FOOD AND
NUTRITION
TECHNICAL
ASSISTANCE

USAID
FROM THE AMERICAN PEOPLE

Developing and Validating Simple Indicators of Dietary Quality and Energy Intake of Infants and Young Children in Developing Countries: Summary of findings from analysis of 10 data sets

August 2006

Working Group on Infant and Young Child Feeding Indicators

FANTA
FHI 360
1825 Connecticut Ave., NW
Washington, DC 20009-5721
Tel: 202-884-8000 Fax: 202-884-8432
fantamail@fhi360.org www.fantaproject.org

fhi 360
THE SCIENCE OF IMPROVING LIVES

FOOD AND NUTRITION TECHNICAL ASSISTANCE

USAID FROM THE AMERICAN PEOPLE

IFPRI

Developing and Validating Simple Indicators of Dietary Quality and Energy Intake of Infants and Young Children in Developing Countries: Summary of findings from analysis of 10 data sets

Working Group on Infant and Young Child Feeding Indicators

August 2006

FANTA
FHI 360
1825 Connecticut Ave., NW
Washington, DC 20009-5721
Tel: 202-884-8000   Fax: 202-884-8432
fantamail@fhi360.org   www.fantaproject.org

fhi 360 THE SCIENCE OF IMPROVING LIVES

This publication is made possible by the generous support of the American people though the support of the Office of Health, Infectious Disease, and Nutrition, Bureau for Global Health, United States Agency for International Development (USAID), under terms of Cooperative Agreement No. HRN-A-00-98-00046-00, through FANTA Project, operated by) + , . The contents are the responsibility of) + , and do not necessarily reflect the views of USAID or the United States Government.

Published 2006

Recommended citation:

Working Group on Infant and Young Child Feeding Indicators. *Developing and Validating Simple Indicators of Dietary Quality and Energy Intake of Infants and Young Children in Developing Countries: Summary of findings from analysis of 10 data sets.* Food and Nutrition Technical Assistance Project (FANTA),) + , Washington, D.C., August 2006.

Copies of the publication can be obtained from:

Food and Nutrition Technical Assistance Project (FANTA)
FHI 360
1825 Connecticut Avenue, NW
Washington, D.C. 20009-5721
Tel: 202-884-8000
Fax: 202-884-8432
Email: fantamail@fhi360.org
Website: www.fantaproject.org

Table of Contents

ACKNOWLEDGMENTS

This report was prepared as part of a project that aims to develop indicators for assessing infant and young child feeding practices, undertaken as a joint effort by the Department of Child and Adolescent Health and Development of the World Health Organization (WHO/CAH), the Food Consumption and Nutrition Division of the International Food Policy Research Institute (IFPRI), the Program in International and Community Nutrition at the University of California, Davis (UC-Davis), the Food and Nutrition Technical Assistance (FANTA) Project of FHI 360, and the United States Agency for International Development (USAID).

The report was prepared by Kathryn G. Dewey, Mary Arimond, and Marie T. Ruel on behalf of the Working Group on Infant and Young Child Feeding Indicators. Working Group members include the following individuals (usually the principal investigators) who conducted analyses of previously collected data for ten study sites using a standard protocol (country of data set in parentheses):

- Cecilia C. Santos-Acuin, Institute of Clinical Epidemiology, National Institutes of Health, University of the Philippines, Manila (Philippines);
- Nita Bhandari, Society for Applied Studies, New Delhi (India);
- Hilary Creed de Kanashiro, Instituto de Investigación Nutricional, Lima (Trujillo, Peru);
- Roberta Cohen and Kathryn Dewey, UC-Davis (Bangladesh; Ghana; Honduras; Huascar, Peru);
- Christine Hotz, HarvestPlus (Malawi);
- Mourad Moursi, Institute of Research for Development, Montpellier (Madagascar);
- Helena Pachon, International Center for Tropical Agriculture, Cali (Brazil).

Other Working Group members include: Marie T. Ruel and Mary Arimond of IFPRI, who provided technical advice throughout the process and conducted additional data analysis for several data sets; Andre Briend, Bernadette Daelmans, and Jose Martines of WHO/CAH, who provided technical advice and oversight to several of the analyses; Anne Swindale of the FANTA Project and Eunyong Chung of USAID, who contributed through workshop participation, discussions, and document reviews. The report was reviewed and endorsed by the principal investigators and the members of the project steering group at WHO/CAH, IFPRI, and the FANTA Project.

Four country analysis (Bangladesh, Ghana, Honduras, and Huascar, Peru): We gratefully acknowledge the other investigators involved in the infant dietary intake studies upon which these analyses were based: Peru: H. Creed de Kanashiro, K. H. Brown, G. Lopez de Romana, T. Lopez, and R. E. Black; Honduras: L. Landa Rivera; Ghana: A. Lartey, A. Manu, J. Peerson, and K. H. Brown; and Bangladesh: J. E. Kimmons, E. Haque, J. Chakraborty, S. J. M. Osendarp, and K. H. Brown.

Brazil: We acknowledge Y. Shang for assisting with the implementation of the early steps of the protocol, C. Araujo for helping during the food coding, C. Lutter for providing financial support for improvements to the ***Pro*PAN** food composition table that benefited the current analyses, and M. Arimond for technical support.

India: A number of researchers collaborated in analyzing and reporting results for India. Researchers were V. Suri, Research Associate; B. Dube, Research Associate; N. Soin, Research Associate; S. Taneja, Research Coordinator; and N. Bhandari, Joint Director, all of the Society for Applied Studies, New Delhi, India. We would also like to acknowledge the support provided by S. Mazumder and T. Rongsen during data analysis. We are thankful to K. Bhatia for the assistance provided in statistical analysis. We also thank M. Bagdwal and A. Verma for their secretarial assistance in compilation of the report.

Madagascar: We would like to thank M. Arimond, M. T. Ruel, K. Dewey, and colleagues from the FANTA Project for a great collaboration. Special thanks to FANTA for their financial support for data entry. We also gratefully acknowledge the important contribution of L. Arnaud, C. Monvois, and O. Bruyeron from Research and Technological Exchange Group/Nutrimad and S. Trèche and F. Delpeuch from Institute of Research for Development.

Malawi: R. Gibson is acknowledged for her supervision of the data collection and analysis of this project.

Trujillo, Peru: We should like to express our thanks to M. Marin, for conducting the data analysis; M. R. Liria, for assistance with the implementation of the protocol; L. Ganoza, for adapting the IIN Peruvian food composition table to the requirements of the protocol; and K. Escajadillo, for secretarial assistance in compiling the report.

Philippines: We gratefully acknowledge D. Marcelo for her assistance in the data management and statistical processing for this report; P. Alday, M. Fulache, and N. Cerillo and the RITM IFIS Study Team for their assistance in data encoding, editing, and inputs to the final report; M. Arimond and K. Dewey for their very helpful comments and technical assistance; and the administrations of the RITM Department of Biostatistics and Epidemiology, De La Salle University AK Medical Research Center, and the University of the Philippines Department of Clinical Epidemiology for their support.

Finally, at IFPRI, we would like to thank A. Subandoro, who constructed most of the summary tables, as well as standardized collaborators' reports for easier comparability, and J. Willis, who formatted and helped finalize numerous reports throughout this project.

ACRONYMS

AUC	Area under the receiver operating curve
FGI	Food group indicator
FGI7	Food group indicator summing 7 food groups, with a 1-g minimum for inclusion
FGI7R	Food group indicator summing 7 food groups, with a 10-g minimum for inclusion
FGI8	Food group indicator summing 8 food groups, with a 1-g minimum for inclusion
FGI8R	Food group indicator summing 8 food groups, with a 10-g minimum for inclusion
MMDA	Mean micronutrient density adequacy
MMDA50	Dichotomous indicator coded 1 if MMDA < 50%
MMDA75	Dichotomous indicator coded 1 if MMDA ≥ 75%
PAHO	Pan American Health Organization
ROC	Receiver operating curve; also receiver operating characteristics
WHO	World Health Organization

EXECUTIVE SUMMARY

Introduction

The lack of simple indicators of appropriate feeding practices has hampered progress in measuring and improving infant and young child feeding in developing countries. In response to these concerns, the World Health Organization (WHO) and the Pan American Health Organization (PAHO) set in place a process in 2002 to review and develop indicators of appropriate feeding practices. The "Guiding Principles for Complementary Feeding of the Breastfed Child," published in 2003 (PAHO/WHO 2003), provided guidance and scientific rationale for 10 different aspects of appropriate feeding practices, but it was still necessary to develop simple, yet valid and reliable population-level indicators for assessment, targeting, and monitoring and evaluation at a global level.

The process required to develop and validate global indicators involves a series of activities including analysis of existing data sets, field-testing of selected indicators, and technical meetings and workshops to promote interinstitutional dialogue and to reach consensus on best indicators. The research described in this report is based on analysis of existing data sets. The overall goal of the research was to initiate a process of developing and validating indicators of diet "quality" and "quantity" during the first two years of life. These indicators are intended to help measure progress with regard to two of the 10 Guiding Principles described above, specifically those pertaining to "Nutrient content of foods" and "Amount of food needed." The two main research questions addressed were the following:

1) How well can dietary diversity (sum of foods or food groups consumed over a reference period) or sentinel food group (selected nutrient-dense food groups) indicators predict dietary quality[1] for infants and young children in different populations with varying dietary patterns?

2) How well does the frequency of feeding of foods and nutritive liquids other than breast milk (hereafter referred to simply as "foods") predict energy intake – either energy from foods alone or total energy intake – in different populations with varying dietary patterns?

Methods

Ten data sets with information on dietary intake of children between the ages of 6 and 24 mo were used for these analyses: 3 from Africa (Ghana, Madagascar, and Malawi), 3 from Asia (India, the Philippines, Bangladesh), and 4 from Latin America (2 from Peru, 1 from Honduras, and 1 from Brazil). In total, for breastfed children there were 5,244 child-days of dietary intake data for 6-11 mo and 3,266 child-days of data for 12-23 mo. Data on intake of *non-breastfed* children were available for 1,504 and 978 child-days for 6-11 mo and 12-23 mo, respectively.

Dietary quality was defined on the basis of the micronutrient density (amount per 100 kcal) of all foods and fluids other than breast milk. For breastfed infants 6-11 mo, nine key micronutrients were included (vitamin A, thiamin, riboflavin, vitamin B6, folate, vitamin C, calcium, iron, and zinc). For breastfed children 12-23 mo and for all non-breastfed children, vitamin B12 was also

[1] Dietary quality is defined in this report as "adequate micronutrient density of foods and liquids other than breast milk."

included. For each micronutrient, the individual nutrient density adequacy was calculated as the percentage of the desired nutrient density for that age and breastfeeding status. The overall dietary quality score, or Mean Micronutrient Density Adequacy (MMDA), was calculated as the mean of all 9 or 10 individual micronutrient density adequacies, with each capped at 100%. Thus, the maximum possible MMDA was 100%. For these analyses, two cutoffs for MMDA were used: < 50%, considered low micronutrient density, and ≥ 75%, considered "better" micronutrient density.

Four different indicators of dietary diversity were used: two were based on consumption of eight food groups (FGI8 and FGI8R): 1) grains, roots and tubers, 2) legumes and nuts, 3) dairy products, 4) flesh foods (meat, fish, poultry, and liver/organ meats), 5) eggs, 6) vitamin A-rich fruits and vegetables (> 130 RE of vitamin A per 100 g), 7) other fruits and vegetables, and 8) fats and oils. The other two indicators (FGI7 and FGI7R) were based on the first seven food groups in the list (i.e., they excluded the fats and oil group). For the FGI7 and FGI8, a food group was counted in the index if at least 1 g was consumed, whereas for the FGI7R and FGI8R, a food group was counted only if at least 10 g were consumed, except for fats and oils, for which the cutoff of ≥ 1 g was used. This summary report focuses on FGI7 and FGI7R because they performed better than FGI8 and FGI8R as indicators of micronutrient density.

To examine whether consumption of infant formula or fortified infant foods affected the relationship between dietary diversity and MMDA, we tested for an interaction term. If the interaction was significant (at $p < 0.10$), child-days when fortified products were consumed were excluded (if the sample size was relatively small) or treated separately in the analysis.

The association between dietary diversity and MMDA was assessed using bivariate analyses (comparison of mean values and correlation coefficients) and tests of linearity from simple regression models. Sensitivity and specificity analyses were done to compare the performance of food group indicators in accurately differentiating cases with low vs. higher MMDA using two different cutoff points (< 50% and ≥ 75%). In addition, sensitivity and specificity were calculated to test whether selected "sentinel" food groups (yes/no for consumption) could be used to accurately differentiate cases with low vs. higher MMDA, using the <50% and ≥ 75% cutoffs.

Similar analytical approaches were used to test the association between feeding frequency and energy intake. For the sensitivity and specificity analyses, the cutoff values used for defining "low" energy intake from complementary foods (for breastfed children) assumed average breast milk intake, and were 202 kcal at 6-8 mo, 307 kcal at 9-11 mo, and 548 kcal at 12-23 mo. For non-breastfed children, the cutoffs for defining "low" total energy intake were 615 kcal at 6-8 mo, 686 kcal at 9-11 mo, and 894 kcal at 12-23 mo.

All sensitivity/specificity analyses included a test of the statistical significance of the indicator; i.e., we performed receiver operating curve (ROC) analyses to assess whether the area under the curve (AUC) was statistically significantly different from the null value of 0.5. Similarly, we also tested for differences between indicators, reflected in significant differences in AUC.

Results

Dietary patterns in the sample populations

The diets of infants and young children in the ten studies reflect a wide range of food intake patterns. Although nearly all children in all sites consumed foods from the “grain products, roots and tubers” group, there was great variability across sites in the consumption of the other food groups, even within the same region. Despite this variability, mean food group diversity (FGI7) was similar within each age group among breastfed children in a given region. Diversity was lowest in the three Asian sites, intermediate in the three African sites, and highest in the Latin American sites. Diversity was higher among non-breastfed children than among breastfed children in the four sites with data for both feeding groups. The mean micronutrient density adequacy (MMDA) of the diet also varied by age, region, breastfeeding status, and consumption of fortified foods. Mean MMDA was higher among non-breastfed children than among breastfed children, and also among infants in the Philippines who consumed fortified foods compared to those who did not.

Mean number of meals per day was 2.2-2.9 at 6-8 mo, 2.5-3.1 at 9-11 mo, and 2.9-3.1 at 12-23 mo in both breastfed and non-breastfed children. The consistency across sites was striking. Mean number of feeding episodes per day (meals plus snacks, not including breast milk) for breastfed children was 3.0-4.5 at 6-8 mo, 3.9-5.1 at 9-11 mo, and 4.2-5.9 at 12-23 mo. Mean number of feeding episodes per day for non-breastfed children was higher and more variable across sites.

The relationship between food group diversity and mean micronutrient density adequacy

In most sites, few children consumed infant formula or specially-fortified foods for infants and young children, so they were generally excluded from these analyses. In the Philippines, however, 25% of child-days included consumption of fortified products (mostly infant formula) and thus analyses for this country were done separately for child-days with and without consumption of fortified products.

Food group diversity (FGI7) was positively associated with MMDA at all ages in all sites, in both breastfed and non-breastfed children, except among non-breastfed children who received fortified products in the Philippines. Correlation coefficients were higher among breastfed (most were > 0.5) than non-breastfed children. For the ROC curves describing the relationship between FGI7 and MMDA < 50% among children not receiving fortified products, all except one of the AUC values differed significantly from the null value and most were > 0.7, meaning that FGI7 had some power to distinguish between children above and below the 50% cutoff. For infants 6-11 mo receiving fortified products in the Philippines, however, none of the AUC values for FGI7 or FGI7R was significant.

For the ROC curves describing the relationship between FGI7 and MMDA ≥ 75% among children not receiving fortified products, all except two of the AUC values were statistically significant; and 14 of the 22 statistically significant AUC values were > 0.7. For infants receiving fortified products in the Philippines, the AUC values were significant for breastfed infants (6-8 and 9-11 mo combined) but not for non-breastfed infants.

To discriminate between children with a diet below vs. above the MMDA cutoff of < 50%, a dietary diversity cutoff point of ≤ 2 food groups generally resulted in a relatively low percentage of misclassification while achieving a reasonable balance of sensitivity and specificity among breastfed infants at 6-11 mo who did not receive fortified products. A cutoff point of ≤ 3 would result in markedly higher sensitivity in all data sets for this age group, but lower specificity and greater percentages of misclassified children. For infants who received fortified products (Philippines), the AUC values were not significant for MMDA < 50%, and thus no cutoff resulted in adequate sensitivity and specificity. For breastfed children at 12-23 mo, the indicator (using a cutoff of ≤ 2 food groups) did not perform as well as at 6-11 mo; increasing the cutoff to ≤ 3 food groups improved sensitivity but resulted in low specificity and a much higher percentage of misclassified children (44-65%). For non-breastfed children, a cutoff of ≤ 2 food groups yielded reasonable results in Madagascar, albeit with low sensitivity, but did not perform as well in India or in the Philippines.

There was less consistency in the results across sites when using MMDA ≥ 75% compared to MMDA < 50%. Cutoffs of ≥ 3 or 4 food groups, depending on the age group and country, offered the best combinations of sensitivity and specificity, but the performance of indicators varied widely between age groups and study sites, and by breastfeeding status.

For all analyses, we compared results for diversity indicators with a 1-g and a 10-g minimum restriction for including a food group in the score. We saw few significant differences in AUC, and where observed, they did not consistently favor either the 1-g or the 10-g restriction. Similarly, the 10-g minimum restriction did not consistently result in lower percentages of misclassified children or higher sensitivities or specificities than the simpler indicator based on a 1-g limit (for practical purposes, equivalent to "any or none" for consumption).

"Sentinel" food groups as predictors of mean micronutrient density adequacy

Consumption of animal source foods (yes/no) performed reasonably well as an indicator of MMDA < 50% in most sites and age groups, except at 6-11 mo in Malawi and the Philippines. However, there was considerable variability across sites in sensitivity, specificity, and the percentage misclassified. The animal source food group indicator did not perform well with the MMDA cutoff point of ≥ 75%. Some of the other sentinel food groups (e.g., dairy products; vitamin A-rich fruits and vegetables; other fruits and vegetables) were reasonably good markers of dietary quality in some sites, but there was insufficient consistency across sites to consider any of them as a universal indicator of mean micronutrient density adequacy.

The relationship between feeding frequency and energy intake

Feeding frequency was strongly correlated with energy intake from complementary foods among breastfed children at all age groups, but correlations for non-breastfed children were generally lower. Our analyses suggested that there was no consistent advantage in distinguishing meals from snacks, in terms of predicting energy intake, and therefore the sensitivity/specificity analyses are reported only for total feeding episodes.

All but one of the AUC values for the ROC curves describing the relationship between feeding frequency and low energy intake from foods were statistically significant, and 17 of 22 were

> 0.7. However, within age groups and breastfeeding status, no single cutoff point for feeding frequency was found to be satisfactory across all sites in terms of sensitivity/specificity trade-offs and percentage of children misclassified.

Discussion and Conclusions

Dietary diversity as an indicator of diet quality

These results indicate that dietary diversity is a useful indicator of dietary quality for infants and young children in developing countries. In all sites, for all age groups, mean MMDA increased with increasing food group diversity, although the relationship was not always fully linear. The only subgroup in which this relationship was not significant was non-breastfed infants in the Philippines who received fortified products (mostly infant formula), which is not surprising given the high nutrient density of infant formula.

The dietary diversity indicator based on seven food groups (FGI7) performed better than the indicator based on eight food groups (FGI8), which included fats and oils. This is probably because the fats/oils group provides energy but not micronutrients (unless fortified), and therefore does not contribute to micronutrient *density* and to the MMDA score. This is not to say that fats/oils are unimportant for the overall quality of the diet, but rather that they do not play a major role for micronutrient density.

The dietary diversity indicator that included a 10-g minimum restriction did not consistently result in lower percentages of misclassified children or higher sensitivities or specificities than the simpler indicator based on a 1-g limit (for practical purposes, equivalent to "any or none" for consumption), and therefore the simpler one is recommended.

Results of our sensitivity and specificity analyses suggest that our dietary diversity indicators performed better and more consistently with the MMDA cutoff of < 50% than with the cutoff of ≥ 75%. Using 50% MMDA, the best cutoff point for accurately differentiating between children with low dietary quality vs. higher dietary quality was ≤ 2 food groups. This cutoff performed well for breastfed infants 6-11 mo who did not receive fortified products, but the results were less consistent for children in the second year of life and for non-breastfed children. For the infants in the Philippines who received fortified products, dietary diversity was not a good predictor of poor dietary quality, regardless of the food group diversity cutoff used. This is because MMDA can be relatively high if a food fortified with several micronutrients is consumed, even if the diet includes only one or two food groups.

In most sites, an indicator based on consumption of animal source foods (yes/no) performed reasonably well as a predictor of micronutrient density of complementary foods among breastfed children, confirming that the absence of animal source foods in the diet is a predictor of a poor quality diet. The animal source foods indicator did not work well in all sites, however, because in some populations too few children consumed animal source foods, whereas in others there were very few who did not. Other food groups (e.g., vitamin A-rich fruits and vegetables) may function as useful "sentinels" in specific contexts, even if the results cannot be generalized to other sites.

Feeding frequency as an indicator of energy intake

Although the correlations between feeding frequency and energy intake from foods other than breast milk were highly significant, the sensitivity/specificity analyses did not yield results that were consistent enough across sites to identify a single, age-specific, universal cutoff for feeding frequency of breastfed or non-breastfed children in any of the age intervals.

Conclusions

The results presented herein support the use of indicators of dietary diversity to assess dietary quality in populations not regularly consuming fortified foods. In contexts where fortified foods are widely consumed, indicators reflecting access to and use of fortified products are clearly needed. Our results suggest that in these contexts, the relationship between dietary diversity and micronutrient density is modified by consumption of fortified products. However, it is still valuable to know whether children are receiving a varied diet. Therefore, we would argue in favor of adopting a universal indicator of food group diversity, along with other indicators reflecting utilization of fortified products.

Regarding indicator cutoffs, a cutoff of ≤ 2 food groups can be recommended as an indicator of poor diet quality for breastfed infants 6-11 months. The results for older children and non-breastfed children were less consistent, and results from some samples suggest that a higher cutoff might be desirable. Further discussions with broader stakeholder groups can help inform decisions about indicator selection for these groups.

Prior to this project, feeding frequency recommendations for both breastfed (PAHO/WHO 2003) and non-breastfed (WHO 2005) children had been developed based on an extensive review of available information. Our analyses did not identify a universal cutoff that could be used across populations to predict low energy intake with an acceptable level of accuracy. However, feeding frequency may still be a useful indicator of feeding practices; therefore, we recommend adoption of feeding frequency indicators that reflect the Guiding Principles documents cited above.

The analyses described herein provide a useful evidence base for the selection of indicators, field testing, and further dialogue towards consensus.

1. INTRODUCTION

The lack of simple indicators of appropriate feeding practices has hampered progress in measuring and improving infant and young child feeding in developing countries. In response to these concerns, the World Health Organization (WHO) and the Pan American Health Organization (PAHO) set in place a process in 2002 to review and develop indicators of complementary feeding practices. The process was timely because the "Guiding Principles for Complementary Feeding of the Breastfed Child," which were being developed at the time, provided a useful framework for addressing the multidimensionality of complementary feeding practices (PAHO/WHO 2003). These Guiding Principles provide guidance and scientific rationale for 10 different aspects of optimal complementary feeding practices. Since they were published, a similar effort to develop guidance and rationale for feeding non-breastfed children 6-24 months of age was undertaken, which resulted in a technical document (Dewey, Cohen, and Rollins 2004) and a parallel set of Guiding Principles (WHO 2005).

Simple, yet valid and reliable, population-level indicators of infant and young child feeding practices are needed globally for the following purposes: (1) *assessment*: to make national and subnational comparisons and to describe trends over time; (2) *targeting*: to identify populations at risk, target interventions, and make policy decisions about resource allocation; and (3) *monitoring and evaluation*: to monitor progress in achieving goals and to evaluate the impact of interventions.

The process required to develop and validate global indicators of feeding practices involves a series of activities including analysis of existing data sets, field-testing of selected indicators, and technical meetings and workshops to promote interinstitutional dialogue and to reach consensus on best indicators. The research described in this report is based on analysis of existing data sets. The overall goal of the research was to initiate a process of developing and validating indicators of diet "quality" and "quantity" during the first two years of life. These indicators are intended to help measure progress with regard to two of the 10 Guiding Principles described above, specifically those pertaining to "Nutrient content of foods" and "Amount of food needed" (Box 1). For reference, Box 1 also includes the Guiding Principle that describes appropriate frequency of feeding.

More specifically, the two main research questions addressed were the following:

1) How well can dietary diversity (sum of foods or food groups consumed over a reference period) or sentinel food group (selected nutrient-dense food groups) indicators predict dietary quality[2] for infants and young children in different populations with varying dietary patterns?

2) How well does the frequency of feeding of foods and nutritive liquids other than breast milk (hereafter referred to simply as "foods") predict energy intake – either energy from foods alone or total energy intake – in different populations with varying dietary patterns?

[2] Dietary quality is defined in this report as "adequate micronutrient density of foods and liquids other than breast milk."

Box 1. Three Guiding Principles for Feeding Breastfed and Non-breastfed Children 6-23 months[a]

Nutrient content of foods

Breastfed children: Feed a variety of foods to ensure that nutrient needs are met. Meat, poultry, fish, or eggs should be eaten daily, or as often as possible. Vegetarian diets cannot meet nutrient needs at this age unless nutrient supplements or fortified products are used. Vitamin A-rich fruits and vegetables should be eaten daily. Provide diets with adequate fat content. Avoid giving drinks with low nutrient value, such as tea, coffee, and sugary drinks such as soda. Limit the amount of juice offered so as to avoid displacing more nutrient-rich foods.

Non-breastfed children: In addition to the above, non-breastfed children need ~200 – 500 mL/d of milk or yogurt, with the amount depending on intake of other animal-source foods. If animal source foods are not eaten in adequate amounts, both grains and legumes should be consumed daily. If dairy products are not consumed in adequate amounts, other foods that contain relatively large amounts of calcium can help fill the gap. The daily diet should include vitamin-A rich foods, vitamin C-rich foods, and foods rich in B vitamins including riboflavin, B6, and folate.

Amount of food needed

Breastfed children: Start at 6 months of age with small amounts of food and increase the quantity as the child gets older, while maintaining frequent breastfeeding. The energy needs from complementary foods for infants with average breast milk intake in developing countries are approximately 200 kcal per day at 6-8 months of age, 300 kcal per day at 9-11 months of age, and 550 kcal per day at 12-23 months of age. In industrialized countries these estimates differ somewhat (130, 310, and 580 kcal/d at 6-8, 9-11, and 12-23 months, respectively) because of differences in average breast milk intake.

Non-breastfed children: Ensure that energy needs are met. These needs are approximately 600 kcal per day at 6-8 months of age, 700 kcal per day at 9-11 months of age, and 900 kcal per day at 12-23 months of age.

Meal frequency and energy density

Breastfed children: Increase the number of times that the child is fed complementary foods as he/she gets older. For the average healthy breastfed infant, meals of complementary foods should be provided 2-3 times per day at 6-8 months of age and 3-4 times per day at 9-11 and 12-24 months of age.

Non-breastfed children: For the average healthy infant/child, meals should be provided 4-5 times per day.

Both breastfed and non-breastfed children: The appropriate number of feedings depends on the energy density of the local foods and the usual amounts consumed at each feeding. If energy density or amount of food per meal is low, or the child is no longer breastfed, more frequent meals may be required. In addition to meals, offer nutritious snacks (such as a piece of fruit or bread or chapatti with nut paste) 1-2 times per day, as desired. Snacks are defined as foods eaten between meals-usually self-fed, convenient and easy to prepare.

[a]Adapted from PAHO/WHO 2003 and WHO 2005.

These two potential indicators, dietary diversity and frequency of feeding, were chosen based on a conceptual framework that had previously been developed for identifying useful indicators of complementary feeding practices (Ruel, Brown, and Caulfield 2003). The objective of the research is to contribute to the development of indicators for use at the population level. Simple one-day indicators of diet diversity or feeding frequency cannot be used to characterize the adequacy of diets on an individual level. Further, the larger aim is to develop indicators for general population-level assessments and comparisons, between geographic areas and across time. We note, however, that the data sets used in this analysis were generally not appropriate for evaluating the responsiveness of the indicators as diets change over time. Finally, we note that summary indicators such as the ones discussed here can, by their nature, obscure specific diet quality problems such as low intakes of one or two key micronutrients. Summary indicators should be viewed as complements to other more specific indicators, which should be used to track micronutrient deficiencies known to be of public health importance in any given context.

