TECHNICAL REPORT

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FOOD AND NUTRITION TECHNICAL ASSISTANCE

USAID FROM THE AMERICAN PEOPLE

Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets in Resource-Poor Areas: Summary of Results from Five Sites

Mary Arimond, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa Daniels, Megan Deitchler, Nadia Fanou, Elaine Ferguson, Maria Joseph, Gina Kennedy, Yves Martin-Prével, Liv Elin Torheim

July 2011

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Foreword

This report is one in a series of technical reports produced under the Women's Dietary Diversity Project (WDDP). The WDDP is a collaborative research initiative to assess the potential of simple indicators of dietary diversity to function as proxy indicators of the micronutrient adequacy of women's diets in resource-poor areas. Work carried out under the WDDP includes the development of a standard analysis protocol and application of that protocol to five existing data sets meeting the analytic criteria established by the project. The data sets analyzed as part of the WDDP are from sites in Bangladesh, Burkina Faso, Mali, Mozambique and the Philippines.

Comparative results across the five sites are presented in a summary report:

Mary Arimond, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa Daniels, Megan Deitchler, Nadia Fanou, Elaine Ferguson, Maria Joseph, Gina Kennedy, Yves Martin-Prével and Liv Elin Torheim. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets in Resource-Poor Areas: Summary of Results from Five Sites*.

Detailed results for each data set are discussed in individual site reports:

- Bangladesh: Mary Arimond, Liv Elin Torheim, Doris Wiesmann, Maria Joseph and Alicia Carriquiry. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Rural Bangladesh Site*.

- Burkina Faso: Elodie Becquey, Gilles Capon and Yves Martin-Prével. *Validation of Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Ouagadougou, Burkina Faso Site*.

- Mali: Gina Kennedy, Nadia Fanou, Chiara Seghieri and Inge D. Brouwer. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Bamako, Mali Site*.

- Mozambique: Doris Wiesmann, Mary Arimond and Cornelia Loechl. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Rural Mozambique Site*.

- Philippines: Melissa Daniels. *Dietary Diversity as a Measure of Women's Diet Quality in Resource-Poor Areas: Results from Metropolitan Cebu, Philippines Site*.

This report presents the comparative results across the five WDDP sites.

The WDDP initiative began in 2006. Funding is provided by the United States Agency for International Development (USAID)'s Food and Nutrition Technical Assistance II Project (FANTA-2) and its predecessor project, FANTA, at FHI 360. The WDDP has been collaboration among researchers a from the International Food Policy Research Institute (IFPRI), FANTA, Akershus University College, Food and Agriculture Organization of the United Nations, Institute of Research for Development, Iowa State University, London School of Hygiene and Tropical Medicine, University of North Carolina at Chapel Hill and Wageningen University.

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- The European Union through the FONIO Project (EU/INCO N° 0015403) (Mali site)
- HarvestPlus Project (Mozambique site)
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Inge D. Brouwer	Wageningen University, Netherlands
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Marie Ruel	International Food Policy Research Institute (IFPRI)
Suzanne Murphy	Cancer Research Center of Hawaii
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Acronyms and Abbreviations

AI	Adequate intake
AUC	Area(s) under the curve
BLUP	Best linear unbiased predictor
BMI	Body mass index
BMR	Basal metabolic rate
CHO	Carbohydrate
CLHNS	Cebu Longitudinal Health and Nutrition Survey
CV	Coefficient of variation
DANIDA	Danish International Development Agency
DGLV	Dark green leafy vegetables
DHS	Demographic and Health Surveys
DRI	Dietary reference intake
EAR	Estimated average requirement
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FANTA	Food and Nutrition Technical Assistance Project
FANTA-2	Food and Nutrition Technical Assistance II Project
FCT	Food composition table
FGI	Food group diversity indicator
FGI-6	Food group diversity indicator summed from 6 groups, minimum intake 1 g per group
FGI-6R	Food group diversity indicator summed from 6 groups, minimum intake 15 g per group
FGI-9	Food group diversity indicator summed from 9 groups, minimum intake 1 g per group
FGI-9R	Food group diversity indicator summed from 9 groups, minimum intake 15 g per group
FGI-13	Food group diversity indicator summed from 13 groups, minimum intake 1 g per group
FGI-13R	Food group diversity indicator summed from 13 groups, minimum intake 15 g per group
FGI-21	Food group diversity indicator summed from 21 groups, minimum intake 1 g per group
FGI-21R	Food group diversity indicator summed from 21 groups, minimum intake 15 g per group
FNRI	Food and Nutrition Research Institute of the Philippines
g	Gram(s)
h	Hour(s)
HIV	Human immunodeficiency virus
IFPRI	International Food Policy Research Institute
INSD	Institut National de la Statistique et de la Démographie
IOM	Institute of Medicine (United States National Academy of Sciences)
IQ	Interquartile
IRD	Institute of Research for Development
ISSP	Institut Supérieur des Sciences de la Population
IZiNCG	International Zinc Nutrition Consultative Group
kg	Kilogram(s)
LSHTM	London School of Hygiene and Tropical Medicine
MPA	Mean probability of adequacy
µg	Microgram(s)
NGO	Nongovernmental organization
NPNL	Non-pregnant non-lactating
NRV	Nutrient reference values of the Codex Alimentarius
OC	Oral contraceptives
OFSP	Orange-fleshed sweet potatoes
ORC Macro	Opinion Research Corporation Macro International, Inc.
PA	Probability of adequacy
RAE	Retinol activity equivalent
RE	Retinol equivalent
REU	HarvestPlus Reaching End Users Project

ROC	Receiver-operating characteristic
SD	Standard deviation
UK	United Kingdom
UNICEF	United Nations Children's Fund
UNU	United Nations University
US	United States
USAID	United States Agency for International Development
WDDP	Women's Dietary Diversity Project
WHO	World Health Organization

Executive Summary

BACKGROUND

In resource-poor environments across the globe, low quality monotonous diets are the norm and the risk for a variety of micronutrient deficiencies is high. Girls and women of reproductive age are among those most likely to suffer from deficiencies. Outside of developed countries, very little information is available on women's micronutrient status, but even with limited data it is clear that poor micronutrient status among women is a global problem and is most severe for poor women.

Comparable information about dietary intakes, dietary patterns and diet quality for women across countries is also scarce and fragmented. Because of the cost and complexity of quantitative dietary intake data collection, very few developing countries have information on micronutrient intakes for women of reproductive age. In addition, most past studies of women's nutrient intakes have employed older analytic methods, which have been shown to provide incorrect estimates of the prevalence of nutrient adequacy.

In this context, simple indicators are needed to characterize diet quality, to assess key diet problems and to identify subgroups particularly at risk of nutrient inadequacy. Simple indicators are also needed to monitor and evaluate intervention programs. The present study contributes to the development of such indicators. At the same time, the study also provides descriptive information on dietary patterns and levels of micronutrient adequacy for women in resource-poor settings.

The broad objective of this study, carried out under FANTA's Women's Dietary Diversity Project (WDDP), is to use existing data sets with dietary intake data from multiple 24-hour (24-h) recalls to analyze the relationship between simple indicators of dietary diversity – such as could be derived from large-scale surveys – and diet quality for women. We developed and employed a standard protocol to analyze data from five sites (three in Africa and two in Asia). This report summarizes results across the sites and extends knowledge of the relationship between simple dietary diversity indicators and nutrient adequacy for women.

METHODS

For each data set, we derived a set of eight candidate indicators of dietary diversity, such as could be constructed from a single day's food group recall. The food group diversity indicators (FGIs) varied in the level of disaggregation of food groups (6, 9, 13 and 21 food groups) and in the minimum amount of consumption (1 gram [g] or 15 g) required in order for a food group to count in a score. Throughout the report, each FGI is abbreviated by reference to the level of aggregation/number of food groups in the score (e.g., FGI-6 is the food group indicator comprised of 6 groups). An "R" indicates that the 15 g "restriction" is used as a minimum in order for a food group to count in the score (e.g., FGI-6R is the food group indicator comprised of 6 groups, where a group is counted positively only if the woman consumed at least 15 g from that group).

Using currently recommended approaches, we assessed the probability of adequacy (PA) for 11 micronutrients. This is equivalent to the prevalence of adequacy in the sample. We also constructed a summary measure of diet quality, the "mean probability of micronutrient adequacy" (MPA). The MPA summarizes micronutrient adequacy across the 11 micronutrients.

We used correlations and simple linear regressions to describe relationships between the eight FGIs, energy intake and MPA. Using receiver-operating characteristics (ROC) analysis, we tested the performance of the eight candidate indicators in predicting MPA. Finally, we assessed the potential for identifying dichotomous indicators of diet quality through examination of indicator characteristics (sensitivity, specificity and total misclassification) for several cutoffs of MPA, at various food group diversity cutoffs. Results are presented for non-pregnant non-lactating (NPNL) women in all sites and for lactating women in three sites where sub-sample sizes allowed (Mozambique, Bangladesh and the Philippines).

RESULTS

Dietary Patterns and Food Group Diversity Indicator Scores

Dietary patterns varied across the five sites. Diets in the two rural sites (Mozambique and Bangladesh) were heavily dominated by starchy staples and the contribution of fats/oils/sweets to energy intakes was very low. The percent of energy from starchy staples varied from 46 percent in urban Mali to 86 percent in rural Bangladesh. Diets in the three urban/peri-urban sites (Burkina Faso, Mali and the Philippines) were better balanced with respect to macronutrient intakes.

The two urban West African sites also had the highest mean FGI scores, for all candidate indicators. For six of eight FGIs, the highest average score was in the Mali sample. However, FGI scores were not high in the third urban/peri-urban site (Philippines). Mozambique ranked lowest on all "unrestricted" FGIs (1 g minimum), but when the 15 g restriction was applied, Mozambique ranked third (3 FGIs) or fourth (1 FGI). Conversely, women in the Philippines ranked last in 3 of the 4 indicators with the 15 g restriction. The Bangladesh sample ranked third or fourth for all indicators.

Micronutrient Intakes and Adequacy

Median micronutrient intakes varied by site, with substantial differences for a number of nutrients. Intakes were notably low, relative to average requirements, for a number of micronutrients in each site. This was reflected in low prevalence of adequacy. Among NPNL women, the estimated prevalence of adequacy was below 50 percent in most sites for thiamin, riboflavin, niacin, folate, vitamin B12, calcium and iron. When examined by site, prevalence of adequacy was below 50 percent for five of 11 micronutrients in Mali, six in Mozambique, seven in both Burkina Faso and Bangladesh, and nine micronutrients in the Philippines. Results for lactating women indicated even more severe gaps between intakes and requirements.

Among sites, the MPA for the 11 micronutrients ranged from 34-54 percent for NPNL women and from 24-34 percent for lactating women. MPA was lowest for the two Asian samples and highest in Mozambique; however, data collection occurred during mango season in Mozambique and it is very likely that MPA would be lower in Mozambique in other seasons.

Relationships between Food Group Diversity Indicators, Energy Intakes and Mean Probability of Adequacy

As has been shown previously, FGIs in our study showed positive relationships with energy intakes. Overall, correlations were moderate, with most falling between 0.20-0.30. Given this demonstrated relationship between FGI scores and energy intakes, we explored relationships between FGIs and MPA both with and without controlling for energy.

All eight FGIs were significantly correlated with MPA in all sites, and for both NPNL and lactating women. For NPNL women, all correlations remained significant when energy was controlled for. For lactating women, all except FGI-6 remained significant in Mozambique; however, in Bangladesh and the Philippines, several other FGIs were not significant. Correlations were higher for FGIs with the 15 g minimum.

Three FGIs emerged as the "best candidates": the 9 group, 13 group and 21 group indicators, each with the 15 g minimum (FGI-9R, FGI-13R and FGI-21R). Considering these three best candidate indicators, correlations ranged from 0.30-0.53, and from 0.23-0.48 when controlling for energy. Correlations were lower for lactating women than for NPNL women.

Simple linear regressions including women's age, height and FGI, and with or without energy in the model, confirmed that FGI remained a significant predictor of MPA in most models. In all of the "no energy" models, FGIs were significant among both NPNL and lactating women. Coefficients for the three best candidate FGIs ranged from 0.05-0.13, and from 0.02-0.10 when controlling for energy. As with correlations, coefficients tended to be lower for lactating women.

Interpretation of coefficients, particularly across sites, is not straightforward due to transformation of the dependent variable in three sites. However, for the two West African sites, coefficients for the three best candidate FGIs ranged from 0.06 – 0.10. This would indicate increases of 0.06 – 0.10 in MPA for each 1 point increase in the FGI.

Considering the overall explanatory power of the models, adjusted R^2 for the models with the three best candidate indicators ranged from 0.11-0.30 and from 0.36-0.60 when energy was included in the model. This indicates that even though models were simple, they explained a substantial portion of the variability in MPA.

Indicator Performance

Indicator performance was assessed first through ROC analysis and then through assessment of sensitivity, specificity and misclassification for dichotomous indicators. Given the distribution of MPA in our samples, we evaluated dichotomous indicators for NPNL women at MPA cutoffs of > 0.50, > 0.60 and > 0.70 MPA. Results from ROC analysis were consistent with those for correlations and regressions, and showed better performance for FGIs that imposed the 15 g minimum. The 6 group indicators performed poorly in most sites, but beyond that no specific FGI could be identified that out-performed others, across most or all sites.

To provide a dichotomous indicator, cutoffs for FGI scores were also examined with the objective of determining whether or not a specific FGI cutoff could be identified where indicator performance was acceptable across sites. Among the three best candidate indicators, there was no single cutoff for the number of food groups that performed "best" across all sites. There was no indicator, and no cutoff, that yielded an acceptable balance of sensitivity, specificity and misclassification across all sites.

The summary analysis masks the fact that within individual sites acceptable indicators were identified. However, these may be best considered as indicators of poor diet quality rather than adequate diet quality, as few women in any site reached MPA levels that could be considered "high."

CONCLUSIONS

The main conclusions of this study are:

- There were very substantial gaps between micronutrient intakes and requirements for women of reproductive age in all five diverse, resource-poor settings.
- Gaps between intakes and requirements extended beyond the few micronutrients that are the usual focus of supplementation programs.
- The gaps were present in two poor rural sites, but also in three urban/peri-urban sites.
- Gaps were more pronounced for lactating women.
- Simple indicators of food group diversity were meaningfully related to micronutrient adequacy in both the rural and urban/peri-urban sites.
- Relationships between FGI scores and nutrient adequacy may vary by season, as evidenced by the strong impact of mango season in the Mozambique site. This should be considered if FGIs are used to compare results across time or between regions with different agricultural cycles.
- Due to low distributions of MPA in all sites, indicators of "good" nutrient adequacy could not be explored. The best indicator performance was found for the lowest MPA cutoff (0.50); below an MPA of 0.50 diets could be described as very poor.
- FGIs that imposed a minimum of 15 g for a food group to "count" performed better than those that did not.
- Sensitivity and specificity analyses showed that no indicator and no cutoff yielded an acceptable balance of sensitivity, specificity and misclassification across all sites.

Several of our conclusions have practical implications for FGI data collection efforts. As the "restricted" FGIs performed better than non-restricted ones, we suggest that questionnaire design should reflect this. Methods for excluding trivial amounts should be incorporated in questionnaire design and interviewer training. Also, we note that the least disaggregated FGIs (6 group indicators) generally did not perform well, so we recommend selection of more disaggregated FGIs, though the highest levels of disaggregation may present challenges related to classification of foods into groups. This may be challenging both at the level of questionnaire design and at the level of data collection.

Finally, while our results do not support selection of a particular indicator with a particular diversity cutoff for global use, they support the relevance of simple indicators to reflect diet quality. They may provide some basis for site-specific indicators. They also provide support for the use of food group diversity indicators that reflect country-level food-based dietary guidelines, where such guidelines exist. Our results add to the evidence base that such indicators may be meaningful both in rural areas where diets are very monotonous and in urban/peri-urban areas where diets may be more balanced at the level of macronutrient intake but remain micronutrient-poor.

1. Background

In resource-poor environments across the globe, low quality monotonous diets are the norm. When grain- or tuber-based staple foods dominate and diets lack animal-source foods and fruits and vegetables, the risk for a variety of micronutrient deficiencies is high. Those most likely to suffer from deficiencies include infants and young children, and adolescent girls and women of reproductive age. The high nutrient demands of pregnancy and lactation, and sometimes of closely-spaced pregnancies, put poor women at high risk. HIV infections also play a role in elevating risk for some women.

Unfortunately, outside of developed countries very little information is available on women's micronutrient status. However, even with limited data, it is clear that poor micronutrient status among women is a global problem and is most severe for poor women.[1]

Similarly, comparable information about dietary intakes, dietary patterns and diet quality for women across countries is also scarce. Because of the cost and complexity of quantitative dietary intake data collection, very few developing countries have nationally representative surveys providing information on micronutrient intakes for women of reproductive age. Available information on women's intakes is very fragmented, usually from small studies representing either specific population subgroups or convenience samples. Further, most past studies of women's nutrient intakes have employed older analytic methods, which are now believed to provide incorrect estimates of the prevalence of nutrient adequacy (see **Section 5.6**).

The broad objective of this study, carried out under FANTA's Women's Dietary Diversity Project (WDDP), is to use existing data sets with dietary intake data from multiple 24-hour (24-h) recalls to analyze the relationship between simple indicators of dietary diversity – such as could be derived from the DHS and other surveys – and diet quality for women.

Simple indicators are urgently needed in developing countries to characterize diet quality, to assess key diet problems (such as lack of animal products, fruits and vegetables) and to identify subgroups particularly at risk of nutrient inadequacy. Simple indicators are also needed to monitor and evaluate intervention programs. The present study contributes to development of such simple indicators. At the same time, the study also provides descriptive information on dietary patterns and levels of micronutrient adequacy for women in resource-poor settings.

For the purposes of this work, we define adequate diet quality as a diet that has a high probability of delivering adequate amounts of selected micronutrients to meet the needs of women of reproductive age. We recognize that definitions of diet quality often include other dimensions, such as moderation (e.g. in intakes of energy, saturated/trans fat, cholesterol, sodium and refined sugars) and balance. But because low micronutrient intakes remain the dominant problem in many of the poorest regions, our focus in this work is on micronutrient adequacy only.

This report summarizes results across five sites; detailed descriptive results are available for each site in site-specific reports.[2]

[1] Kennedy and Meyers 2005.
[2] Arimond et al. 2009; Becquey, Capon and Martin-Prével 2009; Kennedy et al. 2009; Wiesmann, Arimond and Loechl 2009; Daniels 2009.

2. Dietary Diversity

Dietary diversity – i.e. the number of foods consumed across and within food groups over a reference period – is widely recognized as being a key dimension of diet quality and is reflected in food-based dietary guidelines. It reflects the concept that increasing the variety of foods and food groups in the diet helps to ensure adequate intake of essential nutrients and promotes good health. There is ample evidence from developed countries showing that dietary diversity is indeed strongly associated with nutrient adequacy and is thus an essential element of diet quality.[3] There is less evidence from developing countries where monotonous diets, relying mostly on a few plant-based staple foods, are typical. Even fewer studies from developing countries have aimed to confirm this association specifically among adult women. The available studies have generally supported the association between diversity and nutrient adequacy.[4] One exception to this was reported in a study from urban Guatemala, but in this study diversity was defined as the number of unique foods consumed over 14 24-hour periods; this meant that even very infrequently consumed items counted in the score.[5]

Previous studies have generally been context-specific and diversity has been operationalized differently in each study.[6] While this has made comparisons difficult, it has also suggested that the relationship is robust. We developed and employed a standard protocol to analyze data from five sites. This report summarizes results across the sites and extends knowledge of the relationship between simple diversity indicators and nutrient adequacy for women.

[3] Randall, Nichaman and Contant, Jr. 1985; Krebs-Smith et al. 1987; Kant 1996; Drewnowski et al. 1997; Cox et al. 1997; Lowik, Hulshof and Brussaard 1999; Bernstein et al. 2002; Foote et al. 2004.
[4] Ogle, Hung and Tuyet 2001; Torheim et al. 2003, 2004; Roche et al. 2007.
[5] Fitzgerald et al. 1992.
[6] Ruel 2003.

