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Complementary Feeding and Diarrhea and Respiratory Infection Among HIV-exposed Tanzanian Infants

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Abstract

Objective—To examine the association between complementary feeding (CF) and risks of diarrhea and acute respiratory infection (ARI) among HIV-exposed infants aged 6–24 months.

Design—We prospectively employed an Infant and Child Feeding Index (ICFI) to measure CF practices (breastfeeding status, food consistency, dietary diversity, food group frequency and meal frequency). We determined the association of ICFI and each of its components with the risk of diarrhea and ARI. Generalized estimating equations (GEE) were used to estimate the relative risks for morbidity episodes.

Setting—Dar es Salaam, Tanzania.

Subjects—2092 HIV-exposed infants followed from 6 months of age to 24 months of age.

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Authors Contributions: PK: analysis plan, data analysis, interpretation of analysis results, and writing this article; CD, KPM, DS, WWF (Principal Investigator): contributed to the study design of the original trial of multivitamins study, the present study being a secondary analysis of data collected in the trial of multivitamins; EL, EH, DS, WWF: provided statistical guidance in data analysis; RK, RRR: study design, data collection and daily management of the field study; SA: contributed to the study implementation in the field, in the laboratory.

Results—The ICFI score ranged from 0 to 9; the median score was 6 (Inter-Quartile Range; IQR=4, 7). Low ICFI scores were likely associated with increased risk of dysentery (low vs. high tertile Risk Ratio, RR: 1.40; 95% CI: 0.93, 2.10; P for trend=0.02) and respiratory infection (low vs. high tertile RR: 1.16; 95% CI: 0.96, 1.41; P for trend=0.01). Low dietary diversity scores were likely associated with higher risk of dysentery (low vs. high tertile RR: 1.47; 95% CI: 0.92, 2.35; P for trend=0.03) and respiratory infection (low vs. high tertile RR: 1.41; 95% CI: 1.13, 1.76; P for trend=0.01). Low food consistency scores were associated with higher risk of respiratory infection (RR: 1.77; 95% CI: 1.40, 2.26; P<0.01).

Conclusions—In this setting, low ICFI, dietary diversity and food consistency scores were likely associated with increased risk of diarrhea and acute respiratory infection among HIV-exposed infants.

Introduction

Diarrhea and acute respiratory infections (ARI) are among the leading causes of death among under-fives⁽¹⁾, the global burden disproportionately affecting children in low- and middle- income countries⁽²⁾. The risk of morbidity and mortality is higher for HIV-exposed children^(3–7) who are estimated to be born at a global rate of over one million annually, chiefly in resource-limited settings⁽⁸⁾.

Adequate nutrition during infancy is fundamental as the period from birth to two years age is a “critical window” for the promotion of optimal growth and behavioral development⁽⁹⁾. Undernutrition compromises immune function and predisposes to infections⁽¹⁰⁾. Particular nutrients (such as Vitamin A, iron and zinc) are required for optimal immune response, and deficiencies in one or more of these diminish immune function and provide a window of opportunity for infectious agents⁽¹⁰⁾. Breastfeeding plays a role in protection against childhood infections⁽¹⁰⁾. WHO recommends that HIV-infected mothers take antiretroviral (ARV) drugs and exclusively breastfeed (EBF) for six months, then introduce appropriate complementary foods and continue breastfeeding at least until the child’s first birthday⁽²⁾. Thus, beyond six months of age, adequate complementary feeding (CF) is crucial for the overall health and survival of the HIV-exposed child. However, there is limited information on the impact of CF practices on the incidence of acute infections such as diarrhea and ARI in this vulnerable population.

Quantifying CF practices and assessing their association with child health outcomes has been limited since these practices include a series of inter-related behaviours that must be considered simultaneously and are, therefore, difficult to summarize into one or a few variables that accurately reflect them^(11, 12). An age-specific scoring system, the infant and child feeding index (ICFI) was developed by Ruel and Menon to examine the effect of child feeding practices on stunting in Latin America⁽¹¹⁾. The score has since been adapted by investigators in various settings^(13–17).

Most studies based on HIV-exposed children’s data in sub-Saharan Africa have focused on single feeding behaviours such as EBF^(18–22). To our knowledge, no other study has employed a longitudinal analysis using the ICFI to assess the relation of CF practices to the risk of diarrhea and ARI in this subpopulation.