Data to address the two questions above were available from 10 studies in developing countries: 3 in Africa, 3 in Asia, and 4 in Latin America. Most of the study sites were in urban or peri-urban settings (Ghana, Madagascar, the Philippines, Brazil, Honduras, and two sites in Peru), while the remaining 3 (Malawi, Bangladesh, and India) were in rural areas. In four sites – Ghana, Malawi, India, and one of the Peruvian sites (Trujillo) – the original data collection occurred in the context of intervention studies that included dietary improvement as an objective. Therefore both dietary diversity and diet quality (micronutrient density) could have been different from the typical patterns in those settings.[3] Details of the methods and results for each study are presented in separate reports (Dewey et al. 2005; Acuin 2006; Creed-Kanashiro et al. 2006; Hotz 2006; Moursi 2006; Pachon and Frongillo 2006; Suri et al. 2006). This report summarizes the findings across all 10 studies.

[3] In one additional site (the Philippines), the data were collected in an intervention study, but the data used for this analysis were not from the treatment cohort. In Honduras, the data were collected as part of an iron supplementation trial, but there was no food- or diet-related intervention. For the purposes of these analyses, the fact that some observation days may reflect the impact of interventions does not pose a problem and may in fact increase variability so that the relationship between diversity and nutrient density is easier to detect. Note that while four studies included pre- and post-intervention observations, either the sample size or the intervention design constrain the usefulness of these data for assessments of responsiveness.

2. METHODS

A protocol document was developed and followed by all collaborating researchers (Arimond et al. 2005); methods are summarized here. In each of the ten studies, data on dietary intake of children under two years of age had been originally collected for other purposes. For use in this study, data sets had to include the amount of all foods (not including breast milk) consumed by each child for at least one 24-hour period, obtained either by maternal recall or by an observer in the home who weighed all items consumed. The data were collected between 1994 and 2004, except for the Peru-Huascar data, collected in 1982-84, and the Philippines data, collected in 1986-1988. Data on food intake of *breastfed* children were available from Ghana, Bangladesh, the Philippines, Honduras, and Peru-Huascar for the age interval 6-11 mo, from India for the age interval 12-23 mo, and from Madagascar, Malawi, and Peru-Trujillo for both of these age intervals. In total, for breastfed children there were 5,244 child-days of dietary intake data for 6-11 mo and 3,266 child-days of data for 12-23 mo. Data on intake of *non-breastfed* children were available from the Philippines for ages 6-11 mo, from Madagascar and Peru-Trujillo for both age intervals, and from India and Brazil for 12-23 mo. In total, for non-breastfed children there were 1,504 child-days of data for 6-11 mo (1,369 from the Philippines) and 978 child-days of data for 12-23 mo. Table 1 summarizes sample sizes by age and breastfeeding status.

Food composition data were obtained from a variety of sources, as described in each of the individual reports. When converting food intake data into nutrient intake data, the estimated bioavailability of zinc, calcium, and iron from different foods was used to estimate the amount of each nutrient *absorbed*. Zinc absorption was based on the phytate to zinc (P/Z) ratio as follows: 30% for $P/Z \leq 18$ and 22% for $P/Z > 18$ (Hotz and Brown 2004). Absorption of calcium was assumed to be 25% for legumes, roots/tubers and grains, 5% for foods with high oxalate content (e.g., spinach), 45% for other fruits and vegetables, and 32% for all other foods (including dairy products) (Weaver, Proulx, and Heaney 1999). Absorption of iron was assumed to be 6% from plant source foods and 11% from animal source foods (including milk, which has lower iron bioavailability than meats). These are rough estimates based on reported values for absorption of iron from complementary foods (Hurrell 2003; Lynch and Stoltzfus 2003). Our estimates of vitamin A intake took into account recent information on the conversion of beta-carotene to retinol equivalents[4] (Arimond et al. 2005).

The dietary quality of the foods consumed was defined on the basis of micronutrient density (amount per 100 kcal of food) because of the variability in breast milk intake among individual children. For breastfed infants 6-11 mo, nine key micronutrients were considered (vitamin A, thiamin, riboflavin, vitamin B6, folate, vitamin C, calcium, iron, and zinc). These are the nine "problem" micronutrients identified in technical documents on complementary feeding of young children in developing countries (Dewey and Brown 2003). For breastfed children 12-23 mo and for all non-breastfed children, vitamin B12 was also included (because it is only available from animal source foods), for a total of 10 key micronutrients. For each micronutrient, the individual nutrient density adequacy was calculated as the percentage of the desired nutrient density for that age and breastfeeding group (Arimond et al. 2005). The overall dietary quality score, or Mean Micronutrient Density Adequacy (MMDA), was calculated as the mean of all 9 or 10 individual

4 See, for example, http://ivacg.ilsi.org/file/webBookmark.pdf (accessed July 14, 2006) for conversion factors and related information.

micronutrient density adequacies, with each capped at 100%. Thus, the maximum possible MMDA was 100%. For these analyses, two cutoffs for MMDA were used: $< 50\%$, considered low micronutrient density, and $\geq 75\%$, considered "better" micronutrient density.

Four different indicators of dietary diversity were used. In initial analyses, two food group indicators (FGI) based on a total of eight possible food groups were used (FGI8 and FGI8R). The eight food groups included (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products, (4) flesh foods (meat, fish, poultry, and liver/organ meats), (5) eggs, (6) vitamin A-rich fruits and vegetables (> 130 RE of vitamin A per 100 g), (7) other fruits and vegetables, and 8) fats and oils. For FGI8, a food group was counted in the indicator if at least 1 g was consumed. For FGI8R, a food group was counted only if at least 10 g were consumed, except for fats and oils, for which the cutoff of ≥ 1 g was used. Descriptive results for these indicators appear in the individual reports (Dewey et al. 2005; Acuin 2006; Creed-Kanashiro et al. 2006; Hotz 2006; Moursi 2006; Pachon and Frongillo 2006; Suri et al. 2006).

In subsequent analyses, we examined the performance of the food group indicators after excluding the fats and oils group. These two indicators are FGI7 and FGI7R, defined using the 1 g and 10 g minimum consumption, respectively. Descriptive results for these indicators are also in the individual reports, cited above.

This summary report focuses on FGI7 and FGI7R because they performed better than FGI8 and FGI8R as indicators of micronutrient adequacy. This is probably because the fats/oils group provides energy but not micronutrients (with the exception of red palm oil and fortified products), and therefore does not contribute to micronutrient *density* and to the MMDA score. Summary results for FGI7 and FGI7R are presented in the main report, and results for FGI8 and FGI8R are presented in Appendix 1.

For all analyses, the unit of analysis was one child-day, corresponding to one 24-hour record of food intake. In initial analyses of the relationship between dietary diversity and MMDA, we examined whether consumption of infant formula or fortified infant foods affected the relationship by testing for the interaction term. If the interaction was significant (at $p < 0.10$), child-days when fortified products were consumed were excluded (if the sample size was relatively small) or treated separately in the analysis.

The association between dietary diversity and MMDA was first assessed by simple bivariate analyses such as comparison of mean values and correlation coefficients. Simple regression models were used to test if relationships between dietary diversity and micronutrient density adequacy were linear. Next, sensitivity and specificity analyses were done to compare the performance of food group indicators in correctly differentiating cases with MMDA above vs. below two different cutoff points for MMDA (50% and 75%). In addition, sensitivity and specificity were calculated to test whether selected "sentinel" food groups (yes/no for consumption) could be used to accurately differentiate cases with MMDA above or below each of the cutoffs (50% and 75%).

Feeding episodes and meals were defined in various ways in each of the studies (Appendix 2). Within each site, the association between feeding frequency and energy intake was examined using bivariate analyses (comparison of means and correlation coefficients) and sensitivity/specificity calculations. For the latter, the cutoff values used for defining "low" energy intake from complementary foods (for breastfed children) assumed average breast milk intake, and were 202 kcal at 6-8 mo, 307 kcal at 9-11 mo, and 548 kcal at 12-23 mo. For non-breastfed children, or breastfed children whose breast milk intake, and thus total energy intake, was measured, the cutoffs for defining "low" total energy intake were 615 kcal at 6-8 mo, 686 kcal at 9-11 mo, and 894 kcal at 12-23 mo (WHO 1998).

For all analyses in which an indicator was being evaluated, we calculated the area under the curve (AUC) for the receiver operating characteristics (ROC) relationship, and tested whether AUC was significantly different from the "null" value of 0.5. A value of 0.5 means that the indicator has no predictive value. Indicators were also compared using the ROCCOMP command in STATA (version 8); this procedure compares the area under the curve for two indicators and tests the significance of any difference. A significantly larger AUC signifies better performance.

3. RESULTS

3.1 Dietary patterns in the sample populations

The diets of infants and young children in the ten studies reflect a wide range of food intake patterns. Although nearly all children in all sites consumed foods from the "grain products, roots and tubers" group, there was great variability across sites in the consumption of the other food groups, even within the same region (Table 2). Nutrient-dense animal source foods – meat, dairy, and eggs – were least frequently consumed in Malawi and Bangladesh, and were more frequently consumed in the Latin American samples. Dairy products were also consumed on a very high proportion of child-days in the Indian sample of children 12-23 months, and for non-breastfed children in the Philippines (6-11 mo), Brazil (12-23 mo), and Peru (all ages). Vitamin A-rich fruits and vegetables were most frequently eaten in Malawi and Peru; in all other locations frequencies remained at or well below one-third of child-days.

Despite this variability, mean food group diversity (FGI7) was similar within each age group among breastfed children in a given region (Table 3). In the three African sites, mean food group diversity among breastfed children was 2.5-2.6 at 6-8 mo, 3.0-3.2 at 9-11 mo, and 3.3-3.4 at 12-23 mo. Mean values for breastfed children were higher in the Latin American sites (2.8-3.7 at 6-8 mo, 3.4-3.9 at 9-11 mo, and 4.3 (Peru-Trujillo only) at 12-23 mo), and lower in Bangladesh (1.6 at 6-8 mo; 2.0 at 9-11 mo), the Philippines (2.0 at 6-8 mo; 2.1 at 9-11 mo), and India (2.8 at 12-23 mo). Food group diversity was higher among non-breastfed children than among breastfed children in the four sites with data for both feeding groups (Madagascar, India, the Philippines, and Peru-Trujillo). When considering only food groups from which at least 10 g were consumed (using the same indicator with a 10-gram minimum restriction for each food group (FGI7R)), the mean diversity scores were lower (by 0.1-1.0 food groups) for both breastfed and non-breastfed children (Table 4). During the first year of life, the diets of most of the children included foods from less than three of the seven food groups on any given day. This improved slightly with age, but only in the Latin American sites did the mean food group diversity exceed four during the second year of life.

The mean micronutrient density adequacy (MMDA) of the diet varied by age, region, and breastfeeding status in ways similar to those described above for food group diversity (Table 5). Mean MMDA among breastfed children in the three African sites was 49-56% at 6-8 mo, 64-70% at 9-11 mo, and 67-71% at 12 -23 mo. Mean values for breastfed children were higher in the Latin American sites at 6-8 mo (56-64%) but similar at 9-11 mo (63-70%) and only slightly higher at 12-23 mo (Peru-Trujillo only: 75%). Mean MMDA was low in Bangladesh (35% at 6-8 mo; 49% at 9-11 mo) and the Philippines (48% at 6-8 mo; 52% at 9-11 mo), whereas the mean for breastfed children in India at 12-23 mo (67%) was similar to that for Africa. Mean MMDA was higher among non-breastfed children than among breastfed children. In the Philippines, mean MMDA was higher among infants who consumed fortified foods than among those who did not. As seen for food group diversity, mean MMDA generally increased with age, but only in Peru among non-breastfed children did the mean values exceed 80%. Information on adequacy of individual nutrient intakes and densities is presented in Appendix 3; as with diet patterns, there is wide variation between sites in the density adequacy of specific nutrients. Adequacy of (absorbed) mineral intake, and particularly iron intake, was the most problematic across sites. Variation in vitamin A density adequacy was widest, ranging from 0 among the youngest infants in Ghana and Bangladesh, to 553% for infants 6-8 mo in Peru-Trujillo. The tables in Appendix 3 also illustrate that even in sites where most densities were adequate, problem nutrients remain (see, e.g., Brazil).

Table 6 shows the percentage of each sample with MMDA < 50%, a cutoff that we are using to describe “poor” dietary quality. At 6-8 mo, this percentage was generally high among breastfed infants in Africa (35-53%), Bangladesh (71%), and the Philippines (54%), but not as high in Latin America (15-34%) or among non-breastfed infants in Madagascar (22%) or the Philippines (17%). At 9-11 mo, the percentage with MMDA < 50% was still high among breastfed infants in Bangladesh (55%) and the Philippines (45%), but was < 20% in all other situations. By the second year of life, the percentage with MMDA < 50% was < 10% except in breastfed children in Madagascar (16%) and India (11%). Table 7 shows the percentage of each sample with MMDA > 75%, a cutoff indicating “better” dietary quality. Relatively few (≤ 25%) of breastfed infants at 6-8 mo had an MMDA above 75%, but the situation improved somewhat by 9-11 mo (22-44% except in Bangladesh and the Philippines, where only 8-10% had MMDA > 75%) and 12-23 mo (34-57%). For non-breastfed children, the percentage with MMDA > 75% was low in Madagascar (25-44%, depending on age) and the Philippines (27-37%), intermediate in India and Brazil (48-50% at 12-23 mo), and high in Peru-Trujillo (91-97%).

Mean number of meals per day was 2.2-2.9 at 6-8 mo, 2.5-3.1 at 9-11 mo, and 2.9-3.1 at 12-23 mo in both breastfed and non-breastfed children (Table 8). The consistency across sites was striking, especially given the variation in the definition of meals (Appendix 2). Mean number of feeding episodes per day (meals plus snacks, not including breast milk) for breastfed children was 3.0-4.5 at 6-8 mo, 3.9-5.1 at 9-11 mo, and 4.2-5.9 at 12-23 mo (Table 9). Feeding frequency was highest in Peru-Trujillo and lowest in Bangladesh. Mean number of feeding episodes per day for non-breastfed children was 8.7-9.3 in Peru (depending on age group), compared to 4.6-5.5 in Madagascar and India (12-23 mo) and 8.1 in Brazil (also 12-23 mo). Thus, there was much more variability across sites in feeding frequency than in meal frequency, though some of this could be due to differences in the definitions of a feeding episode.

Table 10 shows the percentage of children receiving less than the recommended number of meals (PAHO/WHO 2003; WHO 2005). Among breastfed children, this varied across sites, with 9-12% in Madagascar and Honduras, 15-30% in Malawi, 22-42% in Peru-Trujillo, and 39-40% in Bangladesh not meeting this criterion. Among non-breastfed children, 92-100% did not meet the recommended number of meals. Table 11 shows the same percentages, but based on all feeding episodes (meals and snacks, but excluding breast milk). In this case, the percentages not meeting the recommended minimum were considerably lower for both breastfed and non-breastfed children: ≤ 10% in Madagascar, Malawi, Brazil, Honduras, and Peru-Trujillo, 8-15% in India, 18-20% in Peru-Huascar, and 24-27% in Bangladesh. Thus, the large majority of the children in each site met the minimum feeding frequency guidelines, when all feeding episodes are considered.

3.2 Fortified foods

The consumption of infant formula and/or specially-fortified foods could potentially modify the relationship between food group diversity and MMDA. Because of this, in initial analyses of four of the data sets (Ghana, Bangladesh, Honduras, and Peru-Huascar), children who had consumed fortified infant foods were excluded from the analysis (Dewey et al. 2005). With the exception of the Ghana sample, where a subset of children had received a fortified complementary food as part of an intervention, the number of children excluded was very small (fewer than 1% of child days). In subsequent analyses (Madagascar, Malawi, India, Philippines, Brazil, and Peru-Trujillo) we aimed to test whether the consumption of fortified products modified the relationship between food group diversity and MMDA. However, no consumption of fortified products was reported in Madagascar and Malawi. In Brazil, only 4 of 80 child-days included fortified products; there was no significant interaction and these child-days were included in subsequent analyses. In India, the Philippines, and Peru-Trujillo, the consumption of fortified products appeared to modify the relationship, as evidenced by a significant interaction. In India and Peru-Trujillo, there were relatively few child-days with fortified products (24 days in India (< 2% of sample) and 180 child-days in Peru (6% of sample)), and thus they were dropped from further analyses. In the Philippines, however, there were 658 child-days (25% of the total) when fortified products (mostly infant formula) were consumed. Therefore, for this site the data regarding the relationship between food group diversity and MMDA are shown separately for child-days with and without intake of fortified products.

3.3 The relationship between food group diversity and mean micronutrient density adequacy

Food group diversity (FGI7) was positively associated with MMDA at all ages in all sites, in both breastfed and non-breastfed children (Table 12), except among non-breastfed children who received fortified products in the Philippines. Among breastfed children, the correlation coefficients ranged from 0.21 to 0.76, with most of them > 0.5. The correlation coefficients were weaker among non-breastfed children, ranging from 0.26 to 0.50 (excluding those who received fortified products). Imposing a 10-gram minimum in counting the number of foods groups (FGI7R) generally did not improve the correlations among breastfed children, though it did increase them somewhat among non-breastfed children (Table 13).

Figures 1-3 show mean MMDA at each level of food group diversity (FGI7) for breastfed children in each of the age groups. For breastfed children in the first year of life who did not consume fortified products, MMDA was generally < 60% when only two food groups were consumed, increasing gradually with each additional food group until reaching an average of ~70% at 6-8 mo and 70-80% at 9-11 mo with five or more food groups. In the only study site (Philippines) where large numbers of infants had formula and/or other foods specially fortified for infants, MMDA was substantially higher for these infants. In the second year of life, mean MMDA for breastfed children was ~55-70% when only two food groups were consumed, increasing to 75-90% with five or more food groups. Among children 12-23 mo, very few consumed fortified products and these observations were dropped; the Philippines samples included infants 6-11 mo only. Excluding children consuming fortified products, the patterns of relationship between FGI7 and MMDA were remarkably similar across sites for breastfed children in all three age groups.

The Philippines site was also the only one where very substantial numbers of infants 6-11 mo were not breastfed. Figure 4 shows the relationship between FGI7 and MMDA for these infants, separating those who consumed formula and/or specially fortified infant foods from those who did not. For those who had fortified products, the relationship between FGI7 and MMDA is essentially flat. For those who did not consume these products, the relationship is similar to the other sites, with MMDA increasing markedly as food group diversity increases. Figure 5 shows the same relationship for non-breastfed children 12-23 mo of age, with each curve showing a similar upward trend in MMDA with each additional food group.

Table 14 shows the area under the curve (AUC) values for the ROC curves describing the relationship between FGI7 and MMDA < 50% in each age group and site. For children not receiving fortified products, all except one of the AUC values differed significantly from the null value, meaning that FGI7 had some power to distinguish between children above and below the 50% cutoff. The exception was for non-breastfed children in India at 12-23 mo (AUC = 0.64). Nearly all of the remainder of the AUC values were > 0.7 and highly significant. When these analyses were repeated using the 10-gram minimum for counting the number of food groups (FGI7R), none of the AUC values were significantly higher than when using FGI7, except for non-breastfed infants 9-11 mo in the Philippines (see Appendix 4). For infants receiving fortified products in the Philippines, none of the AUC values for FGI7 or FGI7R were significant.

Table 15 shows the AUC values for the ROC curves describing the relationship between FGI7 and MMDA ≥ 75%. For children not receiving fortified products, all except two of the AUC values were statistically significant. The exceptions were for breastfed children in Malawi at 9-11 mo (AUC = 0.56) and non-breastfed children in Brazil at 12-23 mo (AUC = 0.61). Fourteen of the 22 statistically significant AUC values were > 0.7. When these analyses were repeated using the 10-gram minimum for counting the number of food groups (FGI7R), only three of the AUC values were significantly higher than when using FGI7. For infants receiving fortified products in the Philippines, the AUC values were significant for breastfed infants (6-8 and 9-11 mo combined) but not for non-breastfed infants, and there was no advantage of FIG7R over FGI7.

The AUC values for the ROC curves of FGI7 with MMDA < 50% were generally higher than those with MMDA ≥ 75% in Madagascar, Malawi, the Philippines (breastfed children), Honduras, Peru-Huascar, and Peru-Trujillo, but the opposite was true in Ghana and India and among non-breastfed children in the Philippines. Overall, there was more consistency in the findings across study sites with MMDA < 50% than with MMDA ≥ 75%.

Sensitivity/specificity analyses were performed to explore the ability of the food group diversity indicator to accurately identify children with MMDA above vs. below two different MMDA cutoff points (< 50% and ≥ 75%). In general, imposing the 10-gram minimum for the food group diversity score did not result in reduced misclassification. Because a simple indicator is easier to implement in the field, it is preferable to choose one that does not require collecting information on quantities consumed, unless there is a clear advantage to doing so. Thus, we present the sensitivity and specificity results only for the analyses using FGI7.

Since we are primarily interested in population-level assessment and possibly geographic targeting, it is appropriate to look for some balance between sensitivity and specificity, and, similarly, to consider minimizing overall misclassification. In this situation (assessment) there are no risks to false positives (low specificity), though there are cost implications when programs use the information for targeting interventions. For targeting, positive predictive value should be maximized – i.e., the percentage of those screened by the indicator as being at risk who actually are at risk. However, for pure assessment purposes, we favor sensitivity more heavily, to avoid false negatives. This may also be most appropriate for advocacy purposes.

Tables 16-18 summarize the sensitivity/specificity results for discriminating between children with a diet below vs. above the MMDA cutoff of < 50%, using FGI7[5]. For breastfed infants at 6-11 mo (Table 16) who did not receive fortified products, a cutoff point of ≤ 2 food groups generally resulted in a relatively low percentage of misclassification while achieving a reasonable balance of sensitivity and specificity. With this cutoff, sensitivity was 63-92%, specificity was 43-90%, and the percentage misclassified was 13-28%, depending on the site. A cutoff point of ≤ 3 would result in markedly higher sensitivity in all data sets (76-99%), but lower specificity (11-66%) and greater percentages of misclassified children (31-50%). For infants who received fortified products (Philippines only), the AUC values were not significant for MMDA < 50%, and thus no cutoff resulted in adequate sensitivity + specificity. For breastfed children at 12-23 mo (Table 17), the indicator (using a cutoff of ≤ 2 food groups) did not perform as well as at 6-11 mo, with sensitivity being lower (55-63%), specificity ranging from 58 to 95%, and the percentage misclassified ranging from 8 to 41%. Increasing the cutoff to ≤ 3 food groups improved sensitivity to 82-90%, but in three of the four sites (the exception being Peru-Trujillo), specificity decreased sharply (to 28-51%) and the percentage misclassified became unacceptably high (44-65%). In Peru-Trujillo, however, the cutoff point of ≤ 3 generally performed better than the cutoff point of ≤ 2 in terms of balance between sensitivity and specificity, although the percentage of misclassified children increases from 8 to 20% when moving from the cutoff point of 2 to 3.

For non-breastfed children (Table 18), a cutoff of ≤ 2 food groups yielded reasonable results in Madagascar, albeit with low sensitivity (all ages combined: sensitivity 56%, specificity 93% and percentage misclassified 11%), but did not perform as well in India (12-23 mo only: percentage misclassified 39%) or in the Philippines (6-11 mo only: percentage misclassified 38-52%).

In all scenarios, FGI7 generally outperformed FGI8 (Appendix 4), mainly because sensitivity was higher. In Peru-Trujillo, however, both cutoff points (≤ 2 or ≤ 3) performed quite well (sensitivity of 75% at both cutoff points; specificity of 75 and 90%, respectively, and percentage misclassified of 3 and 11%, respectively).

Tables 19-21 summarize the sensitivity/specificity results for discriminating children with a diet above or below the MMDA cutoff point of ≥ 75%, based on the FGI7 diversity indicator.[6.] There was less consistency in the results across sites for this outcome than for MMDA < 50%. Using a cutoff of ≥ 4 food groups for breastfed infants at 6-11 mo (Table 19) who did not receive fortified products, sensitivity was 5-96%, specificity was 49-99%, and the percentage misclassified was 4-43%. The cutoff point of ≥ 3 gives consistently higher sensitivity (76-99%

[5] Sensitivity is defined here as the percentage of children with low MMDA (< 50%) who are correctly identified by the food group diversity indicator. Specificity is the percentage of children who do not have a low MMDA (≥ 50%) and who are correctly identified by the diversity indicator.

[6] In this case, sensitivity is defined as the percentage of children with higher MMDA (≥ 75%) who are identified correctly by the food group diversity indicator. Specificity is defined as the percentage of children with lower MMDA (< 75%) who are correctly identified by the food group diversity indicator.

except in the Philippines, where it was only 30%), but at the expense of lower specificities (22-94%) and higher misclassification (8-58%). For breastfed children at 12-23 mo (Table 20), sensitivity at the ≥ 4 cutoff point was 45-90%, specificity was 44-85%, and the percentage misclassified was 30-40%. For this age group, a cutoff of ≥ 3 food groups performed better in India relative to sensitivity, but the percentage misclassified was still 30%.

For non-breastfed children who did not receive fortified products (Table 21), the cutoff of ≥ 4 food groups yielded sensitivity of 2-100%, specificity of 10-100% and a percentage misclassified of 9-45%. For this subgroup, the best cutoff differed by site: ≥ 2 food groups for the Philippines, ≥ 3 food groups for India, and ≥ 5 food groups in Peru-Trujillo. This shows that for non-breastfed children, there is inconsistency across sites in the best cutoff to use for food group diversity for predicting MMDA ≥ 75%. For non-breastfed children who received fortified products (Philippines only), the AUC values were not significant, and thus there was no cutoff that resulted in adequate sensitivity + specificity.

3.4 "Sentinel" food groups as predictors of mean micronutrient density adequacy

To screen for individual food groups as potential indicators of MMDA, we considered those for which the sum of sensitivity plus specificity was ≥ 1.25. Although this is an arbitrary cutoff, it is a criterion that is not dependent on sample size and was used simply to narrow down the number of potential indicators to be considered. Using this criterion, the animal source foods group performed quite well (using an MMDA < 50% cutoff point) in most sites and age groups except at 6-11 mo in Malawi and the Philippines (Table 22). For breastfed children in the sites in which the animal source foods indicator met this criterion, sensitivity was generally good (67-93%) except in India (12-23 mo), Honduras (6-8 mo), and Peru-Trujillo (12-23 mo), where it was < 50%. Specificity was ≥ 68% except in Malawi and Bangladesh, and the percentage misclassified was 10-32% except in Malawi. The animal source food group indicator did not perform as well with the MMDA cutoff point of ≥ 75% (Table 23): the sum of sensitivity and specificity reached ≥ 1.25 in only 6 of the 14 site-age subgroups, and in those six, the percentage misclassified was relatively high (34-49%) except in Bangladesh (22%).

Some of the other sentinel food groups (e.g., dairy products; vitamin A-rich fruits and vegetables; other fruits and vegetables) were reasonably good markers of dietary quality in some sites, but there was insufficient consistency across sites to consider any of them as a universal indicator of mean micronutrient density adequacy.

3.5 The relationship between feeding frequency and energy intake

Feeding frequency was strongly correlated with energy intake from complementary foods, with correlation coefficients among breastfed children of 0.47-0.78 at 6-8 mo, 0.37-0.72 at 9-11 mo, and 0.32-0.62 at 12-23 mo (Table 24). Correlations were lowest in Madagascar and highest in Peru (both data sets).

Figures 6-8 show the association between the number of feeding episodes (feeding frequency) and mean energy intake from complementary foods for breastfed children in each of the age groups. With the exception of Bangladesh, there was remarkable similarity across sites: for example, 3 feeding episodes corresponded to an average energy intake from complementary foods of 100-200 kcal at 6-8 mo, 200-300 kcal at 9-11 mo, and ~300 kcal at 12-23 mo. In Bangladesh, average energy intake from complementary foods was considerably lower than in the other sites at 6-8 mo when there were 5 feeding episodes, and at 9-11 mo when there were 3 or more feeding episodes.

Figure 9 shows a slightly less consistent relationship across sites for non-breastfed children than was seen for breastfed children 12-23 mo of age. Within sites, correlations for non-breastfed children were also generally lower than for breastfed children (Table 24) and ranged from 0.32 to 0.40. There are several possible explanations for the lower correlations among non-breastfed children. First, as would be expected, there are fewer non-breastfed children with a very low frequency of feeding, so the range is smaller. Second, the relationship may be influenced by the presence of large milk feeds. We have data from four sites for non-breastfed children 12-23 mo: Madagascar, India, Brazil, and Peru-Trujillo. In three of those sites, 88-97% consumed dairy products (Table 2), with median intakes ranging from 300 g (India) to 900 g (Brazil, Peru). The exception was Madagascar, where only 25% consumed dairy products, and median intake among consumers was only 125 g.