3. Objectives

To assess the potential of simple indicators of dietary diversity to function as proxy indicators of diet quality, we identified the following main objectives:

1. Develop a set of diversity indicators varying in complexity but all amenable to construction from simple survey data
2. Develop an indicator of diet quality using current best practices to assess adequacy across a range of key micronutrients
3. Explore relationships among diversity indicators, energy intake and the indicator of diet quality
4. Test the performance of various indicators using cut-points along the range of diversity scores; assess performance (sensitivity, specificity and misclassification) relative to various cutoffs for diet quality, as data allow

As a secondary objective, we aimed to characterize micronutrient adequacy for each study site and compare adequacy across sites. This study is among the first to employ currently recommended methods for estimating prevalence of adequacy to provide estimates of micronutrient adequacy for women of reproductive age in developing countries

For the purpose of achieving these objectives, the WDDP was undertaken beginning in 2006. Funding was provided by the United States Agency for International Development (USAID) through the Food and Nutrition Technical Assistance (FANTA) Project of FHI 360.
The WDDP has been a collaboration among researchers from the International Food Policy Research Institute (IFPRI), FANTA, Akershus University College, Food and Agriculture Organization of the United Nations, the Institute of Research for Development, London School of Hygiene and Tropical Medicine, University of North Carolina at Chapel Hill and Wageningen University.

4. Description of Data Sets and Study Sites

The data sets included in the study met several criteria: they each included at least two 24-h recalls for at least a subsample of women of reproductive age (15-49 years) and had a minimum sample size of 100. Data were analyzed separately for pregnant, lactating and non-pregnant non-lactating (NPNL) women when subsample sizes allowed (at least 100 women in the physiological subgroup, with repeat recalls for at least 30 women in the subgroup). Investigators had to be available within the project timeframe and willing to follow a common analytic protocol developed for the project. The protocol is summarized in **Section 5** and detailed in Arimond et al, 2008. Five data sets (3 from Africa and 2 from Asia) were identified and selected for inclusion in the study.

4.1. BANGLADESH

The first data set to be analyzed was an older data set from IFPRI research in Bangladesh. The analytic protocol for the current project was developed during several iterations of analysis with this data set. The data comprised a subset of women's dietary intake data from surveys undertaken by IFPRI and collaborators in 1996. The surveys were originally designed to determine both nutrition and resource allocation effects of several nongovernmental organization (NGO)-disseminated agricultural technologies in three rural study areas in Bangladesh.[7]

While the three study areas varied across a number of dimensions (e.g., landholding), they were similar to each other – and to rural Bangladesh in general – in average per capita income (approximately US$200 per capita per year). Diets were dominated by rice, with similar rice intakes across all income strata. Fortified foods were not consumed by women in the study sample. Intakes of animal-source foods, fruits and vegetables were low. Anemia prevalence was very high (50-60 percent of women, depending on study area). There was no information gathered on iron/folate supplement use during pregnancy, but approximately 20 percent of the non-pregnant women reported receiving and consuming iron tablets that were routinely distributed with birth control pills for a median duration of approximately two years. No information was available on the frequency of consumption of iron tablets.

The study also showed that within households, women consumed a disproportionately low share of preferred foods, such as animal-source foods, potentially exacerbating a poor nutrition (and micronutrient) situation.[8] Further details are available in Arimond et al. 2009 (site report for the current study) and in Bouis et al. 1998 (donor report for original study).

4.2. BURKINA FASO

The data for Burkina Faso are from the latest in a series of qualitative and quantitative explorations of food habits and dietary intakes in the study area.[9] Unlike other data sets represented in this report, data collection in Burkina Faso shared the same main objective as the WDDP; that is, data were gathered with the objective of validating simple dietary diversity indicators as a measure of micronutrient adequacy for adult women. Secondary objectives were to explore links between nutrition knowledge, food habits and the nutritional status of women, and also to examine changes in dietary diversity over time, because data from a previous (2005) survey were available for the same individuals.

The study was conducted in two districts of Ouagadougou, the capital city of Burkina Faso, in 2006. The city is divided into districts with amenities in the town center (the so-called "structured districts") and peripheral districts without amenities (the so-called "non-structured districts"). One "structured" district and one "non-structured" district were purposively selected for the study because of the availability of demographic and socio-economic data from a previously instituted monitoring system. Comparison of study sample characteristics, including level of education, size of the household, gender of the head of

[7] Bouis et al. 1998.
[8] Ibid.
[9] Becquey 2006; Savy et al. 2008.

household, water and electricity supply, and quality of housing and assets (e.g., TV, radio, bicycle, moped, car, refrigerator, phone) showed good agreement with recent DHS data for Ouagadougou.[10] See Becquey, Capon, and Martin-Prével 2009 for a more detailed description of the study site.

4.3. MALI

Data for Mali are from a European Union (EU)-funded research project, FONIO[11], which aims to upgrade the quality and competitiveness of fonio in West Africa by improving production, technology and market systems for local and export markets. Data collection included two 24-h recalls of food consumption among women aged 15-49 years with the objective of determining the role of fonio in dietary patterns and the contribution of fonio to iron and zinc intake and iron status of women of reproductive age living in an urban area in Mali.

The research was carried out in Bamako, the capital city of Mali. The study sample was selected to be representative of NPNL women of reproductive age. Women belonged to a Malian sociolinguistic group and preferably were responsible for household food preparation. See the site report, Kennedy et al. 2009, for further details.

4.4. MOZAMBIQUE

Data for Mozambique were gathered as part of a baseline survey for an impact evaluation of an on-going HarvestPlus Reaching End Users Project (REU) implemented in Zambezia Province. REU aims to reduce vitamin A deficiency through encouraging the adoption of vitamin A-rich orange-fleshed sweet potatoes (OFSP) as an agricultural crop and a household food; infants and young children and women of reproductive age constitute two targeted groups. The project aims to simultaneously increase access to planting materials and develop markets and increase demand for OFSP. Agricultural and nutrition extensionists work with volunteer "promoters" to reach large numbers of households with new knowledge and practices.

The study areas in Mozambique are characterized by high levels of malnutrition, a very monotonous diet and a very poor resource base. Few households have regular cash income and most practice subsistence agriculture, in some cases supplemented by fishing and other activities. Much of the area is drought- and/or flood-prone, although some areas of higher elevation are less so. Maize and, to a lesser extent, cassava and rice are the primary staples. Both maize and cassava are cooked as a paste and served with simple sauces, usually made of beans, dark green leaves and/or dried or fresh fish. Coconut is available in some parts of the study area. Importantly, it was mango season at the time of the baseline survey. More details are available in the site report, Wiesmann, Arimond and Loechl 2009.

4.5. PHILIPPINES

Data for the Philippines are from the Cebu Longitudinal Health and Nutrition Survey (CLHNS) and include all women of reproductive age present during the 2005 round of that study. The CLHNS began in 1983 as a prospective study of infant feeding patterns, their determinants and consequences. At the inception of the CLHNS, all pregnant women in selected communities were invited to participate in the survey. Since that time, extensive data have been collected on the mothers and these offspring, as well as other family members and household residents. The initial phase led to an expanded focus on pregnancy outcomes, maternal and child health, and birth spacing issues for which a prospective design was favorable for research.[12] No interventions have been provided to the cohort.

The CLHNS is a community-based survey of metropolitan Cebu, which surrounds and includes Cebu City, the second largest city of the Philippines. Families were surveyed live in a variety of circumstances, including densely populated urban areas, urban squatter settlements, peri-urban neighborhoods, and

[10] INSD and ORC Macro 2004.
[11] EU/INCO funded project N° 0015403.
[12] OPS 1989.

rural areas stretching into the mountains and some small surrounding islands. Sampling consisted of two independent two-stage cluster samples, one urban and one rural. The CLHNS was not originally intended to be nationally or provincially representative of Filipino women, but only to reflect existing variation in infant feeding strategies. However, women in the CLHNS are generally similar in socioeconomic status to women in the Philippine DHS, as well as to women in national surveys from the Food and Nutrition Research Institute of the Philippines (FNRI).[13] See the site report, Daniels 2009, for further details.

[13] Personal communication with Linda Adair, Principal Investigator for CLHNS, Aug 1, 2008.

5. Methods

Descriptive reports for each site provide detailed information on sampling, data collection and data processing methods.[14] The development of the analytic protocol is fully described in Arimond et al. 2008. Key elements of the analytic protocol are also described here.

5.1. EXCLUSIONS FROM ORIGINAL SAMPLES

The Bangladesh data set was the first to be analyzed, and the study protocol was developed in an iterative process during this analysis and in dialogue with collaborating researchers. In the case of Bangladesh, many years had passed since the data were collected and it was not possible to review raw data. Methods of data collection necessitated selection of a subsample for which more complete household-level recipe information was available.[15]

In addition, there were a number of extreme high outliers for energy intake which appeared to be associated with implausible estimates of rice intake. This suggested a possible issue with over-reporting. Therefore, basal metabolic rate (BMR)-based criteria were chosen to define exclusion ranges. We examined distributions and excluded women whose energy intakes were either below a BMR factor of 0.9 or above a factor of 3.0.[16]

These criteria were initially adopted for use by other sites in the WDDP. However, in a subsequent working group meeting it was agreed that those researchers who had been more directly involved in data collection and who could review and assess raw data might make different decisions about exclusions. We recognized that single-day intakes can, indeed, be very extreme and that caution must be used in applying BMR-based cutoffs.[17] Therefore slightly different approaches to exclusions were employed in Burkina Faso, Mali and Mozambique, and are detailed in those site reports.

The Philippines data set presented a different situation. Across survey rounds, the 24-h recalls in the CLHNS generated estimated intakes that are low by comparison to other data from the Philippines and by comparison to estimated intakes in other studies from South and South East Asia.[18] Further, if the 0.9 X BMR cutoff had been applied to the CLHNS sample, nearly half of the sample would have been excluded. This was viewed as unacceptable because of the possibility of introducing unknown/undefined biases. For the CLHNS sample, the decision was made to exclude outliers judged to be extreme for the sample by reference to the observed distribution of energy intakes.[19,20] The potential for substantial under-reporting in the CLHNS sample is therefore considered in the use and interpretation of results from the Philippines site.

[14] Arimond et al. 2009; Becquey, Capon and Martin-Prével 2009; Kennedy et al. 2009; Wiesmann, Arimond and Loechl 2009; Daniels 2009.

[15] See Arimond et al. 2009 for details.

[16] Goldberg et al. 1991 provides a method for assessing the quality of dietary data through evaluating estimated energy intake. The estimated energy intake (EI_{rep}) is compared with the person's estimated BMR (BMR_{est}). The ratio between EI_{rep} and BMR_{est} is called the BMR factor. The BMR factor can be used as a lower cutoff value for identifying under-reporters. The lower cutoff value, with a 95 percent confidence interval, is based on an energy requirement of 1.55 X BMR for a person with a sedentary lifestyle, adjusted for the number of days of recall data. For a single recall day, the lower cutoff value is 0.90 X BMR. The highest energy intake that can be sustained over a longer period of time is 2.4 X BMR (FAO/WHO/UNU 2001). An upper cutoff value of 2.4 X BMR has therefore been used by some. However, a single day's energy intake can be more extreme. For our purposes we set the upper cutoff to 3.0 X BMR to identify likely over-reporters.

[17] Black 2000.

[18] Literature on dietary intakes for women of reproductive age is currently being compiled and reviewed by WDDP members. Results of the review are not yet available, but tables summarizing intakes across a range of studies support the observation the CLHNS intakes appear very low.

[19] To avoid excessive bias while eliminating the most extreme low outliers, women with energy intakes less than 0.3 X BMR were excluded. The same upper limit as was used in Bangladesh (3.0 X BMR) was used.

[20] See Daniels 2009 for details.

5.2. DEVELOPMENT OF ANALYTIC PROTOCOL

This report results from a collaborative process begun in early 2006. A draft research protocol was discussed with a group of potential collaborators who were invited to meet in Copenhagen on April 27-28, 2006, in conjunction with the Sixth International Conference on Dietary Assessment Methodology. Following the meeting, discussions continued on several issues (e.g., selection of source[s] for requirements, definition of food groups). Statistical methods were also further elaborated by colleagues at Iowa State University.[21] These discussions and exercises formed the basis for a revised protocol.[22] The protocol details a number of decisions which are also summarized below, including:

- Selection of key nutrients
- Selection of requirements (estimated average requirements [EARs]) and estimates of variability in requirements (standard deviation [SD] or coefficient of variation [CV])
- Definition and construction of food group diversity indicators (FGIs)
- Definition and construction of a summary measure of diet quality (mean probability of adequacy [MPA])
- Statistical methods for analysis

As noted, for the purposes of this work we defined adequate diet quality as a diet that has a high probability of delivering adequate amounts of selected micronutrients to meet the needs of women of reproductive age.

Macronutrient intakes are reported for descriptive purposes. In addition, we present results relating FGIs to energy intake, and results relating FGIs and MPA both with and without adjusting for energy intakes. This is because in many previous studies, energy intakes have been shown to increase with increases in dietary diversity.[23] We aimed to assess to what extent any observed relationships between FGIs and micronutrient intakes (reflected in MPA) were due to increases in quantity of food consumed (reflected in total energy intake) as compared to increases in micronutrient density (a key dimension of diet quality).

In theory, the implications of this distinction (quantity vs. micronutrient density) could differ depending on the context. In very impoverished settings and wherever energy intakes are insufficient, it may be irrelevant whether increases in micronutrient adequacy are due to quantity or quality. However, in other settings where energy intakes are sufficient or even excessive, increases in micronutrient density are desirable while increases in energy intake may be undesirable.

5.3. KEY NUTRIENTS

The selection of a set of micronutrients was discussed at the Copenhagen meeting. Considerations included known public health relevance, as well as availability of nutrient data both in data sets collected by the potential collaborators and in a range of food composition tables (FCTs) likely to be used.

In previous work with infants and young children, we used a set of "problem" nutrients identified in a global review.[24] To our knowledge, there is no such global review identifying a list of "problem" nutrients for women of reproductive age. The recent review cited previously[25] concluded that available information is extremely limited. However, it is known that poor pregnancy outcomes can result from a wide range of micronutrient deficiencies, including deficiencies in iron, folate, B vitamins, antioxidants, vitamin D and iodine.[26] Similarly, low maternal intake or stores during lactation can also affect breast milk levels of B vitamins, vitamin A and iodine. In addition, low intakes of calcium have also been documented among

[21] See Joseph 2007.
[22] Arimond et al. 2008.
[23] See, for example: Ogle, Hung and Tuyet 2001; Foote et al. 2004; Torheim et al. 2004.
[24] WHO/UNICEF 1998.
[25] Kennedy and Meyers 2005.
[26] Allen 2005.

women of reproductive age.[27] Consequences for child-bearing and lactation are not the only concerns; micronutrient deficiencies affect women's health from adolescence through aging.

For the purposes of this study, the following micronutrients were agreed to be of focus:

Vitamins	Minerals
Thiamin	Calcium
Riboflavin	Iron
Niacin	Zinc
Vitamin B6	
Folate	
Vitamin B12	
Vitamin A	
Vitamin C	

Vitamin D had been considered but was dropped both because it does not have an EAR and because of its absence from many FCTs. Similarly, reliable data on the iodine content of foods are generally not available.

5.4. REQUIREMENTS AND REQUIREMENT DISTRIBUTIONS

Appendix 1 defines the EARs and SDs (some calculated from CV) selected for use in the project; the table of EARs also identifies the units to be used, which follow from the selection of requirements. Group consensus was that the World Health Organization (WHO)/Food and Agriculture Organization of the United Nations (FAO) EARs[28] would generally be most appropriate, given the purposes of this project.

Exceptions were made in the case of the minerals (calcium, iron and zinc). The group felt that the WHO/FAO EAR of 840 milligrams per day (mg/d) for calcium[29] is quite high, was not well justified in the supporting document and would certainly pull down any summary measure of adequacy. The WHO/FAO EAR is between the United Kingdom (UK) EAR (525 mg) and the United States (US) "Adequate Intake" value (AI)[30] of 1,000 mg, but is closer to the US AI. The decision was taken to use the US AI and to evaluate probability of adequacy (PA) following the method used by Foote et al. 2004.

For iron intakes, assessment of the PA requires special attention to the shape of the requirement distribution. When evaluating PA for most nutrients, analysis methods assume a symmetric distribution of requirements in the population. However, it is well established that the requirement distribution for iron is strongly skewed, particularly for menstruating women. The US Dietary Reference Intakes (DRI) provide a solution to assessing PA for iron through provision of a separate reference table.[31] However, this table incorporates an assumption regarding absorption (18 percent) that is likely to be inappropriate for our data sets. For the purposes of this project, the US Institute of Medicine (IOM) Table, with the US requirements, has been adapted for absorption levels of either 5 percent or 10 percent for non-pregnant and lactating women and is presented in **Appendix 2**. For pregnant women, an absorption level of 23 percent is used.

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[27] Bartley, Underwood and Deckelbaum 2005.
[28] WHO/FAO 2004.
[29] 840 mg/d is the WHO/FAO (2004) EAR for NPNL women and is the same for lactating women. The EAR is 940 mg/d for pregnant women.
[30] The US Dietary Reference Intakes (DRI) include "Adequate Intakes" where there was judged to be insufficient basis for setting an EAR. An AI is an experimentally determined estimate of nutrient intake by a defined group of healthy people. Some seemingly healthy individuals may require higher intakes and some individuals may be at low risk on even lower intakes. The AI is believed to cover their needs, but lack of data or uncertainty in the data prevents being able to specify with confidence the percentage of individuals covered by this intake (IOM 1997).
[31] Table G-7 in Otten, Hellwig and Meyers 2006.

In the case of zinc, the International Zinc Nutrition Consultative Group (IZiNCG) recently presented updated recommendations for international use,[32] which were adopted for this study. IZiNCG suggests two sets of requirements, reflecting different assumptions about absorption depending on dietary patterns. For both NPNL and pregnant adult women consuming mixed diets or refined vegetarian diets, absorption is assumed to be 34 percent (44 percent during lactation). For NPNL and pregnant women consuming unrefined cereal-based diets, absorption is assumed to be 25 percent (35 percent during lactation).

In addition to the use of US and IZiNCG values for mineral requirements, US values were also used when SD/CV were not available from WHO/FAO, as was the case for vitamin A.

Finally, for both iron and zinc, individual collaborating researchers in the WDDP working group needed to select absorption levels appropriate for the dietary patterns observed in their research context. For the purposes of this project, it was agreed that assumptions regarding absorption levels could be made at sample level and used for all women rather than attempting to characterize individual diets and set absorption levels on an individual basis. **Appendix 1** also provides the available guidance for selection of absorption levels at the population level.

Decisions regarding bioavailability assumptions differed across sites and are reflected in descriptive statistics for PA for these nutrients. Bioavailability assumptions for NPNL women were:

- Burkina Faso (high extraction maize and rice staples; low intake of flesh foods): Low absorption of both iron (5 percent) and zinc (25 percent)
- Mali (white rice, refined wheat and millet staples; some intake of flesh foods): Intermediate absorption of both iron (10 percent) and zinc (34 percent)
- Mozambique (high extraction maize as dominant staple; very low intake of flesh foods): Low absorption of both iron (5 percent) and zinc (25 percent)
- Bangladesh (white rice as dominant staple; some flesh food): Intermediate absorption of both iron (10 percent) and zinc (34 percent)
- Philippines (white rice as dominant staple; some flesh food): Intermediate absorption of both iron (10 percent) and zinc (34 percent)

Bioavailability assumptions for lactating women were (for sites where sub-sample sizes allowed for analyses):

- Mozambique (high extraction maize as dominant staple; very low intake of flesh foods): Low absorption of both iron (5 percent) and zinc (35 percent)
- Bangladesh (white rice as dominant staple; some flesh food): Intermediate absorption of both iron (10 percent) and zinc (44 percent)
- Philippines (white rice as dominant staple; some flesh food): Intermediate absorption of both iron (10 percent) and zinc (44 percent)

5.5. FOOD GROUP DIVERSITY INDICATORS

As noted in **Section 2**, dietary diversity has been operationalized in a wide variety of ways, and one contribution of this study is our direct comparison of several indicators. See Arimond et al. 2008 for details on discussions and criteria leading to selection of the candidate FGIs used in this study.

