 (1)	37.3 (1)	75.2 (1)	48.4 (1)
Other fruits and vegetables	6	73.9 (1)	11.4 (1)	52.6 (1)	23.9 (1)	39.9 (1)	37.2 (1)	34.6 (1)
	9	71.0 (1)	68.9 (1)	73.4 (1)	67.9 (1)	62.1 (1)	84.3 (2)	70.7 (1)
	12	76.8 (2)	78.9 (2)	85.0 (2)	79.9 (2)	69.9 (1)	89.3 (2)	80.0 (2)
	18	75.7 (2)	94.3 (2)	87.9 (2)	84.3 (2)	81.7 (1)	90.9 (2)	87.3 (2)
	24	72.5 (2)	94.7 (2)	91.9 (2)	78.0 (2)	83.7 (2)	89.3 (2)	86.9 (2)
Juice	6	27.5 (1)	9.2 (1)	19.7 (1)	0.6 (1)	45.1 (1)	3.3 (1)	16.4 (1)
	9	49.3 (1)	19.3 (1)	15.6 (1)	5.7 (1)	46.4 (1)	20.7 (1)	23.3 (1)
	12	52.2 (2)	24.6 (1)	20.2 (1)	12.6 (1)	60.8 (1)	43.0 (1)	32.3 (1)
	18	55.7 (1)	29.8 (1)	17.3 (1)	27.7 (1)	56.9 (1)	50.4 (2)	36.4 (1)
	24	40.6 (1)	44.7 (1)	29.5 (1)	39.0 (1)	63.4 (1)	65.3 (1)	46.4 (1)
Sweet beverages	6	23.2 (1)	1.8 (1.5)	1.7 (1)	6.3 (1)	4.6 (1)	0.0 (0)	4.4 (1)
	9	14.5 (1)	6.1 (1)	6.4 (1)	11.3 (1)	5.2 (1)	0.0 (0)	6.8 (1)
	12	34.8 (1.5)	11.8 (1)	9.8 (1)	24.5 (1)	11.8 (1)	8.3 (1)	15.0 (1)
	18	48.6 (2)	17.5 (1)	16.2 (1)	44.0 (1)	25.5 (1)	33.9 (1)	27.9 (1)
	24	1.4 (3)	25.4 (1)	23.1 (1)	59.7 (1)	35.9 (1)	51.2 (1)	34.4 (1)
Soup	6	66.7 (1)	4.4 (1)	12.1 (1)	0.0 (0)	38.6 (1)	0.0 (0)	15.1 (1)
	9	63.8 (2)	26.3 (1)	10.4 (1)	1.9 (1)	42.5 (1)	0.8 (1)	21.2 (1)
	12	47.8 (2)	34.2 (1)	8.7 (1)	2.5 (1)	40.5 (1)	3.3 (1)	21.7 (1)
	18	37.1 (1)	39.0 (1)	5.2 (1)	6.9 (1)	30.1 (1)	5.0 (1)	20.7 (1)
	24	21.7 (1)	34.2 (1)	10.4 (1)	9.4 (1)	26.1 (1)	2.5 (1)	18.7 (1)

Table II (*Continued*)

Food subgroups	Age (mo)	Brazil (*n* =69)	Ghana (*n* =228)	India (*n* =173)	Norway (*n* =159)	Oman (*n* =153)	USA (*n* =121)	All (*n* =903)
				Sites				
Fats & oils	6	0.0 (0)	6.6 (1)	15.6 (1)	2.5 (1)	1.3 (1)	0.0 (0)	5.3 (1)
	9	0.0 (0)	59.2 (1)	32.9 (1)	36.5 (1)	3.9 (2)	0.8 (2)	28.5 (1)
	12	0.0 (0)	72.8 (2)	45.1 (1)	64.2 (2)	2.0 (1)	10.7 (1)	40.1 (1)
	18	0.0 (0)	89.5 (2)	45.1 (1)	81.8 (2)	3.9 (1)	22.3 (1)	49.2 (2)
	24	2.9 (1)	94.3 (2)	43.4 (1)	83.6 (2)	4.6 (1)	19.8 (1)	50.5 (2)

[a] In Brazil, vitamin A-rich fruits and vegetables were not separated from other types of fruits and vegetables.

children, and in India vitamin B_{12} was taken by 10–17% of children. In Brazil, Oman and the USA, use of vitamin supplements was rare (generally <10%). Use of mineral supplements was rare except for iron in Brazil (7–19% of children) and iron and zinc in India (9–13% of children). Among non-compliant subjects, use of nutrient supplements was generally similar to the patterns observed for compliant subjects.