We examined the relation of CF practices as measured by the ICFI with the risk of diarrhea and ARI among HIV-exposed infants who participated in a randomized controlled trial of micronutrients in Tanzania.

Methods

Study design and population

Detailed descriptions of the trial design and follow-up procedures have been published elsewhere^(23, 24). Briefly, between 2004 and 2007, HIV-exposed infants whose mothers were residents of Dar es Salaam, Tanzania were enrolled in a randomized, double-blind, placebo-controlled trial of micronutrients and followed for 24 months. The trial aimed to evaluate whether direct supplementation of micronutrients to HIV-exposed infants reduces morbidity and mortality. Eligibility for infant participation in the trial included singleton birth, aged 5–7 weeks at randomization.

Data Collection

At baseline, information on demographic characteristics including maternal age, occupation, and education was collected through structured interviews. Maternal and child anthropometry were measured monthly using standardized procedures and calibrated instruments.

Laboratory Methods

All children were tested for HIV infection at 6 weeks age by using the Amplicor HIV-1 DNA assay version 1.5 (Roche Molecular Systems Inc). Tests at 18 mo of age were performed by using HIV ELISAs followed by Enzygnost anti-HIV-1/2 Plus (Dade Behring). Discordant results were resolved by using a Western blot test. Children who were HIV-negative at 18 months and still breastfed were tested again before they were discharged from the study after 24 months of follow-up. Maternal blood specimens were requested at baseline to measure complete blood counts and T-cell subset counts. Complete blood counts and T-cell subset counts were measured for children at baseline and every six months thereafter⁽²⁴⁾.

Assessment and Definition of Infant Feeding

At monthly clinic visits, women were asked about infant feeding practices in the prior week including breastfeeding status and frequency and introduction of other foods. Mothers were counseled on risks and benefits of EBF in keeping with contemporaneous WHO recommendations.

Infant and Child Feeding Index—CF was measured using a composite index combining multiple dimensions of child feeding practices based on current infant and young child feeding recommendations^(12, 26) and previous work on the subject. We defined the score for 3 age groups: 6–8 months, 9–11 months and 12–24 months. The index consisted of five components: current breastfeeding status, complementary food consistency, dietary diversity score (DDS), food group frequency score (FGFS) and meal frequency score (MFS),

attributed in a manner reflecting the age change over the study period. Table 1 summarizes the variables and scoring system used to create the ICFI by age group.

Current Breastfeeding—A score of +1 was given to breastfeeding children while a score of 0 was given to non-breastfeeding children at all ages.

Complementary Food Consistency—Like a previous study⁽¹³⁾, we replaced the bottle feeding component used in Ruel and Menon's ICFI⁽¹¹⁾ with food consistency since we lacked data on the use of bottles for feeding. WHO recommends gradually increasing food consistency as the infant gets older. This component was defined as the thickest consistency of complementary food the child received in the previous week. For 6–8 month old infants, liquid food was scored as 0, gruel-like food such as porridge +1, and semi-solid or solid foods +2. For older children, liquid or gruel-like foods, semi-solid foods, and solid foods were scored as 0, +1, and +2, respectively. In the analysis, we combined the low (0) and medium (+1) categories since the numbers of visits in the low category were very small.

Dietary Diversity Score—WHO recommends that children aged 6–23 months receive a minimum of four food groups in the previous day. DDS was based on the number of food groups consumed in the previous day. We categorized food items into four food groups: 1) cereals; 2) dairy (cow's milk, milk powder and infant formula); 3) flesh foods (example meat, fish); (4) fruits and vegetables. Each food group consumed in the previous day was scored as 1. These scores were summed to give a possible range of 0–4 then categorized for each age-group, based on tertiles. Consuming 0 to 2 food groups in the previous day was categorized as a DDS score of 0 (low), 3 food groups +1 (medium) and 4 food groups +2 (high).

Food Group Frequency Score—FGFS was based on the frequency of infant consumption of the four food groups over the previous week. Each food group scored 0 if not consumed during the previous week, +1 if consumed on 1 to 3 days and +2 if consumed on 4 days or more^(13–16). These scores were summed to give a possible range of 0–8 then new scores were assigned for each age-group, based on tertiles.

Meal Frequency Score—MFS was based on current WHO feeding recommendations, according to which 6–8 month old breastfed children should receive soft, semi-solid or solid foods at least twice a day and 9–23 month old breastfed children at least thrice a day⁽²⁴⁾; while non-breastfed children aged 6–23 months should receive soft, semi-solid or solid foods (including milk feeds) four to five times a day^(12, 26).