The discussions and decisions are reflected in the food groupings shown in **Table 1**. Four sets of food groups are listed, which were summed to form 6 group, 9 group, 13 group and 21 group diversity indicators. At present, only the two most aggregated indicators (6 group and 9 group) can be constructed

[32] IZiNCG 2004; Hotz 2007.

from the DHS questions. However, with slight modification in a future round, the 13 group indicator could be constructed.[33]

For each of the four groupings, two indicators were calculated, one with a 1 gram (g) requirement for minimum consumption in order for a group to count in the score, and one with a 15 g minimum consumption criterion. This allowed exploration of the impact of inclusion of foods eaten in very trivial amounts, which might nevertheless be counted in simple recalls (e.g., if small quantities of chilies in a sauce were scored positively as vegetables). Throughout the report, each food group indicator (FGI) is abbreviated by reference to the level of aggregation/number of food groups in the score (e.g., FGI-6 is the food group indicator comprised of 6 food groups). An "R" indicates that the 15 g "restriction" is used as a minimum in order for a food group to count in the score (e.g., FGI-6R is the food group indicator comprised of 6 food groups, where a group is counted positively only if the woman consumed at least 15 g from that group).

In general, the intent was to provide indicators that represent most major food groups, while emphasizing the contributions of micronutrient-dense food groups. To do this, animal-source foods, fruits and vegetables were more disaggregated than were starchy staples. Several energy-dense but generally micronutrient-poor food groups were excluded: fats and oils; sweets, including sugary drinks; and alcohol.

[33] In order to construct the 13 group indicator, questions would need to be added for small fish eaten whole, vitamin C-rich fruits and vitamin C-rich vegetables.

Table 1. Food Groups Summed in Diversity Indicators [a,b]

6-group indicators	9-group indicators	13-group indicators	21-group indicators
All starchy staples	All starchy staples	All starchy staples	Grains and grain products All other starchy staples
All legumes and nuts	All legumes and nuts	All legumes and nuts	Cooked dry beans and peas Soybeans and soy products Nuts and seeds
All dairy	All dairy	All dairy	Milk/yogurt Cheese
Other animal source foods	Organ meat Eggs Flesh foods and other miscellaneous small animal protein	Organ meat Eggs Small fish eaten whole with bones All other flesh foods and miscellaneous small animal protein	Organ meat Eggs Small fish eaten whole with bones Large whole fish/dried fish/shellfish and other seafood Beef, pork, veal, lamb, goat, game meat Chicken, duck, turkey, pigeon, guinea hen, game birds Insects, grubs, snakes, rodents and other small animals
Vitamin A-rich fruits and vegetables [c]	Vitamin A-rich dark green leafy vegetables Other vitamin A-rich vegetables and fruits [c]	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits [c]	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits [c]
Other fruits and vegetables	Other fruits and vegetables	Vitamin C-rich vegetables Vitamin C-rich fruits All other fruits and vegetables	Vitamin C-rich vegetables Vitamin C-rich fruits All other vegetables All other fruits

[a] For each set of food groups (6, 9, 13 and 21 groups), two indicators were constructed. The first counted a food group as eaten if at least 1 g was consumed; the second counted the food group if at least 15 g was consumed. Thus, a total of eight food group diversity indicators (FGIs) were constructed. Grams (g) of intake were assessed based on foods as eaten (e.g., raw, cooked).
[b] "Vitamin A-rich" is defined as > 60 RAE/100 g; "vitamin C-rich" is defined as > 9 mg/100 g. These represent 15 percent of the Nutrient Reference Values (NRV) defined in the Codex Alimentarius. These cutoffs correspond to the definition of a "source." See Codex Alimentarius Commission, Guidelines adopted 1997, revised 2004, for a definition of "source." For a definition of NRV, see Codex Alimentarius Commission, Guidelines adopted 1985, revised 1993.
[c] Including red palm products.

5.6. A SUMMARY MEASURE OF DIET QUALITY: MEAN PROBABILITY OF ADEQUACY

This study used the probability approach to assess nutrient adequacy for a population. This approach incorporates information (or assumptions) both about the distribution of nutrient requirements in the population and about day-to-day (intra-individual) variation in nutrient intake.[34] The probability approach has replaced earlier methods of assessing adequacy which did not incorporate such information and have been shown to yield incorrect assessments. The approach is appropriate, given the ultimate objective of this work, which is to develop simple indicator(s) for use at the population level.[35]

[34] Barr, Murphy and Poos 2002; IOM 2000a.
[35] When only population-level estimates are needed, there is an alternative and simpler method of estimating prevalence of adequacy. This method, called the ear cut-point method, was not appropriate for this study because we aimed to assign a PA at the level of each individual woman in order to examine correlations and regressions.

In order to use the probability approach, the entire distribution of requirements should be known. The method appears to be robust to misspecification of variance, so long as the distribution is symmetric (however, requirements are known to be nonsymmetric for iron). The PA associated with "usual intake" is calculated for each individual in the sample and the prevalence of adequacy for the sample is estimated as the average of the individual PA for a nutrient. In practice, the usual intake can be estimated from repeated 24-h recalls. Once PA is estimated for all nutrients, these can be averaged across nutrients to construct a MPA. This average, in turn, can be correlated with dietary diversity indicators and further analyses can be performed.

5.7. SUMMARY OF ANALYTICAL APPROACH AND STATISTICAL METHODS

We completed the following six main tasks:

1. Derived a set of eight simple candidate indicators of dietary diversity for adult women, such as could be based on a single day's food group recall (see **Section 5.5**)
2. Constructed the summary indicator "mean probability of micronutrient adequacy" (MPA), incorporating information on nutrient requirement distributions and on day-to-day variability in intakes (see **Section 5.6** and details below)
3. Assessed distributions of variables and transformed as needed to approximate normal distributions
4. Used correlations and simple linear regressions to describe relationships between the various dietary diversity indicators, energy intake and MPA
5. Tested the performance of simple one-day dietary diversity indicators in predicting micronutrient adequacy of the diet as measured by MPA using receiver-operating characteristic (ROC) analysis
6. Assessed indicator qualities (sensitivity, specificity and total misclassification) for several cutoffs of MPA at various diversity cutoffs

For all statistical tests, values of $P < 0.05$ were considered significant. Nonparametric tests were used when appropriate, for example when testing differences between skewed variables. Chi-square tests were used for comparisons of categorical variables. Regression diagnostics were performed, including assessment of normality of residuals and heteroskedasticity tests. In cases where regression diagnostics indicated violation of assumptions (e.g., lactating women in Bangladesh and NPNL women in Mali for FGI-13 and FGI-13 R with total energy intake included in the model) regression results are not presented.

For some descriptive results (e.g., FGIs, food group patterns) results are presented using data from a single day. This is because data are not available from all women for multiple days. All results related to probability of adequacy, however, reflect the contribution of information (estimated variances) from multiple recall days, as detailed below.

The second task – construction of MPA – required a series of steps that can be summarized as follows:[36]

- We transformed nutrient intakes; since nutrient intakes are nearly always skewed, intake distributions were adjusted to approximate normal. We used a Box-Cox transformation (a power transformation) for each nutrient.[37]
- We calculated individual and population means for intakes of each nutrient using the transformed variables (note that some individuals had only one observation).
- We calculated intra- and inter-individual variances for the transformed intake variables.
- Using these variances, we calculated the "best linear unbiased predictor" (BLUP) of the usual intake for each nutrient for each woman.

However, as a form of triangulation, we also estimated population-level prevalence of adequacy using the ear cut-point method. Results of this comparative analysis are presented in Appendix 5.

[36] See Arimond et al. 2008 and Joseph 2007 for a more detailed description of the construction of MPA.

[37] Distributions of the FGIs were considered acceptable (approximately normal) for use without transformation in correlations and regressions.

- Using the BLUPs, we calculated the PA for iron (NPNL women) from the table in **Appendix 1**. We also calculated the PA for calcium using the method of Foote et al. 2004 (also described in **Appendix 1**).
- With the exception of calcium for all women and of iron specifically for NPNL women, information on the distribution of requirements (CV/SD) is available and distributions are assumed to be approximately normal. For these remaining nutrients and for iron for pregnant and lactating women, we needed to transform the requirement distributions using the same power transformation as selected above for each nutrient. We did this by generating a random normal variable (with "n" = 800) to simulate the requirement distribution; this distribution was then Box-Cox transformed.
- The PA for each nutrient (excluding calcium for all women and iron specifically for NPNL women) was then calculated. Then all PA, including iron and calcium, were averaged to form MPA. The distribution of MPA was also transformed, if necessary, to approximate normality. Untransformed values are presented in descriptive tables and the transformed variable was used in correlation and regression analyses.

6. Results

Table 2 provides basic descriptive information and final sample sizes for each study site, and provides the same for physiological status subgroups where subsample sizes allowed analysis of these.

Median age ranged from 29 to 35. Women were tallest and heaviest in the urban West African samples. Although women were shorter in the Philippines, mean body mass index (BMI) was similar in all three urban/peri-urban samples (Burkina Faso, Mali and Philippines). Higher mean BMI in the urban samples was accompanied by higher prevalence of overweight (28-33 percent in these sites). Mean BMI for Mozambique was lower, but a relatively low proportion (7 percent) of NPNL women had low BMI. Prevalence of low BMI was also relatively low in Burkina Faso and was intermediate (16-17 percent) in Mali and the Philippines. In contrast, nearly half the NPNL women in the rural Bangladesh site had low BMI.

Available data on education and literacy varied across studies and therefore are not directly comparable. However, it is possible to say that education and literacy levels appear higher in the urban/peri-urban samples, as would be expected, and lowest in Mozambique, as would also be expected given the extreme poverty and absence of infrastructure and services in that study area.

Table 2. Characteristics of Samples

Country (year)	n [a]	2nd recall n (3rd recall n)	Age (mean)	Height (cm) (mean)	Weight (kg) (mean)	BMI (mean)	BMI < 18.5 (percent)	BMI ≥ 25 (percent)	Education (percent)	(description of education variable)
Burkina Faso (2006)										
NPNL [b]	130[d]	133[e] (126)[f]	31.7	163.3	63.1	23.7	8.7	33.1	51.6	Ever attended school
All [c]	178[d]	181[e] (173)[f]	31.1	163.1	61.7	23.2	9.2	29.1	46.7	
Mali (2007)										
NPNL [b]	102	96	31.5	166.0	65.0	23.6	17.2	28.1	65.1	Attended primary school or Islamic school
All	102	96	31.5	166.0	65.0	23.6	17.2	28.1	65.1	
Mozambique (2006)										
Lactating	252	51	28.3	153.6	50.5	21.4	6.4	6.4	19.1	Literate
NPNL [b]	103	30	30.3	153.8	50.3	21.2	11.6	6.8	18.4	
All [c]	409	94	28.8	153.6	50.9	21.5	7.1	7.4	19.1	
Bangladesh (1996)										
Lactating	111	48	27.6	150.4	42.1	18.6	50.4	0.0	36.0	Literate
NPNL [b]	299	99	32.7	150.3	42.7	18.9	47.2	2.0	30.8	
All	412	147	31.3	150.3	42.6	18.8	47.8	1.7	32.5	
Philippines (2005)										
Lactating	167	167	28.3	150.2	49.4	21.9	15.6	16.2	95.8	Completed grade 3 or higher
NPNL [b]	1,798	1798	35.9	151.1	52.8	23.1	15.5	32.2	96.7	
All	2,045	2045	34.8	151.0	52.4	23.0	15.3	30.3	96.6	

[a] In some sites, sample sizes for subgroups do not sum to the sample size for "all women" because "all women" include subgroups too small for separate analysis (e.g., pregnant women in Mozambique and Philippines). Sample sizes for specific characteristics are smaller, as follows: Burkina - missing age for 1 woman, height for 17 women, weight and BMI for 18 women; Mali - missing all anthropometry for 38 women; Mozambique - missing age for 111 women, literacy for 1 woman; Bangladesh - missing lactation status for 2 women.
[b] NPNL = non-pregnant non-lactating
[c] In Burkina Faso, the sample of all women included 35 lactating women and 13 pregnant women. The 13 pregnant women are excluded from the presentation of anthropometric indicators. In Mozambique, the sample of all women includes 58 pregnant women; in Mozambique, mean weight and BMI are higher for the sample of all women due to the inclusion of pregnant women.
[d] In Burkina Faso, the sample sizes reported here correspond to the second day of recall.
[e] In Burkina Faso, the sample sizes reported here correspond to the first day of recall.
[f] In Burkina Faso, the sample sizes reported here correspond to the third day of recall.

6.1. FOOD GROUP PATTERNS

Table 3 and **Figure 1** show the proportion of women consuming different food groups.[38] The table reflects information for the 9 group indicator, but two of the nine groups are omitted from the figure. Starchy staple foods are omitted because they were consumed by 100 percent of women across all sites; organ meats are omitted because they were not consumed at all in four sites and were consumed by only few women in the fifth site (Philippines).

Both consumption of food groups and the impact of imposing the 15 g minimum varied across sites.

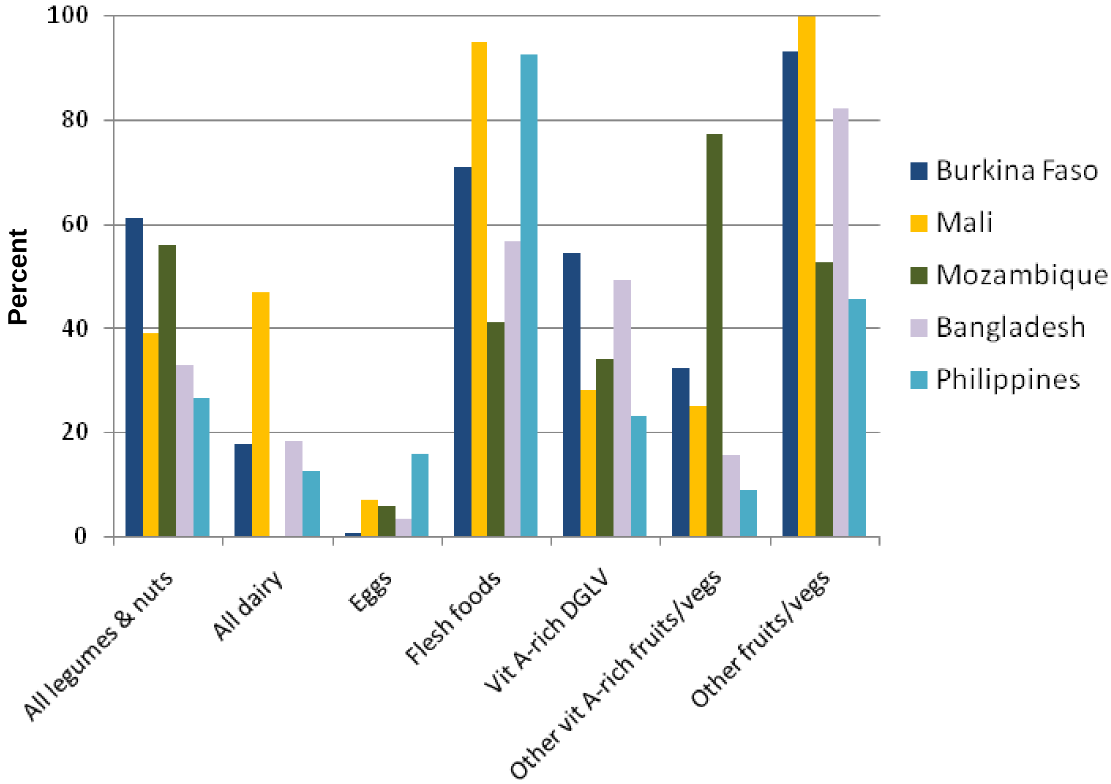
Table 3. Percentage of All Women who Consumed 9 Food Groups, by Study Site

		Burkina Faso	Mali	Mozambique	Bangladesh	Philippines
All starchy staples						
	≥ 1 g	100	100	100	100	100
	≥ 15 g	100	100	100	100	100
All legumes & nuts						
	≥ 1 g	85	73	58	35	41
	≥ 15 g	61	39	56	33	26
All dairy						
	≥ 1 g	18	48	0	19	26
	≥ 15 g	18	47	0	18	13
Organ meat						
	≥ 1 g	0	0	0	0	11
	≥ 15 g	0	0	0	0	6
Eggs						
	≥ 1 g	1	8	6	7	26
	≥ 15 g	1	7	6	3	16
Flesh foods [a]						
	≥ 1 g	93	98	46	72	99
	≥ 15 g	71	95	41	57	93
Vit A-rich DGLV [b,c]						
	≥ 1 g	78	41	34	51	30
	≥ 15 g	55	28	34	49	23
Other vit A-rich fruits/vegs [c]						
	≥ 1 g	72	86	77	64	22
	≥ 15 g	32	25	77	16	9
Other fruits & vegetables						
	≥ 1 g	96	100	63	100	63
	≥ 15 g	93	100	53	82	46

[a] Flesh foods include other miscellaneous small protein such as insects, grubs snakes, etc.
[b] DGLV = dark green leafy vegetables
[c] Vitamin A-rich foods are those with ≥ 60 RAE/100 g.

[38] In general, food group patterns did not vary markedly with physiological status. Therefore, results in this section are presented for all women together and not for subgroups of lactating and NPNL women.

Figure 1. Percentage of All Women who Consumed at Least 15 Grams of Selected Food Groups, by Study Site



Staple Foods

As would be expected, starchy staples were consumed by all women in all sites. Consumption of legumes and nuts with the 15 g minimum ranged from 26-33 percent of women in Bangladesh and the Philippines to around 60 percent in Burkina Faso and Mozambique. Imposing a 15 g minimum had no impact for starchy staples. For legumes and nuts, this made no difference in the two rural sites but resulted in a 15-34 percentage point difference in the urban/peri-urban sites. That is, substantial numbers of women in these sites consumed legumes, nuts and/or seeds in very small quantities.

Animal-Source Foods

Dairy (with the 15 g minimum) was not consumed at all in Mozambique and was widely consumed only in one site (Mali, 47 percent). As noted, organ meat was only consumed in one site, and eggs (15 g minimum) were also rarely consumed (fewer than 10 percent of women, except in the Philippines [16 percent]). Flesh foods with the 15 g minimum – including domestic and wild meat, poultry and fish – were nearly universally consumed in Mali and the Philippines and were widely consumed in Burkina Faso (71 percent) and Bangladesh (57 percent). Consumption was least frequent in Mozambique, with 41 percent of women consuming at least 15 g.

In the Bangladesh, Burkina Faso and Mali sites, imposing the 15 g minimum generally did not make a substantial difference for dairy intake because most women who consumed dairy consumed at least 15 g. In the Philippines, the proportion dropped from 26 percent to 13 percent when the cutoff was applied due to small amounts of milk/cream used in coffee. In the fifth site, Mozambique, dairy was not consumed.Flesh foods comprised the only other widely-consumed animal-source food group, besides dairy. For this group, the 15 g cutoff did not make much difference Mali, Mozambique, and the Philippines but did matter in Burkina Faso (22 percentage point drop) and Bangladesh (15 percentage point drop).

Fruits and Vegetables

Consumption of vitamin A-rich dark green leafy vegetables (DGLV) with the 15 g minimum ranged from 23 percent in the Philippines to 55 percent in Burkina Faso. Consumption of other vitamin A-rich fruits and vegetables with the 15 g minimum, such as mango, pumpkin and yellow-orange squash, was lowest in Bangladesh and the Philippines (9-16 percent), intermediate in Mali and Burkina Faso (25-32 percent) and high in Mozambique (77 percent) where it was mango season. Other fruits and vegetables with the 15 g minimum were consumed by roughly half the women in the Philippines and Mozambique and by most women (82-100 percent) in the other sites.