Discussion

These results document that the complementary feeding practices for the subjects included in the "compliant" group for the MGRS were generally consistent with the recently published *Guiding Principles for Complementary Feeding of the Breastfed Child* [6].

The overall mean age of introduction of solid or semi-solid foods was 5.4 mo, with relatively little variability across sites. The MGRS was initiated before the WHO policy on the optimal duration of exclusive breastfeeding was changed in 2001 from "4–6 months" to "6 months" [15,16], although in three of the six sites (Brazil, Ghana and India)

national policy recommended 6 mo. The two highest mean values for age of introduction of complementary foods were in two of these three sites (5.8 mo in Ghana and 5.6 mo in Brazil), though the means in Norway (5.5 mo) and the USA (5.4 mo) were not much lower. The lowest mean value was in Oman (4.8 mo), where the policy at the time was to recommend introduction at 5 mo. It should be noted that these mean values are biased towards older ages because the actual age of introduction of solid or semi-solid foods could have occurred up to a month prior to the date of the interview.

Solids or semi-solids were fed on average about twice per day at 6 mo, three times per day at 9 mo, four times per day at 12 mo and 4–5 times per day at 14–24 mo. These means are consistent with the recommendations in the *Guiding Principles*, which state that breastfed infants should be given meals of complementary foods 2–3 times per day at 6–8 mo and 3–4 times per day at 9–11 and 12–24 mo, with additional nutritious snacks offered 1–2 times per day as desired [6].

There was considerable variability in the types of food consumed by children in each of the sites, which

Table III. Mean and median dietary diversity index[a] at selected ages.

Age (mo)		Brazil (*n* = 69)	Ghana (*n* = 228)	India (*n* = 173)	Norway (*n* = 159)	Oman (*n* = 153)	USA (*n* = 121)	All (*n* = 903)
				Sites				
6	Mean (SD)	1.4 (0.8)	2.2 (1.3)	2.8 (1.3)	1.3 (0.9)	2.9 (1.3)	1.6 (1.0)	2.1 (1.3)
	Median (min., max.)	1.0 (0,4)	2.0 (0,7)	3.0 (0,7)	1.0 (0,4)	3.0 (0,7)	2.0 (0,4)	2.0 (0,7)
9	Mean (SD)	2.8 (1.0)	4.7 (1.8)	4.1 (1.2)	3.2 (1.5)	4.1 (1.2)	3.3 (1.3)	3.9 (1.5)
	Median (min., max.)	3.0 (0,5)	5.0 (0,8)	4.0 (0,7)	3.0 (0,7)	4.0 (0,7)	3.0 (0,6)	4.0 (0,8)
12	Mean (SD)	3.5 (1.3)	5.3 (1.6)	4.6 (1.1)	4.3 (1.2)	4.4 (1.2)	4.8 (1.2)	4.6 (1.4)
	Median (min., max.)	4.0 (0,6)	6.0 (0,8)	5.0 (2,7)	4.0 (2,7)	4.0 (0,7)	5.0 (0,8)	5.0 (0,8)
18	Mean (SD)	4.3 (1.1)	6.2 (1.2)	4.9 (1.3)	4.9 (1.1)	4.7 (1.0)	5.3 (1.0)	5.2 (1.3)
	Median (min., max.)	4.0 (0,6)	6.0 (0,8)	5.0 (0,8)	5.0 (0,7)	5.0 (0,7)	5.0 (3,8)	5.0 (0,8)
24	Mean (SD)	4.3 (1.2)	6.3 (1.3)	5.1 (1.0)	4.9 (1.2)	4.8 (1.0)	5.3 (1.2)	5.3 (1.3)
	Median (min., max.)	4.0 (0,6)	6.0 (0,8)	5.0 (2,8)	5.0 (0,7)	5.0 (2,8)	5.0 (0,8)	5.0 (0,8)