The final ICFI was a summation of the scores obtained for each component and ranged from 0 to 9 for the three age groups. For each age group, the feeding index was grouped into tertiles to form three categories: low, medium and high.

Assessment and Definition of Outcomes

At monthly visits, women were asked to report occurrence of any signs of respiratory illness, diarrhea and fever on the day of clinic visit and during the previous month. Every three months, and/or when acute complaints of illness were noted, children underwent a physical

examination and medical treatment by study physicians. Mothers were encouraged to present to the study clinic for a sick visit including a physician exam when the child was unwell.

We defined the respiratory endpoint as the occurrence of cough plus at least one additional symptom: difficult breathing, chest retractions or refusal to feed. Diarrhea was defined as three or more watery stools in a 24-hour period in the previous month. Diarrhea episodes were defined as acute if they occurred for one or more days but less than 14 days or persistent (lasting 14 days or more). If mucus or blood was present, episodes of acute diarrhea were classified as dysenteric; other episodes were categorized as watery diarrhea. Since few children had persistent diarrhea, it was not analyzed herein.

Statistical Analyses

In total, 2387 singleton children were born alive to HIV-infected women in the randomized trial. Of these, 273 lacked data in the relevant age period and 22 lacked data on infant feeding, leaving 2092 children available for this analysis.

Separate analyses of associations of ICFI and each of its components with the incidence of diarrhea and respiratory infection episodes were performed using generalized estimating equations in the GENMOD procedure of the Statistical Analysis Systems package version 9.3 (SAS Institute)⁽²⁷⁾. The binomial distribution with the log link function and a working exchangeable covariance structure was specified for repeated measures⁽²⁸⁾. Potential confounders were selected a priori and included maternal socioeconomic and health factors, and child nutrition factors associated with child morbidity. Covariates with $P < .2$ in univariate analysis were included in multivariate models⁽²⁹⁾. No adjustments were made for multiple testing. Missing data for covariates were retained in the analysis using the missing indicator method for variables missing $>1\%$ of the observations⁽³⁰⁾. ICFI and its components were treated as time-varying variables as were seasons, maternal: body mass index (BMI), CD4 cell count, hemoglobin levels, and child's: age, nutritional status indicators, HIV-infection status, CD4 cell percentage, and hemoglobin levels. Covariates were lagged by one visit. Stepwise regression was performed to identify which of ICFI's components drove its association with morbidity, variables were added and deleted based on the robust score test. Effect estimates were risk ratios (RR) and their corresponding 95% confidence intervals. For ICFI and its components (excluding breastfeeding and food consistency), we reported P values from trend tests using the underlying score variables. All P values were 2-sided and $P < 0.05$ was considered statistically significant.

Institutional approval was granted by the Harvard T.H. Chan School of Public Health Human Subjects Committee, the Muhimbili University of Health and Allied Sciences Committee of Research and Publications, the Tanzanian National Institute of Medical Research, and the Tanzanian Food and Drugs Authority.

Results

Of the 2092 children, 54% were male (Table 2). At enrollment, 8% of the children were HIV infected. Of 1919 children not known to be HIV-infected at 6 weeks of age, 3.8% were

diagnosed with HIV infection by the end of follow-up. Most (86%) were exclusively breastfed; median breastfeeding duration was 4.4 months (IQR: 3, 6.3). At six weeks post-partum, 12% of the mothers were in the WHO HIV disease stage III or IV.

The ICFI score ranged from 0 to 9, the median score was 6 (IQR: 4, 7); age-group median ICFI scores were 7, 7 and 5 for 6–8, 9–11 and 12–24 month old infants, respectively. With increasing age, breast feeding decreased and more children received foods of thicker consistency (Table 3). A dietary diversity of four food groups in the previous 24 hours was reported in 50%, 62% and 49% visits at 6–8, 9–11 and 12–24 months, respectively. Minimum meal frequency conforming to WHO recommendations was reported in 40%, 33% and 4% visits at 6–8, 9–11 and 12–24 months, respectively.