Imposing the 15 g minimum made little difference for DGLV in Bangladesh and Mozambique and made the most difference in Mali and Burkina Faso (a 13-23 percentage point drop). This may relate to the use of dried leaves in mixed dishes in small quantities. For other vitamin A-rich fruits and vegetables, the minimum made no difference in Mozambique (mango) and made a large difference in all other sites (very large in Burkina Faso, Bangladesh and Mali at 40-61 percentage points). In Bangladesh, this was entirely due to the use of chilies in very small quantities, and in Burkina Faso and Mali this was almost entirely due to the use of tomato paste in very small quantities. In the case of other fruits and vegetables, the minimum made very little difference in Burkina Faso and Mali; in other sites the changes ranged from 7-18 percentage points.

Summary

In summary, with the exception of starchy staples, each site presented a different pattern of consumption for the main food groups. The impact of imposing the 15 g minimum in order for a food group to count also varied by food group and by site. However, overall it is clear that for a number of food groups and in a number of sites, imposing the minimum made a substantial difference in the proportion of women who were considered to have consumed the group. Looked at site by site, this is true in most sites for at least three of the nine food groups (i.e. there are substantial percentage point drops when the 15 g minimum is imposed). This was not true in Mozambique, where, overall, the proportion consuming any amount of the food group was similar to the proportion consuming at least 15 g. This may reflect the fact that diets and mixed dishes in this poor rural site were generally very simple and the few foods/ingredients consumed tended to be consumed in substantial quantities.

Two very simple indicators of diet quality are the proportion of energy intakes that are accounted for by starchy staples and the proportion contributed by animal-source foods. Other micronutrient-dense foods such as fruits and vegetables generally would not be expected to contribute a substantial proportion of energy, although there are exceptions, such as mango and orange-fleshed sweet potatoes). **Table 4** shows the proportion of energy intakes accounted for by several foods groups, for all sites.

The two urban samples from West Africa, Burkina Faso and Mali, show a lower proportion of total energy intake from starchy staples. In particular, women in the Mali site had a higher proportion of energy intake from animal-source foods. In Mozambique, energy intake from fruits and vegetables was higher than in other sites; this is accounted for by mango. For example, on the first observation day, mango was consumed by 72 percent of women and it accounted for 11 percent of total energy intake for the entire sample (15 percent among consumers). The extremely high proportion of energy intake from starchy staples (rice) in Bangladesh no doubt reflects a monotonous diet, but may also reflect over-reporting of rice intake (see **Section 6.3,** where energy intakes relative to estimated BMR are described).

Table 4. Percent of Energy (kilocalories) from Starchy Staples, Legumes, Animal-Source Foods, and Fruits and Vegetables, by Study Site

	Burkina Faso	Mali	Mozambique	Bangladesh	Philippines [a]
All starchy staples	56	46	68	86	n/a
Legumes	10	11	11	2	n/a
All animal-source foods	7	12	4	4	n/a
All fruits and vegetables	7	6	15	4	n/a
Fats, oils, sweets, alcohol	20	25	2	4	n/a

[a] Results not available (n/a) for the Philippines study site.

Note also that the proportion of energy not accounted for by the food groups included in the diversity scores also varies widely across sites. In the rural samples (Mozambique and Bangladesh), only 2-4 percent of energy intakes are accounted for by fats, oils, sweets and alcohol. In the two urban samples from West Africa (Burkina Faso and Mali), 20-25 percent of energy intakes are accounted for by these food groups, which provide energy but do not provide substantial micronutrients.[39]

6.2. FOOD GROUP DIVERSITY INDICATOR SCORES

Table 5 shows the FGI scores for each site by FGI. In summary, the highest mean scores were observed in the two urban samples from West Africa, Burkina Faso and Mali. This was true across all levels of food group disaggregation. For six of the eight FGIs and for all four "restricted" FGIs, the highest average score was in the Mali sample (also the sample with the highest prevalence of overweight and the highest proportion of energy from fats, oils, sweets and alcohol).

Mozambique ranked lowest on all "unrestricted" FGIs, but when the 15 g restriction was applied, Mozambique ranked third (in three FGIs) or fourth (in one FGI). This is consistent with the observation from **Table 3** that in the Mozambique sample it was rare for women to report trivial intakes (less than 15 g); fewer foods were eaten, but in "non-trivial" quantities. Conversely, women in the Philippines ranked last in three of the four indicators with the 15 g restriction. The Bangladesh sample ranked third or fourth for all indicators.

Table 5 also illustrates the variability of the FGIs. With increasing disaggregation of the FGIs, the spread of observed scores also increased, but not in proportion to the full range of "possibility" in the score. For example, in Burkina Faso, the range in the 6 group score was from 2 to 6 (out of a possible range of 0-6). But for the 21 group score, the range was only from 2-11, or 2-9 when the 15 g restriction was imposed. Thus, increasing disaggregation did provide more variability (and potentially better ability to detect relationships with other study variables, such as intake or adequacy), but this variability did not increase in proportion to the increase in disaggregation.

[39] The exception to this is red palm oil, which is extremely rich in vitamin A. In our analysis, red palm fruit and red palm oil, where encountered (e.g., Burkina Faso), were counted along with vitamin A-rich fruits and vegetables.

Table 5. Mean (Standard Deviation) and Range of Food Group Diversity Indicator Scores for All Women, by Study Site

	Burkina Faso		Mali		Mozambique		Bangladesh		Philippines	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
FGI-6 [a]	4.8 (0.7)	2-6	5.1 (0.7)	3-6	3.5 (0.9)	2-5	4.1 (0.9)	2-6	3.8 (1.2)	2-6
FGI-6R	4.2 (0.9)	2-6	4.3 (0.9)	2-6	3.4 (0.8)	1-5	3.5 (1.0)	1-6	3.1 (1.0)	1-6
FGI-9	5.4 (1.0)	2-7	5.5 (1.0)	3-8	3.8 (0.9)	2-7	4.5 (1.1)	2-7	4.2 (1.5)	2-9
FGI-9R	4.3 (1.1)	2-7	4.4 (1.1)	2-7	3.7 (0.8)	1-7	3.6 (1.1)	1-7	3.3 (1.1)	1-7
FGI-13	6.6 (1.6)	2-10	6.4 (1.3)	3-10	4.2 (1.2)	2-8	5.7 (1.3)	2-10	4.6 (1.8)	2-11
FGI-13R	4.6 (1.2)	2-8	4.9 (1.3)	2-9	3.9 (1.0)	1-7	3.7 (1.3)	1-8	3.5 (1.3)	1-9
FGI-21	7.3 (1.8)	2-11	7.1 (1.5)	3-11	4.7 (1.6)	2-9	6.5 (1.6)	2-11	5.7 (2.4)	2-15
FGI-21R	4.9 (1.4)	2-9	5.6 (1.6)	2-10	4.4 (1.3)	2-9	4.4 (1.5)	1-9	4.1 (1.6)	1-11

[a] FGI = food group diversity indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must have been consumed in order for the food group/subgroup to "count" in the score.

6.3. ENERGY AND MACRONUTRIENT INTAKES

Table 6 summarizes information on energy and macronutrient intakes for a single observation day for each study site.[40] Median energy intakes (2,024-2,086) were very similar for NPNL women in four of the five sites. Intakes for lactating women were higher than for NPNL women in Bangladesh but not in Mozambique. In the fifth study site (Philippines) energy intakes were substantially lower both in absolute terms and when considered as a ratio of estimated energy to estimated BMR. Energy intakes were slightly higher for lactating women than for NPNL women in this site.

The proportion of total energy provided by protein, carbohydrates and fat was also considered relative to WHO[41] recommendations for populations.[42] In the three urban/peri-urban sites (Burkina Faso, Mali and the Philippines), protein, carbohydrate and fat intakes as a percent of energy were within or very close to WHO recommended ranges. In Mali, fat intakes were on the high side. In contrast, in the two rural sites (Bangladesh and Mozambique), the proportion of energy from carbohydrates exceeded the recommended range of 55-75 percent, and the proportion of energy from fat was well below the minimum recommended level of 15 percent. Protein intakes as a percent of energy were in or very near the accepted range of 10-15 percent in all sites.

[40] For most sites, data are from the first observation day of two. For Burkina Faso, data are from the second of three observation days.
[41] 2003.
[42] In the Philippines, these results should be interpreted with caution, due to lack of knowledge of the nature of under-reporting. For example, if a major food group such as starchy staples was under-reported, or if high fat snack foods were under-reported, the proportion of energy from carbohydrate, protein and fat would differ.

Table 6. Median Intakes of Energy and Macronutrients, by Study Site and Physiological Status [a]

Country	Energy (kcal)	Protein (g)	Protein as % of kcal	CHO (g)	CHO as % of kcal	Fat (g)	Fat as % of kcal	BMR factor [b] (median)	BMR factor [b] (IQ range)
Burkina Faso [c]									
NPNL [d]	2078	53	11	338	66	44	22	1.49	1.26-1.76
All	2189	54	11	357	66	50	22	1.48	1.23-1.74
Mali [e]									
NPNL [d]	2024	54	11	320	57	72	32	1.42	1.15-1.84
All	2024	54	11	320	57	72	32	1.42	1.15-1.84
Mozambique [f]									
Lactating	2012	56	12	436	86	11	7	1.63	1.29-2.08
NPNL [d]	2086	60	12	446	86	11	7	1.68	1.34-2.20
All	2029	58	12	435	86	12	7	1.64	1.29-2.09
Bangladesh [g]									
Lactating	2360	57	10	490	83	13	6	2.05	1.69-2.40
NPNL [d]	2083	49	10	435	82	13	6	1.78	1.84-2.05
All	2163	51	10	448	82	13	6	1.84	1.54-2.19
Philippines [h]									
Lactating	1264	43	14	213	70	16	15	1.02	0.71-1.52
NPNL [d]	1211	45	16	190	65	20	20	0.98	0.69-1.35
All	1219	44	16	193	65	20	19	0.99	0.70-1.36

[a] Shaded cells are outside WHO (2003) recommended population averages for adults: 10-15 percent of kilocalories (kcal) from protein; 55-75 percent of kcal from carbohydrates; 15-30 percent of kcal from fat. However, differences of 1-2 percentage points from recommended ranges are not meaningful and are likely to be within the range of measurement error. CHO = carbohydrate; BMR = basal metabolic rate; IQ = interquartile.
[b] The "BMR factor" is the ratio of estimated (day 1) energy intake to estimated BMR, based on age and weight (Schofield 1985).
[c] Burkina Faso: Slightly different BMR calculations and cutoffs were applied (Black 2000). See Becquey, Capon and Martin-Prével 2009 for details. Here the BMR factor is the ratio of the estimated mean energy intake across all records to the estimated BMR. No cases were accepted with BMR factor < 0.9 or > 3.0; some other less extreme cases were also excluded.
[d] NPNL = non-pregnant non-lactating
[e] Mali: The BMR factor is based on a subsample of participants (n=64) with anthropometric data. Intakes were examined and accepted for 7 women (11 percent) with a BMR factor < 0.9 and 1 woman with a BMR factor > 3.0.
[f] Mozambique: Intakes were examined and accepted for 16 women (4 percent) with a BMR factor < 0.9 and 2 women (< 1 percent) with a BMR factor > 3.0.
[g] Bangladesh: BMR factor cutoffs were applied and no cases were accepted with a BMR < 0.9 or > 3.0.
[h] Philippines: BMR factor cutoffs were not applied; see discussion in Section 5.1.

BMR factors were calculated for each individual woman as the ratio of energy intake to estimated BMR. The factors reported in **Table 6** provide a yardstick for comparing study sites and considering issues of possible over- and under-reporting. In the Philippines, a decision was made not to employ BMR factor cutoffs to define exclusions (see **Section 5.1**). Nearly half the sample (44 percent) had BMR factors below 0.9; the decision to include these women is reflected in the descriptive statistics in **Table 6**. BMR factors were markedly low and suggest a problem with under-reporting; however, under-reporting could not be established or characterized with the information available to us.

While energy intakes were similar across the other four sites, there were some differences in BMR factors. After the Philippines, the next-lowest BMR factors were in the two urban samples in West Africa, Mali and Burkina Faso. Note that the women in these two samples were heavier than those in the other sites (median of 63-65 kilograms [kg] compared to 50-53 kg in Mozambique and the Philippines and 43 kg in Bangladesh) and thus their estimated BMRs are higher.

Differences in BMR factors may also be due in-part to site-specific decisions regarding exclusions. For example, in the final Mali sample, 11 percent of women for whom BMR could be estimated had BMR factors below 0.9, while 0.9 was used as a lower cutoff for inclusion in Burkina Faso and Bangladesh.

However, even considering these reasons for differences, it is notable that BMR factors appear higher in Bangladesh, reflecting high intakes relative to body size. Intakes are similar to other sites but weights and BMIs are much lower. Levels of physical activity were moderate, with limited involvement in agricultural labor and water sources near to households.[43] Given these BMR factors and also considering the high proportion of energy reported from rice (**Table 4**), over-reporting of rice intake is a potential concern in this study site.

6.4. MICRONUTRIENT INTAKES

Table 7 presents median intakes for selected micronutrients. Differences between sites reflect differences in diet patterns and also differences in FCT values. In the case of the Philippines, under-reporting may have resulted in low estimates of intake for some or all micronutrients. A few other marked differences in intakes are notable. Intakes of iron are notably higher in Burkina Faso; this is largely accounted for by consumption of dried leaves and dried okra, which have very high iron values in the FCT. Overall, 94 percent of the iron consumed by women in the Burkina Faso sample was from plant sources.[44] Median intakes of vitamin B12 are low in several sites and are near zero in Mozambique, reflecting very low intakes of animal-source foods.

Despite the extreme poverty of the study area in Mozambique, median intakes of some micronutrients are highest in this site (notably vitamins A and C and, to a lesser extent, vitamin B6). The high intakes of vitamins A and C are related to high intake of mango, which accounted for roughly half of the total intakes for these two vitamins. Despite the fact that it is not a very rich source, mango also provided 22 percent of the vitamin B6 consumed by the women in the sample. Cassava leaves are also a rich source of vitamin B6 and were widely consumed and in substantial quantities.[45]

[43] Personal communication from senior field staff (W. Quabili, 2007).
[44] Becquey, Capon and Martin-Prével 2009.
[45] Wiesmann, Arimond and Loechl 2009.

Table 7. Median Micronutrient Intakes, by Study Site and Physiological Status

Country	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vit B6 (mg)	Folate (µg)	Vit B12 (µg)	Vit C (mg)	Vit A (RE)	Calcium (mg)	Iron (mg)	Zinc (mg)
Burkina Faso											
NPNL[a]	0.9	0.7	8.4	1.3	194	0.4	55	515	394	20.4	8.5
All	1.0	0.7	8.4	1.4	202	0.4	53	425	411	21.4	9.1
Mali											
NPNL[a]	0.9	0.7	8.3	1.2	119	1.3	58	245	375	14.2	8.8
All	0.9	0.7	8.3	1.2	119	1.3	58	245	375	14.2	8.8
Mozambique											
Lactating	1.0	0.7	10.0	1.6	289	0.1	112	652	279	10.7	8.9
NPNL[a]	1.1	0.9	10.8	1.9	310	0.0	129	792	305	10.8	9.4
All	1.0	0.8	10.4	1.7	289	0.1	119	695	285	10.8	9.0
Bangladesh											
Lactating	0.7	0.7	11.1	1.6	137	0.8	42	363	358	9.4	9.0
NPNL [a]	0.6	0.6	9.3	1.4	132	0.5	42	316	283	8.2	7.8
All	0.6	0.7	9.9	1.5	133	0.6	41	322	308	8.5	8.0
Philippines											
Lactating	0.5	0.5	11.4	1.0	377	3.6	13	244	280	8.8	5.1
NPNL[a]	0.5	0.5	13.0	1.1	312	3.4	12	232	264	8.2	5.0
All	0.5	0.5	12.8	1.1	318	3.4	13	232	267	8.2	5.0

[a] NPNL = non-pregnant non-lactating

6.5. PROBABILITY OF ADEQUACY

Because dietary patterns and micronutrient intakes were similar across physiological subgroups, results have been described for all women together. However, given the much higher requirements of pregnancy and lactation, PA varies strongly with physiological status. Therefore, PA results are described separately for NPNL women and for lactating women. No study site had a sufficiently large subsample of pregnant women for an assessment of PA.

Table 8 shows the estimated PA (equivalent to population prevalence of adequacy) for each micronutrient and **Figures 2** and **3** summarize this for NPNL women. For NPNL women, considering all micronutrients and all sites, the estimated prevalence of adequacy was below 50 percent for more than half (34 of 55 cells in **Table 8**). Looked at by site, the number of micronutrients for which prevalence of adequacy was below 50 percent was five of 11 in Mali, six in Mozambique, seven in Burkina Faso and Bangladesh, and nine in the Philippines.

Estimates of prevalence of adequacy exceeded 75 percent in only nine instances (and in only two for lactating women):

NPNL women:

- Vitamin B6 Mozambique and Bangladesh
- Vitamin B12 Philippines
- Vitamin C Mali and Mozambique
- Vitamin A Mozambique
- Zinc Mali, Mozambique and Bangladesh

Lactating women:

- Vitamin C Mozambique
- Zinc Bangladesh

Another way to summarize the magnitude and consistency of micronutrient gaps is to consider the number of sites with very low estimates of prevalence of adequacy, arbitrarily set at < 25 percent. Among NPNL women, estimated prevalence of adequacy was very low for 20 of 55 cells in **Table 8**:

- Thiamin Bangladesh and Philippines
- Riboflavin Burkina Faso, Bangladesh and Philippines
- Niacin Burkina Faso
- Vitamin B6 No sites
- Folate Burkina Faso, Mali, and Bangladesh
- Vitamin B12 Burkina Faso, Mali[46], and Bangladesh (Mozambique was 26 percent)
- Vitamin C Philippines
- Vitamin A No sites
- Calcium Mozambique, Bangladesh and Philippines
- Iron Burkina Faso, Mozambique, Bangladesh and Philippines
- Zinc No sites

[46] Estimated prevalence of adequacy was very low in the West African sites (Burkina Faso and Mali), despite high the prevalence of intake of animal-source foods. In Burkina Faso, quantities of animal-source food were often quite small. In Mali, quantities were more substantial. Estimated intakes and estimates of adequacy are also affected by regional differences in the micronutrient content of foods. For Burkina Faso and Mali, the FCT vitamin B12 values for commonly-eaten flesh foods were low relative to some other FCTs. However, these values were carefully evaluated and judged to be the best choice for foods consumed in the Burkina Faso and Mali samples.