[a] Dietary diversity index: the sum (1 =yes, 0 =no) of eight food groups (seven food groups for Brazil): 1) grains and tubers; 2) legumes and nuts; 3) milk products; 4) flesh foods; 5) eggs; 6) vitamin-A rich fruits and vegetables; 7) other fruits and vegetables and juices; 8) fats and oils.
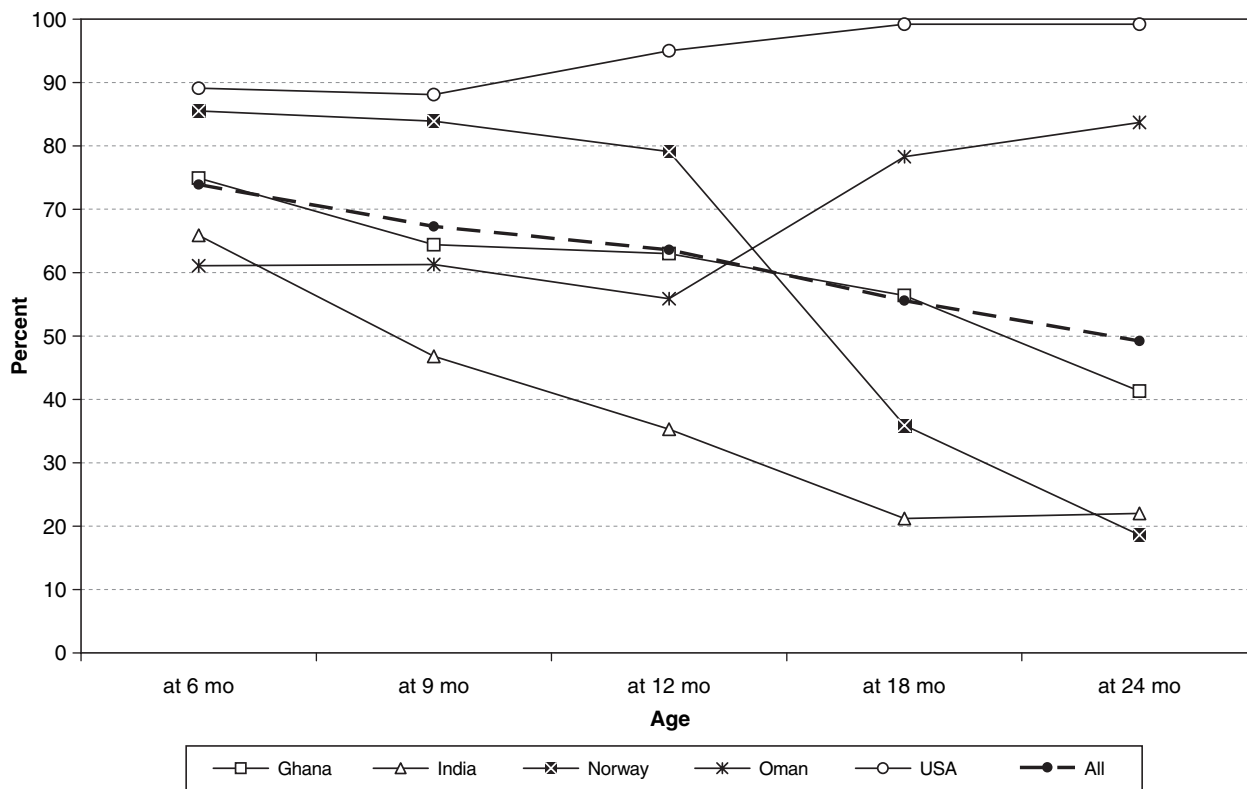
Figure 3. Percentage of compliant children consuming iron-fortified foods at selected ages.