Median follow-up duration was 16.2 months (IQR: 10.4, 17.5); there was no differential loss-to-follow-up by ICFI or its components. ICFI was not associated with the number of missed visits or with mortality. The incidence rates of AWD, dysentery and ARI were 0.51, 0.15 and 0.30 episodes/child-year, respectively. Occurrence of dysentery was significantly lower in the harvest season (June–September) while ARI was lower in the long rains (April–May) and harvest seasons and higher in the short rains season (October–November). AWD showed no seasonality. ICFI scores were significantly lower in the harvest and the short rains seasons.

In multivariate regression, for every unit increase in the ICFI score, there were 9% and 5% reduction in the risks of dysentery (RR:0.91; 95% CI:0.83, 0.99; P=0.02) and ARI (RR:0.95; 95% CI:0.91, 0.99; P=0.01), respectively. Low ICFI scores were likely associated with increased risk of dysentery (low versus high tertile RR 1.40, 95% CI: 0.93, 2.10; P for trend=0.02) and ARI (low versus high tertile RR 1.16, 95% CI: 0.96, 1.41; P for trend=0.01) (Table 4). Using stepwise regression we determined that FGFS drove the association between the ICFI and dysentery (P=0.02) and food consistency drove the association between the ICFI and ARI (P<0.01).

Breastfeeding at six months age and beyond was not significantly associated with morbidity (Table 5). However, on adding the DDS component into the breastfeeding model, breastfeeding was protective of ARI (RR: 0.60; 95% CI: 0.37, 0.97; P=0.04). Low DDS were likely associated with increased risk of dysentery (low versus high tertile RR 1.47, 95% CI: 0.92, 2.35; P for trend=0.03) and ARI (low versus high tertile RR 1.41, 95% CI: 1.13, 1.76; P for trend=0.01) while low FGFS were associated with increased risk of dysentery (low versus high tertile RR 1.74, 95% CI: 1.11, 2.74; P for trend=0.01) and ARI (low versus high tertile RR 1.44, 95% CI: 1.14, 1.81; P for trend<0.01). Low food consistency scores were associated with ARI (RR 1.77; 95% CI: 1.40, 2.26; P<0.01). MFS were not associated with morbidity.

Discussion

We employed a feeding index to assess nutritional adequacy of CF and its relation with acute infection among HIV-exposed children in an urban setting in sub-Saharan Africa. Overall, CF practices were suboptimal. Low ICFI scores were likely associated with dysentery and

ARI. Among its components, low 24-hour and 7-day dietary diversity and low food consistency scores were likely associated with dysentery and ARI.

The rate of AWD was comparable to that reported among under-fives in India⁽³¹⁾ but higher than in Nicaragua⁽³²⁾ while that of ARI was lower than in India⁽³¹⁾ but comparable to rates of clinical pneumonia reported in the WHO Africa and South-East Asia regions⁽³³⁾.

ICFI scores in this cohort are similar to those from a study in Senegal⁽³⁴⁾ where majority of children scored between four and six, but differed from results from Burkina Faso⁽¹⁷⁾ where 6–11 month old infants had a median score of two. Previous studies have reported that low ICFI scores were associated with poor nutritional status in general pediatric populations^(11, 13, 15, 17) and among HIV-exposed children^(35–37). It is noteworthy that children with low ICFI scores in this cohort were more likely to be stunted and underweight. Undernutrition compromises barrier function, allowing easier access by pathogens, and compromises immune function, decreasing the ability of the host to eliminate pathogens once they enter the body which predisposes to infections⁽¹⁰⁾; this could explain why low ICFI scores were likely associated with dysentery and ARI.

In this cohort, few children were breastfed beyond six months of age. Similar results were reported from a cohort of HIV-exposed infants in Cote d'Ivoire⁽³⁷⁾ where the median breastfeeding duration was four months and few children were breastfed beyond six months age. These findings may be due to contemporaneous WHO recommendations which were that HIV-exposed children be exclusively breastfed “for the first months of life” and breastfeeding be discontinued as soon as was feasible⁽³⁸⁾. Studies among HIV-exposed children in low-resource settings have reported associations between a lack or early cessation of breastfeeding and diarrhea^(39–44) and pneumonia^(44,45). In this cohort, breastfeeding at six months age and beyond was not significantly protective of morbidity and this did not differ by HIV-infection status. Based on the feeding recommendations, perhaps mothers who continued breastfeeding were those unable to provide adequate CF due to socioeconomic factors, thus not meeting energy and nutrient requirements so that breastfed children were not significantly less likely to suffer morbidity. Indeed, breastfed children may have been more likely to receive less diverse diets since adding the DDS component to the breastfeeding model revealed a protective association between breastfeeding and ARI. Moreover, it has previously been demonstrated that mothers may prolong breastfeeding for malnourished children⁽⁴⁶⁾; this could explain why breastfed children were not less likely to suffer morbidity.