In the five sites in which meal frequency was also recorded and was not “capped” at a predetermined maximum, the correlations with energy intake from foods were higher for meal frequency than for feeding frequency in Malawi and Bangladesh, but the opposite was true in Madagascar, Honduras, and Peru-Trujillo (Table 25). This suggests that there is no consistent advantage in distinguishing meals from snacks, in terms of predicting energy intake. Furthermore, at any given meal frequency, there was considerable variability across sites in energy intake (Appendix 5), in contrast to the situation described above for feeding frequency. If meals had been defined more consistently across sites, it is possible that this relationship might look different. Instead, meals were defined by researchers quite differently in different contexts (Appendix 2), whereas there was more consistency in definition of feeding episodes. For this reason, the sensitivity/specificity analyses are shown only for total feeding episodes.

Tables 26 and 27 show the AUC values for the ROC curves describing the relationship between feeding frequency or meal frequency and low energy intake from foods. In Table 26 (with feeding frequency), all but one of the AUC values were statistically significant, and 17 of 22 were > 0.7. In Table 27 (with meal frequency), all of the AUC values for breastfed children were significant, but none of those for non-breastfed children were significant. Of the 13 AUC values for breastfed children, only 7 were > 0.7.

Because the relationship of energy intake was more consistent with feeding (episode) frequency than with meal frequency, and there was greater variability in the definition of “meals” (including truncation in some sites), we focus on feeding frequency when discussing the sensitivity/specificity analyses (Tables 28-31). The sensitivity/specificity analyses with number of meals are shown in Appendix 6.

For breastfed children 6-8 mo (Table 28), the best cutoff for predicting low energy intake from complementary foods was ≤ 3 feeding episodes in Bangladesh, Honduras, and Peru-Huascar, and ≤ 4 feeding episodes in Madagascar, Malawi, and Peru-Trujillo. Using these cutoffs, the percentage misclassified ranged from 15% to 30%. Using a cutoff of $\leq$ 4 for all sites resulted in low specificity in Bangladesh (55%), Honduras (31%), and Peru-Huascar (59%), whereas using a cutoff of $\leq$ 3 for all sites meant low sensitivity for Madagascar (38%), Malawi (37%), and Peru-Trujillo (57%). Thus, no single cutoff was satisfactory across all sites at this age. For breastfed children at 9-11 mo (Table 29), the best cutoff was generally $\leq$ 4 feeding episodes, but this yielded low sensitivity in Madagascar (57%) and Malawi (46%). The percentage misclassified ranged from 19% to 34%. For breastfed children at 12-23 mo (Table 30), the best cutoff was $\leq$ 4 feeding episodes in Madagascar and India, and $\leq$ 5 feeding episodes in Malawi and Peru-Trujillo. However, the percentage misclassified tended to be high (29-47%), especially in Madagascar. For non-breastfed children 12-23 mo (Table 31), there was no good solution in Peru-Trujillo whereas in India and Brazil the best cutoff was $\leq$ 6 feeding episodes (percentage misclassified 18-29%).

4. DISCUSSION AND CONCLUSIONS

4.1 Dietary diversity as an indicator of diet quality

These results indicate that dietary diversity is a useful indicator of dietary quality for infants and young children in developing countries. In all sites, for all age groups, mean MMDA increased with increasing food group diversity, although the relationship was not always fully linear. The only subgroup in which this relationship was not statistically significant was non-breastfed infants in the Philippines who received fortified products (mostly infant formula); this is not surprising given the high nutrient density of infant formula. For all other subgroups, the correlation coefficients between dietary diversity and MMDA were statistically significant; they ranged from 0.21 to 0.74, depending on the age group, country and use of fortified products, but most were > 0.5.

In order to move from use of dietary diversity as a continuous indicator towards an indicator based on selected cutoffs, we employed ROC analyses and examined sensitivity, specificity, and total percent misclassified at various dietary diversity cutoffs. The ROC analyses showed that in almost all cases, the tested dietary diversity indicators have predictive power, indicated by significance tests of the AUC.

ROC analyses also allowed comparisons of different dietary diversity indictors. These comparisons showed that in general, the dietary diversity indicator based on seven food groups (FGI7) performed better than the indicator based on eight food groups (FGI8, which included fats and oils). We compared the performance within each site, age- and feeding group, and for both MMDA50 and MMDA75; in all cases where there were significant differences between indicators, they were in favor of the seven-food-group indicator. This is consistent with an examination of the sensitivity, specificity, and other indicator qualities. As noted previously, the superior performance of the seven-food-group indicator is probably due to the fact that the fats/oils group provides energy but not micronutrients (unless fortified), and therefore does not contribute to micronutrient *density* and to the MMDA score. This is not to say that fats/oils are unimportant for the overall quality of the diet, but rather that they do not play a major role for micronutrient density.

We also compared results for the diversity indicators with 1-g and 10-g minimum restriction for including a food group in the score. We saw few significant differences in AUC, and where observed, they did not consistently favor either the 1-g or the 10-g restriction. Similarly, the 10-g minimum restriction did not consistently result in lower percentages of misclassified children or higher sensitivities or specificities than the simpler indicator based on a 1-g limit (for practical purposes, equivalent to “any or none” for consumption). Therefore the simpler (1-g) indicator is recommended.

Judging by the balance between sensitivity and specificity and the percentage misclassified, the dietary diversity indicator performed better and more consistently when the MMDA cutoff of < 50% was used rather than the cutoff of ≥ 75%.[7] This means that the dietary diversity indicators more accurately predict *poor* dietary quality than *better* dietary quality. This is related

[7] Unlike different diversity indicators, the two MMDA cutoffs could not be compared directly in ROC analyses.

to the fact that the relationship between diversity and MMDA appears to plateau, particularly among breastfed infants under one year. This may also reflect the fact that there are certain problem micronutrients (such as iron) for which it is difficult to achieve adequate densities for this age group, even with high food group diversity.

The best cutoff point for predicting MMDA < 50% was ≤ 2 food groups. This cutoff performed well for breastfed infants 6-11 mo who did not receive fortified products, but the results were less consistent for children in the second year of life and for non-breastfed children. For the infants in the Philippines who received fortified products, dietary diversity was not a good predictor of poor dietary quality, regardless of the food group diversity cutoff used.

In most sites, an indicator based on consumption of animal source foods (yes/no) performed reasonably well as a predictor of adequacy of micronutrient density of complementary foods among breastfed children (when using the MMDA cutoff point of < 50%). In some sites, the animal source foods indicator performed better than the dietary diversity indicator. This indicates that an absence of animal source foods in the diet is a predictor of a poor quality diet. The animal source foods indicator did not work well in all sites, however, because in some populations too few children consumed animal source foods (e.g., Malawi) whereas in others there were very few who did not.

Other food groups may function as useful "sentinels" in specific contexts and may be of use locally as indicators of diet quality, even if the results cannot be generalized to other sites. For example, in Malawi, consumption of vitamin A-rich fruits and vegetables served as the best predictor of "better" dietary quality (MMDA ≥ 75%).

4.2 Feeding frequency as an indicator of energy intake

All correlation coefficients between frequency of feeding and energy from foods were statistically significant. They ranged from 0.32 to 0.78, depending on the age group and site. There was no consistent advantage in using meal frequency rather than feeding frequency to predict energy intake from foods. The association between feeding frequency and energy intake was more consistent across sites than the association between meal frequency and energy intake. We cannot determine to what extent this inconsistency was due to variable definitions of meals across studies. However, given the difficulties in defining meals versus snacks, a simpler indicator based on feeding frequency would be preferable.

Although the correlations between feeding frequency and energy intake from foods were highly significant, the sensitivity/specificity analyses did not yield results that were consistent enough to identify a single universal cutoff for feeding frequency of breastfed children in any of the age intervals. Cutoffs based on the minimum feeding frequencies cited in the Guiding Principles for Complementary Feeding of the Breastfed Child (≤ 2 meals at 6-8 mo and ≤ 3 meals at 9-23 mo) generally had low sensitivity. In other words, these cutoffs yielded a high proportion of "false negatives," or children with "low" energy intakes who were not identified by the indicator. However, without knowing energy intake from breast milk it is difficult to make a judgment about the adequacy of energy intake. Also, it should be noted that the Guiding Principles allow for optional "additional nutritious snacks offered 1-2 times per day, as desired." Thus, the cutoffs for feeding frequency (meals plus snacks) that performed best in these analyses (≤ 3 or 4 at 6-11 mo and ≤ 4 or 5 at 12-23 mo, for breastfed children) are consistent with the Guiding Principles. The better results obtained using slightly higher cutoffs may also be related to the fact that children often do not eat to "gastric capacity" at each meal. The minimum meal frequencies in the Guiding Principles are based on eating to gastric capacity, with the caveat stated that "if energy density or amount of food per meal is low. . ., more frequent meals may be required."

In the two sites where breast milk energy intake was measured (Peru-Huascar and Bangladesh), the association of feeding frequency with total energy intake (from breast milk and complementary foods combined) was weaker than the association with energy from complementary foods only (Dewey et al. 2005). This is not surprising, given that there is usually a trade-off between energy intake from breast milk and energy intake from complementary foods. When evaluating indicators that are predictive of the adequacy of energy intake, it is preferable to use total energy intake as the yardstick, rather than energy intake from complementary foods. Otherwise, the risk of misclassification may be high (e.g., concluding that a child with a low feeding frequency had low energy intake, when energy intake was actually adequate because of a relatively high breast milk intake), particularly in populations with higher than average breast milk intake. The sensitivity and specificity results when total energy intake of breastfed children was the outcome were not satisfactory, suggesting that it may not be valid to predict adequacy of total energy intake of breastfed children based on feeding frequency.

For non-breastfed children 12-23 mo, the best cutoff for predicting low energy intake (in this case, total energy intake) was ≤ 6 feeding episodes. This performed reasonably well in two sites (India and Brazil), but there was no good solution in Peru-Trujillo. The cutoff of ≤ 6 feeding episodes is consistent with the Guiding Principles for Feeding Non-Breastfed Children 6-24 Months of Age (WHO 2005), which specify that "meals should be provided 4-5 times per day, with additional nutritious snacks offered 1-2 times per day, as desired."

4.3 Conclusions

In summary, we found positive and reasonably strong relationships between very simple indicators (food group diversity and feeding frequency) and important dimensions of dietary adequacy for infants and young children. Micronutrient density increases with increasing dietary diversity, and energy intake from foods other than breast milk increases with feeding frequency.

With regard to cutoffs and dichotomous indicators, we call attention to the difference between the situation in regard to food group diversity as compared to feeding frequency. In assessing food group diversity, there has previously been no specific international recommendation other than "diversity is good" or "more is better," our analyses provide substantial new information regarding the shape of this relationship and show fair consistency across widely varying sites and diet patterns. We therefore believe that these analyses can inform selection of food group diversity indicators to reflect diet quality. The results presented herein indicate that an indicator based on low food group diversity is predictive of poor dietary quality across populations not regularly consuming fortified products. However, its use as an indicator in populations where fortified foods are regularly consumed may not be valid, based on the results of the subgroup of infants in the Philippines who received fortified products. Further analysis using data from other sites with substantial use of fortified products is needed to resolve this question. Nonetheless, we would argue that even if use of fortified products "dilutes" the relationship between dietary diversity and micronutrient density adequacy, it is still valuable to know whether children are receiving a varied diet that includes animal source foods, fruits, and vegetables. Therefore, we would argue in favor of adopting a universal indicator of food group diversity, along with other indicators reflecting utilization of fortified products.

Regarding cutoffs, a cutoff of ≤ 2 food groups can be recommended as an indicator of poor diet quality for breastfed infants 6-11 months. The results for older children and non-breastfed children were less consistent, and results from some samples suggest a higher cutoff might be desirable. Further discussions with broader stakeholder groups can help inform decisions about indictor selection for these groups. Such discussions should include consideration of the trade-offs mentioned previously; specifically, cutoffs of ≤ 3 or ≤ 4 groups increased misclassification in many settings, but also in many of these same settings substantially improved sensitivity. Depending on the proposed uses for the indicators, improved sensitivity may be preferred. We also recommend that further discussions place our results in the context of other information and knowledge about diet patterns and needs for these older (12-23 mo) and non-breastfed children. For example, in a number of our data sets, and the majority of the data sets with non-breastfed children 12-23 months, families had access to substantial amounts of dairy foods. This is not the case in many low resource settings, and this should be considered in interpreting our results and in coming to consensus about indicators for these children.

With regard to feeding frequency as an indicator of food energy intake, we note that the situation differs from that for dietary diversity because specific recommendations for feeding frequency existed prior to this project. Extensive review of a range of different kinds of studies (WHO 1998; Dewey, Cohen, and Rollins 2004) had previously resulted in consensus documents with feeding frequency recommendations for both breastfed (PAHO/WHO 2003) and non-breastfed (WHO 2005) children. Our analyses did not identify a universal cutoff that could be used across populations with an acceptably low level of misclassification. However, feeding frequency may still be a useful indicator of the adequacy of feeding practices, given that the published guidelines represent the *minimum* recommended number of feeding episodes. Therefore, we recommend adoption of feeding frequency indicators that reflect the Guiding Principles documents cited above.

As noted earlier, the process required to develop and validate global indicators of feeding practices involves a series of steps and activities, including analysis of existing data sets, field-testing of selected indicators, and technical meetings and workshops to promote interinstitutional dialogue and to reach consensus on best indicators. Each of these steps is essential. The analyses described here provide a firm basis for selection of indicators, field testing, and further dialogue towards consensus.

REFERENCES

Acuin, C. Developing and Validating Simple Indicators of Complementary Food Intake and Nutrient Density for Infants and Young Children in Developing Countries: Report from the Philippines. Report submitted to the World Health Organization, June, 2006.

Arimond, M., R. Cohen, K. Dewey, and M. T. Ruel. Developing and Validating Simple Indicators of Complementary Food Intake and Nutrient Density for Infants and Young Children in Developing Countries: Protocol for Data Analysis. Report submitted to the Food and Nutrition Technical Assistance Project, FHI 360, Washington, D.C., 2005.

Creed-Kanashiro, H., M. Marin, L. Ganoza, and M. R. Liria. Development and Validation of Indicators of Nutrient Density, Nutrient Adequacy and Energy Intake for Infants and Children in Developing Countries. Report submitted to the Food and Nutrition Technical Assistance (FANTA) Project/FHI 360, May, 2006.

Dewey, K. G., and K. H. Brown. "Update on Technical Issues Concerning Complementary Feeding of Young Children in Developing Countries and Implications for Intervention Programs." *Food and Nutrition Bulletin* 24 (2003): 5-28.

Dewey, K. G., R. J. Cohen, and N. C. Rollins. "Feeding of Non-Breastfed Children 6-24 Months of Age in Developing Countries." *Food and Nutrition Bulletin* 25 (2004): 377-402.

Dewey, K. G., R. J. Cohen, M. Arimond, and M. T. Ruel. Developing and Validating Simple Indicators of Complementary Food Intake and Nutrient Density for Breastfed Children in Developing Countries. Report submitted to the Food and Nutrition Technical Assistance (FANTA) Project/FHI 360, September,
Washington, D.C., 2005.

Hotz, Christine. Validating Simple Indicators of Food Intake and Nutrient Density for Infants and Young Children: Malawi. Report submitted to the World Health Organization, March, 2006.

Hotz, C., and K. H. Brown. "Assessment of the Risk of Zinc Deficiency in Populations and Options for its Control. International Zinc Nutrition Consultative Group (IZiNCG) Technical Document #1. *Food and Nutrition Bulletin* 25 (2004): S94-S203.

Hurrell, R. F. "Influence of Vegetable Protein Sources on Trace Element and Mineral Bioavailability." *Journal of Nutrition* 133 (2003: 2973S-2977S.

Lynch, S. R., and R. J. Stoltzfus. "Iron and Ascorbic Acid: Proposed Fortification Levels and Recommended Iron Compounds." *Journal of Nutrition* 133 (2003): 2978S-2984S.

Moursi, M. Developing and Validating Indicators of Nutrient Density and Energy Intake for Infants and Young Children in Developing Countries: Madagascar Report. Report submitted to the Food and Nutrition Technical Assistance (FANTA) Project/FHI 360, February, 2006.

Pachon, H., and E. A. Frongillo. Developing and Validating Simple Indicators of Complementary Food Intake and Nutrient Density for Infants and Young Children in Developing Countries: Report on Analysis of Data from Brazil. Report submitted to the World Health Organization, February, 2006.

PAHO/WHO (Pan American Health Organization/World Health Organization). *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington, D.C./Geneva: PAHO/WHO, 2003.

Ruel, M. T., K. H. Brown, and L. E. Caulfield. "Moving Forward with Complementary Feeding: Indicators and Research Priorities." *Food and Nutrition Bulletin* 24 (2003) (3): 289-90.

Suri, V., D. Brinda, N. Soin, S. Taneja, and N. Bhandari. Developing and Validating Simple Indicators of Complementary Food Intake and Nutrient Density for Infants and Young Children in Developing Countries: Final Report for India. Report submitted to the World Health Organization, May, 2006.

Weaver, C. M., W. R. Proulx, and R. Heaney. "Choices for Achieving Adequate Dietary Calcium with a Vegetarian Diet." *American Journal of Clinical Nutrition* 70 (1999) (suppl.): 548S.

WHO (World Health Organization). *Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge*. WHO/NUT/98.1. Geneva: WHO, 1998.

WHO (World Health Organization). *Guiding Principles for Feeding Non-Breastfed Children 6-24 Months of Age*. Geneva: WHO, 2005.

TABLES

Table 1. Study dates and sample sizes (child-days) by country, age, and breastfeeding status

Country/age (months)	Date of data collection	Total sample size (n)	Sample size by breastfeeding status and age group: Breastfed	Non-breastfed
Africa				
Ghana	1994-1996	381		
6-8 mo			209	–
9-11 mo			172	–
Madagascar	2004	1,594		
6-8 mo			383	9
9-11 mo			309	16
12-23 mo			693	184
Malawi	1998-1999	398		
6-8 mo			66	–
9-11 mo			92	–
12-23 mo			240	–
Asia				
Bangladesh	1999	116		
6-9 mo			49	–
9-12 mo			67	–
India	1998-2002	1,486		
12-23 mo			1,151	335
Philippines	1986-1988	2,654		
6-8 mo			703	665
9-11 mo			582	704
Latin America				
Brazil	2002-2003	80		
12-23 mo			–	80
Honduras	1997	658		
6-9 mo			658	–
Peru (Huascar)	1982-1984	573		
6-9 mo			318	–
9-12 mo			255	–
Peru (Trujillo)[a]	1999-2002	3,052		
6-8 mo			905	50
9-11 mo			476	60
12-23 mo			1,182	379
Total child-days				
6-8 mo		4,015	3,291	724
9-11 mo		2,733	1,953	780
12-23 mo		4,244	3,266	978
All ages		10,992	8,510	2,482

[a] Sample size for nutrient data is lower than for frequency of feeding; this is the sample for frequency.

Table 2. Percent of child-days food groups were consumed, by country, age, and breastfeeding status (1 g minimum)

	Africa			Asia			Latin America			
Energy and nutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
	Percent consuming									
Breastfed 6-8 mo. (n)	(220)	(383)	(66)	(54)	(0)	(703)	(0)	(709)	(365)	(897)
Grains, roots, tubers	100	95	100	96	–	97	–	95	92	98
Legumes and nuts	67	10	27	18	–	13	–	14	4	15
Dairy	18	22	0	10	–	36	–	53	40	45
Flesh foods	43	39	17	2	–	17	–	28	28	59
Eggs	3	5	6	4	–	14	–	42	11	24
Vitamin A -rich fruits/vegs	5	24	47	4	–	0	–	16	60	69
Other fruits and vegetables	15	68	49	27	–	20	–	69	49	57
Fats and oils	10	38	9	4	–	5	–	19	13	21
Breastfed 9-11 mo. (n)	(174)	(309)	(92)	(70)		(582)	(0)	(0)	(274)	(473)
Grains, roots, tubers	99	100	100	99	–	99	–	–	99	99
Legumes and nuts	70	27	49	30	–	15	–	–	5	26
Dairy	12	30	2	21	–	38	–	–	48	47
Flesh foods	58	50	26	9	–	28	–	–	38	65
Eggs	1	8	8	1	–	16	–	–	16	24
Vitamin A -rich fruits/vegs	13	23	63	12	–	0	–	–	66	65
Other fruits and vegetables	48	80	63	31	–	18	–	–	69	59
Fats and oils	44	63	21	6	–	5	–	–	30	18
Breastfed 12-23 mo. (n)	(0)	(693)	(240)	(0)	(1,151)		(0)	(0)	(0)	(1,182)
Grains, roots, tubers	–	100	100	–	93	–	–	–	–	100
Legumes and nuts	–	35	49	–	33	–	–	–	–	39
Dairy	–	24	0	–	87	–	–	–	–	49
Flesh foods	–	51	38	–	0	–	–	–	–	72
Eggs	–	13	6	–	1	–	–	–	–	33
Vitamin A -rich fruits/vegs	–	29	70	–	9	–	–	–	–	64
Other fruits and vegetables	–	89	69	–	51	–	–	–	–	75
Fats and oils	–	70	22	–	64	–	–	–	–	15

(continued)

	Africa			Asia			Latin America			
Energy and nutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
	Percent consuming									
Non breastfed 6-8 mo. (n)	(0)	(9)	(0)	(0)	(0)	(665)	(0)	(0)	(0)	(50)
Grains, roots, tubers	–	–	–	–	–	94	–	–	–	94
Legumes and nuts	–	–	–	–	–	10	–	–	–	18
Dairy	–	–	–	–	–	97	–	–	–	98
Flesh foods	–	–	–	–	–	19	–	–	–	60
Eggs	–	–	–	–	–	15	–	–	–	16
Vitamin A -rich fruits/vegs	–	–	–	–	–	0	–	–	–	68
Other fruits and vegetables	–	–	–	–	–	20	–	–	–	60
Fats and oils	–	–	–	–	–	5	–	–	–	12
Non breastfed 9-11 mo. (n)	(0)	(16)	(0)	(0)	(0)	(704)	(0)	(0)	(0)	(60)
Grains, roots, tubers	–	–	–	–	–	98	–	–	–	100
Legumes and nuts	–	–	–	–	–	11	–	–	–	27
Dairy	–	–	–	–	–	98	–	–	–	95
Flesh foods	–	–	–	–	–	29	–	–	–	68
Eggs	–	–	–	–	–	17	–	–	–	28
Vitamin A -rich fruits/vegs	–	–	–	–	–	0	–	–	–	73
Other fruits and vegetables	–	–	–	–	–	19	–	–	–	55
Fats and oils	–	–	–	–	–	6	–	–	–	27
Non breastfed 12-23 mo. (n)	(0)	(184)	(0)	(0)	(335)	(0)	(80)	(0)	(0)	(379)
Grains, roots, tubers	–	99	–	–	92	–	100	–	–	99
Legumes and nuts	–	26	–	–	33	–	84	–	–	42
Dairy	–	25	–	–	97	–	96	–	–	88
Flesh foods	–	47	–	–	0	–	80	–	–	75
Eggs	–	10	–	–	1	–	21	–	–	33
Vitamin A -rich fruits/vegs	–	26	–	–	9	–	34	–	–	71
Other fruits and vegetables	–	81	–	–	53	–	94	–	–	78
Fats and oils	–	59	–	–	69	–	89	–	–	21

Table 3. Mean (SD) of food group diversity, by country, age group, and breastfeeding status (FGI7: range 0-7, 1-gram minimum)

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	2.5 (1.0)	3.0 (1.1)	–	–	–	–
Madagascar	2.6 (1.1)	3.2 (1.2)	3.4 (1.1)	–	–	3.7 (1.0)
Malawi	2.5 (1.2)	3.1 (1.2)	3.3 (1.0)	–	–	–
Asia						
Bangladesh	1.6 (0.8)	2.0 (0.9)	–	–	–	–
India	–	–	2.8 (1.0)	–	–	2.9 (1.0)
Philippines	2.0 (1.0)	2.1 (1.0)	–	2.6 (0.9)	2.7 (0.9	–
Latin America						
Brazil	–	–	–	–	–	5.1 (1.0)
Honduras	3.2 (1.3)	–	–	–	–	–
Peru (Huascar)	2.8 (1.2)	3.4 (1.2)	–	–	–	–
Peru (Trujillo)	3.7 (1.2)	3.9 (1.3)	4.3 (1.3)	4.1 (1.1)	4.4 (1.2)	4.9 (1.1)

Table 4. Mean (SD) of food group diversity, by country, age group, and breastfeeding status (FGI7R: range 0-7, 10-gram minimum)

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	2.0 (0.9)	2.5 (0.9)	–	–	–	–
Madagascar	2.1 (1.1)	2.7 (1.1)	2.9 (1.0)	–	–	3.3 (1.0)
Malawi	2.1 (1.1)	2.6 (1.0)	2.9 (0.9)	–	–	–
Asia						
Bangladesh	1.3 (0.9)	1.7 (1.0)	–	–	–	–
India	–	–	2.4 (1.1)	–	–	2.6 (1.0)
Philippines	1.8 (0.9)	1.9 (0.9)	–	2.4 (0.8)	2.6 (0.9)	–
Latin America						
Brazil	–	–	–	–	–	4.4 (0.9)
Honduras	2.3 (1.1)	–	–	–	–	–
Peru (Huascar)	1.8 (1.1)	2.5 (1.2)	–	–	–	–
Peru (Trujillo)	3.2 (1.3)	3.4 (1.3)	4.0 (1.3)	3.7 (1.1)	4.1 (1.3)	4.6 (1.2)

Table 5. Mean Micronutrient Density Adequacy (MMDA), by country, age group, and breastfeeding status[a]

Countries	Breastfed children			Non-breastfed children		
	6–8 mo	9–11 mo	12–23 mo	6–8 mo	9–11 mo	12–23 mo
Africa						
Ghana	49 (15)	64 (15)	–	–	–	–
Madagascar	56 (17)	66 (16)	67 (16)	–	–	72 (12)
Malawi	52 (20)	70 (14)	71 (13)	–	–	–
Asia						
Bangladesh	35 (19)	49 (16)	–	–	–	–
India	–	–	67 (15)	–	–	73 (11)
Philippines	48 (18)	52 (16)	–	68 (19)	66 (15)	–
No fortified foods	43 (16)	50 (15)	–	56 (14)	60 (12)	–
Fortified foods	69 (12)	79 (10)	–	82 (13)	82 (12)	–
Latin America						
Brazil	–	–	–	–	–	76 (9)
Honduras	64 (14)	–	–	–	–	–
Peru (Huascar)	56 (20)	63 (17)	–	–	–	–
Peru (Trujillo)	64 (13)	70 (13)	75 (15)	83 (7)	86 (10)	87 (10)

[a] Standard deviation in the parentheses.

Table 6. Percent of sample below MMDA 50%, by country, age group, and breastfeeding status

	Breastfed children			Non-breastfed children		
Countries	6–8 mo	9–11 mo	12–23 mo	6-8 mo	9-11 mo	12-23 mo
Africa						
Ghana	53	19	–	–	–	–
Madagascar	35	18	16	22[a]	13[a]	7
Malawi	49	13	8			
Asia						
Bangladesh	71	55	–	–	–	–
India	–	–	11	–	–	4
Philippines	54	45	–	17	12	–
No fortified foods	64	49	–	30	16	–
Fortified foods	6	0	–	3	2	–
Latin America						
Brazil	–	–	–	–	–	1
Honduras	18	–	–	–	–	–
Peru (Huascar)	34	18	–	–	–	–
Peru (Trujillo)	15	9	7	–	2	1

[a] In Madagascar, very few infants were not breastfed (9 infants aged 6-8 mo and 16 infants aged 9-11 mo).

Table 7. Percent of sample above MMDA 75%, by country, age group, and breastfeeding status

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	5	22	–	–	–	–
Madagascar	15	32	34	33[a]	25[a]	44
Malawi	20	44	42	–	–	–
Asia						
Bangladesh	2	8	–	–	–	–
India	–	–	38	–	–	48
Philippines	9	10	–	37	27	–
No fortified foods	3	5	–	6	12	–
Fortified foods	41	68	–	73	70	–
Latin America						
Brazil	–	–	–	–	–	50
Honduras	25	–	–	–	–	–
Peru (Huascar)	18	29	–	–	–	–
Peru (Trujillo)	17	42	57	94	97	91

[a] In Madagascar, very few infants were not breastfed (9 infants aged 6-8 mo and 16 infants aged 9-11 mo).