is not surprising given the cultural differences in food habits across countries. Nonetheless, there were certain commonalities that indicate that the diets were generally of high nutritional quality in all sites. For example, in the second year of life, >75% of children in each site consumed milk products and fruits/vegetables, and 50–95% consumed meat, poultry or fish (except in India) on the day of the recall. These dietary characteristics reflect the high socio-economic status of the subjects included in the MGRS. Some of the differences across sites may be due to variability in the complementary feeding guidelines that parents were given, either from the MGRS staff or from healthcare providers. For example, advice to avoid potentially allergenic foods such as eggs and nuts (in families with a history of allergy, though this caveat is not always added by healthcare providers) was given in Norway, Oman and the USA, which may explain the lower percentage of children with intake from the egg (except Oman) and legumes/nuts food groups in these sites, at least during the first year of life. The guidelines in these three sites also advised limiting the intake of juice, which may account for the low frequency of juice consumption at 6–9 mo in Norway and the USA (though this was not evident in Oman). In addition, the guidelines in Norway advised against adding salt to foods for infants, and the rates of salt usage during the first year of life were correspondingly low in that site

(though they were also low in the USA, which may reflect general public concern about excessive salt intake).

Median dietary diversity on the day of the recall increased from two food groups at 6 mo to five food groups (out of a maximum of eight) at 12–24 mo. Using the same dietary diversity indicator [14], the values at 9–12 mo (generally 4–5 food groups) are higher than the averages observed for low-income populations in Peru (3.7 food groups), Ghana (3.4 food groups) and Bangladesh (2.1 food groups). This indicates that MGRS subjects generally consumed a varied diet, which on any given day typically included fruits and/or vegetables and at least one type of animal-source food, in addition to the usual staple foods. Dietary diversity is correlated with nutritional adequacy of the complementary food diet at this age ($r = 0.4$–0.7) [14].

Use of fortified foods and nutrient supplements varied greatly across sites. Most infants received iron-fortified foods at 6 mo, but the percentage continuing to receive such foods through the first and second years of life was not consistently high. This probably reflects the lack of uniform policies about the recommended duration of use of such products for infants and toddlers. Vitamin supplements (which included vitamin D) were commonly given in Norway, presumably because of recommendations that breastfed infants in populations at high latitudes receive an

Table IV. Percentages of compliant children who received supplements at selected ages.

Supplement	Age (mo)	Brazil (*n* = 69)	Ghana (*n* = 228)	India (*n* = 173)	Norway (*n* = 159)	Oman (*n* = 153)	USA (*n* = 121)	All (*n* = 903)
					Sites			
Vitamin A	6	8.7	29.8	39.3	78.6	2.6	0.0	30.0
	9	7.2	35.1	28.9	80.5	11.8	1.7	31.3
	12	13.0	36.4	24.3	78.0	2.6	2.5	29.3
	18	2.9	30.3	18.5	74.2	1.3	5.0	25.3
	24	1.4	33.8	12.1	74.8	0.7	14.0	26.1
Vitamin D	6	8.7	29.8	39.9	78.6	2.0	0.0	30.0
	9	7.2	35.1	30.6	80.5	0.7	1.7	29.8
	12	13.0	36.4	26.0	80.5	2.0	2.5	30.0
	18	4.3	32.0	25.4	76.7	0.7	5.0	27.5
	24	1.4	34.2	16.8	77.4	0.7	14.0	27.6
Vitamin E	6	4.3	7.0	25.4	77.4	0.0	0.0	20.6
	9	1.4	9.2	19.1	78.6	0.7	0.0	20.0
	12	4.3	7.9	15.6	77.4	0.0	1.7	19.2
	18	2.9	7.0	8.1	73.0	0.0	3.3	16.8
	24	0.0	7.5	5.2	76.1	0.0	11.6	17.8
Vitamin C	6	2.9	26.3	34.1	20.8	3.3	0.0	17.6
	9	5.8	31.1	23.1	30.2	1.3	1.7	18.5
	12	8.7	31.1	19.7	28.9	3.3	2.5	18.3
	18	5.7	27.6	18.5	29.6	0.7	6.6	17.1
	24	1.4	25.0	12.1	32.7	2.0	15.7	16.9
Vitamin B_1	6	2.9	26.3	43.9	21.4	3.3	0.0	19.6
	9	5.8	36.4	31.8	30.2	1.3	0.0	21.3
	12	7.2	33.3	27.7	28.9	3.3	1.7	20.2
	18	7.1	39.9	22.5	29.6	0.7	2.5	20.6
	24	0.0	36.0	15.6	32.7	2.0	9.9	19.5
Vitamin B_2	6	2.9	25.9	43.9	21.4	3.3	0.0	19.5
	9	5.8	35.5	31.2	30.2	1.3	0.0	20.9
	12	7.2	32.5	27.2	28.9	3.3	1.7	19.8
	18	7.1	38.6	22.0	29.6	0.7	2.5	20.1
	24	0.0	32.9	16.2	32.7	2.0	10.7	18.9
Vitamin B_6	6	2.9	25.9	43.9	20.8	2.6	0.0	19.3
	9	1.4	36.0	30.6	30.2	1.3	0.0	20.6
	12	4.3	32.9	26.0	28.9	2.6	1.7	19.4
	18	4.3	38.6	22.5	29.6	0.7	2.5	20.0
	24	1.4	36.0	16.2	32.7	2.0	11.6	19.9
Vitamin B_{12}	6	2.9	2.6	12.1	5.7	0.0	0.0	4.2
	9	5.8	7.9	9.8	8.2	0.7	0.0	5.9
	12	7.2	9.2	13.3	8.8	0.0	0.8	7.1
	18	7.1	17.1	16.8	11.3	0.0	3.3	10.5
	24	0.0	19.3	15.0	14.5	0.7	10.7	11.8
Folate	6	2.9	0.0	8.7	15.7	0.0	0.0	4.7
	9	1.4	0.9	8.7	22.0	0.0	0.0	5.9
	12	4.3	1.3	6.9	20.1	0.0	0.0	5.5
	18	2.9	3.1	4.0	19.5	0.0	2.5	5.5
	24	1.4	3.1	5.2	20.1	0.7	9.9	6.9
Niacin	6	2.9	22.8	0.0	6.3	3.3	0.0	7.6
	9	5.8	29.4	0.0	8.2	1.3	0.0	9.5
	12	7.2	28.1	0.0	8.8	3.3	1.7	10.0
	18	7.1	28.5	0.0	11.3	0.7	2.5	10.2
	24	1.4	25.9	0.0	14.5	2.0	10.7	11.0
Iron	6	7.2	1.8	13.9	0.6	0.7	0.0	3.9
	9	17.4	4.4	9.2	0.0	0.7	0.8	4.4
	12	18.8	3.9	13.3	0.0	1.3	4.1	5.8
	18	10.0	6.1	9.8	1.3	1.3	2.5	5.0
	24	8.7	7.5	8.7	0.6	0.7	9.9	5.8