Table 8. Probability of Adequacy (Mean for Each Micronutrient) and Mean Probability of Adequacy (MPA) across 11 Micronutrients, by Study Site and Physiological Status [a]

Country	Thiamin	Riboflavin	Niacin	Vit B6	Folate	Vit B12	Vit C	Vit A	Calcium	Iron [c]	Zinc [c]	MPA	SD of MPA
Burkina Faso													
NPNL [b]	0.49	0.16	0.19	0.70	0.15	0.06	0.70	0.73	0.30	0.15	0.70	0.39	0.20
All	0.44	0.13	0.20	0.60	0.12	0.04	0.68	0.67	0.31	0.26	0.71	0.38	0.19
Mali													
NPNL [b]	0.59	0.28	0.31	0.67	0.00	0.17	0.88	0.50	0.27	0.54	0.96	0.47	0.18
All	0.59	0.28	0.31	0.67	0.00	0.17	0.88	0.50	0.27	0.54	0.96	0.47	0.18
Mozambique													
Lactating	0.35	0.06	0.23	0.47	0.12	0.20	0.78	0.67	0.17	0.07	0.65	0.34	0.21
NPNL [b]	0.68	0.45	0.49	0.90	0.45	0.26	0.90	0.86	0.18	0.01	0.76	0.54	0.17
All	0.43	0.17	0.30	0.60	0.19	0.22	0.83	0.74	0.17	0.05	0.64	0.39	0.23
Bangladesh													
Lactating	0.00	0.02	0.21	0.28	0.00	0.18	0.23	0.38	0.26	0.26	0.94	0.25	0.13
NPNL [b]	0.09	0.15	0.30	0.82	0.02	0.20	0.52	0.53	0.21	0.10	0.92	0.35	0.17
All	0.07	0.11	0.28	0.67	0.01	0.19	0.44	0.49	0.22	0.14	0.93	0.32	0.17
Philippines													
Lactating	0.03	0.03	0.39	0.13	0.29	0.71	0.07	0.12	0.17	0.28	0.38	0.24	0.19
NPNL [b]	0.12	0.11	0.60	0.45	0.47	0.78	0.13	0.38	0.15	0.12	0.48	0.34	0.23
All	0.11	0.10	0.58	0.41	0.44	0.77	0.13	0.36	0.16	0.14	0.46	0.33	0.22

[a] When the probability of adequacy is averaged for a group, it is equivalent to an estimated prevalence of adequacy.
[b] NPNL = non-pregnant non-lactating
[c] A low level of absorption was assumed for both iron and zinc for Burkina Faso and Mozambique, and an intermediate level of absorption was assumed for both micronutrients for Mali, Bangladesh and the Philippines.

Among lactating women, who have higher micronutrient requirements, the number of micronutrients per site with very low estimated prevalence of adequacy is even higher (**Table 8**).

When summarized across all 11 micronutrients, the MPA for NPNL women was lowest for the Philippines and Bangladesh (0.34-0.35) and ranged up to 0.54 in Mozambique. There were a sufficiently large number of lactating women for separate analysis only in Mozambique and the two Asian sites; among these, MPA ranged from 0.24-0.25 percent (Asian sites) to 0.34 in Mozambique.

While MPA was highest in Mozambique for both for NPNL and lactating women, it is likely that MPA could be lower outside of mango season. Mango provided half the vitamin A, half the vitamin C and over 10 percent of the energy, thiamin, riboflavin, niacin, vitamin B6, folate and calcium consumed by the women in Mozambique (and a higher proportion of each micronutrient among those who consumed mango). For the 95 women with repeated 24-h recalls, MPA varied strongly with the number of days mango was consumed: median MPA was 0.18 if mango was not consumed, 0.35 percent if consumed one day and 0.45 if consumed both days.

Figure 2. Estimated Prevalence of Adequacy for B Vitamins, by Study Site, for Non-Pregnant Non-Lactating Women

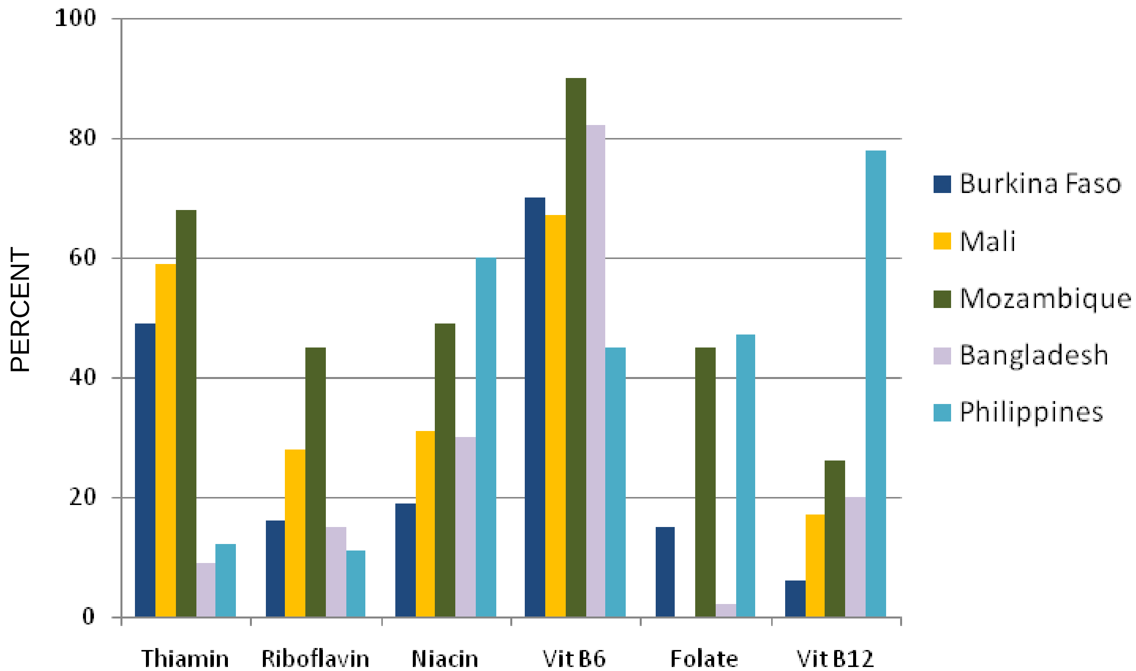
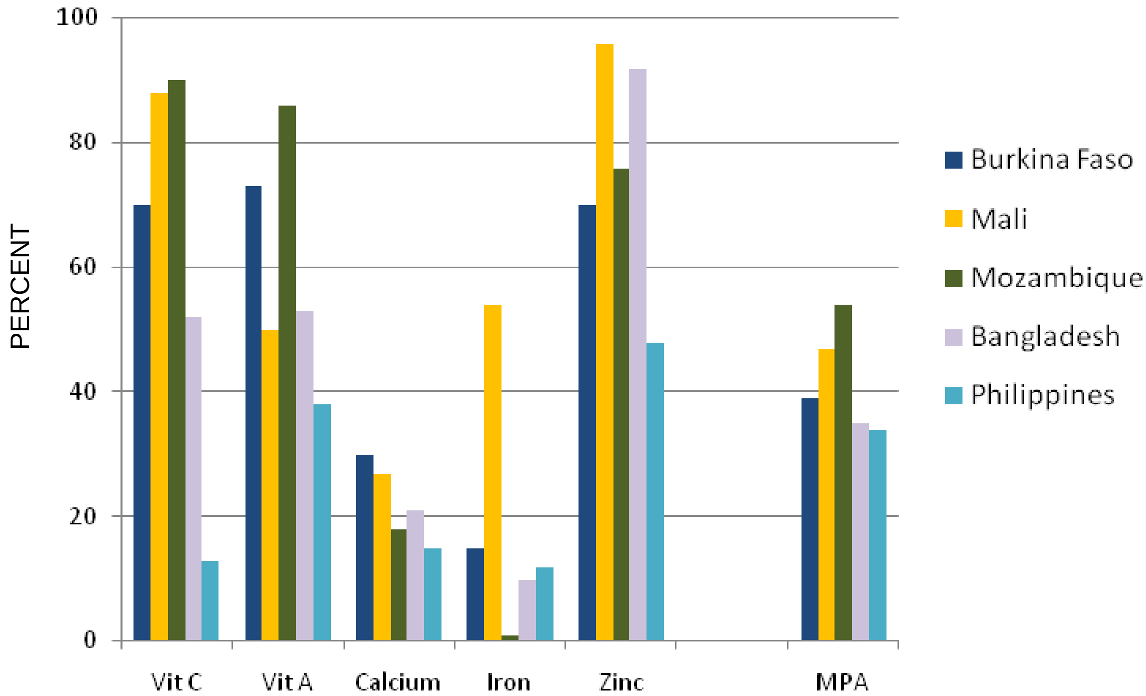


Figure 3. Estimated Prevalence of Adequacy for Vitamins C and A and Minerals, and Mean Probability of Adequacy across 11 Micronutrients, by Study Site, for Non-Pregnant Non-Lactating Women



6.6. FOOD GROUP DIVERSITY AND ENERGY INTAKE

A number of previous studies have demonstrated positive relationships between dietary diversity and energy intakes.[47] Our main objective was to characterize the relationship between food group diversity and micronutrient adequacy, though the relationship between diversity and energy intake was also of interest. Further, it was useful to examine associations between diversity indicators and energy intake in order to understand if any observed relationship between diversity and MPA was due to increased quantity of food, to increased micronutrient density (quality) of diets or to both.

Table 9 shows simple correlations among the various FGIs and energy intake. Most FGIs were significantly correlated with energy intakes across all sites. Differences in significance levels between sites should be interpreted cautiously as sample sizes and statistical power varied across sites.

For NPNL women, correlations were low to moderate, ranging from 0.17 to 0.41, and with most falling between 0.20-0.30. Correlations were somewhat lower (0.13 to 0.31) for lactating women. There was a tendency for correlations to increase with higher disaggregation and with imposition of the 15 g minimum, but neither of these patterns was entirely consistent. Correlations were higher in the rural sites (Mozambique and Bangladesh) for all FGIs; they were lowest in Mali for all except the least disaggregated indicators (FGI-6 and FGI-6R). This may relate to the fact that in the poorer rural sites, the food groups summed in our indicators also accounted for 96-98 percent of energy intakes, whereas they only accounted for 75-80 percent in the two West African sites (Mali and Burkina Faso), see **Table 4**; data not available for the Philippines). Thus, in the two urban West African sites, there is variability in energy intake that is not captured by the food groups summed in our FGIs.

[47] Ogle, Hung and Tuyet 2001; Foote et al. 2004; Torheim et al. 2004.

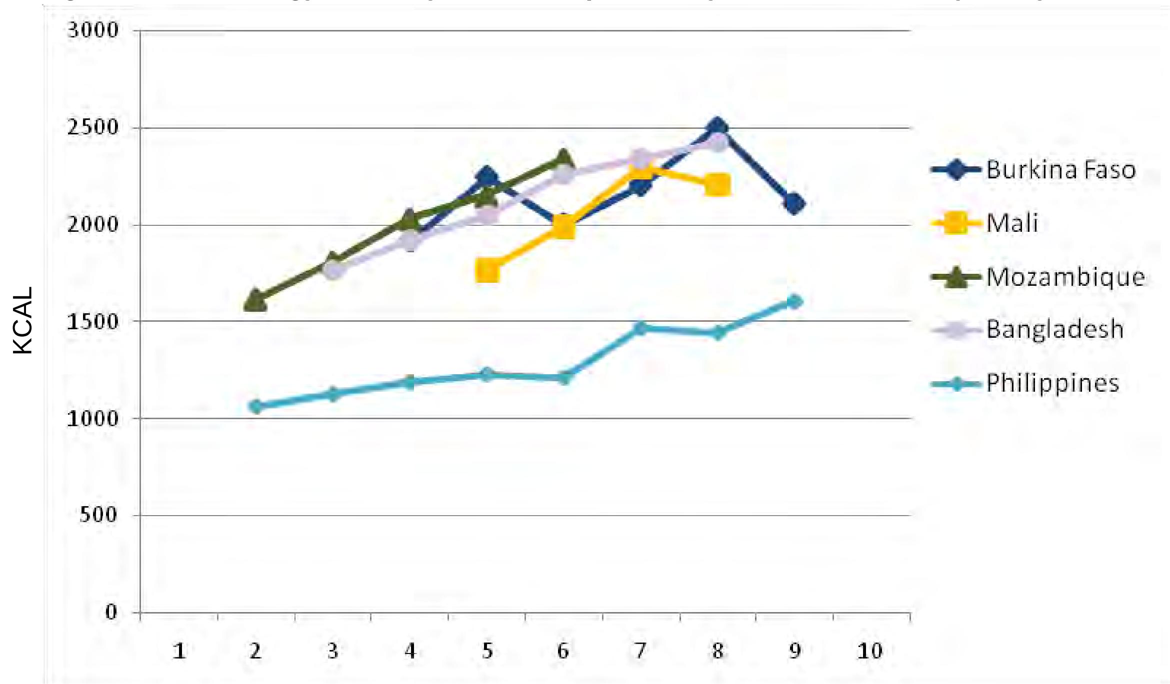
Table 9. Correlation between Food Group Diversity Indicator Scores and Total Energy Intake (kcal), by Study Site and Physiological Status [a,b]

	Burkina Faso	Mali	Mozambique	Bangladesh	Philippines
Non-Pregnant Non-Lactating					
FGI-6[c]	0.206*	0.205*	0.229*	0.256***	0.170***
FGI-6R	0.189*	0.261**	0.330***	0.280***	0.186***
FGI-9	0.232**	0.203*	0.249*	0.248***	0.208***
FGI-9R	0.223*	0.192	0.355***	0.265***	0.236***
FGI-13	0.186*	0.168	0.247*	0.285***	0.206***
FGI-13R	0.252**	0.230*	0.288**	0.291***	0.242***
FGI-21	0.191*	0.184	0.372***	0.299***	0.286***
FGI-21R	0.280**	0.202*	0.407***	0.319***	0.354***
Lactating					
	Burkina Faso [d]	Mali [d]	Mozambique	Bangladesh	Philippines
FGI-6			0.152*	0.325***	0.154*
FGI-6R			0.186**	0.193*	0.126
FGI-9			0.161*	0.275**	0.171*
FGI-9R			0.190**	0.217*	0.199**
FGI-13			0.173**	0.269**	0.160*
FGI-13R			0.180**	0.253**	0.183*
FGI-21			0.246***	0.326***	0.273***
FGI-21R			0.255***	0.313***	0.308***

[a] FGI scores and mean and median energy intakes are from one observation day; BLUP for energy intake (calculated using repeat observations for a subset of the sample) is used for correlation analysis.
[b] Significance: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.
[c] FGI = food group diversity indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must be consumed in order for the food group/subgroup to "count" in the score.
[d] There were too few lactating women for separate analysis in Burkina Faso and none in Mali.

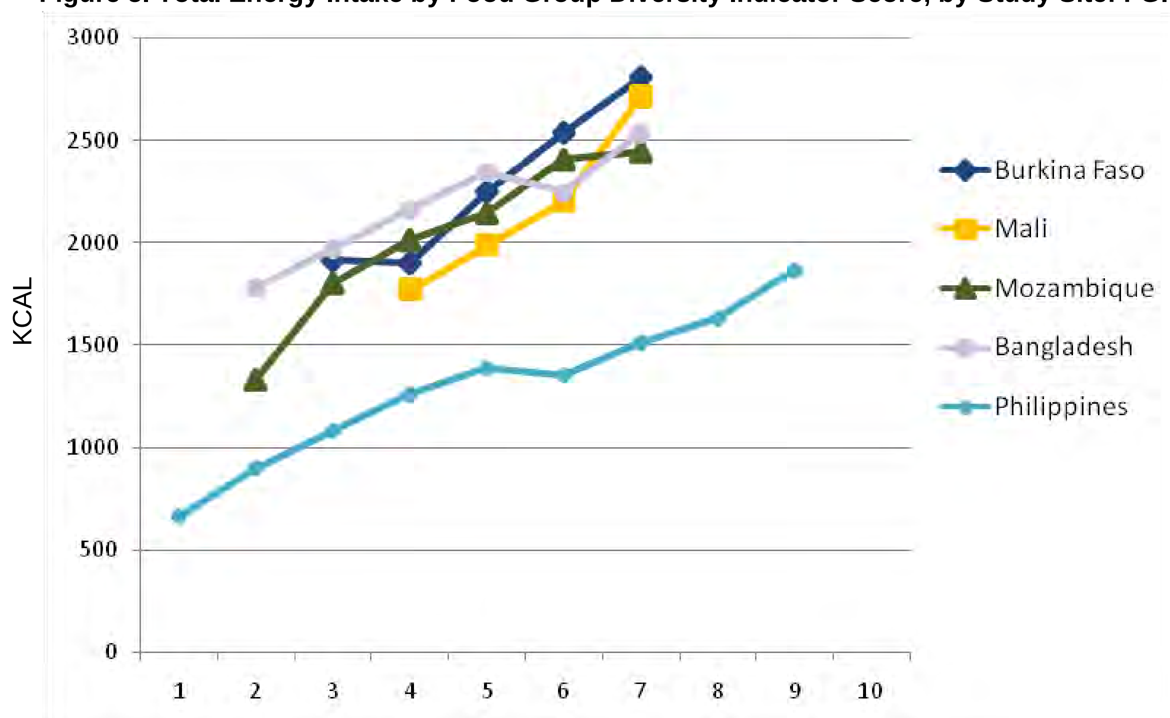
Figures 4 and **5** illustrate the relationship among all women for two of the eight indicators. The relationship (slope) is positive, reasonably similar across sites and appears larger for FGI-21R (**Figure 5**), which had the highest correlation in four of five sites. There was no consistency across sites regarding which FGI had the lowest correlation; FGI-13 (**Figure 4**) had the lowest correlation in two sites. The mean energy intakes at successive FGI scores were fairly consistent across sites, with the exception of the Philippines, for which there is a substantially lower energy intake at each FGI score.

Figure 4. Total Energy Intake by Food Group Diversity Indicator Score, by Study Site: FGI-13 [a]



[a] Data points representing fewer than 10 women are not presented on the graph.

Figure 5. Total Energy Intake by Food Group Diversity Indicator Score, by Study Site: FGI-21R [a]



[a] Data points representing fewer than 10 women are not presented on the graph.

6.7. FOOD GROUP DIVERSITY AND INTAKES OF INDIVIDUAL MICRONUTRIENTS

Tables 10-12 show correlations between three of the food group indicators (FGI-9R, FGI-13R and FGI-21R) and estimated intakes of each micronutrient, by study site and for NPNL women only. Results for other indicators generally showed weaker relationships.

Simple correlations (not controlling for energy) were significant for almost all nutrients in almost all sites. When energy was controlled for, correlations were attenuated and some were not significant; this was most notable in Mozambique, where only four of 11 correlations (thiamin, niacin, vitamin C and zinc) remained significant for FGI-13R and FGI-21R, and only two for FGI-9R (vitamins A and C). This may mean that increases in quantity rather than diversity drive intakes more strongly in Mozambique than in other sites. This is consistent with previous observations about the very limited number of foods and ingredients in the Mozambique diets and specifically with the lack of animal-source foods. In the West African sites (Burkina Faso and Mali), five to eight of 11 correlations remained significant depending on indicator and site; in the two Asian sites, 10 (Philippines) or 11 (Bangladesh) correlations remained significant. Note, however, that the sample size in the Philippines was very large.

Overall, the magnitude of the correlations was highest in Bangladesh and lowest in the Philippines and Mozambique. There was no single micronutrient or subset of micronutrients for which correlations were consistently higher.

6.8. FOOD GROUP DIVERSITY AND MEAN PROBABILITY OF ADEQUACY

For NPNL women, correlations between FGI and MPA were significant for all FGIs and in all sites (**Table 13**). When energy was controlled for, correlations were attenuated, but all remained significant. As with individual nutrient intakes, the attenuation was most marked in Mozambique. When energy was not controlled for, results for Mozambique were similar to or stronger than those in other sites. Correlations were lowest for the Philippines. The size of the correlations ranged from 0.21 to 0.53 and 0.12 to 0.46 when energy was controlled for. Correlations were generally lower for lactating women; this could be due, at least in part, to the narrowed range of MPA for lactating women.

Correlations were consistently higher when the 15 g minimum was imposed ("R" indicators). There also appeared to be a tendency towards higher correlations with higher levels of disaggregation, but this pattern was not entirely consistent. Whether or not energy was controlled for, correlations were lowest for FGI-6 in almost all sites and for both NPNL and lactating women. For NPNL women, correlations were highest for FGI-21R in three sites, but were highest for FGI-6R or FGI-9R in two sites. For lactating women, correlations for FGI-9R were highest in Mozambique and Bangladesh, and were also highest in the Philippines when energy was controlled for.