Table 8. Mean of feeding frequency (meal frequency), by country, age group and breastfeeding status[a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	–	–	–	–	–	–
Madagascar	2.6 (0.7)	2.9 (0.4)	2.9 (0.4)	–	–	2.9 (0.3)
Malawi	2.9 (1.2)	3.1 (1.4)	3.1 (1.4)	–	–	–
Asia						
Bangladesh	2.2 (1.7)	3.0 (2.0)	–	–	–	–
India	–	–	–	–	–	–
Philippines	–	–	–	–	–	–
Latin America						
Brazil	–	–	–	–	–	2.9 (0.2)
Honduras	2.5 (0.7)	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–
Peru (Trujillo)	2.2 (0.9)	2.5 (0.8)	2.9 (0.7)	2.8 (0.7)	2.6 (0.6)	3.0 (0.6)

[a] Meals were as defined in individual study protocols and did not include breastfeeding. Standard deviations are in parentheses.

Table 9. Mean of feeding frequency (feeding episodes), by country, age group and breastfeeding status[a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	–	–	–	–	–	–
Madagascar	4.1 (1.1)	4.5 (0.7)	4.5 (0.7)	–	–	4.6 (0.7)
Malawi	3.5 (1.2)	4.1 (1.2)	4.3 (1.4)	–	–	–
Asia						
Bangladesh	3.0 (1.7)	3.9 (2.1)	–	–	–	–
India	–	–	4.2 (1.6)	–	–	5.5 (1.5)
Philippines	–	–	–	–	–	–
Latin America						
Brazil	–	–	–	–	–	8.1 (2.4)
Honduras	3.2 (1.2)	–	–	–	–	–
Peru (Huascar)	3.6 (2.4)	4.8 (2.7)	–	–	–	–
Peru (Trujillo)	4.5 (1.8)	5.1 (1.9)	5.9 (1.7)	9.2 (1.4)	9.3 (2.0)	8.7 (1.7)

[a] Feeding episodes include all meals and snacks, but not breastfeeding. Standard deviations are in parentheses.

Table 10. Percent of children below recommended number of meals, by country, age group and breastfeeding status[a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	–	–	–	–	–	–
Madagascar	9	12	12	–	–	100
Malawi	15	30	30	–	–	–
Asia						
Bangladesh	39	40	–	–	–	–
India	–	–	–	–	–	–
Philippines	–	–	–	–	–	–
Latin America						
Brazil	–	–	–	–	–	100
Honduras	11	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–
Peru (Trujillo)	23	42	22	92	98	89

[a] Recommendations from PAHO/WHO (2003) Guiding Principles for complementary feeding of the breastfed child and WHO (2005) Guiding principles for feeding non-breastfed children 6-24 months of age. Guidelines for breastfed children are: at 6-8 mo, meals of complementary food 2-3 times/day, with 1-2 snacks as desired; at 9-23 mo, meals of complementary food 3-4 times/day, with 1-2 snacks as desired. For non-breastfed infants and children 0-23 mo, meals should be given 4-5/day, with 1-2 snacks as desired. These guidelines are appropriate when energy density of foods is ≥ 0.8 kcal per gram, and infants/children are fed to gastric capacity at each meal. Therefore, for the purposes of this table, the minimum recommended number of meals is 2 for breastfed infants 6-8 mo, 3 for breastfed infants/children 9-23 mo, and 4 for all non-breastfed infants and children.

Table 11. Percent of children below recommended feeding episodes, by country, age group and breastfeeding status

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	–	–	–	–	–	–
Madagascar	3	2	2	–	–	6.5
Malawi	3	10	8	–	–	–
Asia						
Bangladesh	24	27	–	–	–	–
India	–	–	15	–	–	8
Philippines	–	–	–	–	–	–
Latin America						
Brazil	–	–	–	–	–	1
Honduras	7	–	–	–	–	–
Peru (Huascar)	20	18	–	–	–	–
Peru (Trujillo)	5	8	1	–	–	–

[a] Recommendations from PAHO/WHO (2003) Guiding Principles for complementary feeding of the breastfed child and WHO (2005) Guiding principles for feeding non-breastfed children 6-24 months of age. Guidelines for breastfed children are: at 6-8 mo, meals of complementary food 2-3 times/day, with 1-2 snacks as desired; at 9-23 mo, meals of complementary food 3-4 times/day, with 1-2 snacks as desired. For non-breastfed infants and children 0-23 mo, meals should be given 4-5/day, with 1-2 snacks as desired. These guidelines are appropriate when energy density of foods is ≥ 0.8 kcal per gram, and infants/children are fed to gastric capacity at each meal. Therefore, for the purposes of this table, the minimum recommended number of meals is 2 for breastfed infants 6-8 mo, 3 for breastfed infants/children 9-23 mo, and 4 for all non-breastfed infants and children.

[b] The guideline refers to meals; data are shown here with "feeding episodes" considered as meals, for comparison.

Table 12. Association (correlation coefficient) between mean micronutrient density adequacy (MMDA) and dietary diversity (FGI7), by country, age group, and breastfeeding status [a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.76	0.54	–	–	–	–
Madagascar	0.55*	0.58*	0.53*	–	–	0.46* [b]
Malawi	0.64	0.34*	0.37*	–	–	–
Asia						
Bangladesh	0.74	0.72*	–	–	–	–
India	–	–	0.45	–	–	0.45
Philippines	0.65*	0.67	–	0.26	0.36	–
No fortified foods	0.70*	0.69	–	0.56	0.55	–
Fortified foods	0.51	0.21	–	0.06[c]	0.10[c]	–
Latin America						
Brazil	–	–	–	–	–	0.29*
Honduras	0.41	–	–	–	–	–
Peru (Huascar)	0.61	0.52	–	–	–	–
Peru (Trujillo)	0.57*	0.61*	0.62*	0.28	0.37*	0.50*

[a] All correlations are significant ($p < 0.05$), except where noted.

[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.

[c] Correlation not significant ($p < 0.05$).

* Test for linear trend is significant. i.e., in a linear regression with a quadratic term ($FGI7^2$); a significant coefficient for this term was taken to indicate deviation from linearity.

Table 13. Association (correlation coefficient) between mean micronutrient density adequacy (MMDA) and dietary diversity (FGI7R), by country, age group, and breastfeeding status[a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.66*	0.52*	–	–	–	–
Madagascar	0.55*	0.62*	0.56*	–	–	0.54* [b]
Malawi	0.70	0.37*	0.36	–	–	–
Asia						
Bangladesh	0.58*	0.62*	–	–	–	–
India	–	–	0.46	–	–	0.48
Philippines	0.63	0.66	–	0.29	0.40	–
No fortified foods	0.67	0.68	–	0.59	0.58	–
Fortified foods	0.48	0.35	–	0.10[c]	0.13[c]	–
Latin America						
Brazil	–	–	–	–	–	0.49*
Honduras	0.47	–	–	–	–	–
Peru (Huascar)	0.44*	0.53*	–	–	–	–
Peru (Trujillo)	0.51*	0.65*	0.63*	0.31	0.37	0.56*

[a] All correlations are significant ($p < 0.05$), except where noted.

[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.

[c] Correlation not significant ($p < 0.05$).

* Test for linear trend is significant, i.e., in a linear regression with a quadratic term ($FGI7R^2$); a significant coefficient for this term was taken to indicate deviation from linearity.

Table 14. Area under the curve (AUC) for FGI7 when mean micronutrient density adequacy (MMDA) cutoff is 50% [a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.87*** (*0.02*)	0.69*** (*0.05*)	–	–	–	–
Madagascar	0.79*** (*0.02*)	0.86*** (*0.03*)	0.76*** (*0.02*)	–	–	0.81***[b] (*0.06*)
Malawi	0.87*** (*0.05*)	0.83*** (*0.07*)	0.80*** (*0.06*)	–	–	–
Asia						
Bangladesh	0.85*** (*0.06*)	0.79*** (*0.05*)	–	–	–	–
India	–	–	0.65*** (*0.02*)	–	–	0.64 (*0.09*)
Philippines	0.82*** *(0.02)*	0.87*** *(0.01)*	–	0.69*** *(0.02)*	0.74*** *(0.02)*	–
No fortified foods	0.85*** *(0.02)*	0.86*** *(0.02)*	–	0.73*** *(0.03)*	0.75***[c] *(0.03)*	–
Fortified foods	0.69[d] *(0.08)*		–	0.57 *(0.08)*	0.77 *(0.08)*	–
Latin America						
Brazil	–	–	–	–	–	–[e]
Honduras	0.72*** (*0.03*)	–	–	–	–	–
Peru (Huascar)	0.82*** (*0.02*)	0.81*** (*0.04*)	–	–	–	–
Peru (Trujillo)	0.86*** (*0.02*)	0.94*** (*0.02*)	0.91*** (*0.01*)	–[e]	–[e]	–[e]

* Significant at $p \leq 0.05$.

** Significant at $p \leq 0.01$.

*** Significant at $p \leq 0.001$.

[a] Standard error in parentheses.

[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.

[c] In the Philippines sample of non-breastfed children 9-11 months with no fortified foods, AUC for FGI7R was slightly (significantly higher).

[d] Result for 6-11 mo because there are not enough children in each age subgroup.

[e] In Brazil (non-breastfed children 12-23 months) and in Peru - Trujilllo (non-breastfed children within all age groups), this analysis is not reported because there were too few children (< 5) with MMDA below 50%.

Table 15. Area under the curve (AUC) for FGI7 when mean micronutrient density adequacy (MMDA) cutoff is 75% [a, b]

Countries	Breastfed children 6–8 mo	Breastfed children 9–11 mo	Breastfed children 12–23 mo	Non-breastfed children 6–8 mo	Non-breastfed children 9–11 mo	Non-breastfed children 12–23 mo
Africa						
Ghana	0.90*** (*0.03*)	0.76*** (*0.04*)	–	–	–	–
Madagascar	0.62** (*0.04*)	0.70*** (*0.03*)	0.73*** (*0.02*)	–	–	0.68***[c] (*0.04*)
Malawi	0.75** (*0.06*)	0.56 (*0.06*)	0.64*** (*0.03*)	–	–	–
Asia						
Bangladesh	–[e]	0.88** (*0.09*)	–	–	–	–
India	–	–	0.77*** (*0.01*)	–	–	0.75*** (*0.03*)
Philippines	0.72*** (*0.03*)	0.75*** (*0.03*)	–	0.57* (*0.02*)	0.65*** (*0.02*)	–
No fortified foods	0.67* (*0.07*)	0.78*** (*0.05*)	–	0.81*** (*0.04*)	0.81*** (*0.03*)	–
Fortified foods	0.68***[d] (*0.04*)		–	0.56 (*0.03*)	0.59 (*0.04*)	–
Latin America						
Brazil	–	–	–	–	–	0.61 (*0.06*)
Honduras	0.68*** (*0.02*)	–	–	–	–	–
Peru (Huascar)	0.74*** (*0.04*)	0.69*** (*0.03*)	–	–	–	–
Peru (Trujillo)	0.68*** (*0.02*)	0.74*** (*0.02*)	0.77*** (*0.01*)	–[e]	–[e]	0.77*** (*0.04*)

* Significant at $p \leq 0.05$.

** Significant at $p \leq 0.01$.

*** Significant at $p \leq 0.001$.

[a] Standard error in parentheses.

[b] AUC was significantly higher for FGI7R than FGI7 in Honduras, in both Peru samples for children 9-11 mo, and in Philippines for non-breastfed children aged 6-11 mo who were fed fortified foods.

[c] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184

[d] Result for 6-11 mo because there are not enough children in each age sub-group

[e] In Bangladesh (breastfed children 6-8 mo) and in Peru - Trujillo (non-breastfed children 6-8 mo and 9-11 mo), this analysis is not reported because there were too few children (< 5) with MMDA below 50%.

Table 16. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI7 cutoff for breastfed 6-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Africa							
Ghana	≤ 1	0.20	0.99	0.91	0.01	0.30	0.31
	≤ 2	0.82	0.73	0.65	0.17	0.07	0.23
	≤ 3	0.96	0.32	0.46	0.42	0.02	0.44
	≤ 4	0.99	0.11	0.40	0.56	0.00	0.56
Madagascar	≤ 1	0.46	0.99	0.93	0.01	0.15	0.16
	≤ 2	0.69	0.77	0.53	0.17	0.08	0.25
	≤ 3	0.95	0.40	0.38	0.43	0.01	0.45
	≤ 4	1.00	0.10	0.30	0.66	0.00	0.66
Malawi	≤ 1	0.61	0.98	0.93	0.01	0.11	0.12
	≤ 2	0.77	0.75	0.55	0.18	0.06	0.24
	≤ 3	0.93	0.40	0.37	0.44	0.02	0.46
	≤ 4	0.98	0.11	0.30	0.65	0.01	0.65
Asia							
Bangladesh	≤ 1	0.64	0.93	0.94	0.03	0.22	0.25
	≤ 2	0.90	0.43	0.72	0.22	0.06	0.28
	≤ 3	0.99	0.11	0.65	0.34	0.01	0.34
	≤ 4	1.00	0.00	0.62	0.38	0.00	0.38
India	–	–	–	–	–	–	–
Philippines	≤ 1	0.62	0.93	0.90	0.03	0.19	0.22
	≤ 2	0.92	0.52	0.66	0.24	0.04	0.28
	≤ 3	0.99	0.14	0.54	0.43	0.01	0.43
	≤ 4	1.00	0.02	0.51	0.49	0.00	0.49
No fortified foods	≤ 1	0.63	0.96	0.95	0.02	0.21	0.23
	≤ 2	0.92	0.53	0.72	0.20	0.05	0.25
	≤ 3	0.99	0.14	0.60	0.37	0.01	0.38
	≤ 4	1.00	0.02	0.57	0.42	0.00	0.42
Fortified foods	≤ 1	0.286	0.846	0.077	0.147	0.031	0.178
	≤ 2	0.857	0.487	0.070	0.491	0.006	0.497
	≤ 3	1.000	0.160	0.051	0.804	0.000	0.804
	≤ 4	1.000	0.019	0.044	0.939	0.000	0.939

(continued)

Table 16. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI7 cutoff for breastfed 6-11 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	≤ 1	0.36	0.95	0.61	0.04	0.12	0.16
	≤ 2	0.63	0.74	0.36	0.21	0.07	0.28
	≤ 3	0.76	0.44	0.24	0.45	0.04	0.50
	≤ 4	0.93	0.18	0.20	0.67	0.01	0.68
Peru (Huascar)	≤ 1	0.36	0.96	0.79	0.03	0.18	0.20
	≤ 2	0.67	0.84	0.61	0.12	0.09	0.21
	≤ 3	0.92	0.52	0.42	0.35	0.02	0.37
	≤ 4	0.97	0.14	0.30	0.62	0.01	0.63
Peru (Trujillo)	≤ 1	0.28	0.99	0.78	0.01	0.09	0.10
	≤ 2	0.70	0.90	0.49	0.09	0.04	0.13
	≤ 3	0.92	0.66	0.27	0.30	0.01	0.31
	≤ 4	0.99	0.32	0.17	0.59	0.00	0.60

Table 17. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI7 cutoff for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI7)				
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 1	0.21	0.99	0.79	0.01	0.13	0.14
	≤ 2	0.55	0.86	0.42	0.12	0.07	0.19
	≤ 3	0.82	0.51	0.24	0.41	0.03	0.44
	≤ 4	0.97	0.19	0.19	0.68	0.00	0.68
Malawi	≤ 1	0.45	1.00	0.90	0.00	0.05	0.05
	≤ 2	0.60	0.81	0.22	0.18	0.03	0.21
	≤ 3	0.90	0.51	0.14	0.45	0.01	0.46
	≤ 4	0.95	0.11	0.09	0.81	0.00	0.82
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≤ 1	0.21	0.93	0.27	0.07	0.09	0.16
	≤ 2	0.63	0.58	0.17	0.37	0.04	0.41
	≤ 3	0.89	0.28	0.14	0.64	0.01	0.65
	≤ 4	1.00	0.03	0.12	0.86	0.00	0.86
Philippines	–	–	–	–	–	–	–

(continued)

Table 17. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI7 cutoff for breastfed 12-23 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≤ 1	0.19	1.00	0.88	0.00	0.06	0.06
	≤ 2	0.59	0.95	0.46	0.05	0.03	0.08
	≤ 3	0.86	0.80	0.24	0.19	0.01	0.20
	≤ 4	1.00	0.50	0.13	0.47	0.00	0.47

Table 18. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI7 cutoff for non-breastfed children[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI7)				
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 1	0.28	1.00	1.00	0.00	0.06	0.06
6-23 mo	≤ 2	0.56	0.93	0.42	0.07	0.04	0.11
	≤ 3	0.83	0.60	0.16	0.37	0.01	0.38
	≤ 4	0.94	0.21	0.10	0.72	0.00	0.73
Malawi	–	–	–	–	–	–	–
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≤ 1	0.25	0.93	0.13	0.06	0.03	0.09
12-23 mo	≤ 2	0.58	0.61	0.05	0.37	0.02	0.39
	≤ 3	0.83	0.30	0.04	0.68	0.01	0.69
	≤ 4	1.00	0.02	0.04	0.94	0.00	0.94
Philippines	≤ 1	0.17	0.98	0.61	0.02	0.12	0.14
6-11 mo	≤ 2	0.82	0.53	0.23	0.40	0.03	0.43
	≤ 3	0.97	0.19	0.17	0.69	0.00	0.70
	≤ 4	1.00	0.04	0.15	0.82	0.00	0.82
No fortified foods	≤ 1	0.18	0.99	0.81	0.01	0.18	0.19
	≤ 2	0.82	0.57	0.35	0.34	0.04	0.38
6-11 mo	≤ 3	0.97	0.20	0.25	0.62	0.01	0.63
	≤ 4	1.00	0.05	0.23	0.75	0.00	0.75
Fortified Foods	≤ 1	0.000	0.971	0.000	0.028	0.026	0.055
	≤ 2	0.769	0.475	0.038	0.511	0.006	0.517
6-11 mo	≤ 3	1.000	0.162	0.031	0.816	0.000	0.816
	≤ 4	1.000	0.035	0.027	0.939	0.000	0.939
Latin America							
Brazil		(too few children with MMDA < 50; this analysis could not be performed)					
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)		(too few children with MMDA < 50; this analysis could not be performed)					

[a] In Madagascar there were only a few (n = 25) non-breastfed children < 12 months; analysis was performed on all non-breastfed children combined (n = 184 > 12 mo).

Table 19. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for breastfed 6-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Africa							
Ghana	≥ 2	1.00	0.10	0.14	0.79	0.00	0.79
	≥ 3	0.99	0.53	0.22	0.41	0.01	0.42
	≥ 4	0.96	0.85	0.39	0.13	0.04	0.17
	≥ 5	0.82	0.95	0.39	0.04	0.10	0.14
	≥ 6	0.20	0.99	0.33	0.01	0.12	0.13
	≥ 7	–	–	–	–	–	–
Madagascar	≥ 2	0.99	0.17	0.26	0.64	0.00	0.64
	≥ 3	0.82	0.41	0.29	0.46	0.04	0.50
	≥ 4	0.50	0.75	0.37	0.19	0.11	0.31
	≥ 5	0.16	0.96	0.52	0.03	0.19	0.23
	≥ 6	0.03	1.00	0.67	0.00	0.22	0.23
	≥ 7	0.00	1.00	1.00	0.00	0.23	0.23
Malawi	≥ 2	1.00	0.28	0.41	0.48	0.00	0.48
	≥ 3	0.76	0.43	0.42	0.35	0.08	0.44
	≥ 4	0.40	0.70	0.44	0.17	0.20	0.37
	≥ 5	0.09	0.86	0.39	0.05	0.30	0.35
	≥ 6	0.08	0.96	1.00	0.00	0.31	0.31
	≥ 7	0.00	1.00	n/a	0.00	0.34	0.34

(continued)

Table 19. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for breastfed 6-11 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI7)				
Asia							
Bangladesh	≥ 2	1.00	0.45	0.09	0.53	0.00	0.53
	≥ 3	0.83	0.81	0.19	0.18	0.01	0.19
	≥ 4	0.50	0.97	0.50	0.03	0.03	0.05
	≥ 5	–	–	–	–	–	–
	≥ 6	–	–	–	–	–	–
	≥ 7	–	–	–	–	–	–
India	–	–	–	–	–	–	–
Philippines	≥ 2	0.60	0.73	0.18	0.25	0.04	0.28
	≥ 3	0.26	0.94	0.31	0.05	0.07	0.12
	≥ 4	0.04	0.99	0.33	0.01	0.09	0.10
	≥ 5	0.00	1.00	0.00	0.00	0.09	0.09
	≥ 6	0.00	1.00	0.00	0.00	0.09	0.09
	≥ 7	–	–	–	–	–	–
No fortified foods	≥ 2	0.60	0.73	0.08	0.26	0.01	0.27
	≥ 3	0.30	0.94	0.16	0.06	0.02	0.08
	≥ 4	0.05	0.99	0.17	0.01	0.03	0.04
	≥ 5	0.00	1.00	0.00	0.00	0.04	0.04
	≥ 6	0.00	1.00	-	0.00	0.04	0.04
	≥ 7	–	–	–	–	–	–
Fortified Foods	≥ 2	0.595	0.643	0.610	0.184	0.196	0.380
	≥ 3	0.241	0.929	0.760	0.037	0.368	0.405
	≥ 4	0.038	1.000	1.000	0.000	0.466	0.466
	≥ 5	0.000	1.000	-	0.000	0.485	0.485
	≥ 6	0.000	1.000	-	0.000	0.485	0.485
	≥ 7	–	–	–	–	–	–

(continued)

Table 19. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for breastfed 6-11 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	≥ 2	0.98	0.14	0.27	0.65	0.00	0.66
	≥ 3	0.90	0.40	0.33	0.45	0.02	0.48
	≥ 4	0.59	0.66	0.36	0.26	0.10	0.36
	≥ 5	0.26	0.88	0.41	0.09	0.18	0.28
	≥ 6	0.03	0.98	0.33	0.02	0.24	0.25
	≥ 7	0.00	0.99	0.00	0.00	0.25	0.25
Peru (Huascar)	≥ 2	0.98	0.16	0.25	0.65	0.00	0.66
	≥ 3	0.91	0.36	0.29	0.49	0.02	0.51
	≥ 4	0.68	0.68	0.39	0.24	0.07	0.32
	≥ 5	0.23	0.93	0.48	0.06	0.17	0.23
	≥ 6	0.03	0.99	0.40	0.01	0.22	0.23
	≥ 7	–	–	–	–	–	–
Peru (Trujillo)	≥ 2	1.00	0.06	0.27	0.70	0.00	0.70
	≥ 3	0.97	0.22	0.30	0.58	0.01	0.58
	≥ 4	0.80	0.49	0.35	0.38	0.05	0.43
	≥ 5	0.49	0.79	0.45	0.16	0.13	0.29
	≥ 6	0.16	0.96	0.56	0.03	0.22	0.25
	≥ 7	0.02	1.00	0.67	0.00	0.26	0.26

Table 20. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≥ 2	1.00	0.06	0.36	0.62	0.00	0.62
	≥ 3	0.93	0.28	0.40	0.47	0.02	0.50
	≥ 4	0.70	0.67	0.53	0.22	0.10	0.32
	≥ 5	0.33	0.92	0.68	0.05	0.23	0.28
	≥ 6	0.07	0.99	0.85	0.00	0.32	0.32
	≥ 7	0.00	1.00	1.00	0.00	0.34	0.34
Malawi	≥ 2	1.00	0.07	0.44	0.54	0.00	0.54
	≥ 3	0.85	0.26	0.46	0.42	0.06	0.48
	≥ 4	0.59	0.53	0.52	0.23	0.17	0.40
	≥ 5	0.18	0.84	0.69	0.03	0.34	0.38
	≥ 6	0.02	0.95	1.00	0.00	0.41	0.41
	≥ 7	0.00	1.00	n/a	0.00	0.42	0.42
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≥ 2	1.00	0.14	0.41	0.53	0.00	0.54
	≥ 3	0.85	0.61	0.57	0.24	0.06	0.30
	≥ 4	0.45	0.85	0.65	0.09	0.21	0.30
	≥ 5	0.05	0.99	0.81	0.00	0.36	0.36
	≥ 6	0.00	1.00	1.00	0.00	0.37	0.37
	≥ 7	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–

(continued)

Table 20. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for breastfed 12-23 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≥ 2	1.00	0.03	0.58	0.41	0.00	0.41
	≥ 3	0.98	0.18	0.62	0.35	0.01	0.36
	≥ 4	0.90	0.44	0.68	0.24	0.06	0.30
	≥ 5	0.64	0.77	0.79	0.10	0.21	0.31
	≥ 6	0.28	0.96	0.91	0.02	0.41	0.43
	≥ 7	0.05	1.00	0.97	0.00	0.55	0.55

Table 21. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for non-breastfed children[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI7)			
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≥ 2	1.00	0.04	0.43	0.56	0.00	0.56
6-23 mo	≥ 3	0.94	0.16	0.45	0.49	0.02	0.51
	≥ 4	0.74	0.57	0.56	0.25	0.11	0.36
	≥ 5	0.28	0.87	0.61	0.08	0.30	0.38
	≥ 6	0.06	1.00	1.00	0.00	0.40	0.40
	≥ 7	0.01	1.00	1.00	0.00	0.42	0.42
Malawi	–	–	–	–	–	–	–
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≥ 2	0.99	0.13	0.51	0.46	0.00	0.46
12-23 mo	≥ 3	0.85	0.61	0.66	0.21	0.07	0.28
	≥ 4	0.43	0.84	0.70	0.09	0.27	0.36
	≥ 5	0.04	0.99	0.88	0.00	0.45	0.46
	≥ 6	0.00	1.00	0.00	0.00	0.47	0.47
	≥ 7	–	–	–	–	–	–

(continued)

Table 21. Sensitivity/specificity analysis of the relationship between food group diversity (FGI7) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI7 cutoff for non-breastfed children (...…*continued*)[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI7)				
Asia							
Philippines	≥ 2	0.59	0.57	0.39	0.29	0.13	0.42
6-11 mo	≥ 3	0.25	0.88	0.49	0.08	0.24	0.32
	≥ 4	0.07	0.98	0.63	0.01	0.30	0.31
	≥ 5	0.01	1.00	0.75	0.00	0.32	0.32
	≥ 6	0.00	1.00	-	0.00	0.32	0.32
	≥ 7	–	–	–	–	–	–
No fortified foods	≥ 2	0.52	0.87	0.29	0.12	0.04	0.16
	≥ 3	0.17	0.98	0.45	0.02	0.08	0.10
6-11 mo	≥ 4	0.02	1.00	0.67	0.00	0.09	0.09
	≥ 5	0.00	1.00	-	0.00	0.09	0.09
	≥ 6	0.00	1.00	-	0.00	0.09	0.09
	≥ 7	–	–	–	–	–	–
Fortified foods	≥ 2	0.506	0.624	0.772	0.107	0.354	0.461
	≥ 3	0.186	0.915	0.846	0.024	0.582	0.606
6-11 mo	≥ 4	0.040	0.993	0.941	0.002	0.712	0.714
	≥ 5	0.003	1.000	1.000	0.000	0.713	0.713
	≥ 6	0.000	1.000	-	0.000	0.715	0.715
	≥ 7	–	–	–	–	–	–
Latin America							
Brazil	≥ 2	100.0	0.0	50.0	50.0	0.0	50.0
12-23 mo	≥ 3	100.0	5.0	51.3	47.5	0.0	47.5
	≥ 4	100.0	10.0	52.6	45.0	0.0	45.0
	≥ 5	90.0	30.0	56.3	35.0	5.0	40.0
	≥ 6	35.0	72.5	56.0	13.8	32.5	46.3
	≥ 7	7.5	97.5	75.0	1.3	46.3	47.5
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≥ 2	1.00	0.03	0.91	0.09	0.00	0.09
12-23 mo	≥ 3	0.98	0.15	0.92	0.08	0.02	0.10
	≥ 4	0.92	0.38	0.94	0.06	0.08	0.13
	≥ 5	0.71	0.74	0.97	0.02	0.26	0.29
	≥ 6	0.31	0.94	0.98	0.01	0.63	0.63
	≥ 7	0.05	1.00	1.00	0.00	0.86	0.86

[a] In Madagascar there were only a few (n=25) non-breastfed children < 2 months; analysis was performed on all non-breastfed children combined but results are presented here since most were >12 mo (n= 84>12 mo).