Table IV (*Continued*)

Supplement	Age (mo)	Brazil (n = 69)	Ghana (n = 228)	India (n = 173)	Norway (n = 159)	Oman (n = 153)	USA (n = 121)	All (n = 903)
					Sites			
Zinc	6	2.9	0.4	12.1	0.6	0.0	0.0	2.8
	9	1.4	0.9	12.1	0.0	0.0	0.0	2.7
	12	4.3	1.8	11.0	0.0	0.0	0.0	2.9
	18	2.9	4.8	10.4	1.3	0.0	2.5	4.0
	24	0.0	5.3	8.7	1.3	0.7	7.4	4.3
Iodine	6	0.0	0.0	1.2	0.6	0.0	0.0	0.3
	9	0.0	0.0	0.6	0.0	0.0	0.0	0.1
	12	1.4	0.0	0.6	0.0	0.0	0.0	0.2
	18	0.0	0.0	1.7	1.3	0.0	2.5	0.9
	24	0.0	0.0	0.0	1.3	0.0	6.6	1.1
Calcium	6	2.9	0.4	2.9	0.6	0.0	0.0	1.0
	9	1.4	0.9	2.9	0.6	0.0	0.0	1.0
	12	4.3	0.4	2.9	0.6	0.0	0.8	1.2
	18	5.7	0.4	6.9	0.6	0.0	2.5	2.3
	24	0.0	1.8	5.2	1.3	0.7	6.6	2.7

external source of vitamin D. Vitamin supplements were given to up to 40% of children in Ghana and India but were rarely used in Brazil, Oman and the USA. Mineral supplements were not commonly used in any of the sites.