Table 10. Correlation between Food Group Diversity Indicator Score (FGI-9R) and Estimated Intakes of Individual Nutrients for Non-Pregnant Non-Lactating Women, by Study Site[a,b]

	Burkina Faso (n=130)		Mali (n=102)		Mozambique (n=103)		Bangladesh (n=299)		Philippines (n=1798)	
	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
Energy	0.223*		0.192		0.345***		0.265***		0.236***	
Thiamin	0.242**	0.120	0.187	0.037	0.354***	0.143	0.420***	0.339***	0.254***	0.113***
Riboflavin	0.421***	0.367***	0.481***	0.474***	0.244*	0.040	0.514***	0.457***	0.340***	0.255***
Niacin	0.443***	0.394***	0.278**	0.207*	0.368***	0.185	0.343***	0.229***	0.181***	0.018
Vit B6	0.386***	0.323***	0.191	0.080	0.277**	0.078	0.380***	0.283***	0.264***	0.131***
Folate	0.282**	0.202*	0.471***	0.440***	0.272**	0.042	0.482***	0.430***	0.256***	0.143***
Vit B12	0.244**	0.221*	0.392***	0.349***	0.031	0.076	0.305***	0.265***	0.156***	0.075**
Vit C	0.524***	0.491***	0.093	0.032	0.404***	0.281**	0.374***	0.338***	0.374***	0.328***
Vit A	0.529***	0.494***	0.652***	0.635***	0.412***	0.304**	0.462***	0.422***	0.380***	0.312***
Calcium	0.276**	0.209*	0.469***	0.451***	0.288**	0.109	0.455***	0.411***	0.340***	0.256***
Iron	0.152	0.035	0.111	-0.008	0.220*	-0.047	0.445***	0.380***	0.321***	0.225***
Zinc	0.129	-0.047	0.240*	0.148	0.271**	0.097	0.355***	0.255***	0.268***	0.131***

[a] Diversity scores are from one observation day in each study site. Usual intake of energy and nutrients were estimated by best linear unbiased predictor (see Section 5.7).
[b] Significance: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.

Table 11. Correlation between Food Group Diversity Indicator Score (FGI-13R) and Estimated Intakes of Individual Nutrients for Non-Pregnant Non-Lactating Women, by Study Site[a,b]

	Burkina Faso (n=130)		Mali (n=102)		Mozambique (n=103)		Bangladesh (n=299)		Philippines (n=1798)	
	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
Energy	0.252**		0.230*		0.260**		0.291***		0.242***	
Thiamin	0.277**	0.142	0.209*	0.011	0.344***	0.235*	0.425***	0.329***	0.248***	0.096***
Riboflavin	0.374***	0.291***	0.414***	0.356***	0.286**	0.164	0.499***	0.427***	0.325***	0.225***
Niacin	0.429***	0.360***	0.236*	0.122	0.323***	0.203*	0.351***	0.217***	0.184***	0.016
Vit B6	0.409***	0.334***	0.256**	0.136	0.269**	0.138	0.394***	0.280***	0.267***	0.129***
Folate	0.264**	0.165	0.421***	0.363***	0.283**	0.145	0.454***	0.392***	0.254***	0.136***
Vit B12	0.231**	0.206*	0.352***	0.288**	0.007	0.038	0.331***	0.290***	0.158***	0.075**
Vit C	0.509***	0.469***	0.190	0.123	0.366***	0.280**	0.387***	0.349***	0.371***	0.324***
Vit A	0.485***	0.438***	0.591***	0.563***	0.393***	0.319**	0.398***	0.349***	0.361***	0.286***
Calcium	0.273**	0.194*	0.412***	0.352***	0.250*	0.122	0.446***	0.397***	0.346***	0.260***
Iron	0.174*	0.043	0.108	-0.043	0.179	-0.014	0.427***	0.350***	0.312***	0.202***
Zinc	0.164	-0.026	0.247*	0.113	0.241*	0.117	0.375***	0.253***	0.261***	0.109***

[a] Diversity scores are from one observation day in each study site. Usual intake of energy and nutrients were estimated by best linear unbiased predictor (see Section 5.7).
[b] Significance: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.

Table 12. Correlation between Food Group Diversity Indicator Score (FGI-21R) and Estimated Intakes of Individual Nutrients for Non-Pregnant Non-Lactating Women, by Study Site [a, b]

	Burkina Faso (n=130)		Mali (n=102)		Mozambique (n=103)		Bangladesh (n=299)		Philippines (n=1798)	
	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
Energy	0.280**		0.202*		0.389***		0.319***		0.354***	
Thiamin	0.304***	0.153	0.217*	0.083	0.477***	0.301**	0.475***	0.376***	0.342***	0.109***
Riboflavin	0.371***	0.270**	0.382***	0.336***	0.330***	0.122	0.488***	0.402***	0.415***	0.239***
Niacin	0.459***	0.380***	0.233*	0.140	0.434***	0.242*	0.382***	0.237***	0.322***	0.106***
Vit B6	0.447***	0.365***	0.274**	0.189	0.299**	0.070	0.474***	0.370***	0.410***	0.227***
Folate	0.267**	0.154	0.443***	0.402***	0.394***	0.181	0.437***	0.366***	0.276***	0.075**
Vit B12	0.274**	0.248**	0.349***	0.297**	0.009	0.059	0.331***	0.286***	0.240***	0.124***
Vit C	0.535***	0.492***	0.249*	0.197*	0.364***	0.206*	0.399***	0.358***	0.396***	0.327***
Vit A	0.512***	0.462***	0.604***	0.582***	0.297**	0.144	0.340***	0.281***	0.415 ***	0.294 ***
Calcium	0.243**	0.149	0.375***	0.324***	0.315**	0.111	0.415***	0.357***	0.407***	0.265***
Iron	0.154	-0.001	0.110	-0.018	0.301**	0.029	0.429***	0.341***	0.387***	0.193***
Zinc	0.149	-0.078	0.235*	0.126	0.380***	0.208*	0.396***	0.250***	0.378***	0.156***

[a] Diversity scores are from one observation day in each study site. Usual intake of energy and nutrients were estimated by best linear unbiased predictor (see Section 5.7).
[b] Significance: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.

Table 13. Correlation between Food Group Diversity Indicator Scores and Mean Probability of Adequacy, by Study Site and Physiological Status [a,b]

	Burkina Faso		Mali		Mozambique		Bangladesh		Philippines	
Non-Pregnant Non-Lactating	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
FGI-6 [c]	0.304***	0.229**	0.316**	0.251*	0.300**	0.200*	0.394***	0.315***	0.205***	0.117***
FGI-6R	0.380***	0.347***	0.500***	0.479***	0.380***	0.217*	0.503***	0.436***	0.269***	0.206***
FGI-9	0.329***	0.241**	0.363***	0.327***	0.340***	0.239*	0.476***	0.419***	0.255***	0.151***
FGI-9R	0.424***	0.378***	0.454***	0.481***	0.431***	0.270**	0.520***	0.464***	0.335***	0.253***
FGI-13	0.272**	0.201*	0.299**	0.266**	0.380***	0.301**	0.463***	0.385***	0.255***	0.153***
FGI-13R	0.434***	0.368***	0.418***	0.383***	0.423***	0.324***	0.508***	0.437***	0.334***	0.242***
FGI-21	0.330***	0.277**	0.343***	0.315**	0.480***	0.329***	0.465***	0.379***	0.322***	0.160***
FGI-21R	0.468***	0.394***	0.414***	0.406***	0.529***	0.371***	0.503***	0.417***	0.445***	0.288***
Lactating	Burkina Faso [d]		Mali [d]		Mozambique		Bangladesh		Philippines	
	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
FGI-6					0.193**	0.123	0.280**	0.148	0.192*	0.117
FGI-6R					0.280***	0.213***	0.375***	0.328***	0.226**	0.219**
FGI-9					0.296***	0.260***	0.348***	0.255**	0.226**	0.153*
FGI-9R					0.383***	0.357***	0.405***	0.352***	0.317***	0.276***
FGI-13					0.272***	0.215***	0.387***	0.304**	0.202**	0.125
FGI-13R					0.356***	0.328***	0.412***	0.342***	0.297***	0.263***
FGI-21					0.274***	0.148*	0.289**	0.158	0.276***	0.093
FGI-21R					0.340***	0.233***	0.374***	0.268**	0.392***	0.255***

[a] Food group diversity indicator scores are from one observation day.MPA is based on one observation day and repeat observations for a subset of the sample. When necessary, MPA was transformed to approximate normality, and transformed MPA and BLUP for total energy intake were used for correlation analysis.
[b] Significance: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.
[c] FGI = food group Diveristy indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must be consumed in order for the food group/subgroup to "count" in the score.
[d] There were too few lactating women for separate analysis in Burkina Faso and none in Mali.

Figures 6 and **7** illustrate the central tendency of the relationship between the two FGIs with the highest correlations (FGI-9R and FGI-21R) and MPA, both for NPNL women (**Figure 6**) and lactating women (**Figure 7**) by study site. Both figures show consistent patterns and strongly positive slopes.

Among NPNL women, those in Mozambique had higher MPA scores than in other sites at any given number of food groups. This is consistent with results previously presented, which suggest a pattern of few food groups eaten in substantial amounts and the influence of mango intake. Limited variability in the food group score may limit correlations for Mozambique among NPNL women (**Figure 6**). Results for other sites are remarkably consistent.

Table 13 and **Figures 6** and **7** describe a bivariate relationship between the FGI and MPA. **Tables 14** and **15** provide results (coefficients of FGIs, and adjusted R^2, respectively) from simple linear regressions on MPA for each site for models including age, height and FGI, and both with and without energy in the model.

In all of the "no energy" models, the coefficients for the FGIs were significant. Coefficients represent the increase in MPA, or transformed MPA, which is associated with an increase of 1 point in the corresponding FGI.[48] As with correlations, coefficients were attenuated when total energy was added to the model, but almost all coefficients remained significant for NPNL women (exceptions were for FGI-6, and FGI-21 in Mali, and for FGI-6 and FGI-9 in Mozambique; **Table 14**). For lactating women, coefficients remained significant for six of eight FGIs in Mozambique, and four of eight "restricted" FGIs in the Philippines. The decrease in coefficients highlights that part of the positive relationship between diversity scores and MPA is in fact due to the increase in energy (i.e. quantity of foods consumed) which comes with the increase in FGI.

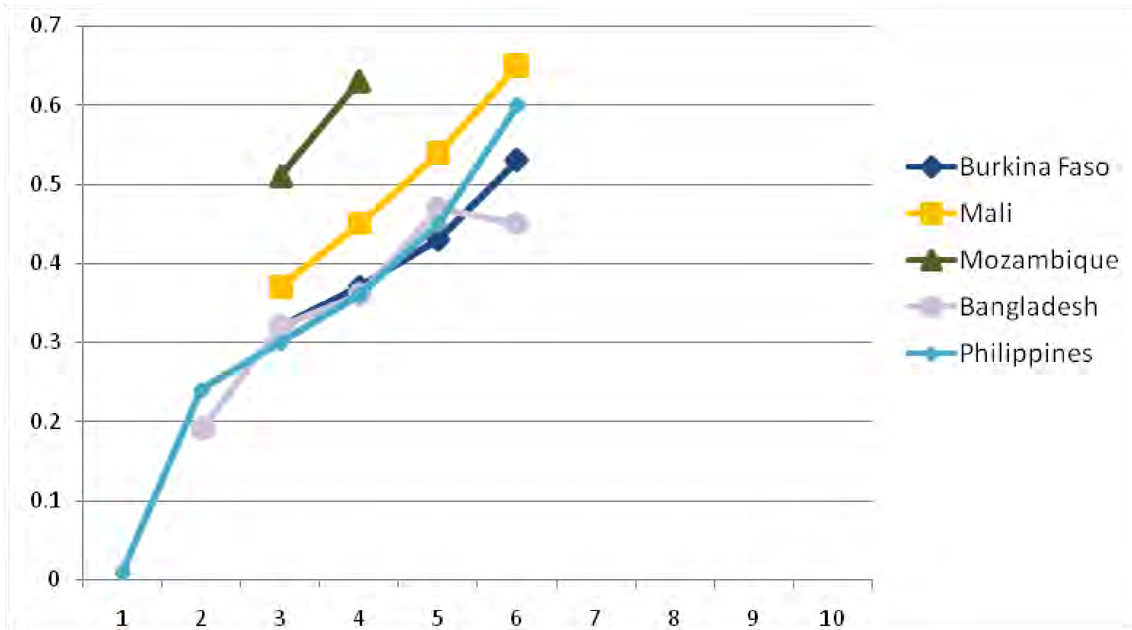
For NPNL women, coefficients ranged from 0.03-0.13 when energy was not in the models and from 0.02-0.10 when energy was controlled for. In the two West African sites (Burkina Faso and Mali), MPA was sufficiently normally distributed and no transformation was necessary. In these sites, for restricted scores, coefficients ranged from 0.06 – 0.10 when energy was not in the models, and from 0.04 – 0.06 when energy was controlled for. This would indicate increases of 0.06 – 0.10 in MPA for each 1 point increase in the FGI.

For NPNL women, with the exception of the FGI-6 "no energy" model in Mozambique, all adjusted R^2 were significant (**Table 15**). Considering only those FGIs with the 15 g minimum, adjusted R^2 range from 0.12-0.31 without energy in the model and from 0.36-0.55 with energy included. As with correlations, results for lactating women were weaker. Coefficients for FGIs were significant in all the "no-energy" models. When energy was added as a covariate, coefficients for FGIs remained significant for all FGIs with the 15 g minimum, but were not significant in six of eight cases with the 1 g minimum.

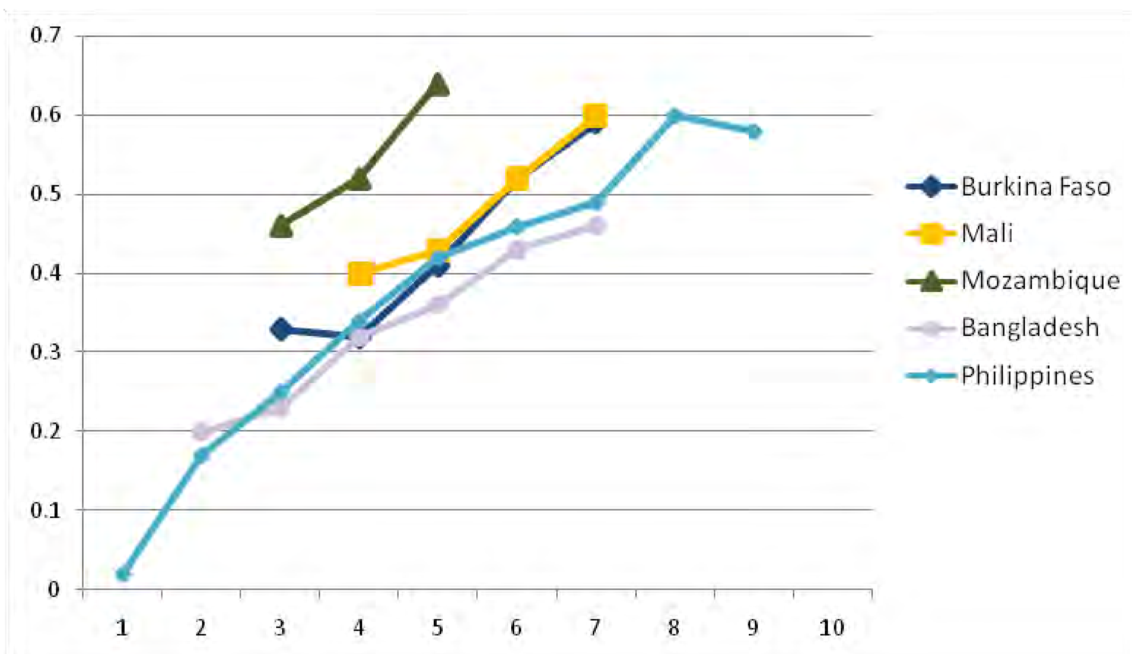
[48] Because MPA was Box-Cox transformed in three sites, interpretation of coefficients and comparisons across sites are not straightforward. See individual site reports for more details.

Figure 6. Mean Probability of Adequacy for Non-Pregnant Non-Lactating Women, by Two Food Group Diversity Indicator Scores**, by Study Site** [a]

FGI-9R

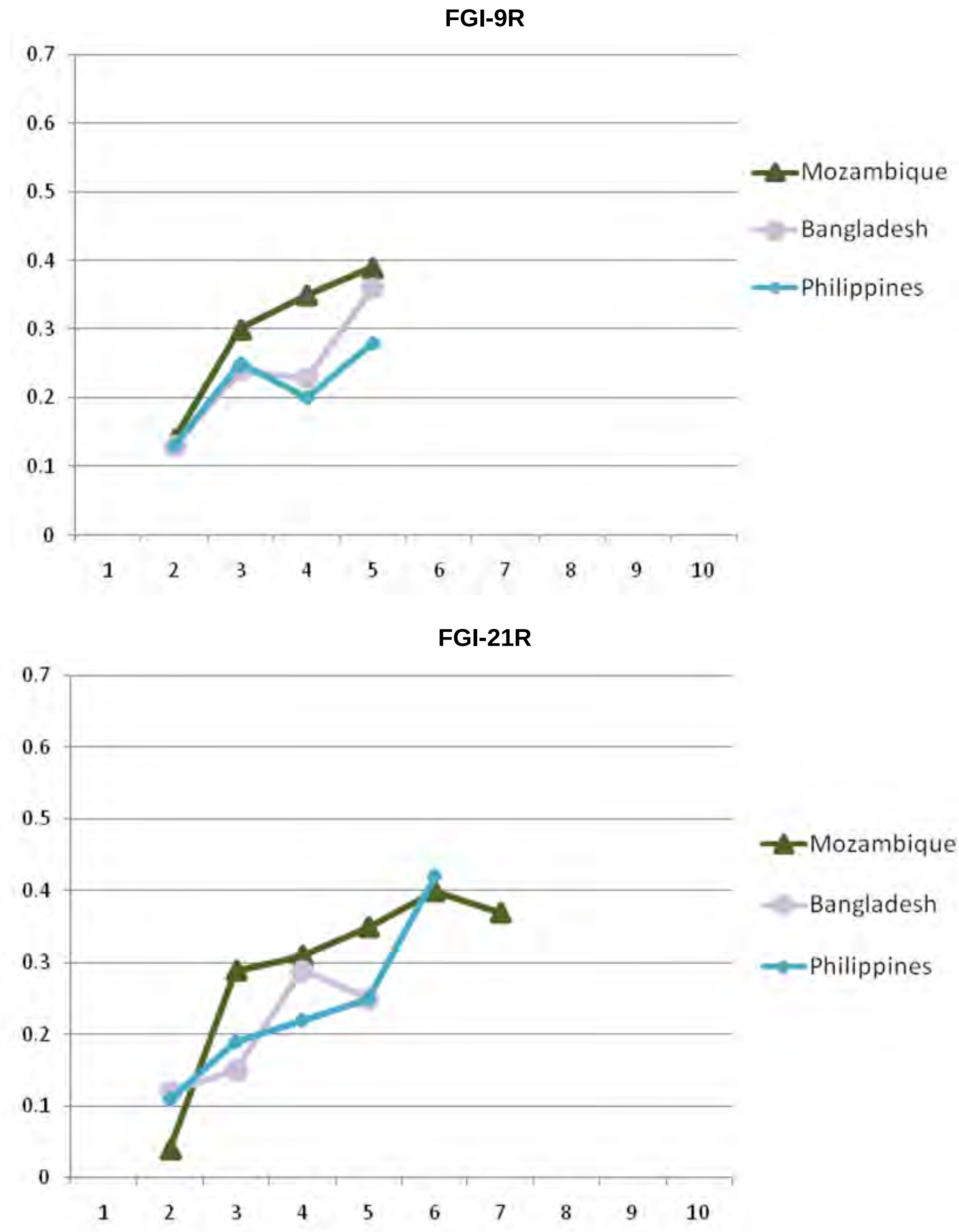


FGI-21R



[a] Data points representing fewer than 10 women are not presented on the graphs.

Figure 7. Mean Probability of Adequacy for Lactating Women, by Two Food Group Diversity Indicator Scores, by Study Site [a]



[a] Data points representing fewer than 10 women are not presented on the graphs.