Like in this cohort, authors in urban China⁽¹³⁾ reported more infants receiving foods of thicker consistency with increasing age. Low food consistency scores were likely associated with morbidity. According to WHO, children aged 6–8 months require 682 Kcal/day, those aged 9–11 months about 830 Kcal/day and those aged 12–23 months about 1092 Kcal/day⁽⁴⁷⁾. Breast milk provides about 413 Kcal/day, 379 Kcal/day and 346 Kcal/day for children aged 6–8 months, 9–11 months and 12–23 months, respectively⁽⁴⁷⁾, the remaining Kcal/day must be provided by CF⁽⁴⁷⁾. The low rates of breastfeeding in this cohort mean even higher energy demands from CF. For complementary foods to have 1.0 Kcal/gram it is necessary for them to be quite thick and contain fat or oil⁽⁴⁸⁾. If complementary foods are

more energy-dilute than breast milk, the child's total energy intake may be less than it was with exclusive breastfeeding possibly causing malnutrition⁽⁴⁸⁾. The resulting compromised immune function and predisposition to infection⁽¹⁰⁾ could explain why low food consistency scores were likely associated with infection.

We measured DDS using both 24-hour and 7-day data to include day-to-day diet variations. Dietary diversity was low in this cohort; children had received foods from four food groups in the previous day in only half of the visits in the 6–8 and 12–24 month ages. Low achievements of the WHO minimum dietary diversity indicator (receiving foods from at least four food groups in the previous day) have been reported in central Tanzania⁽⁴⁹⁾, Ethiopia⁽⁵⁰⁾, Bangladesh, India and Nepal⁽⁵¹⁾, and Zambia⁽⁵²⁾. Conversely, higher achievements were reported in Sri Lanka⁽⁴⁹⁾. Based on our data, low dietary diversity was likely associated with increased risk of dysentery and ARI. Several studies have reported associations between low DDS and poor nutritional status in young children^(52–57). It is noteworthy that in this cohort, children with low DDS and FGFS were more likely to be stunted and underweight; meaning, children on less diverse diets were less likely to meet their energy and nutrient requirements. Since undernutrition compromises immune function and predisposes to infections⁽¹⁰⁾, this could explain why children on less diverse diets were more susceptible to infection.

The minimum meal frequency indicator based on WHO standards was achieved in less than half of visits across the age-groups. Higher achievement of this indicator was reported in Bangladesh, Nepal, Sri Lanka⁽⁵¹⁾ and Zambia⁽⁵⁰⁾. We found no association between MFS and morbidity. Previous studies have reported a protective association between high MFS and child nutrition status^(15, 17, 58); thus it may be expected that higher MFS would be protective against acute infections. Perhaps even those children who achieved the minimum meal frequency indicator received inadequate amounts of food so that they were no better off than the rest of the cohort.

The prospective nature of data collection was a major strength of this study since it allowed for a proper temporal relationship to be assessed between CF practices and morbidity. While utilizing a composite index enabled us to assess the effect of multiple CF practice, running separate models for each component allowed us to examine associations between specific feeding practices and morbidity. Using 24-hour and 7-day infant feeding data may have reduced recall bias since caregivers would be more likely to remember what foods their children had received. Controlling for important confounders in multivariate regression analysis reduced bias in our results. Nevertheless, this study had important limitations. Construction of the DDS was based on four of the seven food groups that WHO considers in tabulating this indicator⁽¹²⁾ since we lacked feeding data on legumes and nuts, eggs, and Vitamin A-rich fruits and vegetables (the latter two of which may have allowed for more evenly distributed DDS). Consequently, the DDS and ICFI scores and their associations with morbidity may be under or overestimated. The loss of potentially useful information that arose from categorizing the ICFI and its components may have reduced this study's power to detect associations, leading to imprecise estimation of the risks. Clinic-based reporting of nutrition behaviors may have led to under-reporting of poor infant feeding behaviors, resulting in non-differential exposure misclassification. Self-report and monthly

ascertainment of morbidity may have led to inaccurate reporting of morbidity and recall bias. Not correcting for multiple testing may have resulted in reporting relationships that occurred by chance. Finally, our results may not be generalizable to children born to mothers with advanced HIV disease since majority of mothers in this study were in the early WHO HIV disease stages at enrolment.