In general, except for practices that were related to the reasons for non-compliance—introduction of solid or semi-solid foods at an earlier age, fewer "milk-only" meals because of a lower frequency of breastfeeding, and greater consumption of milk products other than breast milk—there were few substantive differences in complementary feeding practices between the compliant and non-compliant subjects of the MGRS. This indicates that the compliant group was not an "atypical" subset of the overall MGRS sample with respect to most complementary feeding practices among the relatively economically well-off groups that we studied.
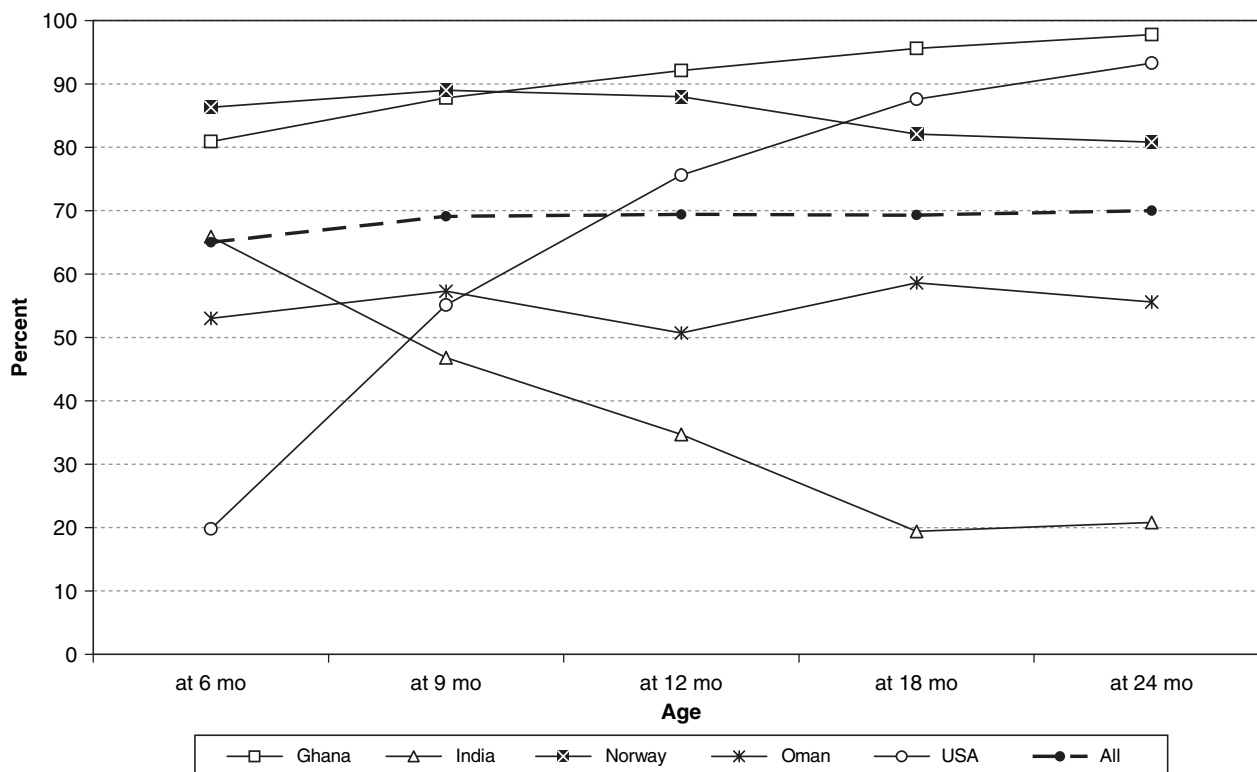

Figure 4. Percentage of compliant children consuming vitamin A-fortified foods at selected ages.

To summarize, these results indicate that the complementary food diets of children in the MGRS were generally of high quality. Global recommendations for complementary feeding stress the need for frequent intake of animal-source foods as well as fruits and vegetables [6]. After the initial period of ∼6–9 mo, when new foods were still being introduced, the majority of children consumed animal-source foods and fruits and vegetables on the day of each dietary recall in all of the MGRS sites. Dietary diversity was relatively high and meal frequency was in accord with global guidelines. The majority of children received iron-fortified complementary foods during the first year of life, and many continued to receive them during the second year of life. Thus, the risk of nutritional deficiencies was low. We conclude that the complementary food patterns of MGRS subjects were adequate to support physiological growth.

Acknowledgements

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