Table 14. Prediction of Mean Probability of Adequacy: Coefficients of Food Group Diversity Indicator Scores for Linear Regressions with Age, Height, Food Group Diversity Indicator Scores and With or Without Total Energy in the Model, by Study Site and Physiological Status [a]

	Burkina Faso		Mali [c]		Mozambique		Bangladesh		Philippines	
Non-Pregnant Non-Lactating	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model
FGI-6 [b]	0.087***	0.047*	0.120**	0.057	0.077*	0.032	0.121***	0.091***	0.053***	0.025***
FGI-6R	0.073***	0.049***	0.122***	0.074**	0.107***	0.041	0.133***	0.104***	0.085***	0.052***
FGI-9	0.064***	0.035**	0.085**	0.053*	0.087**	0.039	0.118***	0.095***	0.051***	0.025***
FGI-9R	0.073***	0.050***	0.099***	0.062**	0.129***	0.057*	0.128***	0.102***	0.091***	0.055***
FGI-13	0.034**	0.018*	0.048*		0.068**	0.034*	0.095***	0.072***	0.042***	0.021***
FGI-13R	0.065***	0.041***	0.083***		0.093***	0.048**	0.106***	0.083***	0.078***	0.046***
FGI-21	0.037***	0.023**	0.049**	0.024	0.071***	0.035**	0.079***	0.058***	0.040***	0.018***
FGI-21R	0.062***	0.040***	0.067***	0.039**	0.092***	0.050***	0.090***	0.068***	0.085***	0.046***

	Burkina Faso [d]		Mali [d]		Mozambique		Bangladesh [d]		Philippines	
Lactating	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model
FGI-6					0.042*	0.016			0.049*	0.014
FGI-6R					0.064***	0.032*			0.066**	0.039*
FGI-9					0.062***	0.038**			0.042**	0.013
FGI-9R					0.082***	0.054***			0.076***	0.045***
FGI-13					0.042**	0.024*			0.033*	0.011
FGI-13R					0.061***	0.039***			0.064***	0.038**
FGI-21					0.036**	0.014			0.035**	0.007
FGI-21R					0.049***	0.023**			0.068***	0.031**

[a] Significance of F-statistic for coefficients of food group diversity indicator scores: * indicates P < 0.05; ** P < 0.01; *** P < 0.001.
[b] FGI = food group diversity indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must be consumed in order for the food group/subgroup to "count" in the score.
[c] The sample size used in the linear regression analyses for the Mali site was reduced from a total sample size of n=102 to n=64 due to height data being available for only a sub-sample of women. Regression residuals for the models with energy included for NPNL women in Mali were not normally distributed for FGI-13 and FGI-13R. Results are therefore not presented.
[d] There were too few lactating women for separate analysis in Burkina Faso and none in Mali. In Bangladesh, MPA for lactating women could not be transformed to approximate normal and regression residuals were non-normally distributed for a majority of models, therefore regression results are not presented.

Table 15. Prediction of Mean Probability of Adequacy: Adjusted R^2 for Linear Regressions with Age, Height, Food Group Diversity Indicator Scores and Total Energy in the Model, by Study Site and Physiological Status [a]

Non-Pregnant Non-Lactating

	Burkina Faso		Mali [c]		Mozambique		Bangladesh		Philippines	
	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model
FGI-6 [b]	0.097**	0.491***	0.183**	0.410***	0.060	0.485***	0.157***	0.320***	0.107***	0.516***
FGI-6R	0.137***	0.523***	0.314***	0.462***	0.121**	0.490***	0.255***	0.375***	0.138***	0.533***
FGI-9	0.111***	0.495***	0.159**	0.431***	0.102*	0.494***	0.231***	0.375***	0.124***	0.520***
FGI-9R	0.175***	0.540***	0.256***	0.460***	0.197***	0.506***	0.269***	0.390***	0.170***	0.542***
FGI-13	0.078**	0.485***	0.098*		0.119**	0.504***	0.218***	0.351***	0.124***	0.521***
FGI-13R	0.180***	0.532***	0.271***		0.185***	0.520***	0.259***	0.380***	0.170***	0.541***
FGI-21	0.119***	0.508***	0.144**	0.406***	0.223***	0.521***	0.216***	0.340***	0.155***	0.524***
FGI-21R	0.213***	0.548***	0.273***	0.446***	0.302***	0.545***	0.252***	0.362***	0.243***	0.552***

Lactating

	Burkina Faso [d]		Mali [d]		Mozambique		Bangladesh [d]		Philippines	
	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model	Energy not in model	With energy in model
FGI-6					0.043*	0.498***			0.126***	0.571***
FGI-6R					0.082***	0.511***			0.142***	0.585***
FGI-9					0.088***	0.522***			0.132***	0.572***
FGI-9R					0.143***	0.548***			0.180***	0.598***
FGI-13					0.068**	0.512***			0.124***	0.572***
FGI-13R					0.116***	0.536***			0.168***	0.596***
FGI-21					0.072**	0.502***			0.149***	0.570***
FGI-21R					0.108***	0.514***			0.213***	0.593***

[a] Significance of F-statistic for adjusted R^2: * indicates P < 0.05; ** P < 0.01; *** P < 0.001. Shaded cells indicate models where the coefficient for the FGI was not significant.
[b] FGI = Food Group Indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must be consumed in order for the food group/subgroup to "count" in the score.
[c] The sample size used in the linear regression analyses for the Mali site was reduced from a total sample size of n=102 to n=64 due to height data being available for only a sub-sample of women. Regression residuals for the models with energy included for NPNL women in Mali were not normally distributed for FGI-13 and FGI-13R. Results are therefore not presented.
[d] There were too few lactating women for separate analysis in Burkina Faso and none in Mali. In Bangladesh, MPA for lactating women could not be transformed to approximate normal. Also, regression residuals were non-normally distributed for a majority of models, therefore regression results are not presented.

6.9. PERFORMANCE OF FOOD GROUP DIVERSITY INDICATORS

FGIs can be presented as ordinal scores[49] or as dichotomous indicators, yielding prevalence estimates for the proportion of the sample or population below/above a specified cutoff for diversity. For communication and advocacy purposes, dichotomous indicators may be preferred and necessary. In order to assess the performance of dichotomous indicators, cutoffs must be selected both for MPA and for the FGI.

Indicators can only be assessed for MPA cutoffs that are possible given observed distributions of MPA. **Table 16** summarizes the proportion of women in each site above selected cutoffs of MPA. Except in the Philippines where the sample size was very large, no women exceeded 0.90 MPA and very few (fewer than 5 women per site) exceeded 0.80 MPA. Therefore, we assessed indicator performance relative to MPA cutoffs of > 0.50, > 0.60 and > 0.70 for NPNL women only.[50] Arguably, none of these cutoffs (0.50, 0.60 or 0.70) can be considered to characterize a "positive" indicator of micronutrient adequacy.

Table 16. Percent (Number) of Women above Selected Cutoffs for Mean Probability of Adequacy, by Study Site and Physiological Status

	MPA > 0.50		MPA > 0.60		MPA > 0.70		MPA > 0.80		MPA > 0.90	
Country	%	(number)	%	(number)	%	(number)	%	(number)	%	(number)
Burkina Faso										
NPNL [a]	28	(36)	15	(20)	9	(12)	2	(3)	0	(0)
All	26	(47)	15	(28)	7	(13)	2	(3)	0	(0)
Mali										
NPNL [a]	46	(47)	25	(25)	11	(11)	4	(4)	0	(0)
All	46	(47)	25	(25)	11	(11)	4	(4)	0	(0)
Mozambique										
Lactating	21	(53)	11	(27)	3	(7)	0	(1)	0	(0)
NPNL [a]	61	(63)	46	(47)	24	(25)	1	(1)	0	(0)
All	31	(126)	19	(79)	8	(32)	1	(2)	0	(0)
Bangladesh										
Lactating	5	(5)	1	(1)	0	(0)	0	(0)	0	(0)
NPNL [a]	20	(59)	7	(21)	4	(12)	1	(2)	0	(0)
All	16	(64)	5	(22)	3	(12)	1	(2)	0	(0)
Philippines										
Lactating	10	(16)	4	(7)	2	(3)	1	(1)	0	(0)
NPNL [a]	27	(482)	16	(284)	8	(134)	3	(45)	1	(11)
All	25	(509)	15	(299)	7	(142)	2	(47)	1	(11)

[a] NPNL = non-pregnant non-lactating

[49] See, e.g., FAO 2007.
[50] Among lactating women very few women exceeded any of the MPA cutoffs tested, except in Mozambique. Therefore, we judged that a cross-site comparison of indicator performance was not possible for lactating women.

Table 17 shows the area under the receiver-operating curve (AUC) for each indicator, in each site and at each of the three MPA cutoffs for NPNL women. The AUC summarizes the predictive power of each indicator across all possible FGI cutoffs. An AUC of 0.50 represents a null value (no predictive power). A statistically significant AUC indicates some predictive power, but AUC can be statistically significant even when predictive power is weak. As noted, because of varying sample sizes, differences in significance (and levels of significance) across sites should be interpreted cautiously. As a rule of thumb, we considered AUC ≥ 0.70 to indicate some promise for the indicator. Within each study site, differences between AUC were also tested; results of these comparisons are reported in **Appendix 2** and summarized below.

Results in **Table 17** are consistent with those for correlations and regressions and show higher AUC for FGIs that impose the 15 g minimum. Results are most consistent at the cutoff for 0.50 MPA; at this cutoff, all AUC are significant. For the three FGIs that have emerged as most promising at the 0.50 MPA cutoff – FGI-9R, FGI-13R and FGI-21R – all AUC are ≥ 0.70 in four sites; only FGI-21R meets this criterion in the Philippines.

Results for higher MPA cutoffs are more mixed. At MPA cutoffs of 0.60 and 0.70, a number of AUC in Mali and Mozambique and one in Burkina Faso are not significantly different from the null value. At the 0.60 cutoff for MPA, AUC is ≥ 0.70 for one site for FGI-9R, two sites for FGI-13R and four sites for FGI-21R. At the 0.70 cutoff for MPA, AUC is ≥ 0.70 for three (FGI-9R and FGI-13R) or four sites (FGI-21R).

Tests comparing AUC within sites are difficult to summarize because of the large number of comparisons (each AUC against the null value and against each other for each MPA cutoff; see **Appendix 2**). Consistent with other results, a number of the tests showed that AUC were larger for FGIs with the 15 g restriction.

The 6 group indicators performed poorly relative to other FGIs in Bangladesh and the Philippines, but not in Mali. FGI-21R clearly performed best in two sites (Mozambique and the Philippines), but did not perform better than any other indicator in two other sites (Mali and Bangladesh). FGI-21R also performed well in Burkina Faso, but differences between FGI-21R and several other restricted indicators were not significant. In Mali, there were no significant differences at the 0.50 cutoff of MPA; at higher cutoffs, FGI-6R and FGI-9R performed best. In Bangladesh at the 0.50 MPA cutoff, FGI-9R and FGI-13R performed best and did not differ significantly from each other. At higher cutoffs, FGI-13R performed best. In summary, no specific FGI could be identified that out-performed others across most or all sites.

Finally, indicator performance can be assessed through examining characteristics of indicator quality – sensitivity, specificity and total misclassification – across a range of cutoffs for varying levels of diversity and for the three MPA cutoffs (**Tables 18-20**). **Box 1** provides an explanation of indicator characteristics, specifically as used in this context.

Table 17. Area Under the Curve for All Food Group Diversity Indicators for Non-Pregnant Non-Lactating Women, by Study Site [a]

	MPA > 0.50									
	Burkina Faso		Mali		Mozambique		Bangladesh		Philippines	
	AUC	P value	AUC	P value	AUC	P value	AUC	P value	AUC	P value
FGI-6 [b]	0.663	< 0.001	0.673	0.003	0.677	0.003	0.588	0.036	0.617	< 0.001
FGI-6R	0.684	< 0.001	**0.753**	< 0.001	0.690	0.001	**0.716**	< 0.001	0.627	< 0.001
FGI-9	0.698	< 0.001	**0.736**	< 0.001	0.685	0.002	0.674	< 0.001	0.640	< 0.001
FGI-9R	**0.721**	< 0.001	**0.753**	< 0.001	**0.700**	0.001	**0.735**	< 0.001	0.657	< 0.001
FGI-13	0.658	0.003	0.679	0.002	**0.710**	< 0.001	0.678	< 0.001	0.631	< 0.001
FGI-13R	**0.741**	< 0.001	**0.738**	< 0.001	**0.704**	0.001	**0.752**	< 0.001	0.653	< 0.001
FGI-21	0.687	0.001	**0.718**	< 0.001	**0.768**	< 0.001	0.672	< 0.001	0.665	< 0.001
FGI-21R	**0.762**	< 0.001	**0.743**	< 0.001	**0.771**	< 0.001	**0.722**	< 0.001	**0.713**	< 0.001
	MPA > 0.60									
	Burkina Faso		Mali		Mozambique		Bangladesh		Philippines	
	AUC	P value	AUC	P value	AUC	P value	AUC	P value	AUC	P value
FGI-6	0.664	0.001	0.624	0.062	0.575	0.193	0.666	0.011	0.633	< 0.001
FGI-6R	0.688	0.001	**0.709**	0.002	0.631	0.023	**0.782**	<0.001	0.638	< 0.001
FGI-9	0.692	0.001	0.653	0.022	0.598	0.087	**0.766**	<0.001	0.660	< 0.001
FGI-9R	0.684	0.001	0.695	0.003	0.648	0.010	**0.815**	<0.001	0.669	< 0.001
FGI-13	0.628	0.025	0.589	0.181	0.633	0.020	**0.760**	<0.001	0.649	< 0.001
FGI-13R	**0.740**	< 0.001	0.683	0.006	0.667	0.004	**0.836**	<0.001	0.666	< 0.001
FGI-21	0.666	0.006	0.618	0.076	**0.710**	< 0.001	**0.735**	<0.001	0.686	< 0.001
FGI-21R	**0.790**	< 0.001	0.676	0.008	**0.743**	< 0.001	**0.800**	<0.001	**0.725**	< 0.001
	MPA > 0.70									
	Burkina Faso		Mali		Mozambique		Bangladesh		Philippines	
	AUC	P value	AUC	P value	AUC	P value	AUC	P value	AUC	P value
FGI-6	0.641	0.003	0.643	0.122	0.541	0.543	0.696	0.022	0.649	< 0.001
FGI-6R	0.631	0.041	**0.777**	0.003	0.556	0.397	**0.784**	0.001	0.677	< 0.001
FGI-9	**0.704**	0.001	0.689	0.041	0.579	0.235	**0.824**	< 0.001	0.676	< 0.001
FGI-9R	0.632	0.384	**0.751**	0.007	0.598	0.142	**0.805**	< 0.001	**0.709**	< 0.001
FGI-13	0.692	0.004	0.539	0.670	0.588	0.186	**0.803**	< 0.001	0.673	< 0.001
FGI-13R	**0.731**	< 0.001	0.660	0.084	0.631	0.050	**0.827**	< 0.001	**0.708**	< 0.001
FGI-21	**0.743**	< 0.001	0.581	0.382	0.663	0.015	**0.808**	< 0.001	0.697	< 0.001
FGI-21R	**0.798**	< 0.001	0.677	0.056	**0.703**	0.002	**0.808**	< 0.001	**0.748**	< 0.001

[a] Cells for non-significant tests are shaded; p-values between 0.05-0.10 have light shading and p-values > 0.10 have dark shading. AUC ≥ 0.70 are in bold font.
[b] FGI = food group diversity indicator. The number following indicates the number of food groups/subgroups summed in the score (i.e. the level of disaggregation of food groups in the score). An "R" indicates that at least 15 g must be consumed in order for the food group/subgroup to "count" in the score.

Box 1. Predicting Higher Diet Quality: Indicator Characteristics

Because we are trying to "predict" higher (better) MPA (above the cutoff), indicator characteristics have different interpretations than they do when the aim is to assess risk, which is the more standard use in epidemiology.

In this case, sensitivity assesses the proportion of all those who truly have better MPA who are identified by the indicator. Specificity assesses the proportion of those who truly have lower MPA who are identified by the indicator.

There are always trade-offs between sensitivity and specificity; which one should be "favored" depends on the intended uses of the indicator and sometimes on other factors, such as level of resources available for helping those identified as in need. For our purposes – the development of indicators to assess and compare diet quality for women and to track change across time – it is reasonable to aim for a balance between sensitivity and specificity, but to favor specificity when trade-offs must be made.

This means that we prefer to be certain to identify all those with low MPA and are willing to accept that some women with better MPA are classified incorrectly. The alternative would be to accept more women with low MPA but classified as "better."

There are no fixed criteria for determining what absolute levels of sensitivity, specificity and misclassification may be acceptable. The costs and risks of misclassification depend on the use of the indicator. In general, yardsticks for population-level assessment may have lower requirements (i.e. more misclassification could be tolerated) than would indicators used to differentially allocate resources or to trigger action. Indicators used at the individual level (e.g., in screening) may have even higher requirements.

For the purposes of the WDDP, we aimed to minimize misclassification but considered levels of misclassification below 30 percent to be acceptable.

Tables 18-20 show indicator characteristics for the three best candidate indicators (FGI-9R, FGI-13R and FGI-21R); **Appendix 3** provides more detailed results by study site. For each of the three indicators at each MPA cutoff tested, there was no single cutoff for the number of food groups that performed "best" across all sites. There was a relationship between the range of diversity scores observed in the site and the "best" food group cutoff. For example, Mali, with the highest diversity, had higher "best" food group cutoffs.

The results in **Tables 18-20** mask the fact that in particular sites there was usually a best indicator and a best cutoff that yielded an acceptable balance of sensitivity, specificity and misclassification. However, the tables show that there is no indicator and no cutoff that meet those criteria across all sites.

For each combination of MPA cutoff and FGI cutoff there is a range of misclassification across the five sites. For example, for MPA > 0.60 and FGI-21R ≥ 6 (one of the "best" cases), misclassification was less than 30 percent in four of the five sites but was 40 percent in the fifth site (Mozambique). In almost every case, at the high end of the range for misclassification overall misclassification remained unacceptably high for all indicators and all cutoffs. The only exceptions were at the 0.70 cutoff for MPA and at food group cutoffs of ≥ 6 (FGI-9R and FGI-13R) and ≥ 7 (FGI-13R and FGI-21R). However, in these cases sensitivity is unacceptably low, ranging from 0-55 percent, meaning that the indicator (and cutoff) identified half or fewer of women who truly had MPA above the cutoff.

Table 18. Summary of Indicator Characteristics for FGI-9R, for Non-Pregnant Non-Lactating Women

Food group cutoffs	Sensitivity	Specificity	Total proportion misclassified	"Best" cutoff [a] for:
MPA > 0.50				
≥ 3	86-100	4-32	33-69	
≥ 4	57-98	30-65	34-54	Mozambique (34), Philippines (37)
≥ 5	14-67	66-100	23-52	Burkina Faso (34), Mali (31), Bangladesh (23)
≥ 6	2-36	94-100	21-60	
MPA > 0.60				
≥ 3	87-100	3-30	49-81	
≥ 4	61-100	23-63	37-60	Mozambique (40), Philippines (37)
≥ 5	15-67	60-96	19-41	Burkina Faso (40), Mali (35), Bangladesh (19), Philippines (20)
≥ 6	0-30	88-98	9-47	
MPA > 0.70				
≥ 3	90-100	2-29	67-87	
≥ 4	68-100	20-62	38-72	*Mozambique (50)*, Philippines(38)
≥ 5	16-82	59-94	17-42	*Burkina Faso (42),* Mali (35), Bangladesh (20), Philippines (17)
≥ 6	0-36	86-99	6-25	Mali (18)

[a] In selecting the "best" cutoff, we considered the balance of sensitivity and specificity, with a preference for specificity; we also considered the total proportion of the sample misclassified. Misclassification is indicated in parentheses for each site's "best" cutoff. In some cases, two cutoffs performed similarly and they are both indicated as "best" for that site. When two cutoffs are indicated, the lower diversity cutoff is associated with better sensitivity and the higher diversity cutoff has lower sensitivity but also lower overall misclassification. Country names are in italics if the AUC was not significantly different from the null value (P ≥ 0.05).