In conclusion, we observed associations between low ICFI scores and dysentery and ARI among children born to early-stage HIV-infected women in Tanzania. Low dietary diversity and food consistency scores were identified as the most important undesirable feeding practices. Our results confirm existing literature that greater dietary diversity and optimal CF are important in improving young children's health. We recommend that nutrition programs in resource-limited settings emphasize educating HIV-exposed children's caregivers on improving quality of CF to facilitate optimal feeding and consequently reduce occurrence of diarrhea and ARI in this subpopulation.

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Table 1

Description of the scoring system used to construct the infant and child feeding index

Variables	6–8 months	9 – 11 months	12–24 months
Currently Breast Feeding	No=0 Yes=+1	No=0 Yes=+1	No=0 Yes=+1
Food Consistency ^a	Liquid=0 Gruel-like= +1 Semi-solid or solid = +2	Liquid or gruel -like=0 Semisolid=+1 Solid=+2	Liquid or gruel -like=0 Semisolid=+1 Solid=+2
Dietary Diversity Score (DDS) past 24 hrs. ^b	0–2 FG=0 3 FG=+1 4 FG=+2	0–2 FG=0 3 FG=+1 4 FG=+2	0–2FG=0 3 FG= +1 4FG=+2
Food Group Frequency Score (FGFS) past 7 days ^c	0–4 FGFS=0 5 or 6 FGFS=+1 >6 FGFS=+2	0–5FGFS=0 6 or 7FGFS=+1 8FGFS=+2	0–5FGFS=0 6 or 7FGFS=+1 8FGFS=+2
Meal Frequency Score (MFS) past 24 hrs. ^d	0 meals for BF, 0–1 for non-BF=0 1 meal for breastfed, 2–3 for non-BF= +1 2 meals for BF, 4 for non BF=+2	0–1 meals for BF, 0–1 for non-BF =0 2 meals for BF, 2–3 for non-BF =+1 3 meals for BF, 4for non BF =+2	0–1 meals for BF, 0–2 meals for non-BF =0 2–3 meals for BF, 3–4 for non BF =+1 4 meals for BF, 5 for non BF =+2

FG=Food Group, BF=breastfed

^aFood consistency was the highest consistency of complementary food taken by the child in the prior week. For 6–8 month-old infants, liquid food was given a score of 0, gruel-like food such as porridge +1, and semi-solid or solid foods +2. For older children, liquid or gruel-like food, semi-solid food, and solid food were scored as 0, +1, and +2, respectively.

^bDDS was based on four food groups: 1). Cereals; 2) dairy products; 3) flesh foods 4) fruits and vegetables. Each food group consumed in the previous 24 hours was scored as 1. These scores were summed to give a possible range of 0–4 then categorized based on tertiles. Consuming 0 to 2 food groups in the previous 24 hours was categorized as a DDS score of 0, 3 food groups a score of +1 and 4 food groups a score of +2.

^cFGFS was based on the frequency of consumption of different food groups over the previous 7 days. A score of 0 was assigned if no foods from any of the food groups were consumed during the previous week, +1 if a food group was consumed on 1–3 days, and +2 if a food group was consumed on 4 or more days. These scores were summed to give a possible range of 0–8 then new scores were assigned based on tertiles.

^dMFS was based on current WHO feeding recommendations, according to which 6–8 month old breastfed children should receive soft, semi-solid or solid foods at least twice a day and 9–23 month old breastfed children at least three times a day; while non breastfed children aged 6–23 months receive solid, semi-solid or soft foods (including milk feeds) four to five times a day.