Table 22. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) – sum of Se and Sp ≥ 1.25

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Africa									
Ghana									
6-11 mo	Flesh foods	0.79	0.68	0.60	0.20	0.08	0.28	0.73 (0.03)	0.68 - 0.79
	Other fruits vegs	0.89	0.41	0.48	0.37	0.04	0.41	0.65 (0.03)	0.59 - 0.70
	Animal-source foods	0.76	0.79	0.69	0.13	0.09	0.22	0.78 (0.03)	0.73 - 0.83
Madagascar									
6-11 mo	Flesh foods	0.75	0.51	0.37	0.36	0.07	0.43	0.63 (0.02)	0.59 - 0.67
	Animal-source foods	0.68	0.68	0.45	0.23	0.09	0.32	0.68 (0.02)	0.64 - 0.72
	Other fruits vegs	0.59	0.85	0.61	0.11	0.11	0.22	0.72 (0.02)	0.68 - 0.76
12-23 mo	Flesh foods	0.77	0.56	0.25	0.37	0.04	0.41	0.66 (0.02)	0.62 - 0.71
	Animal-source foods	0.67	0.68	0.29	0.27	0.05	0.32	0.68 (0.02)	0.63 - 0.72
	Other fruits vegs	0.32	0.93	0.47	0.06	0.11	0.17	0.62 (0.02)	0.58 - 0.67
Malawi									
6-11 mo	Vitamin A-rich[a]	0.93	0.75	0.59	0.18	0.02	0.20	0.16 (0.03)	0.09 - 0.22
	Other fruits vegs	0.75	0.69	0.49	0.22	0.07	0.29	0.28 (0.05)	0.19 - 0.37
12-23 mo	Flesh foods	0.85	0.40	0.11	0.55	0.01	0.56	0.38 (0.06)	0.26 - 0.49
	Animal-source foods	0.85	0.43	0.12	0.53	0.01	0.54	0.36 (0.06)	0.25 - 0.47
	Vitamin A-rich	0.85	0.75	0.24	0.23	0.01	0.24	0.20 (0.05)	0.10 - 0.30
	Other fruits vegs	0.70	0.73	0.19	0.25	0.03	0.28	0.29 (0.06)	0.17 - 0.41

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

(continued)

Table 22. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) – sum of Se and Sp ≥ 1.25 (*….continued*)

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Asia									
Bangladesh									
6-11 mo	Dairy products	0.97	0.39	0.72	0.23	0.02	0.25	0.68 (0.06)	0.57 - 0.79
	Other fruits vegs	0.89	0.59	0.78	0.16	0.07	0.22	0.74 (0.05)	0.64 - 0.84
	Animal-source foods	0.93	0.50	0.75	0.19	0.04	0.23	0.72 (0.05)	0.61 - 0.82
India									
12-23 mo	Dairy	0.45	0.92	0.48	0.07	0.07	0.14	0.68 (0.02)	0.65 - 0.73
	Animal-source foods	0.45	0.92	0.48	0.07	0.07	0.14	0.68 (0.02)	0.65 - 0.73
Philippines									
6-11 mo	Dairy	0.88	0.62	0.70	0.19	0.06	0.25	0.75 (0.01)	0.72 - 0.78
No fortified Foods	Dairy	0.88	0.54	0.72	0.20	0.06	0.26	0.71 (0.01)	0.69 - 0.74
Fortified foods	Dairy	0.57	0.85	0.14	0.15	0.02	0.17	0.71 (0.10)	0.51 - 0.91
Latin America									
Honduras									
6-8 mo	Dairy products	0.72	0.59	0.28	0.34	0.05	0.39	0.65 (0.03)	0.60 - 0.71
	Eggs	0.88	0.48	0.28	0.42	0.02	0.44	0.68 (0.02)	0.64 - 0.73
	Other fruits vegs	0.59	0.75	0.35	0.20	0.08	0.28	0.67 (0.03)	0.61 - 0.72
	Animal-source foods	0.49	0.87	0.45	0.11	0.09	0.20	0.68 (0.03)	0.62 - 0.74
Peru (Huascar)									
6-11 mo	Flesh foods	0.87	0.40	0.36	0.43	0.04	0.47	0.64 (0.02)	0.59 - 0.68
	Dairy products	0.78	0.51	0.38	0.35	0.06	0.41	0.65 (0.03)	0.60 - 0.70
	Vitamin A-rich fruits	0.70	0.75	0.52	0.18	0.08	0.26	0.73 (0.03)	0.68 - 0.77
	Other fruits vegs	0.63	0.66	0.41	0.25	0.10	0.35	0.64 (0.03)	0.59 - 0.69
	Animal-source foods	0.60	0.81	0.54	0.14	0.11	0.26	0.70 (0.03)	0.65 - 0.75

(continued)

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

Table 22. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) – sum of Se and Sp ≥ 1.25 *(….continued*)

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Latin America									
Peru (Trujillo)									
6-11 mo	Dairy	0.99	0.52	0.23	0.42	0.00	0.42	0.76 (0.01)	0.73 - 0.78
	Flesh foods	0.76	0.67	0.24	0.29	0.03	0.32	0.71 (0.02)	0.67 - 0.75
	Animal-source foods	0.72	0.90	0.51	0.09	0.03	0.12	0.81 (0.02)	
	Vitamin A-rich[a]	0.74	0.73	0.28	0.23	0.03	0.27	0.74 (0.02)	0.69 - 0.78
12-23 mo	Dairy	0.99	0.53	0.13	0.44	0.00	0.44	0.76 (0.02)	0.72 - 0.79
	Flesh foods	0.51	0.74	0.12	0.25	0.03	0.28	0.63 (0.03)	0.56 - 0.69
	Eggs	0.98	0.36	0.10	0.60	0.00	0.60	0.67 (0.02)	0.62 - 0.71
	Animal-source foods	0.48	0.93	0.32	0.07	0.00	0.10	0.70 (0.04)	0.63 - 0.77
	Vitamin A-rich	0.83	0.68	0.16	0.30	0.01	0.32	0.75 (0.03)	0.70 - 0.80
	Other fruits vegs	0.50	0.77	0.14	0.22	0.03	0.25	0.63 (0.03)	0.57 - 0.70
Non-breastfed									
Asia									
India									
12-23 mo	Dairy	0.46	0.98	0.55	0.01	0.02	0.04	0.72 (0.07)	0.58 - 0.86
	Animal-source foods	0.46	0.98	0.55	0.01	0.02	0.04	0.72 (0.07)	0.58 - 0.86

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

(continued)

Table 22. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) – sum of Se and Sp ≥ 1.25 (*….continued*)

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Non-breastfed									
Asia									
Philippines	None								
6-11 mo									
No fortified	None								
Fortified foods									
	None								
Latin America									
Peru (Trujillo)	(too few children with MMDA < 50; this analysis could not be performed)								

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

Table 23. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) – sum of Se and Sp ≥ 1.25

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Africa									
Ghana									
6-11 mo	Flesh foods	0.77	0.54	0.19	0.40	0.03	0.43	0.65 (0.04)	0.57 - 0.73
	Other fruits vegs	0.72	0.76	0.30	0.21	0.03	0.24	0.74 (0.40)	0.67 - 0.82
	Animal-source foods	0.89	0.46	0.19	0.47	0.01	0.49	0.68 (0.04)	0.61 - 0.75
Madagascar									
12-23 mo	Dairy	0.45	0.88	0.65	0.08	0.19	0.27	0.66 (0.02)	0.63 - 0.70
	Flesh foods	0.69	0.59	0.47	0.27	0.11	0.38	0.64 (0.02)	0.60 - 0.68
	Animal-source foods	0.88	0.51	0.48	0.32	0.04	0.37	0.69 (0.02)	0.66 - 0.73
Malawi									
6-11 mo	Vitamin A-rich[a]	0.93	0.62	0.55	0.25	0.03	0.28	0.77 (0.04)	0.70 - 0.85
	Other fruits vegs	0.62	0.46	0.37	0.36	0.13	0.49	0.54 (0.05)	0.45 - 0.64
12-23 mo	Animal-source foods	0.56	0.71	0.58	0.17	0.18	0.35	0.63 (0.04)	0.56 - 0.71
	Vitamin A-rich	0.86	0.41	0.51	0.34	0.06	0.40	0.64 (0.04)	0.57 - 0.71

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

(continued)

Table 23. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) – sum of Se and Sp ≥ 1.25 (*….continued*)

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Asia									
Bangladesh[b]									
6-11 mo	Other fruits vegs	0.67	0.73	0.12	0.26	0.02	0.28	0.70 (0.11)	0.47 - 0.92
	Vitamin A-rich fruits	0.50	0.94	0.30	0.06	0.03	0.09	0.72 (0.13)	0.46 - 0.97
	Animal-source foods	0.67	0.94	0.15	0.20	0.02	0.22	0.73 (0.11)	0.50 - 0.95
India									
12-23 mo	Other fruits vegs	0.80	0.63	0.50	0.25	0.07	0.32	0.71 (0.01)	0.69 - 0.74
Philippines									
6-11 mo	Dairy	0.82	0.68	0.21	0.29	0.02	0.31	0.75 (0.02)	0.71 – 0.79
	Animal-source foods	0.99	0.47	0.16	0.48	0.00	0.48	0.73 (0.02)	0.70 – 0.77
No fortified	Dairy	0.48	0.70	0.06	0.28	0.02	0.30	0.59 (0.04)	0.51-0.67
Foods	Animal-source foods	0.98	0.49	0.07	0.49	0.00	0.49	0.73 (0.02)	0.70-0.76
Fortified foods	Dairy	1.00	0.33	0.59	0.34	-	0.34	0.67 (0.03)	0.62-0.72
	Animal-source foods	1.00	0.29	0.57	0.37	-	0.37	0.64 (0.03)	0.59-0.69
Latin America									
Honduras									
6-8 mo	Eggs	0.65	0.66	0.39	0.26	0.09	0.34	0.66 (0.03)	0.61 - 0.71
Peru (Huascar)									
6-11 mo	Flesh foods	0.54	0.73	0.37	0.43	0.04	0.31	0.64 (0.03)	0.58 - 0.70
	Vitamin A-rich fruits	0.85	0.44	0.30	0.44	0.03	0.47	0.64 (0.03)	0.59 - 0.69
	Animal-source foods	0.88	0.36	0.29	0.49	0.03	0.34	0.62 (0.03)	0.57 - 0.67

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

[b] Sample size was small in Bangladesh, and only 6 children (of 116) exceeded an MMDA of 75%. P-values for the three food groups reported above were 0.10, 0.07, and 0.06 ,respectively.

(continued)

Table 23. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) – sum of Se and Sp ≥ 1.25 *(….continued)*

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Breastfed									
Latin America									
Peru (Trujillo)									
6-11 mo	Dairy	0.71	0.63	0.40	0.27	0.08	0.35	0.67 (0.02)	0.64 - 0.70
	Flesh foods	0.87	0.48	0.37	0.39	0.03	0.42	0.68 (0.02)	0.64 - 0.71
12-23 mo	Dairy	0.69	0.78	0.81	0.10	0.18	0.27	0.73 (0.02)	0.70 - 0.76
	Eggs	0.44	0.81	0.75	0.08	0.32	0.41	0.62 (0.02)	0.59 - 0.65
Non-breastfed									
Africa									
Madagascar									
6-23 mo	Dairy	0.44	0.86	0.70	0.08	0.23	0.32	0.65 (0.03)	0.59 - 0.71
Asia									
India									
12-23 mo	Other fruits vegs	0.76	0.64	0.62	0.22	0.10	0.31	0.70 (0.03)	0.65 - 0.75
Philippines									
6-11 mo	None								
No fortified foods	Eggs	0.72	0.90	0.43	0.09	0.02	0.11	0.81 (0.03)	0.76-0.86
Fortified foods	None								

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

(continued)

Table 23. Sensitivity/specificity analysis of the relationship between individual food group intake (1-gram minimum) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) – sum of Se and Sp ≥ 1.25 (*….continued*)

	Food group	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified	Area under the curve (SEM)	95% CI
Non-breastfed									
Latin America									
Peru (Trujillo)									
6-11 mo	Dairy	0.98	0.40	0.97	0.03	0.02	0.05	0.69 (0.15)	0.40 - 0.98
	Flesh foods	0.66	1.00	1.00	0.00	0.33	0.33	0.83 (0.05)	0.72 - 0.93
	Animal-source foods	1.00	0.50	0.99	0.01	0.00	0.01	0.60 (0.15)	0.31 - 0.89
12-23 mo	Dairy	0.94	0.68	0.97	0.03	0.06	0.08	0.81 (0.05)	0.71 - 0.90
	Vitamin A-rich	0.73	0.53	0.94	0.04	0.25	0.29	0.63 (0.05)	0.53 - 0.73

[a] Vitamin A-rich fruits and vegetables (> 130 RE per 100 g edible portion).

Table 24. Relationship (correlation coefficient) between energy intake and number of feeding episodes, by country, age group, and breastfeeding status

	Breastfed children[a]			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana[b]	–	–	–	–	–	–
Madagascar	0.47*	0.37*	0.32*	–	–	0.32* [a]
Malawi	0.63*	0.49*	0.52*	–	–	–
Asia						
Bangladesh	0.48*	0.57*	–	–	–	–
India	–	–	0.50	–	–	0.36
Philippines[c]	–	–	–	–	–	–
Latin America						
Brazil	–	–	–	–	–	0.60[a]*
Honduras	0.54*	–	–	–	–	–
Peru (Huascar)	0.78	0.66*	–	–	–	–
Peru (Trujillo)	0.70*	0.72*	0.62*	0.21[a]	0.40[a]	0.40[a]*

[a] All correlations are significant ($p < 0.05$).

[b] There is no information on frequency of feeding in the Ghana data set.

[c] In the Philippines data set, in contrast to other countries, milk feeds were not counted as feeding episodes so results are not comparable.

* Test for linear trend is significant, i.e., in a linear regression a quadratic term (# episodes^2); a significant coefficient for this term was taken to indicate deviation from linearity.

Table 25. Relationship (correlation coefficient) between energy intake and number of meals, by country, age group, and breastfeeding status

	Breastfed children[a]			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana[b]	–	–	–	–	–	–
Madagascar	0.32*	0.19*	0.14*	–	–	0.05
Malawi	0.76	0.75*	0.71*	–	–	–
Asia						
Bangladesh	0.62*	0.64*	–	–	–	–
India[c]	–	–	–	–	–	–
Philippines[d]	n/a	n/a	n/a	n/a	n/a	n/a
Latin America						
Brazil[e]	–	–	–	–	–	–
Honduras	0.37*	–	–	–	–	–
Peru (Huascar)[c]	–	–	–	–	–	–
Peru (Trujillo)[f]	0.38*	0.41*	0.24*	0.19	-0.07	0.08

[a] All correlations are significant ($p < 0.05$).

[b] There is no information on frequency of feeding in the Ghana data set.

[c] Meals were not defined (see results for feeding episodes) in India and Peru-Huascar.

[d] In the Philippines data set, in contrast to other countries, milk feeds were not counted so results are not comparable.

[e] The coefficient is not calculated for Brazil because 75/80 child-days included 3 meals and only 5/80 had 2 meals

[f] In Trujillo, number of meals was sometimes truncated at 3 by field staff.

* Test for linear trend: in a linear regression with a quadratic term (# meals^2); a significant coefficient for this term was taken to indicate deviation from linearity. An "*" indicates that the relationship was linear.

Table 26. Area under the curve (AUC) for indicator "number of feeding episodes," when assessing low energy intake from complementary food[a, b]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6-8 mo**	**9-11 mo**	**12-23 mo**
Africa						
Ghana[c]	–	–	–	–	–	–
Madagascar	0.74** (*0.02*)	0.68** (*0.03*)	0.62** (*0.02*)	–	–	–
Malawi	0.81*** (*0.05*)	0.73*** (*0.05*)	0.75*** (*0.04*)	–	–	–
Asia						
Bangladesh	0.74* *(0.07)*	–[d]	0.69* *(0.06)*	–	–	–
India	–	–	0.24*** *(0.01)*	–	–	0.34*** (0.04)
Philippines	–	–	–	–	–	
Latin America						
Brazil	–	–	–	–	–	0.81*** (*0.06*)
Honduras	0.78*** *(0.02)*	–	–	–	–	–
Peru (Huascar)	0.90*** *(0.02)*	0.83*** *(0.03)*	0.86*** *(0.02)*	–	–	–
Peru (Trujillo)	0.83*** *(0.01)*	0.83*** *(0.02)*	0.78*** *(0.01)*	0.52 *(0.88)*	0.79** *(0.07)*	0.70*** *(0.03)*

* Significant at $p \leq 0.05$.
** Significant at $p \leq 0.01$.
*** Significant at $p \leq 0.001$.

[a] Low food energy intake is defined as follows: for breastfed children, it is defined as below estimated kilocalorie requirements from complementary food, when average breast milk intake is assumed (i.e., < 202 kcal for 6-8 mo; < 307 kcal for 9-11 mo; < 548 kcal for 12-23 mo); for non-breastfed children it is defined as < 615 kcal for 6-8 mo; < 686 kcal for 9-11 mo; < 894 kcal for 12-23 mo (WHO 1998). Food energy intake does not include energy intake from breast milk, but does include energy intake from other nutritive liquids (e.g., milk and juice).

[b] Standard error in the parentheses.

[c] There were no data on frequency of feeding in the Ghana data set.

[d] This analysis is not reported because there were too few children aged 9-11 mo with energy intakes above the cut-off.

Table 27. Area under the curve (AUC) for indicator "number of meals," when assessing low energy intake from complementary food[a, b]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana[c]	–	–	–	–	–	–
Madagascar	0.61** (*0.02*)	0.56** (*0.02*)	0.53* (*0.01*)	–	–	–
Malawi	0.91*** (*0.03*)	0.87*** (*0.04*)	0.84*** (*0.03*)	–	–	–
Asia						
Bangladesh	0.84* *(0.06)*	–[d]	0.78*** *(0.05)*			
India	–	–	–	–	–	–
Philippines	–	–	–	–	–	–
Latin America						
Brazil[e]	–	–	–	–	–	0.60 (*0.06*)
Honduras	0.68*** *(0.02)*	–	–	–	–	–
Peru (Huascar)[f]						
Peru (Trujillo)	0.73*** *(0.02)*	0.67*** *(0.03)*	0.58*** *(0.02)*	0.47 *(0.11)*	0.40 *(0.09)*	0.51 *(0.03)*

* Significant at $p \leq 0.05$.

** Significant at $p \leq 0.01$.

*** Significant at $p \leq 0.001$.

[a] Low food energy intake is defined as follows: for breastfed children, it is defined as below estimated kilocalorie requirements from complementary food, when average breast milk intake is assumed (i.e., < 202 kcal for 6-8 mo; < 307 kcal for 9-11 mo; < 548 kcal for 12-23 mo); for non-breastfed children it is defined as < 615 kcal for 6-8 mo; < 686 kcal for 9-11 mo; < 894 kcal for 12-23 mo (WHO, 1998). Food energy intake does not include energy intake from breast milk, but does include energy intake from other nutritive liquids (e.g., milk and juice).

[b] Standard error in the parentheses.

[c] There were no data on frequency of feeding in the Ghana data set.

[d] This analysis is not reported because there were too few children aged 9-11 mo with energy intakes above the cut-off.

[e] AUC is not reported for Brazil because 75/80 child-days included 3 meals and only 5/80 had 2 meals.

[f] There were no data on number of meals in the Huascar data set.

Table 28. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of feeding episodes) and low energy intake for breastfed 6-8 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.17	0.98	0.90	0.01	0.45	0.46
	≤ 3	0.38	0.93	0.87	0.03	0.34	0.37
	≤ 4	0.73	0.65	0.71	0.16	0.14	0.30
	≤ 5	1.00	0.00	0.54	0.46	0.00	0.46
	≤ 6	1.00	0.00	0.54	0.46	0.00	0.46
Malawi	≤ 2	0.05	1.00	1.00	0.00	0.55	0.55
	≤ 3	0.37	1.00	1.00	0.00	0.36	0.36
	≤ 4	0.76	0.75	0.81	0.11	0.14	0.24
	≤ 5	0.92	0.36	0.66	0.27	0.05	0.32
	≤ 6	0.97	0.07	0.59	0.39	0.02	0.41
Asia							
Bangladesh	≤ 2	0.64	0.91	0.96	0.28	0.02	0.30
	≤ 3	0.87	0.55	0.87	0.10	0.10	0.20
	≤ 4	0.95	0.27	0.82	0.04	0.16	0.20
	≤ 5	1.00	0.09	0.80	0.16	0.04	0.20
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	≤ 2	0.38	0.94	0.92	0.39	0.02	0.41
	≤ 3	0.79	0.60	0.76	0.13	0.15	0.28
	≤ 4	0.95	0.31	0.69	0.03	0.26	0.29
	≤ 5	1.00	0.06	0.63	0	0.36	0.36
Peru (Huascar)	≤ 2	0.60	0.93	0.95	0.28	0.02	0.30
	≤ 3	0.87	0.80	0.91	0.09	0.06	0.15
	≤ 4	0.96	0.59	0.84	0.03	0.20	0.16
	≤ 5	1.00	0.34	0.77	0	0.24	0.21

(continued)

Table 28. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of feeding episodes) and low energy intake for breastfed 6-8 mo children (...…*continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Latin America							
Peru (Trujillo)	≤ 2	0.31	0.97	0.88	0.02	0.29	0.31
	≤ 3	0.57	0.88	0.77	0.07	0.18	0.25
	≤ 4	0.82	0.70	0.66	0.18	0.07	0.25
	≤ 5	0.94	0.43	0.54	0.33	0.03	0.36
	≤ 6	0.99	0.19	0.46	0.48	0.00	0.48

Table 29. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of feeding episodes) and low energy intake for breastfed 9-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.03	1.00	1.00	0.00	0.53	0.53
	≤ 3	0.16	0.97	0.87	0.01	0.46	0.47
	≤ 4	0.57	0.76	0.75	0.11	0.23	0.34
	≤ 5	1.00	0.00	0.55	0.45	0.00	0.45
	≤ 6	1.00	0.00	0.55	0.45	0.00	0.45
Malawi	≤ 2	0.00	1.00	–	0.00	0.45	0.45
	≤ 3	0.22	1.00	1.00	0.00	0.35	0.35
	≤ 4	0.46	0.82	0.68	0.10	0.24	0.34
	≤ 5	0.83	0.47	0.56	0.29	0.08	0.37
	≤ 6	0.95	0.24	0.50	0.42	0.02	0.45
Asia							
Bangladesh[a]							
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	≤ 2	0.40	0.98	0.97	0.38	0.01	0.39
	≤ 3	0.59	0.89	0.90	0.27	0.04	0.31
	≤ 4	0.76	0.75	0.84	0.16	0.09	0.25
	≤ 5	0.90	0.49	0.76	0.07	0.18	0.25
Peru (Trujillo)	≤ 2	0.18	0.99	0.94	0.00	0.34	0.34
	≤ 3	0.41	0.92	0.78	0.05	0.24	0.29
	≤ 4	0.72	0.80	0.71	0.12	0.12	0.24
	≤ 5	0.90	0.56	0.58	0.26	0.04	0.31
	≤ 6	0.97	0.31	0.49	0.41	0.01	0.42

[a] In Bangladesh, too few children had adequate energy intakes for this analysis to be performed.

Table 30. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of feeding episodes) and low energy intake for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.02	1.00	1.00	0.00	0.71	0.71
	≤ 3	0.15	0.96	0.90	0.01	0.62	0.63
	≤ 4	0.45	0.76	0.83	0.07	0.40	0.47
	≤ 5	1.00	0.01	0.73	0.27	0.00	0.27
	≤ 6	1.00	0.00	0.73	0.27	0.00	0.27
Malawi	≤ 2	0.02	1.00	1.00	0.00	0.69	0.69
	≤ 3	0.11	0.99	0.95	0.00	0.63	0.63
	≤ 4	0.40	0.89	0.90	0.03	0.42	0.45
	≤ 5	0.72	0.66	0.83	0.10	0.20	0.30
	≤ 6	0.89	0.45	0.80	0.16	0.08	0.24
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≤ 2	0.22	0.97	0.94	0.01	0.52	0.53
	≤ 3	0.44	0.90	0.90	0.03	0.37	0.40
	≤ 4	0.73	0.67	0.81	0.11	0.18	0.29
	≤ 5	0.90	0.35	0.73	0.22	0.06	0.28
	≤ 6	0.99	0.16	0.69	0.29	0.01	0.29
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≤ 2	0.02	1.00	1.00	0.00	0.51	0.51
	≤ 3	0.12	1.00	0.96	0.00	0.46	0.47
	≤ 4	0.35	0.95	0.88	0.03	0.34	0.37
	≤ 5	0.62	0.79	0.77	0.10	0.20	0.30
	≤ 6	0.84	0.54	0.67	0.22	0.09	0.31

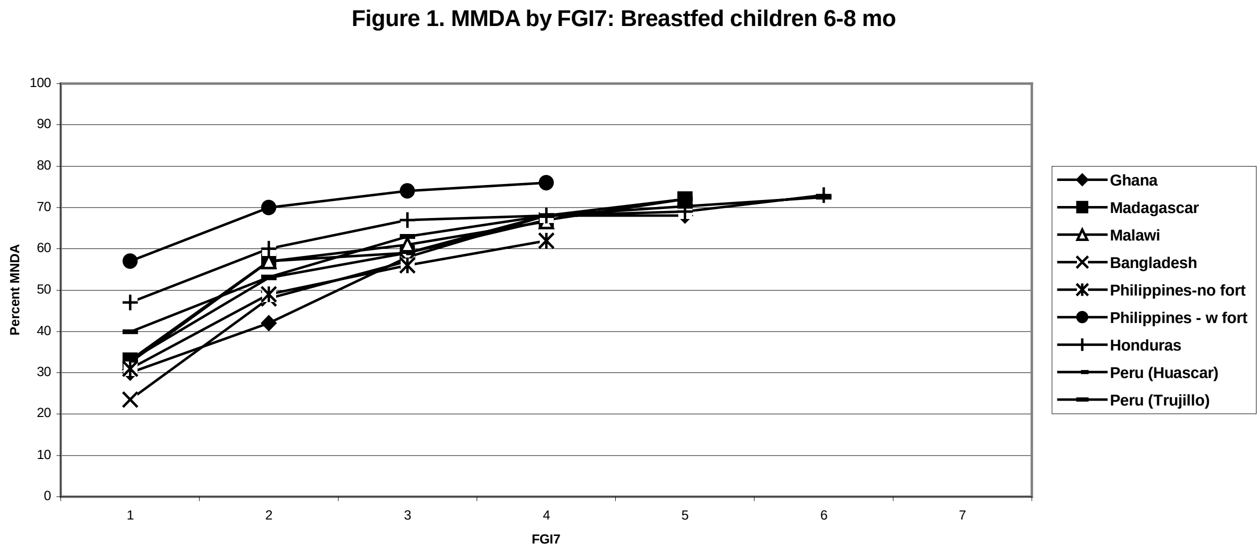
Table 31. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of feeding episodes) and low energy intake for non-breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar[a]	–	–	–	–	–	–	–
Malawi	–	–	–	–	–	–	–
Asia							
Bangladesh	–	–	–	–	–	–	–
India	≤ 2	0.01	0.99	0.75	0.00	0.74	0.74
	≤ 3	0.08	0.94	0.81	0.02	0.68	0.70
	≤ 4	0.27	0.86	0.85	0.04	0.55	0.58
	≤ 5	0.59	0.65	0.83	0.09	0.31	0.39
	≤ 6	0.82	0.42	0.81	0.15	0.13	0.28
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	≤ 2	0.00	1.00	0.00	0.00	0.16	0.16
	≤ 3	0.08	1.00	1.00	0.00	0.15	0.15
	≤ 4	0.23	0.97	0.60	0.03	0.13	0.15
	≤ 5	0.23	0.94	0.43	0.05	0.13	0.18
	≤ 6	0.69	0.85	0.47	0.13	0.05	0.18
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≤ 2	0.00	1.00	0.00	0.00	0.30	0.30
	≤ 3	0.00	1.00	0.00	0.00	0.30	0.30
	≤ 4	0.03	1.00	1.00	0.00	0.29	0.29
	≤ 5	0.05	0.99	0.67	0.01	0.29	0.29
	≤ 6	0.22	0.97	0.76	0.02	0.24	0.26

[a] In Madagascar, too few children had adequate energy intakes for this analysis to be performed.

FIGURES

Note that for all figures, data points are presented when they represent 5 or more observations.



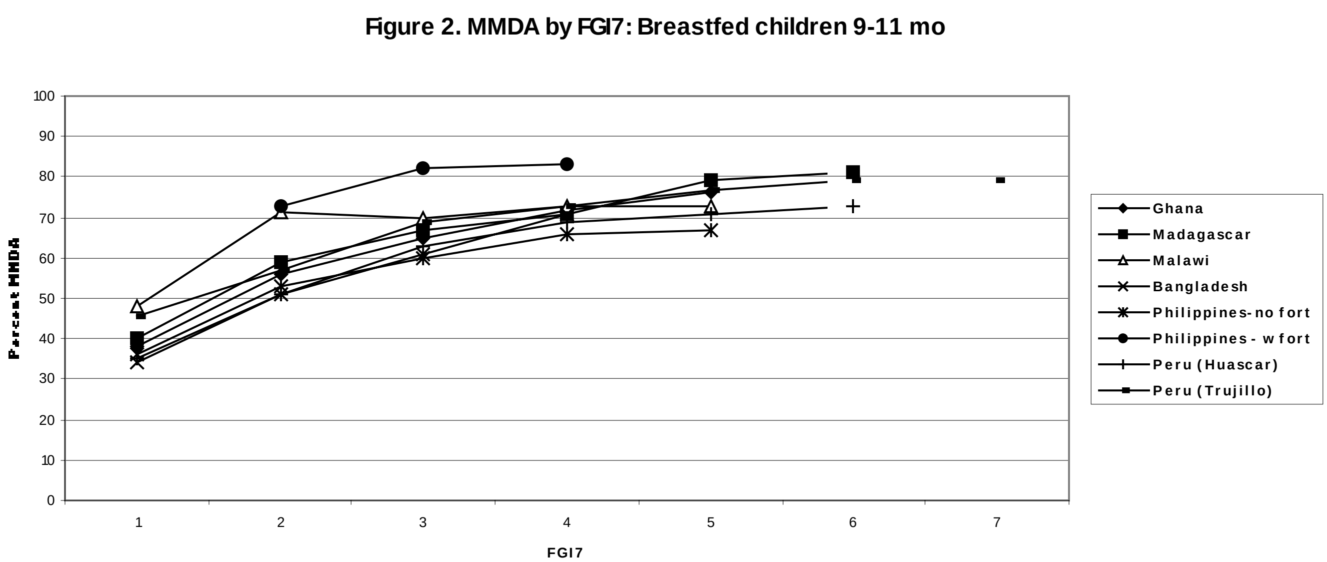


Figure 3. MMDA by FGI7: Breastfed children 12-23 mo.

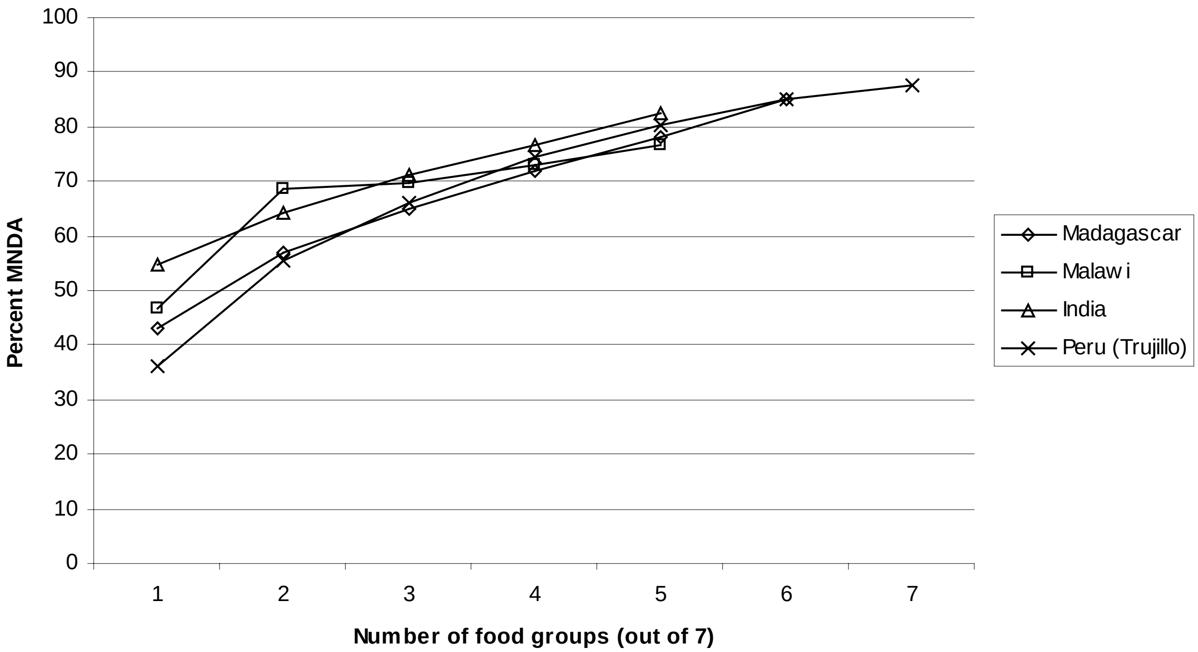


Figure 4. MMDA by FGI7: Non-breastfed Philippines children 6-11 mo

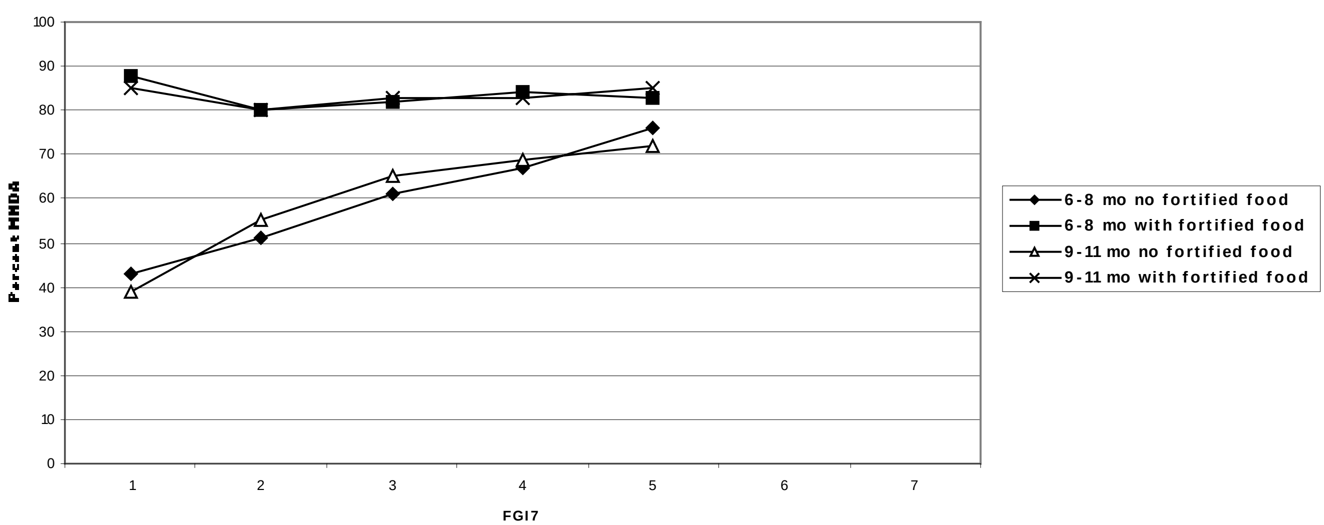


Figure 5. MMDA by FGI7: Non-breastfed children 12-23 mo.

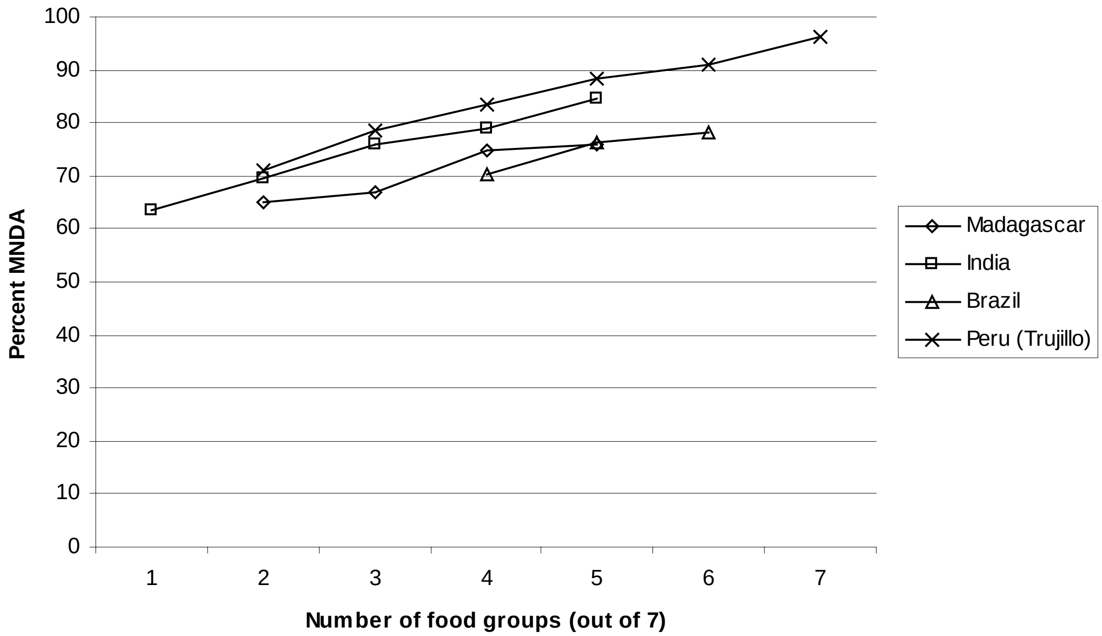


Figure 6. Energy intake from complementary food by number of feeding episodes:
Breastfed children 6-8 mo.

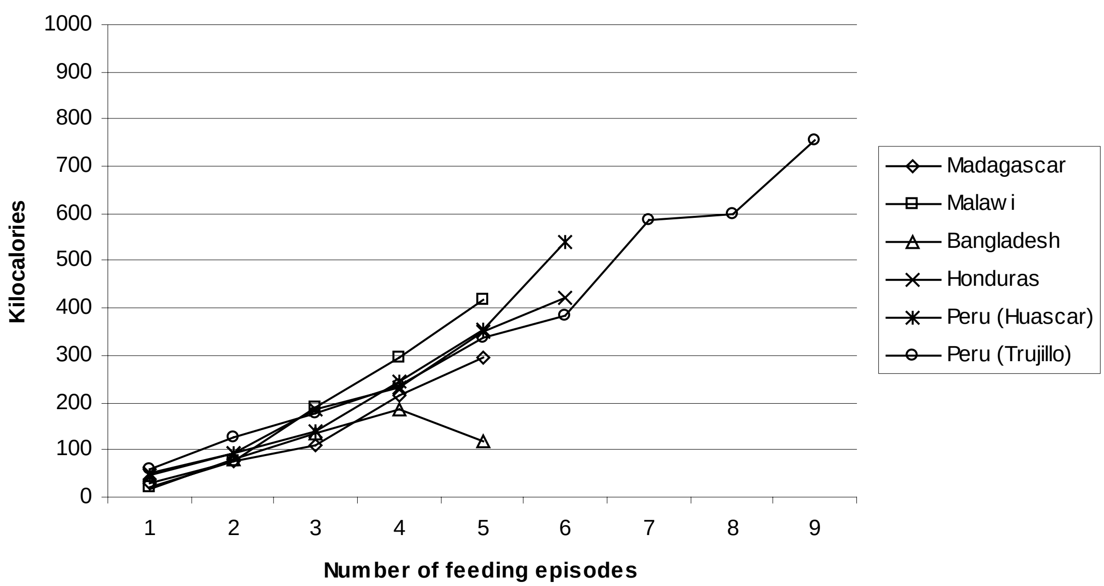


Figure 7. Energy intake from complementary food by number of feeding episodes: Breastfed children 9-11 mo.

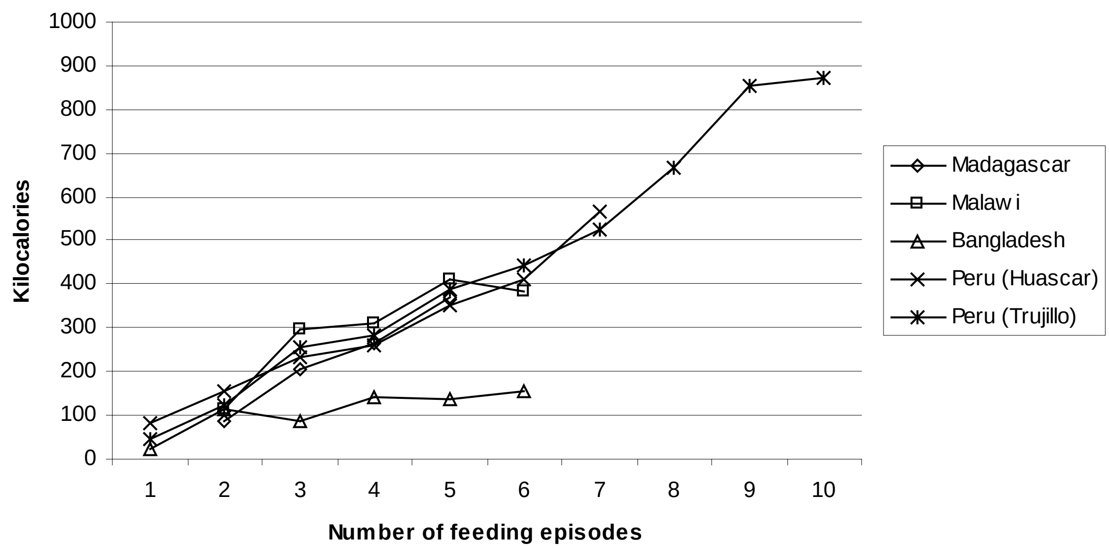


Figure 8. Energy intake from complementary food by number of feeding episodes: Breastfed children 12-23 mo.

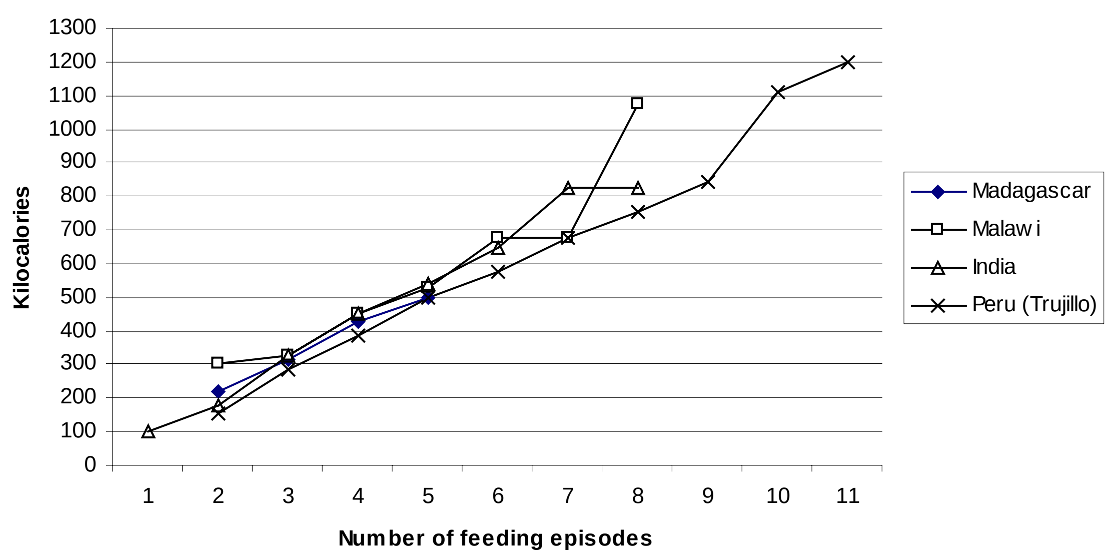
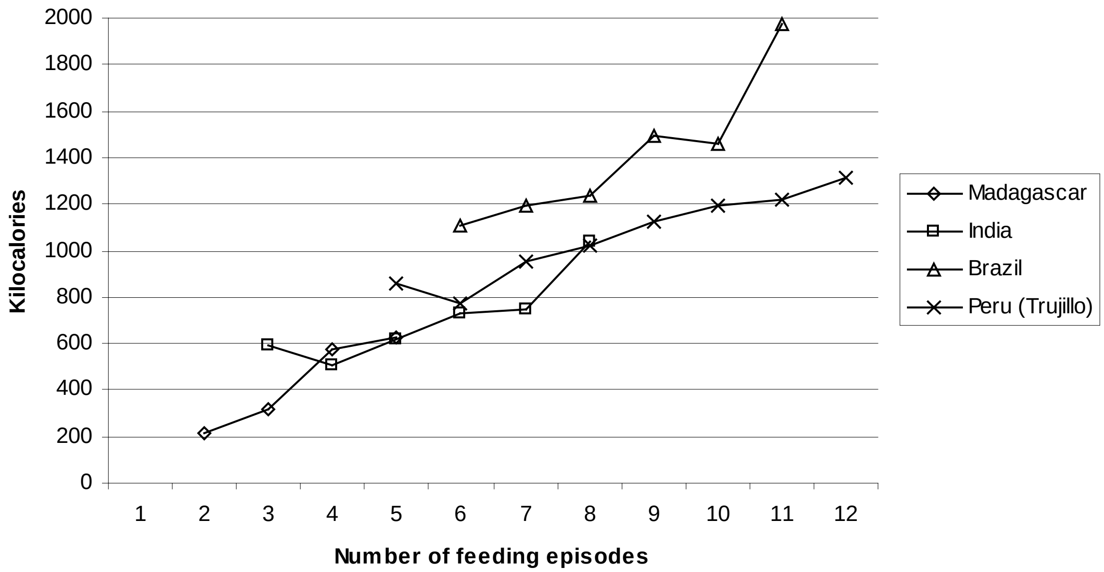


Figure 9. Total energy intake by number of feeding episodes: Non-breastfed children 12-23 mo.



APPENDIX 1. DESCRIPTIVE RESULTS FOR FGI8 AND FGI8R

Table A1-1. Mean (SD) of food group diversity, by country, age, and breastfeeding status (FGI8: range 0-8, 1-gram minimum)

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	2.6 (1.2)	3.4 (1.3)	–	–	–	–
Madagascar	3.0 (1.4)	3.8 (1.3)	4.1 (1.3)	–	–	4.4 (1.2)
Malawi	2.6 (1.4)	3.3 (1.4)	3.5 (1.2)	–	–	–
Asia						
Bangladesh	1.7 (0.9)	2.1 (1.0)	-	–	–	–
India	–	–	3.4 (1.3)	–	–	3.5 (1.3)
Philippines	2.0 (1.0)	2.2 (1.1)	–	2.6 (1.0)	2.8 (1.0)	–
Latin America						
Brazil	–	–	–	–	–	6.0 (1.1)
Honduras	3.3 (1.5)	–	–	–	–	–
Peru (Huascar)	3.0 (1.3)	3.7 (1.4)	–	–	–	–
Peru (Trujillo)	3.9 (1.4)	4.0 (1.4)	4.5 (1.4)	4.2 (1.2)	4.7 (1.4)	5.1 (1.2)

Table A1-2. Mean (SD) of food group diversity, by country, age and breastfeeding status (FGI8R: range 0-8, 10-gram minimum)

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	2.0 (1.0)	2.8 (1.1)	–	–	–	–
Madagascar	2.5 (1.3)	3.4 (1.3)	3.7 (1.2)	–	–	4.0 (1.2)
Malawi	2.2 (1.3)	2.8 (1.2)	3.1 (1.1)	–	–	–
Asia						
Bangladesh	1.3 (0.9)	1.6 (1.0)	–	–	–	–
India	–	–	3.0 (1.4)	–	–	3.2 (1.3)
Philippines	1.8 (1.0)	2.0 (1.0)	–	2.4 (0.9)	2.6 (1.0)	–
Latin America						
Brazil	–	–	–	–	–	5.3 (1.1)
Honduras	2.4 (1.3)	–	–	–	–	–
Peru (Huascar)	1.9 (1.2)	2.8 (1.3)	–	–	–	–
Peru (Trujillo)	3.4 (1.4)	3.6 (1.5)	4.1 (1.4)	3.8 (1.1)	4.4 (1.4)	4.8 (1.3)

Table A1-3. Relationship (correlation coefficient) between mean micronutrient density adequacy (MMDA) and dietary diversity (FGI8), by country, age and breastfeeding status

	Breastfed children [a]			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.70	0.44	–	–	–	–
Madagascar	0.48	0.50*	0.48*	–	–	0.36* [a, b]
Malawi	0.59	0.23*	0.29	–	–	–
Asia						
Bangladesh	0.74*	0.70*	–	–	–	–
India	–	–	0.34	–	–	0.34 [a]
Philippines	0.63*	0.66*	–	0.25*	0.34	–
No fortified foods	0.67*	0.68*	–	0.56*	0.52	–
Fortified foods	0.50	0.22(ns)	–	0.06 (ns)	0.10 (ns)	–
Latin America						
Brazil	–	–	–	–	–	0.23* [a]
Honduras	0.37	–	–	–	–	–
Peru (Huascar)	0.56	0.44	–	–	–	–
Peru (Trujillo)	0.54*	0.60*	0.60*	0.26	0.34* [a]	0.45* [a]

[a] All correlations are significant ($p < 0.05$), except where noted as “ns”.
[b] The result is for all children (6-23 months), n < 12 = 25 and n > 12 = 184.
* The relationship is linear.

Table A1-4. Relationship (correlation coefficient) between mean micronutrient density adequacy (MMDA) and dietary diversity (FGI8R), by country, age, and breastfeeding status [a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.61*	0.41*	–	–	–	–
Madagascar	0.47	0.52	0.50*	–	–	0.45* [b]
Malawi	0.63	0.25*	0.26	–	–	–
Asia						
Bangladesh	0.62*	0.64*	–	–	–	–
India	–	–	0.36	–	–	0.35
Philippines	0.61	0.65	–	0.28	0.37	–
No fortified foods	0.66	0.67	–	0.57	0.55	–
Fortified foods	0.48	0.33	–	0.09 (ns)	0.12 (ns)	–
Latin America						
Brazil	–	–	–	–	–	0.43*
Honduras	0.42	–	–	–	–	–
Peru (Huascar)	0.41*	0.47	–	–	–	–
Peru (Trujillo)	0.49*	0.63*	0.62*	0.29	0.36*	0.52*

[a] All correlations are significant ($p < 0.05$), except where noted as “ns”.
[b] The result is for all children (6-23 months), n < 12 = 25 and n > 12 = 184.
* The relationship is linear.

Table A1-5. Area under the curve (AUC) for FGI8 when mean micronutrient density adequacy (MMDA) cutoff is 50% [a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.85*** *(0.03)*	0.65** *(0.05)*	–	–	–	–
Madagascar	0.76*** *(0.03)*	0.84*** *(0.03)*	0.74*** (*0.02*)	–	–	0.78*** [b] (*0.06*)
Malawi	0.85*** *(0.05)*	0.77** *(0.08)*	0.77*** (*0.07*)	–	–	–
Asia						
Bangladesh	0.85*** *(0.06)*	0.77*** *(0.05)*	–	–	–	–
India	–	–	0.60*** *(0.02)*	–	–	0.60 *(0.07)*
Philippines	0.82*** *(0.02)*	0.86*** *(0.02)*	–	0.69*** *(0.03)*	0.73*** *(0.03)*	–
No fortified foods	0.84*** *(0.02)*	0.86*** *(0.02)*	–	0.73*** *(0.03)*	0.74*** *(0.03)*	–
Fortified foods	-	-	–	0.58 *(0.08)*	0.77 *(0.10)*	–
Fortified foods	0.70[c] *(0.08)*		-	0.63 *(0.06)*		-
Latin America						
Brazil	–	–	–	–	–	–
Honduras	0.72*** *(0.03)*	–	–	–	–	–
Peru (Huascar)	0.79*** *(0.03)*	0.79*** (*0.04*)	–	–	–	–
Peru (Trujillo)	0.86*** (*0.02*)	0.93*** (*0.02*)	0.90*** *(0.02)*	–	0.97 (*0.03*)	0.88** *(0.10)*

*** Significant at $p \leq 0.001$.
** Significant at $p \leq 0.01$.
* Significant at $p \leq 0.05$.
[a] Standard error in parentheses.
[b] The result is for all children (6-23 months), n < 12 = 25 and n > 12 = 184.
[c] Results for 6 to 11months, not enough children within age subgroups.

Table A1-6. Area under the curve (AUC) for FGI8 when mean micronutrient density adequacy (MMDA) cutoff is 75% [a]

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.88*** (*0.03*)	0.75*** (*0.04*)	–	–	–	–
Madagascar	0.59* (*0.04*)	0.65*** (*0.03*)	0.71*** (*0.02*)	–	–	0.60** [b] (*0.04*)
Malawi	0.73* (*0.06*)	0.52 (*0.06*)	0.60* (*0.04*)	–	–	–
Asia						
Bangladesh	n/a[c]	0.87** *(0.09)*	–	–	–	–
India	–	–	0.73*** *(0.02)*	–	–	0.73*** *(0.03)*
Philippines	0.72*** *(0.03)*	0.74** *(0.03)*	–	0.57** *(0.02)*	0.65*** *(0.02)*	–
No fortified foods	0.66* *(0.07)*	0.76*** *(0.05)*	–	0.80*** *(0.04)*	0.80*** *(0.02)*	–
Fortified foods	-	-	–	0.56 *(0.04)*	0.59 *(0.04)*	–
Fortified foods	0.68 [d] *(0.04)*			0.57 *(0.03)*		
Latin America						
Brazil	–	–	–	–	–	0.58 *(0.06)*
Honduras	0.67*** *(0.02)*	–	–	–	–	–
Peru (Huascar)	0.72*** *(0.04)*	0.63*** *(0.03)*	–	–	–	–
Peru (Trujillo)	0.66*** *(0.02)*	0.74*** *(0.02)*	0.77*** *(0.01)*	0.48 (*0.13*)	0.84 (*0.11*)	0.76*** *(0.05)*

*** Significant at $p \leq 0.001$.
** Significant at $p \leq 0.01$.
* Significant at $p \leq 0.05$.
[a] Standard error in parentheses.
[b] The result is for all children (6-23 months), n < 12 = 25 and n > 12 = 184.
[c] Insufficient sample size.
[d] Results for 6 to 11months , not enough children within age subgroups.