Table 2

Characteristics of HIV-infected mothers and their children enrolled in a micronutrient supplementation clinical trial in Dar es Salaam, Tanzania (n=2092) (Mean $\pm$ SD or %)

	Frequency	Mean $\pm$ SD or %
Maternal Characteristics		
Age (years) Mean $\pm$ SD		28 $\pm$ 5
Married/ living with partner	1804	87.1
Education		
None	148	7.1
1–7 years	1491	71.9
8+ years	435	21
Spouse's Education		
None	25	1.5
1–7 years	1032	59.9
8+ years	665	38.6
Daily food expenditure per person < Tshs. 500 ¹	1021	51.7
BMI (kg/m ²) ²		
<18.5	89	4.3
18.5 – <25	1154	55.9
25–30	623	30.2
30	200	9.7
CD4 count (cells/mm ³) ²		
< 200	170	9
200 – <350	372	19.8
350+	1339	71.2
Hemoglobin < 11g/dL ²	566	29.7
WHO HIV disease stage III/IV ²	160	12
Used antiretroviral therapy during pregnancy ³	388	19.5
Number of prior pregnancies		
None	450	21.7
1	699	33.7
2	457	22.1
3+	467	22.5
Child Characteristics		
Male sex	1130	54
Low birth weight (<2500g)	129	6.4
HIV-infected at baseline ³	173	8.4
CD4 cell % at baseline		
<15%	37	2.2
15% – <25%	158	9.4
25%+	1487	88.4

	Frequency	Mean $\pm$ SD or %
Child's hemoglobin level at baseline <10g/dL ³	823	41.2
Underweight at baseline ³	159	7.7
Wasted at baseline ³	140	6.8
Stunted at baseline ³	165	8
Exclusively breastfed	1806	86.3
Exclusive breastfeeding duration < 3 months	828	39.6

¹ 1250 Tshs = ~ 1 US\$ at the time of the study.

² Maternal characteristics measured at 6 weeks postpartum.

³ Child's characteristics measured at randomization.

Table 3

Feeding practices categorized by the infant and child feeding index by age group

Variables	6–8 months N=5666 visits	9 – 11 months N=4885 visits	12–24 months N=17,271 visits
Currently Breast Feeding	577 (10.2%)	132(2.7%)	106(0.6%)
Food Consistency			
Low	108 (2.0%)	182(3.7%)	211(1.2%)
Medium	879(16.3%)	42(0.9%)	85(0.5%)
High	4401(81.7%)	4646(95.4%)	16958(98.3%)
Dietary Diversity Score (DDS) past 24 hrs.			
Low	1114 (19.7%)	378 (7.7%)	2390 (13.8%)
Medium	1726 (30.5%)	1458 (29.9%)	6464 (37.4%)
High	2825 (49.9%)	3049 (62.4%)	8416 (48.7%)
Food Group Frequency Score (FGFS) past 7 days			
Low	702 (13.1%)	382 (7.9%)	2434 (14.1%)
Medium	1643 (30.7%)	1567 (32.2%)	6622 (38.4%)
High	3006 (56.2%)	2915 (59.9%)	8179 (47.5%)
Meal Frequency Score (MFS) past 24 hrs.			
Low	81 (1.5%)	68 (1.4%)	7793 (45.4%)
Medium	3085 (58.2%)	3193 (66 %)	8600 (50.1%)
High	2133 (40.3%)	1580 (32.6%)	760 (4.4%)
ICFI			
Low	2265 (40%)	1932 (40%)	5912 (34%)
Medium	2249 (40%)	1883 (39%)	6043 (35%)
High	1152 (20%)	1070 (22%)	5316 (31%)

Table 4
Multivariate Risk Ratios (RRs), 95% Confidence Intervals and P-Values for Diarrhea and Acute Respiratory Infection

Infant and Child Feeding Index Score (ICFI)	Acute Watery Diarrhea (500 events)		Dysentery (148 events)		Acute Respiratory Infection ⁵ (625 events)	
	ARR ² (95% CI)	P ¹	ARR ³ (95% CI)	P ¹	ARR ⁴ (95% CI)	P ¹
Low	1.13 (0.91, 1.41)	0.15 ⁶	1.40 (0.93, 2.10)	0.02 ⁶	1.16 (0.96, 1.41)	0.01 ⁶
Medium	1.00 (0.80, 1.24)		1.02 (0.67, 1.56)		0.84 (0.68, 1.04)	
High	Reference		Reference		Reference	

ARR, Adjusted Risk Ratio; CI, Confidence Interval

¹ Risk Ratios, 95% Confidence Intervals, and corresponding P values were estimated by log-binomial models.

² Adjusted for maternal: age, level of education, spouse's education level, employment status, food expenditure per person per day, Filmer-Pritchett wealth index, WHO HIV stage at baseline, ARV use in pregnancy, number of prior pregnancies, and child's: birth weight, EBF duration, multivitamin use and the following time varying variables: season, maternal BMI, child's age, hemoglobin level and underweight status.

³ Adjusted for season, maternal: age, ARV use in pregnancy, number of previous pregnancies, employment status, Filmer-Pritchett wealth index, food expenditure per person per day, and child's birth weight and multivitamin use.

⁴ Adjusted for maternal: age, food expenditure per person per day, marital status, employment status, spouse's education level, Filmer-Pritchett wealth index, ARV use in pregnancy, WHO HIV stage at baseline, number of previous pregnancies, and child's birth weight, EBF status, multivitamin use, and the following time-varying variables: season, maternal CD4 count, child's age, wasting status, HIV infection status, CD4 cell percentage, and hemoglobin level.

⁵ Defined as cough with one or more of the following events: difficulty breathing, chest retractions, and refusal to eat, drink, or breastfeed.

⁶ P values from trend test using the underlying ICFI score variable.

Table 5

Multivariate Risk Ratios (RRs), 95% Confidence Intervals and P-Values for Diarrhea and Acute Respiratory Infection

Variables*	Acute Watery Diarrhea (500 events)		Dysentery (148 events)		Acute Respiratory Infection ⁵ (625 events)	
	ARR ² (95% CI)	P ¹	ARR ³ (95% CI)	P ¹	ARR ⁴ (95% CI)	P ¹
Current Breastfeeding		0.38		0.22		0.30
No	Reference		Reference		Reference	
Yes	1.24 (0.76, 2.01)		1.76 (0.72, 4.28)		0.78 (0.50, 1.24)	
Dietary Diversity Score (DDS) Past 24 hrs.		0.06 ⁶		0.03 ⁶		0.01 ⁶
0–2 Food Groups	1.13 (0.85, 1.48)		1.47 (0.92, 2.35)		1.41 (1.13, 1.76)	
3 Food Groups	1.22 (1.01, 1.48)		1.50 (1.08, 2.09)		1.15 (0.97, 1.37)	
4 Food Groups	Reference		Reference		Reference	
Food Group Frequency Score (FGFS) past 7d.		0.40 ⁶		0.01 ⁶		<0.01 ⁶
Low	1.03 (0.78, 1.38)		1.74 (1.11, 2.74)		1.44 (1.14, 1.81)	
Medium	1.16 (0.96, 1.41)		1.47 (1.05, 2.06)		1.14 (0.97, 1.35)	
High	Reference		Reference		Reference	
Food consistency		0.11		0.24		<0.01
Low	1.33 (0.94, 1.88)		1.48 (0.77, 2.83)		1.77 (1.40, 2.26)	
High	Reference		Reference		Reference	
Meal Frequency Score (MFS) past 24 hrs.		0.80 ⁶		0.61 ⁶		0.46 ⁶
Low	0.97 (0.70, 1.35)		1.09 (0.65, 1.81)		0.90 (0.67, 1.20)	
Medium	1.11 (0.87, 1.42)		0.88 (0.54, 1.43)		0.94 (0.77, 1.14)	
High	Reference		Reference		Reference	

ARR, Adjusted Risk Ratio; CI, Confidence Interval

¹ Risk Ratios, 95% Confidence Intervals, and corresponding P values were estimated by log-binomial models.² Adjusted for maternal: age, level of education, spouse's education level, employment status, food expenditure per person per day, Filmer-Pritchett wealth index, WHO HIV stage at baseline, ARV use in pregnancy, number of prior pregnancies, and child's: birth weight, EBF duration, multivitamin use and the following time varying variables: season, maternal BMI, child's age, hemoglobin level and underweight status.

⁵ Adjusted for season, maternal: age, ARV use in pregnancy, number of previous pregnancies, employment status, Filmer-Pritchett wealth index, food expenditure per person per day, and child's birth weight and multivitamin use.

⁴ Adjusted for maternal: age, food expenditure per person per day, marital status, employment status, spouse's education level, Filmer-Pritchett wealth index, ARV use in pregnancy, WHO HIV stage at baseline, number of previous pregnancies, and child's birth weight, EBF status, multivitamin use, and the following time-varying variables: season, maternal CD4 count, child's age, wasting status, HIV infection status, CD4 cell percentage, and hemoglobin level.

⁵ Defined as cough with one or more of the following events: difficulty breathing, chest retractions, and refusal to eat, drink, or breastfeed.

⁶ P values from trend test using underlying score variable.

* Separate models were run for each of the ICFI components.