Table A1-7. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI8 cutoff for breastfed 6-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Africa							
Ghana	≤ 1	0.19	0.99	0.93	0.01	0.30	0.31
	≤ 2	0.78	0.77	0.67	0.14	0.08	0.23
	≤ 3	0.88	0.42	0.48	0.36	0.05	0.41
	≤ 4	0.97	0.21	0.43	0.49	0.01	0.50
Madagascar	≤ 1	0.35	0.99	0.90	0.01	0.18	0.19
	≤ 2	0.55	0.85	0.58	0.11	0.12	0.23
	≤ 3	0.82	0.60	0.44	0.29	0.05	0.34
	≤ 4	0.97	0.28	0.34	0.52	0.01	0.53
Malawi	≤ 1	0.61	0.98	0.93	0.01	0.11	0.12
	≤ 2	0.71	0.76	0.53	0.17	0.08	0.25
	≤ 3	0.89	0.43	0.38	0.41	0.03	0.44
	≤ 4	0.98	0.18	0.31	0.60	0.01	0.60
Asia							
Bangladesh	≤ 1	0.63	0.93	0.94	0.03	0.23	0.26
	≤ 2	0.88	0.43	0.72	0.22	0.08	0.29
	≤ 3	0.99	0.16	0.66	0.32	0.01	0.33
	≤ 4	1.00	0.02	0.63	0.37	0.00	0.37
India	–	–	–	–	–	–	–

(continued)

Table A1-7. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI8 cutoff for breastfed 6-11 mo children (*……continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Asia							
Philippines	≤ 1	0.62	0.93	0.90	0.03	0.19	0.22
	≤ 2	0.90	0.54	0.66	0.23	0.05	0.28
	≤ 3	0.98	0.18	0.55	0.41	0.01	0.42
	≤ 4	1.00	0.05	0.51	0.48	0.00	0.48
No fortified foods	≤ 1	0.63	0.96	0.95	0.02	0.21	0.23
	≤ 2	0.90	0.55	0.72	0.20	0.05	0.25
	≤ 3	0.98	0.18	0.61	0.36	0.01	0.37
	≤ 4	1.00	0.04	0.58	0.41	0.00	0.42
Fortified foods	≤ 1	0.29	0.85	0.08	0.15	0.03	0.18
	≤ 2	0.86	0.49	0.07	0.48	0.01	0.49
	≤ 3	1.00	0.20	0.05	0.77	0.00	0.77
	≤ 4	1.00	0.04	0.04	0.91	0.00	0.91
Latin America							
Brazil		–	–	–	–	–	–
Honduras	≤ 1	0.33	0.95	0.62	0.04	0.12	0.16
	≤ 2	0.61	0.76	0.36	0.20	0.07	0.27
	≤ 3	0.75	0.49	0.25	0.42	0.05	0.47
	≤ 4	0.88	0.24	0.21	0.62	0.02	0.64
Peru (Huascar)	≤ 1	0.35	0.96	0.79	0.03	0.18	0.20
	≤ 2	0.62	0.85	0.61	0.11	0.10	0.22
	≤ 3	0.84	0.58	0.43	0.31	0.05	0.35
	≤ 4	0.96	0.24	0.32	0.55	0.01	0.57
Peru (Trujillo)	≤ 1	0.27	0.99	0.80	0.01	0.09	0.10
	≤ 2	0.66	0.91	0.51	0.08	0.04	0.12
	≤ 3	0.90	0.69	0.29	0.27	0.01	0.28
	≤ 4	0.97	0.40	0.18	0.53	0.00	0.53

Table A1-8. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI8 cutoff for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Africa							
Ghana		–	–	–	–	–	–
Madagascar	≤ 1	0.12	0.99	0.76	0.01	0.14	0.15
	≤ 2	0.29	0.94	0.46	0.05	0.12	0.17
	≤ 3	0.64	0.75	0.33	0.21	0.06	0.27
	≤ 4	0.86	0.43	0.22	0.48	0.02	0.50
Malawi	≤ 1	0.45	1.00	0.90	0.00	0.05	0.05
	≤ 2	0.60	0.82	0.24	0.16	0.03	0.20
	≤ 3	0.80	0.56	0.14	0.40	0.02	0.42
	≤ 4	0.90	0.21	0.09	0.73	0.01	0.74
Asia							
Bangladesh		–	–	–	–	–	–
India	≤ 1	0.09	0.92	0.15	0.07	0.12	0.19
	≤ 2	0.34	0.73	0.16	0.24	0.09	0.32
	≤ 3	0.68	0.51	0.18	0.42	0.04	0.47
	≤ 4	0.90	0.26	0.16	0.64	0.01	0.66
Philippines		–	–	–	–	–	–

(continued)

Table A1-8. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI8 cutoff for breastfed 12-23 mo children (*……continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Latin America							
Brazil		–	–	–	–	–	–
Honduras		–	–	–	–	–	–
Peru (Huascar)		–	–	–	–	–	–
Peru (Trujillo)	≤ 1	0.19	1.00	0.94	0.00	0.05	0.06
	≤ 2	0.54	0.95	0.44	0.05	0.03	0.08
	≤ 3	0.85	0.81	0.25	0.17	0.01	0.18
	≤ 4	0.99	0.55	0.14	0.42	0.00	0.42

Table A1-9. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA < 50% cutoff point) by FGI8 cutoff for non-breastfed children[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Africa							
Ghana		–	–	–	–	–	–
Madagascar	≤ 1	0.22	1.00	1.00	0.00	0.07	0.07
6-23 mo	≤ 2	0.39	0.95	0.41	0.05	0.05	0.10
	≤ 3	0.56	0.85	0.26	0.14	0.04	0.18
	≤ 4	0.89	0.50	0.14	0.45	0.01	0.46
Malawi		–	–	–	–	–	–
Asia							
Bangladesh		–	–	–	–	–	–
India	≤ 1	0.00	0.93	0.00	0.06	0.04	0.10
12-23 mo	≤ 2	0.31	0.76	0.05	0.23	0.03	0.26
	≤ 3	0.69	0.55	0.06	0.43	0.01	0.44
	≤ 4	0.85	0.29	0.05	0.69	0.01	0.69
Philippines	≤ 1	0.17	0.98	0.61	0.02	0.12	0.14
6-11 mo	≤ 2	0.80	0.53	0.23	0.40	0.03	0.43
	≤ 3	0.97	0.21	0.18	0.67	0.00	0.68
	≤ 4	1.00	0.06	0.16	0.80	0.00	0.80
No fortified foods	≤ 1	0.18	0.99	0.81	0.01	0.18	0.19
	≤ 2	0.80	0.57	0.34	0.34	0.04	0.38
	≤ 3	0.97	0.23	0.26	0.60	0.01	0.61
	≤ 4	0.99	0.07	0.23	0.73	0.00	0.73
Fortified foods	≤ 1	0.00	0.97	0.00	0.03	0.03	0.06
	≤ 2	0.77	0.48	0.04	0.51	0.01	0.52
	≤ 3	1.00	0.18	0.03	0.80	0.00	0.80
	≤ 4	1.00	0.06	0.03	0.92	0.00	0.92
Latin America							
Brazil		–	–	–	–	–	–
Honduras		–	–	–	–	–	–
Peru (Huascar)		–	–	–	–	–	–
Peru (Trujillo)	≤ 1	0.25	1.00	0.50	0.00	0.01	0.01
12-23 MO	≤ 2	0.75	0.97	0.23	0.03	0.00	0.03
	≤ 3	0.75	0.91	0.09	0.08	0.00	0.09
	≤ 4	0.75	0.73	0.03	0.27	0.00	0.27

[a] In Madagascar there were only a few (n = 25) non-breastfed children < 12 months; analysis was performed on all non-breastfed children combined but results are presented here since most were > 12 mo (n = 184 > 12 mo).

Table A1-10. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for breastfed 6-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Africa							
Ghana	≥ 2	1.00	0.09	0.13	0.80	0.00	0.80
	≥ 3	0.96	0.50	0.22	0.44	0.01	0.44
	≥ 4	0.81	0.76	0.36	0.20	0.02	0.23
	≥ 5	0.38	0.89	0.51	0.09	0.07	0.16
	≥ 6	0.15	0.97	0.62	0.03	0.10	0.13
	≥ 7	0.02	1.00	0.88	0.00	0.12	0.12
Madagascar	≥ 2	0.99	0.01	0.25	0.67	0.00	0.67
	≥ 3	0.89	0.11	0.27	0.53	0.03	0.56
	≥ 4	0.66	0.34	0.31	0.33	0.08	0.41
	≥ 5	0.32	0.68	0.34	0.14	0.15	0.29
	≥ 6	0.11	0.89	0.55	0.02	0.20	0.22
	≥ 7	0.02	1.00	0.60	0.00	0.22	0.22
Malawi	≥ 2	1.00	0.28	0.41	0.48	0.00	0.48
	≥ 3	0.76	0.43	0.40	0.38	0.08	0.46
	≥ 4	0.42	0.70	0.41	0.20	0.20	0.40
	≥ 5	0.11	0.86	0.29	0.10	0.30	0.39
	≥ 6	0.08	0.96	0.50	0.03	0.31	0.34
	≥ 7	0.06	1.00	1.00	0.00	0.32	0.32
Asia							
Bangladesh	≥ 2	1.00	0.44	0.09	0.53	0.00	0.53
	≥ 3	0.83	0.79	0.21	0.20	0.01	0.21
	≥ 4	0.50	0.96	0.50	0.04	0.03	0.07
	≥ 5	0.17	1.00	1.00	0.00	0.04	0.04
	≥ 6	–	–	–	–	–	–
	≥ 7	–	–	–	–	–	–
India		–	–	–	–	–	–

(continued)

Table A1-10. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for breastfed 6-11 mo children (*……continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI8)				
Asia							
Philippines	≥ 2	0.60	0.71	0.17	0.26	0.04	0.30
	≥ 3	0.30	0.92	0.28	0.27	0.06	0.13
	≥ 4	0.07	0.98	0.26	0.02	0.09	0.11
	≥ 5	0.01	1.00	0.20	0.00	0.09	0.09
	≥ 6	0.00	1.00	-	0.00	0.09	0.09
	≥ 7	0.00	1.00	-	0.00	0.09	0.09
No fortified foods	≥ 2	0.60	0.72	0.07	0.27	0.01	0.28
	≥ 3	0.30	0.92	0.12	0.08	0.02	0.10
	≥ 4	0.08	0.98	0.12	0.02	0.03	0.05
	≥ 5	0.00	1.00	0.00	0.00	0.04	0.04
	≥ 6	0.00	1.00	0.00	0.00	0.04	0.04
	≥ 7	0.00	1.00	-	0.00	0.00	0.00
Fortified foods	≥ 2	0.60	0.63	0.60	0.19	0.20	0.39
	≥ 3	0.30	0.92	0.77	0.04	0.34	0.38
	≥ 4	0.30	0.98	0.71	0.01	0.45	0.46
	≥ 5	0.06	1.00	1.00	0.00	0.48	0.48
	≥ 6	0.01	1.00	1.00	0.00	0.48	0.48
	≥ 7	0.00	1.00	-	0.00	0.48	0.48

(continued)

Table A1-10. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for breastfed 6-11 mo children (*……continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Latin America							
Brazil		–	–	–	–	–	–
Honduras	≥ 2	0.98	0.13	0.27	0.66	0.00	0.66
	≥ 3	0.90	0.38	0.34	0.46	0.02	0.48
	≥ 4	0.62	0.62	0.44	0.27	0.09	0.36
	≥ 5	0.34	0.82	0.53	0.13	0.15	0.28
	≥ 6	0.12	0.94	0.65	0.04	0.20	0.25
	≥ 7	0.02	0.99	0.77	0.01	0.24	0.24
Peru (Huascar)	≥ 2	0.99	0.16	0.26	0.65	0.00	0.66
	≥ 3	0.91	0.34	0.30	0.50	0.02	0.52
	≥ 4	0.71	0.61	0.40	0.29	0.06	0.35
	≥ 5	0.29	0.85	0.57	0.11	0.15	0.26
	≥ 6	0.09	0.96	0.65	0.03	0.20	0.23
	≥ 7	0.02	0.99	0.79	0.01	0.22	0.22
Peru (Trujillo)	≥ 2	1.00	0.06	0.27	0.70	0.00	0.70
	≥ 3	0.97	0.20	0.30	0.59	0.01	0.60
	≥ 4	0.82	0.45	0.34	0.41	0.05	0.46
	≥ 5	0.55	0.72	0.40	0.21	0.12	0.33
	≥ 6	0.25	0.91	0.48	0.07	0.20	0.26
	≥ 7	0.06	0.99	0.66	0.01	0.24	0.25

Table A1-11. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			1-gram minimum per food group (FGI8)				
Africa							
Ghana		–	–	–	–	–	–
Madagascar	≥ 2	0.99	0.04	0.35	0.63	0.00	0.63
	≥ 3	0.96	0.13	0.36	0.57	0.01	0.58
	≥ 4	0.85	0.40	0.43	0.39	0.05	0.44
	≥ 5	0.59	0.73	0.53	0.18	0.14	0.31
	≥ 6	0.25	0.94	0.67	0.04	0.26	0.30
	≥ 7	0.06	0.99	0.82	0.00	0.32	0.32
Malawi	≥ 2	1.00	0.07	0.44	0.54	0.00	0.54
	≥ 3	0.85	0.26	0.45	0.43	0.06	0.50
	≥ 4	0.62	0.53	0.48	0.28	0.16	0.43
	≥ 5	0.24	0.84	0.51	0.10	0.32	0.41
	≥ 6	0.08	0.95	0.53	0.03	0.38	0.41
	≥ 7	0.00	1.00	n/a	0.00	0.42	0.42
Asia							
Bangladesh		–	–	–	–	–	–
India	≥ 2	1.00	0.11	0.35	0.60	0.00	0.60
	≥ 3	0.88	0.36	0.39	0.44	0.04	0.48
	≥ 4	0.74	0.64	0.49	0.25	0.08	0.33
	≥ 5	0.43	0.85	0.58	0.10	0.18	0.28
	≥ 6	0.05	0.99	0.79	0.00	0.30	0.31
	≥ 7	0.00	1.00	1.00	0.00	0.32	0.32
Philippines		–	–	–	–	–	–

(continued)

Table A1-11. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for breastfed 12-23 mo children (*……continued*)

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Latin America							
Brazil		–	–	–	–	–	–
Honduras		–	–	–	–	–	–
Peru (Huascar)		–	–	–	–	–	–
Peru (Trujillo)	≥ 2	1.00	0.03	0.58	0.41	0.00	0.41
	≥ 3	0.98	0.17	0.61	0.35	0.01	0.36
	≥ 4	0.91	0.42	0.68	0.25	0.05	0.30
	≥ 5	0.68	0.72	0.77	0.12	0.18	0.30
	≥ 6	0.36	0.93	0.88	0.03	0.37	0.40
	≥ 7	0.09	0.99	0.94	0.00	0.52	0.53

Table A1-12. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for non-breastfed children[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Africa							
Ghana		–	–	–	–	–	–
Madagascar	≥ 2	1.00	0.03	0.43	0.56	0.00	0.56
6-23 mo	≥ 3	0.94	0.10	0.43	0.52	0.02	0.54
	≥ 4	0.84	0.21	0.44	0.46	0.07	0.53
	≥ 5	0.57	0.60	0.51	0.23	0.18	0.41
	≥ 6	0.24	0.88	0.60	0.07	0.32	0.39
	≥ 7	0.05	1.00	1.00	0.00	0.40	0.40
Malawi		–	–	–	–	–	–
Asia							
Bangladesh		–	–	–	–	–	–
India	≥ 2	0.99	0.11	0.46	0.51	0.00	0.51
12-23 mo	≥ 3	0.91	0.37	0.52	0.36	0.04	0.40
	≥ 4	0.74	0.61	0.59	0.22	0.11	0.33
	≥ 5	0.44	0.85	0.69	0.09	0.24	0.33
	≥ 6	0.03	0.99	0.67	0.01	0.42	0.43
	≥ 7	–	–	–	–	–	–
Philippines	≥ 2	0.59	0.57	0.39	0.29	0.13	0.43
6-11 mo	≥ 3	0.27	0.86	0.47	0.10	0.23	0.33
	≥ 4	0.10	0.97	0.57	0.02	0.29	0.31
	≥ 5	0.03	0.99	0.68	0.00	0.32	0.32
	≥ 6	0.00	1.00	0.50	0.00	0.32	0.32
	≥ 7	-	-	-	-	-	-
No fortified foods	≥ 2	0.55	0.85	0.28	0.14	0.04	0.18
	≥ 3	0.21	0.96	0.37	0.03	0.07	0.10
	≥ 4	0.06	0.99	0.45	0.01	0.09	0.09
	≥ 5	0.01	1.00	0.50	0.00	0.09	0.09
	≥ 6	0.00	1.00	.	0.00	0.09	0.09
	≥ 7	-	-	-	-	-	-
Fortified foods	≥ 2	0.51	0.62	0.77	0.11	0.35	0.46
	≥ 3	0.21	0.90	0.84	0.03	0.57	0.60
	≥ 4	0.07	0.98	0.89	0.01	0.67	0.68
	≥ 5	0.02	1.00	1.00	0.00	0.70	0.70
	≥ 6	0.00	1.00	-	0.00	0.72	0.72
	≥ 7	-	-	-	-	-	-

(continued)

Table A1-12. Sensitivity/specificity analysis of the relationship between food group diversity (FGI8) and Mean Micronutrient Density Adequacy (using MMDA ≥ 75% cutoff point) by FGI8 cutoff for non-breastfed children (*……continued*)[a]

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				1-gram minimum per food group (FGI8)			
Latin America							
Brazil	≥ 2	100.0	0.0	50.0	50.0	0.0	50.0
12-23 mo	≥ 3	100.0	5.0	51.3	47.5	0.0	47.5
	≥ 4	100.0	7.5	51.9	46.3	0.0	46.3
	≥ 5	100.0	12.5	53.3	43.8	0.0	43.8
	≥ 6	82.5	30.0	54.1	35.0	8.8	43.8
	≥ 7	32.5	72.5	54.2	13.8	33.8	47.5
Honduras		–	–	–	–	–	–
Peru (Huascar)		–	–	–	–	–	–
Peru (Trujillo)	≥ 2	1.00	0.03	0.91	0.09	0.00	0.09
12-23 mo	≥ 3	0.98	0.15	0.92	0.08	0.02	0.10
	≥ 4	0.93	0.35	0.94	0.06	0.06	0.12
	≥ 5	0.76	0.68	0.96	0.03	0.22	0.25
	≥ 6	0.38	0.88	0.97	0.01	0.56	0.57
	≥ 7	0.12	0.97	0.98	0.00	0.80	0.80

[a] In Madagascar there were only a few (n = 25) non-breastfed children < 12 months; analysis was performed on all non-breastfed children combined but results are presented here since most were > 12 mo (n = 184 > 12 mo.

APPENDIX 2. DEFINITIONS OF FEEDING EPISODES AND MEALS

Country	Data type	Feeding episodes
Brazil	24-hr recall	Sum of meals and snacks as self-defined by mothers
Honduras	24-hr recall	Sum of meals and snacks as self-defined by mothers
Huascar	12-hr weighed intake; PM[a] recall	No distinction between snacks and meals; observer present
Trujillo	24-hr recall	Episodes separated by ≥ 1 hour
Ghana	12-hr weighed intake; no PM eating	No data on feeding frequency
Malawi	24-hr interactive recall	Eating occasions separated by ≥ 1 hour, providing ≤ 10% of age-specific mean kcals
Madagascar	24-hr recall	Total of meals and snacks as self-defined by mothers
Bangladesh	12-hr weighed intake; PM recall	Observer present; no time gap mentioned for defining episodes
India	24-hr recall	Defined as all foods eaten within a 45-minute interval
Philippines[b]	24-hr recall	Sum of meals and snacks as self-defined by mothers; episodes with liquids not counted

Country	Data type	Meals
Brazil	24-hr recall	Meals truncated at 3 by instrument
Honduras	24-hr recall	Self-defined by mothers
Huascar	12-hr weighed intake; PM recall	Not defined; results for feeding episodes only
Trujillo	24-hr recall	Each episode coded as breakfast, lunch, dinner, or snack; this usually resulted in truncation at 3 but some mothers reported two lunches or two dinners
Ghana	12-hr weighed intake; no PM eating	No data
Malawi	24-hr interactive recall	As before but kcals >10% of age specific mean
Madagascar	24-hr recall	Self-defined, but there was a usual meal pattern of 3, and number of meals never exceeded 3
Bangladesh	12-hr weighed intake; PM recall	Any episode where ≥ 10 g of food was consumed
India	24-hr recall	Only feeding episodes were defined; no separate coding as "meals"
Philippines	24-hr recall	Feeding episodes that included rice or rice gruel; liquid-only feeds not counted as meals

[a] "PM recall" refers to recall of all foods/liquids given over the night-time (12 hours) previous to the day intakes were measured.

[b] Philippines data were unique in excluding milk feeds (and other liquid-only feeds) from feeding episodes, and therefore were excluded from certain summary tables.

APPENDIX 3. ADEQUACY OF INTAKES AND DENSITIES FOR INDIVIDUAL NUTRIENTS

Table A3-1. Median percent desired energy and micronnutrient intake from foods, by age and breastfeeding status[a]

	Africa						Latin America			
Energy and micronutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
					Percent desired intake					
Breastfed 6-8 mo. (n)	(220)	(383)	(66)	(54)	(0)	(703)	(0)	(709)	(365)	(897)
Energy	78	92	Missing	39	-	91	-	78	56	120
Vitamin A	0	28	14	**Asia** 0	-	24	-	69	67	880
Thiamin	61	69	67	24	-	51	-	72	30	79
Riboflavin	38	58	47	22	-	75	-	87	49	236
Vitamin B6	51	63	57	7	-	22	-	58	39	154
Folate	49	121	76	29	-	143	-	82	56	239
Vitamin C	7	143	110	0	-	0	-	234	85	552
Absorbed calcium	49	43	25	13	-	62	-	63	22	63
Absorbed iron	14	7	10	2	-	10	-	6	4	18
Absorbed zinc	49	27	37	9	-	14	-	23	20	51
Breastfed 9-11 mo. (n)	(174)	(309)	(92)	(70)	(0)	(582)	(0)	(0)	(274)	(473)
Energy	90	94	Missing	37	-	79	-	-	80	116
Vitamin A	48	28	56	0	-	19	-	-	52	491
Thiamin	88	106	119	33	-	58	-	-	53	104
Riboflavin	53	81	79	24	-	92	-	-	90	262
Vitamin B6	82	96	107	18	-	27	-	-	61	188
Folate	69	172	148	41	-	169	-	-	80	223
Vitamin C	37	140	131	7	-	0	-	-	93	438
Absorbed calcium	126	65	77	19	-	75	-	-	43	77
Absorbed iron	32	11	17	3	-	13	-	-	9	22
Absorbed zinc	52	47	59	17	-	19	-	-	36	68
Breastfed 12-23 mo. (n)	(0)	(693)	(240)	(0)	(1,151)	(0)	(0)	(0)	(0)	(1,182)
Energy	-	76	Missing	-	70	-	-	-	-	98
Vitamin A	-	34	56	-	73	-	-	-	-	280
Thiamin	-	71	75	-	49	-	-	-	-	71
Riboflavin	-	61	60	-	95	-	-	-	-	180
Vitamin B6	-	77	86	-	50	-	-	-	-	143
Folate	-	70	59	-	26	-	-	-	-	72
Vitamin B12	-	40	0	-	127	-	-	-	-	185
Vitamin C	-	161	152	-	43	-	-	-	-	347
Absorbed calcium	-	23	32	-	58	-	-	-	-	32
Absorbed iron	-	29	41	-	14	-	-	-	-	51
Absorbed zinc	-	59	81	-	65	-	-	-	-	94

	Africa						Latin America			
Energy and micronutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
					Percent desired intake					
Non breastfed 6-8 mo. (n)	(0)		(0)	(0)	(0)	(665)	(0)	(0)	(0)	
Energy	-		-	-	-	57	-	-	-	
Vitamin A	-		-	**Asia** -	-	40	-	-	-	
Thiamin	-		-	-	-	68	-	-	-	
Riboflavin	-		-	-	-	115	-	-	-	
Vitamin B6	-		-	-	-	46	-	-	-	
Folate	-		-	-	-	52	-	-	-	
Vitamin B12	-		-	-	-	26	-	-	-	
Vitamin C	-		-	-	-	21	-	-	-	
Absorbed calcium	-		-	-	-	83	-	-	-	
Absorbed iron	-		-	-	-	32	-	-	-	
Absorbed zinc	-		-	-	-	26	-	-	-	
Non breastfed 9-11 mo. (n)	(0)		(0)	(0)	(0)	(704)	(0)	(0)	(0)	
Energy	-		-	-	-	60	-	-	-	
Vitamin A	-		-	-	-	39	-	-	-	
Thiamin	-		-	-	-	72	-	-	-	
Riboflavin	-		-	-	-	148	-	-	-	
Vitamin B6	-		-	-	-	40	-	-	-	
Folate	-		-	-	-	83	-	-	-	
Vitamin B12	-		-	-	-	26	-	-	-	
Vitamin C	-		-	-	-	0	-	-	-	
Absorbed calcium	-		-	-	-	109	-	-	-	
Absorbed iron	-		-	-	-	33	-	-	-	
Absorbed zinc	-		-	-	-	24	-	-	-	
Non breastfed 12-23 mo. (n)	(0)	(184)	(0)	(0)	(335)	(0)	(80)	(0)	(0)	(379)
Energy	-	63	-	-	71	-	141	-	-	118
Vitamin A	-	16	-	-	50	-	23	-	-	335
Thiamin	-	73	-	-	63	-	144	-	-	89
Riboflavin	-	57	-	-	124	-	290	-	-	501
Vitamin B6	-	91	-	-	73	-	152	-	-	193
Folate	-	71	-	-	29	-	119	-	-	80
Vitamin B12	-	27	-	-	141	-	429	-	-	169
Vitamin C	-	67	-	-	19	-	72	-	-	229
Absorbed calcium	-	22	-	-	96	-	259	-	-	191
Absorbed iron	-	35	-	-	17	-	45	-	-	81
Absorbed zinc	-	61	-	-	77	-	162	-	-	149

[a] Intake from “foods” does not include breast milk intake, but does include other nutritive liquids (e.g., milk and juice). For breastfed infants/children, desired intake is calculated based on average breast milk intake (WHO 1998). The percent desired energy or nutrient intake is calculated as: (Energy or individual nutrient intake / desired intake)*100, where desired intake is specific to child’s age and breastfeeding status.

Table A3-2. Median percent desired micronutrient density from foods, by age and breastfeeding status[a]

	Africa			Asia			Latin America			
Micronutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
					Percent desired density					
Breastfed 6-8 mo. (n)	(220)	(383)	(66)	(54)	(0)	(703)	(0)	(709)	(365)	(897)
Vitamin A	0	30	17	0	-	23	-	82	92	553
Thiamin	75	72	81	58	-	61	-	89	49	65
Riboflavin	50	60	58	53	-	75	-	95	92	218
Vitamin B6	64	68	69	15	-	26	-	74	59	125
Folate	60	142	106	54	-	166	-	89	74	169
Vitamin C	11	134	105	0	-	0	-	261	157	483
Absorbed calcium	63	49	24	28	-	60	-	80	52	57
Absorbed iron	13	8	12	5	-	11	-	8	6	13
Absorbed zinc	63	28	43	22	-	18	-	30	37	44
Breastfed 9-11 mo. (n)	(174)	(309)	(92)	(70)	(0)	(582)	(0)	(0)	(274)	(473)
Vitamin A	31	30	57	1	-	23	-	-	65	402
Thiamin	97	102	120	82	-	68	-	-	62	82
Riboflavin	60	84	74	81	-	100	-	-	115	232
Vitamin B6	93	101	105	36	-	35	-	-	83	166
Folate	77	205	140	116	-	245	-	-	87	181
Vitamin C	35	131	132	19	-	0	-	-	130	386
Absorbed calcium	167	66	67	48	-	77	-	-	69	67
Absorbed iron	36	12	18	9	-	16	-	-	10	18
Absorbed zinc	57	46	62	42	-	26	-	-	49	59
Breastfed 12-23 mo. (n)	(0)	(693)	(240)	(0)	(1,151)	(0)	(0)	(0)	(0)	(1,182)
Vitamin A	-	46	74	-	109	-	-	-	-	284
Thiamin	-	93	106	-	71	-	-	-	-	71
Riboflavin	-	75	80	-	127	-	-	-	-	185
Vitamin B6	-	102	111	-	67	-	-	-	-	147
Folate	-	94	73	-	35	-	-	-	-	70
Vitamin B12	-	52	0	-	191	-	-	-	-	164
Vitamin C	-	200	194	-	54	-	-	-	-	370
Absorbed calcium	-	29	37	-	85	-	-	-	-	35
Absorbed iron	-	37	55	-	20	-	-	-	-	48
Absorbed zinc	-	78	111	-	98	-	-	-	-	97

(continued)

	Africa			**Asia**			**Latin America**			
Micronutrients	**Ghana**	**Madagascar**	**Malawi**	**Bangladesh**	**India**	**Philippines**	**Brazil**	**Honduras**	**Peru (Huascar)**	**Peru (Trujillo)**
	Percent desired density									
Non breastfed 6-8 mo. (n)	(0)		(0)	(0)	(0)	(665)	(0)	(0)	(0)	
Vitamin A	-		-	-	-	74	-	-	-	
Thiamin	-		-	-	-	107	-	-	-	
Riboflavin	-		-	-	-	184	-	-	-	
Vitamin B6	-		-	-	-	68	-	-	-	
Folate	-		-	-	-	96	-	-	-	
Vitamin B12	-		-	-	-	52	-	-	-	
Vitamin C	-		-	-	-	27	-	-	-	
Absorbed calcium	-		-	-	-	153	-	-	-	
Absorbed iron	-		-	-	-	54	-	-	-	
Absorbed zinc	-		-	-	-	42	-	-	-	
Non breastfed 9-11 mo. (n)	(0)		(0)	(0)	(0)	(704)	(0)	(0)	(0)	
Vitamin A	-		-	-	-	67	-	-	-	
Thiamin	-		-	-	-	120	-	-	-	
Riboflavin	-		-	-	-	220	-	-	-	
Vitamin B6	-		-	-	-	63	-	-	-	
Folate	-		-	-	-	137	-	-	-	
Vitamin B12	-		-	-	-	45	-	-	-	
Vitamin C	-		-	-	-	0	-	-	-	
Absorbed calcium	-		-	-	-	164	-	-	-	
Absorbed iron	-		-	-	-	48	-	-	-	
Absorbed zinc	-		-	-	-	35	-	-	-	
Non breastfed 12-23 mo. (n)	(0)	(184)	(0)	(0)	(335)	(0)	(80)	(0)	(0)	(379)
Vitamin A	-	26	-	-	79	-	15	-	-	279
Thiamin	-	112	-	-	83	-	87	-	-	69
Riboflavin	-	85	-	-	177	-	186	-	-	395
Vitamin B6	-	141	-	-	90	-	103	-	-	153
Folate	-	115	-	-	38	-	75	-	-	66
Vitamin B12	-	41	-	-	235	-	292	-	-	141
Vitamin C	-	100	-	-	26	-	50	-	-	193
Absorbed calcium	-	40	-	-	151	-	187	-	-	162
Absorbed iron	-	61	-	-	27	-	30	-	-	73
Absorbed zinc	-	92	-	-	113	-	116	-	-	125

[a] Intake from "foods" does not include breast milk intake, but does include other nutritive liquids (e.g., milk and juice). For breastfed infants/children, desired intake is calculated based on average breast milk intake (WHO 1998). The percent desired nutrient density is the nutrient density (ND) per 100 kcal relative to desirable density, and can be calculated as follows: Individual ND = (amount of individual nutrient consumed/total kcal for child-day)*100; Percent desired nutrient density is: %ND = (individual nutrient ND / desired ND for that nutrient)*100

APPENDIX 4. COMPARING INDICATORS

1. Testing differences between areas under receiver operating curves: FGI7 vs. FGI7R.

Table A4-1. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7 and FGI7R, at MMDA cutoff of 50%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.00[a]	0.96	–	–	–	–
Madagascar	0.26	0.19	0.39	–	–	0.13[b]
Malawi	0.09	0.57	0.92	–	–	–
Asia						
Bangladesh	0.35	0.99	–	–	–	–
India	–	–	0.45	–	–	0.16
Philippines	0.94	0.65	–	0.07	0.06	–
No fortified foods	0.98	0.60	–	0.24	0.04[c]	–
Fortified foods	0.61[d]		–	0.24		–
Latin America						
Brazil						
Honduras	0.20	–	–	–	–	–
Peru (Huascar)	0.01[a]	0.57	–	–	–	–
Peru (Trujillo)	0.21	0.62	0.57	–	–	0.32

[a] AUC of FGI7 is greater than AUC of FGI7R.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[c] AUC of FGI7R is greater than AUC of FGI7
[d] Results for 6 to 11 months, not enough children in age sub-groups

Table A4-2. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7 and FGI7R, at MMDA cutoff of 75%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.03[a]	0.78	–	–	–	–
Madagascar	0.22	0.32	0.18	–	–	0.07[b]
Malawi	0.70	0.29	0.72	–	–	–
Asia						
Bangladesh	n/a	0.13	–	–	–	–
India	–	–	0.09	–	–	0.42
Philippines	0.38	0.90	–	0.07	0.03[c]	–
No fortified foods	0.22	0.81	–	0.53	0.09	–
Fortified foods	0.88[d]		–	0.02[c]		–
Latin America						
Brazil	–	–	–	–	–	0.07
Honduras	0.01[c]	–	–	–	–	–
Peru (Huascar)	0.00[a]	0.02[c]	–	–	–	–
Peru (Trujillo)	0.30	0.002[c]	0.63	0.57	0.005[a]	0.14

[a] AUC of FGI7 is greater than AUC of FGI7R.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 & n for > 12 mo = 184.
[c] AUC of FGI7R is greater than AUC of FGI7.
[d] Results for 6 to 11 months, not enough children in age subgroups.

2. Testing differences between areas under receiver operating curves: FGI8 vs. FGI8R.

Table A4-3. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI8 and FGI8R, at MMDA cutoff of 50%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.00[a]	0.16	–	–	–	–
Madagascar	0.57	0.40	0.59	–	–	0.08[b]
Malawi	0.08	0.73	0.75	–	–	–
Asia						
Bangladesh	0.49	0.56	–	–	–	–
India	–	–	0.25	–	–	0.20
Philippines	0.74	0.68	–	0.06	0.05[c]	
No fortified foods	0.92	0.74	–	0.20	0.04[c]	–
Fortified foods	0.67[d]		–	0.23		–
Latin America						
Brazil						
Honduras	0.28	–	–	–	–	–
Peru (Huascar)	0.02[a]	0.42	–	–	–	–
Peru (Trujillo)	0.29	0.66	0.58	–	–	0.31

[a] AUC of FGI8 is greater than AUC of FGI8R.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[c] AUC of FGI8R is greater than AUC of FGI8
[d] Results for 6 to 11 months, not enough children in age subgroups.

Table A4-4. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI8 and FGI8R, at MMDA cutoff of 75%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.17	0.56	–	–	–	–
Madagascar	0.27	0.48	0.30	–	–	0.03[b, c]
Malawi	0.57	0.31	0.53	–	–	–
Asia						
Bangladesh	n/a	0.14	–	–	–	–
India	–	–	0.03 [b]	–	–	0.81
Philippines	0.34	0.82	–	0.08	0.02[b]	
No fortified foods	0.19	0.85	–	0.51	0.09	–
Fortified foods	0.85[d]		–	0.02[b]		–
Latin America						
Brazil	–	–	–	–	–	0.05
Honduras	0.04[b]	–	–	–	–	–
Peru (Huascar)	0.00[a]	0.01[b]	–	–	–	–
Peru (Trujillo)	0.34	0.003[b]	0.62	0.51	0.02[a]	0.07

[a] AUC of FGI8 is greater than AUC of FGI8R.
[b] AUC of FGI8R is greater than AUC of FGI8.
[c] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[d] Results for 6 to 11 months, not enough children in age subgroups.

3. Testing differences between areas under receiver operating curves: FGI7 vs. FGI8

Table A4-5. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7 and FGI8, at MMDA cutoff of 50%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.01[a]	0.03[a]	–	–	–	–
Madagascar	<0.001[a]	0.22	0.02[a]	–	–	<0.001[b]
Malawi	0.28	0.11	0.17	–	–	–
Asia						
Bangladesh	0.55	0.22	–	–	–	–
India	–	–	0.00[a]	–	–	0.07
Philippines	0.54	0.17	–	0.07	0.17	–
No fortified foods	0.51	0.21	–	0.28	0.21	–
Fortified foods	0.20[c]		–	0.11		–
Latin America						
Brazil	–	–	–	–	–	–
Honduras	0.93	–	–	–	–	–
Peru (Huascar)	0.00[a]	0.07	–	–	–	–
Peru (Trujillo)	0.59	0.65	0.53	–	–	0.32

[a] AUC of FGI7 is greater than AUC of FGI8.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[c] Results for 6 to 11 months, not enough children in age subgroups.

Table A4-6. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7 and FGI8, at MMDA cutoff of 75%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.04[a]	0.62	–	–	–	–
Madagascar	0.14	<0.001[a]	0.002[a]	–	–	<0.001[a, b]
Malawi	0.04[a]	0.01[a]	0.00[a]	–	–	–
Asia						
Bangladesh	n/a	0.41	–	–	–	–
India	–	–	0.00[a]	–	–	0.12
Philippines	0.55	0.02[a]	–	0.94	0.23	–
No fortified foods	0.03[a]	0.00[a]	–	0.00[a]	0.65	–
Fortified foods	0.81[c]		–	0.88		–
Latin America						
Brazil	–	–	–	–	–	0.12
Honduras	0.10	–	–	–	–	–
Peru (Huascar)	0.03[a]	0.00[a]	–	–	–	–
Peru (Trujillo)	0.01[a]	0.47	0.51	0.42	0.35	0.44

[a] AUC of FGI7 is greater than AUC of FGI8.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[c] Results for 6 to 11 months, not enough children in age subgroups.

4. Testing differences between areas under receiver operating curves: FGI7R vs. FGI8R.

Table A4-7. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7R and FGI8R, at MMDA cutoff of 50%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.09	0.00[a]	–	–	–	–
Madagascar	<0.001[a]	0.02[a]	0.004[a]	–	–	0.35[b]
Malawi	0.21	0.13	0.13	–	–	–
Asia						
Bangladesh	0.58	0.71	–	–	–	–
India	–	–	0.00[a]	–	–	0.01[a]
Philippines	0.80	0.06	–	0.07	0.18	–
No fortified foods	0.92	0.08	–	0.23	0.19	–
Fortified foods	0.06[c]		–	0.09		–
Latin America						
Brazil	–	–	–	–	–	–
Honduras	0.68	–	–	–	–	–
Peru (Huascar)	0.02[a]	0.21	–	–	–	–
Peru (Trujillo)	0.98	0.58	0.50	–	–	0.37

[a] AUC of FGI7R is greater than AUC of FGI8R.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.
[c] Results for 6 to 11 months, not enough children in age subgroups.

Table A4-8. Micronutrient density adequacy: P-values from test comparing area under the curve for FGI7R and FGI8R, at MMDA cutoff of 75%

	Breastfed children			Non-breastfed children		
Countries	**6–8 mo**	**9–11 mo**	**12–23 mo**	**6–8 mo**	**9–11 mo**	**12–23 mo**
Africa						
Ghana	0.59	0.97	–	–	–	–
Madagascar	0.04[a]	<0.001[a]	<0.001[a]	–	–	<0.001[a, b]
Malawi	0.05	0.004[a]	0.00[a]	–	–	–
Asia						
Bangladesh	n/a	0.22	–	–	–	–
India	–	–	0.00 [a]	–	–	0.10
Philippines	0.54	0.003[a]	–	0.66	0.41	–
No fortified foods	0.01[a]	0.00[a]	–	0.00[a]	0.49	–
Fortified foods	0.71	0.86	–	0.41	0.18	–
Latin America						
Brazil	–	–	–	–	–	0.31
Honduras	0.02[a]	–	–	–	–	–
Peru (Huascar)	0.11	0.00[a]	–	–	–	–
Peru (Trujillo)	0.01[a]	0.14	0.48	0.43	0.22	0.79

[a] AUC of FGI7R is greater than AUC of FGI8R.
[b] Result for all children 6 – 23 mo; n for < 12 mo = 25 and n for > 12 mo = 184.

APPENDIX 5. ADDITIONAL FIGURES

Figure A5-1. Energy intake from complementary food by number of meals: Breastfed children 6-8 mo.

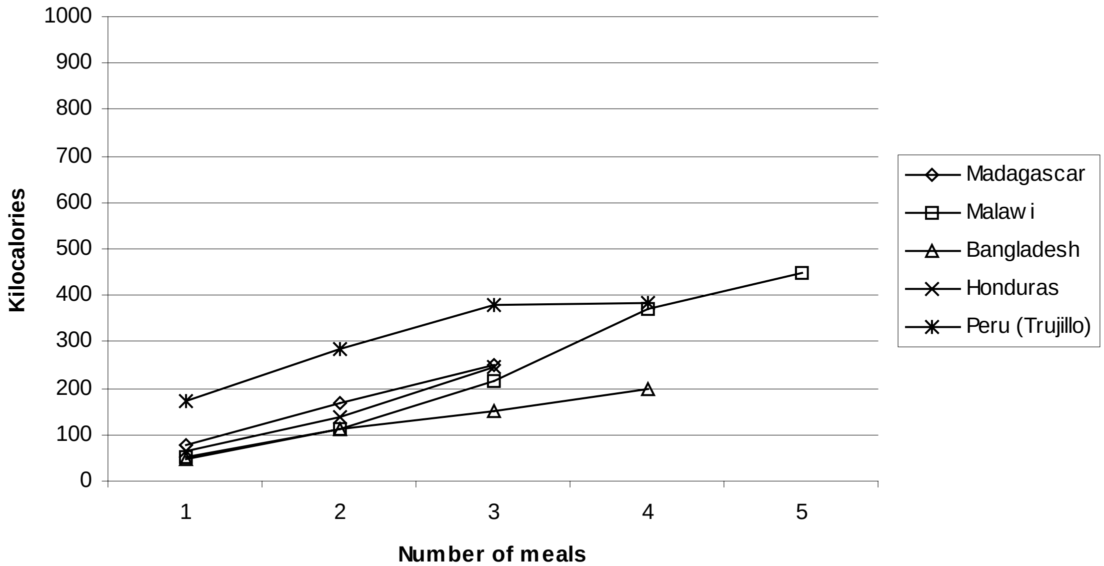


Figure A5-2. Energy intake from complementary food by number of meals: Breastfed children 9-11 mo.

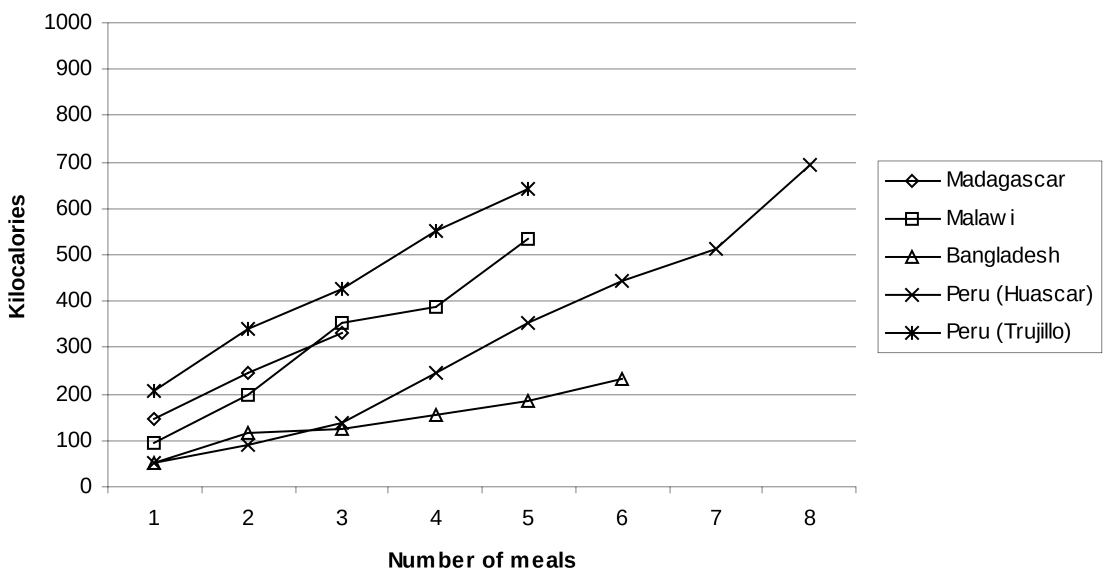


Figure A5-3. Energy intake from complementary food by number of meals: Breastfed children 12-23 mo.

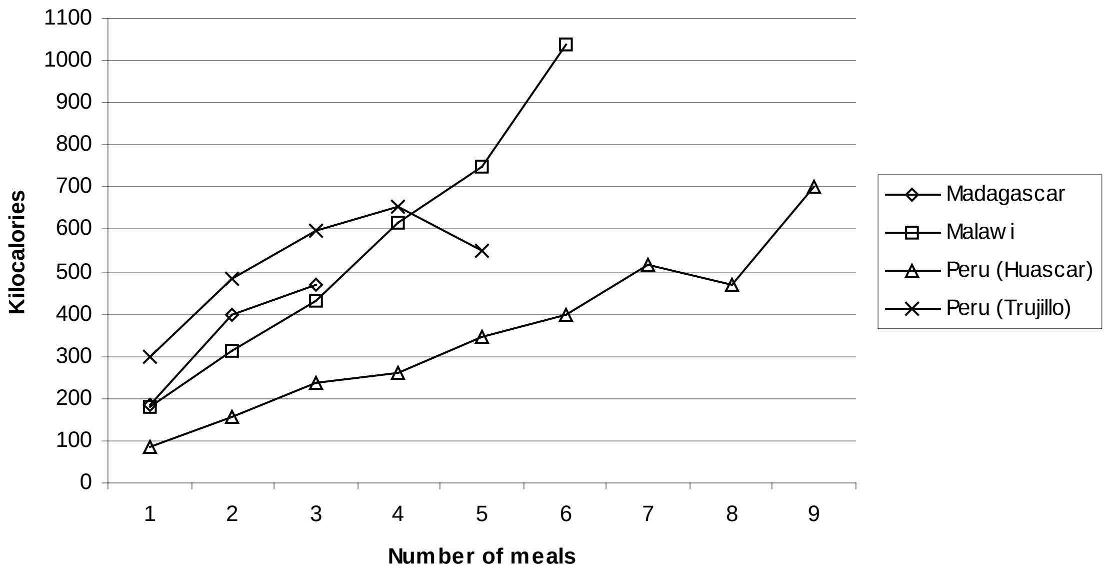


Figure A5-4. Total energy intake by number of meals: Non-breastfed children 12-23 mo.

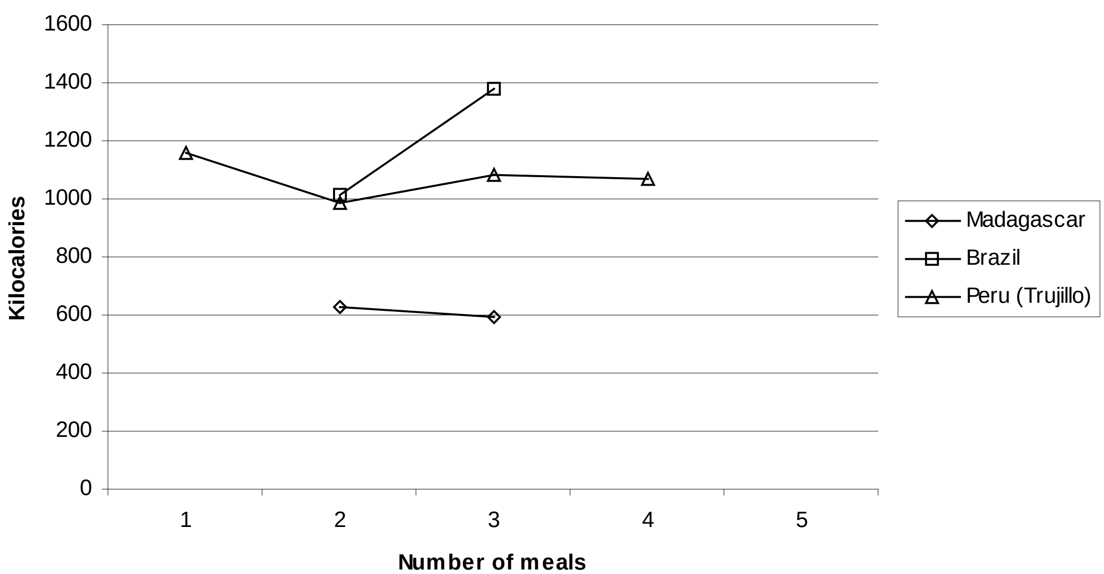


Figure A5-5. Total energy intake by number of feeding episodes: Breastfed children 6-8 mo.

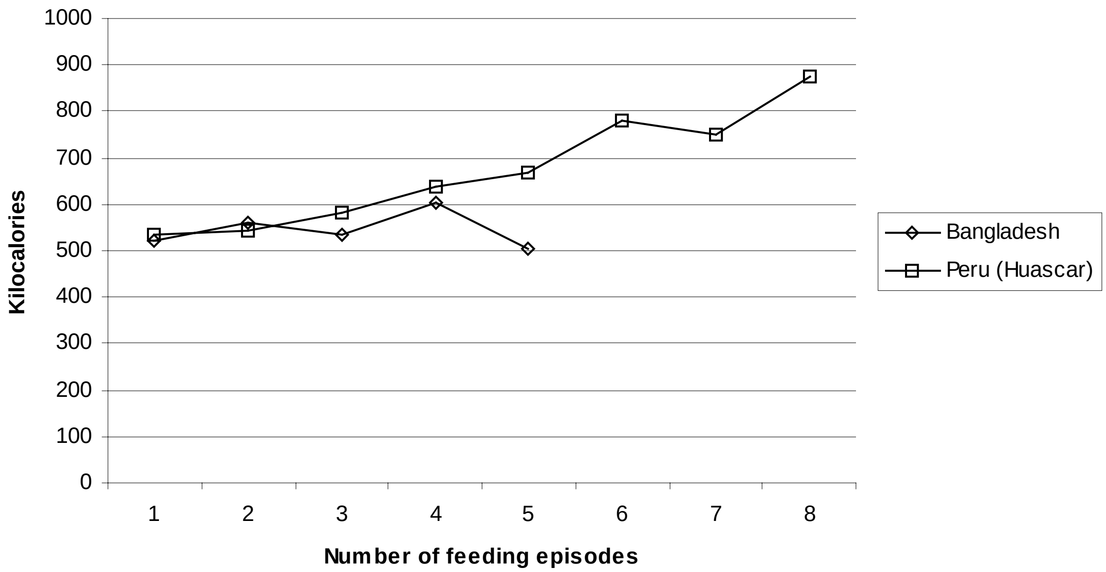


Figure A5-6. Total energy intake by number of feeding episodes: Breastfed children 9-11 mo.

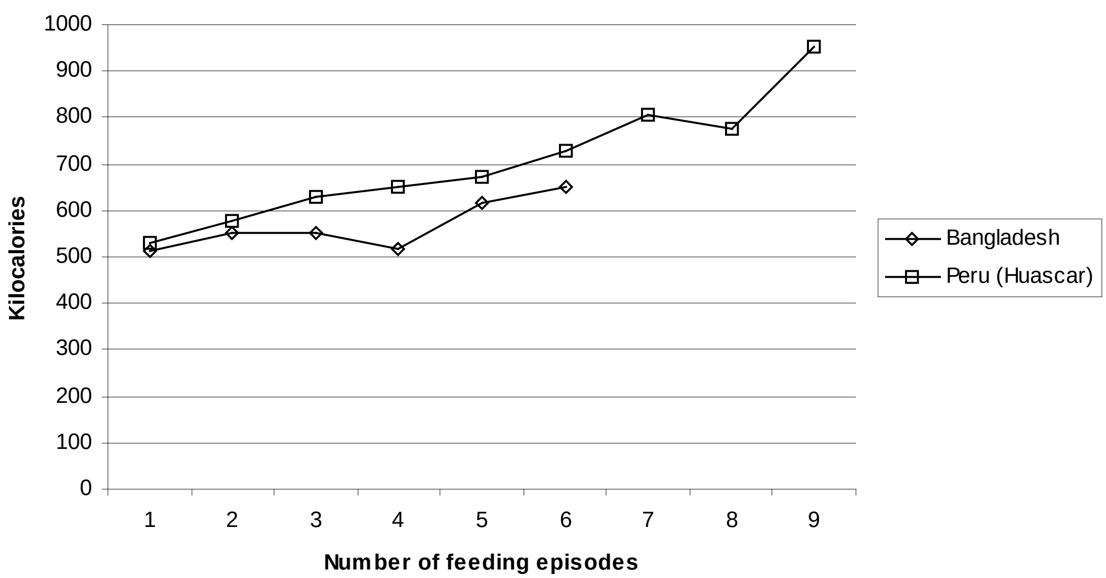
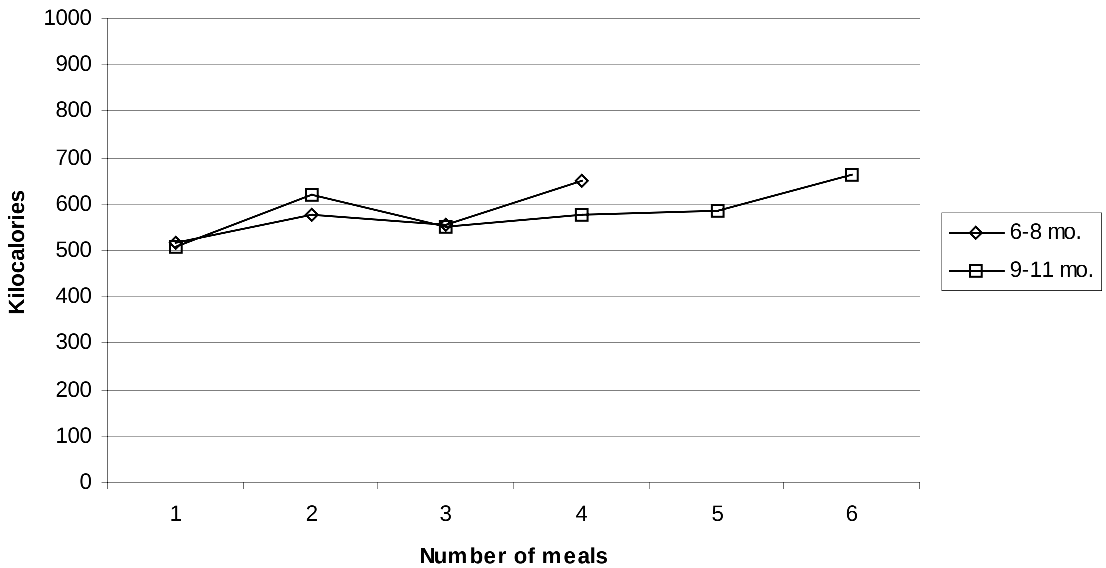


Figure A5-7. Total energy intake by number of meals: Breastfed children in Bangladesh sample



APPENDIX 6. NUMBER OF MEALS AND ENERGY INTAKE FROM NON-BREAST MILK FOODS

Table A6-1. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of meals) and low energy intake for breastfed 6-8 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.36	0.86	0.75	0.07	0.35	0.41
	≤ 3	1.00	0.00	0.50	0.50	0.00	0.50
Malawi	≤ 2	0.61	1.00	1.00	0.00	0.23	0.23
	≤ 3	0.92	0.68	0.80	0.14	0.05	0.18
	≤ 4	1.00	0.29	0.66	0.30	0.00	0.30
Asia							
Bangladesh	–	–	–	–	–	–	–
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
PERU (TRUJILLO)	≤ 2	0.78	0.54	1.00	0.00	0.00	0.00
	≤ 3	1.00	0.05	1.00	0.00	0.00	0.00
	≤ 4	1.00	0.01	1.00	0.00	0.00	0.00

Table A6-2. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of meals) and low energy intake for breastfed 9-11 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.18	0.94	0.79	0.03	0.45	0.48
	≤ 3	1.00	0.00	0.55	0.45	0.00	0.45
Malawi	≤ 2	0.63	0.96	0.93	0.02	0.16	0.19
	≤ 3	0.88	0.61	0.64	0.22	0.05	0.27
	≤ 4	1.00	0.22	0.51	0.44	0.00	0.44
Asia							
Bangladesh	–	–	–	–	–	–	–
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)							
PERU (TRUJILLO)	≤ 2	0.58	0.69	0.99	0.00	0.00	0.01
	≤ 3	0.97	0.10	1.00	0.00	0.00	0.01
	≤ 4	1.00	0.02	1.00	0.00	0.00	0.01

Table A6-3. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of meals) and low energy intake for breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar	≤ 2	0.14	0.92	0.81	0.02	0.63	0.65
	≤ 3	1.00	0.00	0.73	0.27	0.00	0.27
Malawi	≤ 2	0.41	0.96	0.96	0.01	0.41	0.43
	≤ 3	0.81	0.72	0.87	0.08	0.13	0.22
	≤ 4	0.96	0.45	0.81	0.16	0.03	0.19
Asia							
Bangladesh	–	–	–	–	–	–	–
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	–	–	–	–	–	–	–
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
PERU (TRUJILLO)	≤ 2	0.29	0.85	1.00	0.00	0.00	0.00
	≤ 3	0.92	0.12	1.00	0.00	0.00	0.00
	≤ 4	0.99	0.01	1.00	0.00	0.00	0.00

Table A6-4. Sensitivity/specificity analysis of the relationship between frequency of feeding (number of meals) and low energy intake for non-breastfed 12-23 mo children

	Cutoff	Sensitivity	Specificity	Positive predictive value	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
Africa							
Ghana	–	–	–	–	–	–	–
Madagascar[a]	–	–	–	–	–	–	–
Malawi	–	–	–	–	–	–	–
Asia							
Bangladesh	–	–	–	–	–	–	–
India	–	–	–	–	–	–	–
Philippines	–	–	–	–	–	–	–
Latin America							
Brazil	≤ 2	0.23	0.97	0.60	0.03	0.13	0.15
	≤ 3	1.00	0.00	0.16	0.84	0.00	0.84
Honduras	–	–	–	–	–	–	–
Peru (Huascar)	–	–	–	–	–	–	–
Peru (Trujillo)	≤ 2	0.17	0.86	0.35	0.10	0.25	0.35
	≤ 3	0.89	0.11	0.30	0.63	0.03	0.66
	≤ 4	1.00	0.02	0.30	0.69	0.00	0.69

[a] In Madagascar, too few children had adequate energy intakes for this analysis to be performed.