Table 19. Summary of Indicator Characteristics for FGI-13R, for Non-Pregnant Non-Lactating Women

Food group cutoffs	Sensitivity	Specificity	Total proportion misclassified	"Best" cutoff[a] for:
MPA > 0.50				
≥ 3	86-100	2-32	34-69	
≥ 4	59-98	18-62	33-56	Mozambique (33), Philippines (39)
≥ 5	30-79	59-93	23-46	Bangladesh (23), Philippines (29)
≥ 6	10-50	84-100	22-55	Burkina Faso (22), Mali (33)
≥ 7	2-19	95-100	21-60	
MPA > 0.60				
≥ 3	87-100	1-30	50-82	
≥ 4	63-100	14-60	39-65	Mozambique (39), Philippines (40)
≥ 5	32-91	49-88	22-43	Mozambique (38), Bangladesh (22), Philippines (24)
≥ 6	9-50	75-96	12-44	Burkina Faso (22), Mali (31)
≥ 7	0-20	91-99	9-47	
MPA > 0.70				
≥ 3	90-100	1-28	67-88	
≥ 4	72-100	12-59	40-78	Philippines (40)
≥ 5	32-92	45-82	22-51	*Mozambique (30),* Bangladesh (24), Philippines (22)
≥ 6	8-55	73-95	10-29	Burkina Faso (24), *Mali (29)*
≥ 7	0-9	88-99	6-25	

[a] In selecting the "best" cutoff, we considered the balance of sensitivity and specificity, with a preference for specificity; we also considered the total proportion of the sample misclassified. Misclassification is indicated in parentheses for each site's "best" cutoff. In some cases, two cutoffs performed similarly and they are both indicated as "best" for that site. When two cutoffs are indicated, the lower diversity cutoff is associated with better sensitivity and the higher diversity cutoff has lower sensitivity but also lower overall misclassification. Country names are in italics if the AUC was not significantly different from the null value (P ≥ 0.05).

Table 20. Summary of Indicator Characteristics for FGI-21R, for Non-Pregnant Non-Lactating Women

Food group cutoffs	Sensitivity	Specificity	Total proportion misclassified	"Best" cutoff[a] for:
MPA > 0.50				
≥ 4	83-98	13-46	30-61	
≥ 5	59-87	36-83	29-40	Mozambique (31), Bangladesh (34), Philippines (31)
≥ 6	22-75	71-100	23-48	Burkina Faso (23), Mali (28), Bangladesh (24)
≥ 7	11-40	89-100	21-54	
MPA > 0.60				
≥ 4	87-100	10-43	40-68	
≥ 5	63-95	31-75	29-54	Mozambique (29), Philippines (32)
≥ 6	26-80	57-96	21-40	Burkina Faso (28), Mali (40), Bangladesh (21), Philippines (22)
≥ 7	11-44	82-96	12-43	Mali (28)
MPA > 0.70				
≥ 4	88-100	9-41	55-81	
≥ 5	68-100	29-67	33-64	Mozambique (35), Philippines (33)
≥ 6	32-83	54-92	19-44	Burkina Faso (31), Mozambique (22), Bangladesh (20), Philippines (19)
≥ 7	12-46	78-95	10-26	*Mali (26)*

[a] In selecting the "best" cutoff, we considered the balance of sensitivity and specificity, with a preference for specificity; we also considered the total proportion of the sample misclassified. Misclassification is indicated in parentheses for each site's "best" cutoff. In some cases, two cutoffs performed similarly and they are both indicated as "best" for that site. When two cutoffs are indicated, the lower diversity cutoff is associated with better sensitivity and the higher diversity cutoff has lower sensitivity but also lower overall misclassification. Country names are in italics if the AUC was not significantly different from the null value (P ≥ 0.05).

7. Summary and Conclusions

7.1. DIETARY PATTERNS, MACRONUTRIENT INTAKES AND FOOD GROUP DIVERSITY INDICATOR SCORES

Dietary patterns varied and are described in detail in reports for each site.[51] At a very aggregate level, there were important differences in the extent to which diets were dominated by starchy staples and the contribution of oils, fats, sweets and/or alcohol to energy intakes.

Bangladesh represented one extreme, with 86 percent of energy intakes accounted for by starchy staples (almost exclusively polished rice). Even if there may have been some overestimation of rice and total energy intakes (**Section 6.3**), reported quantities of all other foods were very small and it is likely that diets at this site would still be the most monotonous among the five sites examined.

In Mozambique, 68 percent of energy intakes were accounted for by starchy staples, in this case primarily high extraction maize and cassava flour. Fifteen percent of energy intake was accounted for by fruits and vegetables – the highest proportion of any site – and this was nearly entirely due to consumption of mango by most women and in substantial quantities.

In the two urban West African sites, Burkina Faso and Mali, diets were better balanced, with 46-56 percent of energy from starchy staples. Also, unlike in the two rural sites above, in the urban West African sites 20-25 percent of energy was from oils, fats, sweets and/or alcohol (**Table 4**) – food groups not included in our FGI scores.

Relative to WHO-recommended[52] macronutrient ranges for populations, the two rural sites (Bangladesh and Mozambique) had imbalances, with excessive carbohydrate and very low fat intakes as a proportion of total energy. Proportions of energy from macronutrients in the other three urban/peri-urban sites were within or very close to WHO recommended ranges.

The two urban West African sites (Burkina Faso and Mali) had the highest mean FGI scores, and this was true across all levels of disaggregation. For six of eight FGIs and for all four "restricted" FGIs, the highest average score was in the Mali sample. However, FGI scores were not high in the third urban/peri-urban site (Philippines). Mozambique ranked lowest on all "unrestricted" scores, but when the 15 g restriction was applied, Mozambique ranked third (three FGIs) or fourth (one FGI). Conversely, women in the Philippines ranked last in three of the four indicators with the 15 g restriction. The Bangladesh sample ranked third or fourth for all indicators.

7.2. MICRONUTRIENT INTAKES AND ADEQUACY

Our results are among the first from resource-poor settings to characterize prevalence of micronutrient adequacy/inadequacy for adult women using currently recommended analytic approaches. Median micronutrient intakes varied by site with substantial differences for a number of nutrients. Intakes were notably low relative to average requirements for a number of micronutrients in each site. This was reflected in low prevalence of adequacy (**Table 8** and **Figures 2-3**). Among NPNL women, the estimated prevalence of adequacy was below 50 percent in most sites for thiamin, riboflavin, niacin, folate, vitamin B12, calcium and iron. Looked at by site, prevalence of adequacy was below 50 percent for five of 11 micronutrients in Mali, six in Mozambique, seven in both Burkina Faso and Bangladesh, and nine micronutrients in the Philippines. Results for lactating women indicated even more severe gaps between intakes and requirements.

[51] Arimond et al. 2009; Becquey, Capon and Martin- Prével 2009; Kennedy et al. 2009; Wiesmann, Arimond and Loechl 2009; Daniels 2009.
[52] 2003.

Even allowing for the error that is inherent in all dietary studies, these results suggest that micronutrient intakes fall far short of requirements for many or most women in each site. The results also underscore the fact that intakes are inadequate across a range of micronutrients and not just for those that are the usual focus of public health interventions (iodine, iron, folate and vitamin A).

MPA provides a summary of this information, and ranged from 0.34-0.54 for NPNL women and from 0.24-0.34 for lactating women. MPA was lowest for the two Asian samples (Bangladesh and the Philippines) and highest in Mozambique. However, as discussed, it is very plausible that MPA would be lower in Mozambique in other seasons, as mango made a very substantial contribution to intakes of energy and of many micronutrients, not just vitamin A.[53]

It is also likely that true MPA could be higher for the Philippines sample as energy intakes and ratios to estimated BMR suggest the possibility of substantial underreporting in this sample. We have no information to shed light on the nature and extent of underreporting, thus the extent of impact on PA for specific micronutrients and on MPA remains unknown.

7.3. FOOD GROUP DIVERSITY, ENERGY INTAKES AND PROBABILITY OF ADEQUACY

Our study is consistent with previous investigations that have shown positive relationships between food group diversity and energy intakes. This was true even though (unlike in some previous studies) some energy-dense (but micronutrient-poor) foods/groups were excluded from our diversity scores. Since our objective was to develop indicators of micronutrient density, this exclusion of energy-dense foods was appropriate. Correlations between food group diversity and energy intake were highest in the two poorest, rural sites (Bangladesh and Mozambique), where 96-98 percent of energy intake was accounted for by the food groups summed in our diversity scores. Correlations were slightly lower in the urban/peri-urban sites. Overall, correlations were moderate, with most falling between 0.20-0.30.

Given the demonstrated relationship between FGI scores and energy intake, we presented results describing relationships between FGIs and the estimated intake of individual micronutrients both with and without controlling for energy. Three FGIs emerged as the "best candidates:" FGI-9R, FGI-13R and FGI-21R. This summary of results will focus on these three indicators. Each of these three FGIs was correlated with the intake for most individual micronutrients in most or all sites (**Tables 10-12**). When energy was controlled for, correlations were somewhat attenuated but remained significant for most nutrients in most sites. These results suggest that the relationship between FGIs and MPA is not driven by a narrow relationship to one or a few micronutrients. This supports the idea that FGIs can function as indicators of overall micronutrient density, an important dimension of diet quality.

MPA summarizes adequacy across all 11 micronutrients; all FGIs were significantly correlated with MPA in all sites and for both NPNL and lactating women (**Table 13**). For NPNL women, all correlations remained significant when energy was controlled for. For lactating women, all except FGI-6 remained significant in Mozambique, but in Bangladesh and the Philippines, several other "unrestricted" FGIs were not significant. Considering the three best candidate indicators, correlations ranged from:

0.33-0.53	NPNL women, energy not controlled for
0.24-0.48	NPNL women, controlling for energy
0.30-0.41	Lactating women, energy not controlled for
0.23-0.36	Lactating women, controlling for energy

Figures 6-7 illustrate the central tendency of the relationship between FGIs and MPA and show a strongly positive slope, particularly for NPNL women. Among NPNL women, results are consistent across sites, with the exception that MPA is higher for the Mozambique site at any given FGI score. In Mozambique, diets and mixed dishes were very simple, with few foods/ingredients. Each food/ingredient

[53] During other seasons, other foods may replace mango, but there are few "candidate" foods as micronutrient-rich as mango; energy gaps may be filled by increased intake of starchy staples. It is also possible that mango is more like a supplementary food and is not fully replaced, even in terms of energy, during other seasons.

was likely to be consumed in non-trivial amounts (**Table 3**), and mango in substantial quantities was consumed by the majority of women. This may explain the higher MPA observed at lower FGI scores.

Finally, linear regressions including women's age and height, FGI, and with or without energy in the model confirm that FGIs remain a significant predictor of MPA in most models (**Table 14**). In all of the "no energy" models among both NPNL and lactating women, FGIs were significant. Coefficients for the three best candidate FGsI ranged from:

0.06-0.13	NPNL women, total energy not in the model
0.04-0.10	NPNL women, total energy included as a covariate
0.05-0.08	Lactating women, total energy not in the model
0.02-0.05	Lactating women, total energy included as a covariate

Interpretation of coefficients, particularly across sites, is not straightforward due to transformation of the dependent variable in three sites. However, for Burkina Faso and Mali, coefficients for the three best candidates ranged from 0.06 - 0.10. This would indicate increases of 0.06 – 0.10 in MPA for each 1 point increase in the FGI.

Considering the overall explanatory power of the models, adjusted R^2 for the three best candidate indicator models ranged from:

0.17-0.30	NPNL women, total energy not in the model
0.36-0.55	NPNL women, total energy included as a covariate
0.11-0.21	Lactating women, total energy not in the model
0.51-0.60	Lactating women, total energy included as a covariate

This indicates that even though models were simple, they explained a substantial portion of the variability in MPA.

In summary, both correlations and regression coefficients show a consistent relationship between most FGIs and MPA. The magnitude of the correlations is moderate and is higher for FGIs where the 15 g minimum was imposed (i.e. exclude foods eaten in trivial quantities, such as condiments). The magnitude of correlations tends to increase with higher disaggregation of food groups, but this pattern is not entirely consistent. Correlations are lower for lactating women than for NPNL women. Regression results are similar and confirm that FGIs remain a significant predictor of MPA in almost all models controlling for age, height and total energy intake.

7.4. PERFORMANCE OF FOOD GROUP DIVERSITY INDICATORS

FGI scores can be presented as ordinal or as dichotomous indicators; the latter may be preferred for communication and advocacy purposes. In order to assess the performance of dichotomous indicators, cutoffs must be selected both for MPA and for the FGI.

Given the distribution of MPA in our samples, we evaluated dichotomous indicators for NPNL women at 0.50, 0.60 and 0.70 MPA. The AUC statistic from analysis of ROCs provides a summary of the overall potential of indicators to predict MPA across all FGI scores. As a rule of thumb, AUC ≥ 0.70 are considered to indicate reasonable potential for an indicator.

Results (**Table 17**) were consistent with those for correlations and regressions, and show higher AUC for FGIs that imposed the 15 g minimum. Results are most consistent at the cutoff for 0.50 MPA; at this cutoff, all AUC are significant. For the three best candidate FGIs, all AUC are ≥ 0.70 in four sites; only FGI-21R meets this criterion in the Philippines. Results for higher MPA cutoffs are more mixed.

Tests comparing AUC within sites were also consistent with other results and showed that AUC were larger for FGIs with the 15 g restriction (**Appendix 2**). The 6 group indicators performed poorly in most sites, but beyond that no specific FGI could be identified that out-performed others across most or all sites.

To provide a dichotomous indicator, cutoffs for FGI scores were also examined with the objective of determining whether or not a specific FGI cutoff could be identified where indicator performance was acceptable across sites.

Among the three best candidate indicators, there was no single cutoff for number of food groups that performed "best" across all sites (**Tables 18-20**). There was no indicator and no cutoff that yielded an acceptable balance of sensitivity, specificity and misclassification across sites.

The summary analysis masks the fact that within individual sites, acceptable indicators were identified. However, these may be best considered as indicators of poor diet quality rather than adequate diet quality, as few women in any site reached MPA levels that could be considered "high."[54]

7.5 LIMITATIONS AND CONCLUSIONS

Our study had several limitations. First, most of the data sets had relatively small sample sizes, as is typical of quantitative 24-h recalls in developing countries. High-quality dietary data are exceptionally difficult and expensive to gather and process, so most available data sets are small. The two larger data sets showed evidence of underreporting (Philippines) and, to a lesser extent, possible over-reporting (Bangladesh).[55] This may reflect an inevitable trade-off between quantity and quality.

Second, from an analytical perspective, the random error inherent in all dietary data has implications for the possibility of detecting associations. Specifically, high intra-individual variation in intakes across days can attenuate measures of association such as correlation and regression coefficients. This problem has been characterized and addressed analytically, primarily in the context of assessing diet-health associations.[56] It is possible that correlations reported here may reflect such attenuation and future research could aim towards correcting for attenuation.

The main conclusions of this study are as follows:

- There were very substantial gaps between micronutrient intakes and requirements for women of reproductive age in all five diverse, resource-poor settings.
- Gaps between intakes and requirements extended beyond the few micronutrients that are the usual focus of supplementation programs.
- The gaps were present in two poor rural sites, but also in three urban/peri-urban sites.
- Gaps were more pronounced for lactating women.
- Simple indicators of food group diversity were meaningfully related to micronutrient adequacy in both the rural and urban/peri-urban sites.
- Relationships between FGI scores and nutrient adequacy may vary by season, as evidenced by the strong impact of mango season on the Mozambique sample. This should be considered if FGIs are used to compare across time or between regions with different agricultural cycles.
- Due to low distributions of MPA in all sites, indicators of "good" nutrient adequacy could not be explored. The best indicator performance was found for the lowest MPA cutoff tested (0.50); below an MPA of 0.50, diets could be described as very poor.
- FGIs that imposed a minimum of 15 g for a food group to "count" performed better than those that did not.
- In four of five sites (all but Mali), the three best candidate indicators were FGI-9R, FGI-13R and FGI-21R.

[54] See individual site reports for more information.
[55] The sample size for Bangladesh in this analysis was similar to the sample size from Mozambique. However, the Bangladesh data were drawn from a much larger sample of women and data were collected for all household members in the Bangladesh site (see Arimond et al. 2009 for details).
[56] See, e.g., Launer et al. 1991; Berti and Leonard 1998; Ferrari et al. 2008.

- Sensitivity and specificity analyses showed that no indicator and no cutoff yielded an acceptable balance of sensitivity, specificity and misclassification across all sites.

Several of our conclusions have practical implications for FGI data collection efforts. As the "restricted" FGIs performed better than "non-restricted" ones, we suggest that questionnaire design should reflect this. Methods for excluding trivial amounts should be incorporated in questionnaire design and interviewer training. Also, we note that the least disaggregated FGIs (6 group indicators) generally did not perform well, so we recommend selection of more disaggregated FGIs. However, the highest levels of disaggregation may present challenges related to classification of foods into groups. This may be challenging both at the level of questionnaire design and at the level of data collection. We note that both exclusion of trivial amounts and disaggregation of food into groups require good knowledge of local food habits and recipes.

Finally, while our results do not support the selection of a particular indicator with a particular diversity cutoff for global use, they support the relevance of simple indicators to reflect diet quality. They may provide some basis for site-specific indicators. They also provide support for the use of FGIs that reflect country-level food-based dietary guidelines, where such guidelines exist. Our results add to the evidence base that such indicators may be meaningful both in rural areas, where diets are very monotonous, and in urban/peri-urban areas, where diets may be more balanced at the level of macronutrient intake, but remain micronutrient-poor.

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Appendix 1. Estimated Average Requirements

Note that WHO/FAO requirements are not given separately for pregnant or lactating adolescents. For girls aged 15-18 who were pregnant or lactating, we used the requirements for pregnant/lactating adult women for most nutrients, as the requirements are higher. The exception to this is calcium, for which the requirement is higher for adolescents (1,300 mg/d), so this value (US AI) was used for pregnant and lactating adolescents.

Table A1-1. EAR to be Used for Assessing PA [a, b]

	Females 19-50 years		Females 15-18 years		Pregnant women		Lactating women	
	EAR	**SD [c]**	**EAR**	**SD [c]**	**EAR**	**SD [c]**	**EAR**	**SD [c]**
Vit A (RE/d) [d]	270 [e]	54	365 [e]	73	370[e]	74	450 [e]	90
Vit C (mg/d)	38 [f]	3.8	33 [f]	3.3	46 [f]	4.6	58 [f]	5.8
Thiamin (mg/d)	0.9 [f]	0.09	0.9 [f]	0.09	1.2 [f]	0.12	1.2 [f]	0.12
Riboflavin (mg/d)	0.9 [f]	0.09	0.8 [f]	0.08	1.2 [f]	0.12	1.3 [f]	0.13
Niacin (mg/d)	11 [f]	1.6	12 [f]	1.8	14 [f]	2.1	13 [f]	2.0
Vit B_6 (mg/d)	1.1 [f]	0.11	1.0 [f]	0.1	1.6 [f]	0.16	1.7 [f]	0.17
Folate (µg/d)	320 [e]	32	330 [e]	33	520 [e]	52.0	450 [e]	45.0
Vit B_{12} (µg/d)	2.0 [e]	0.2	2.0 [e]	0.2	2.2 [e]	0.22	2.4 [e]	0.24
Calcium (mg/d) [g]	1,000	-	1,300	-	1,000		1,000	
Iron (mg/d)	See table A6-2	-	See Table A6-3	-	22 [h]	2.07	10% bioavail: 11.7 [i]	3.51
							5% bioavail: 23.40	7.02
Zinc (mg/d)	Lower bioavail: 7 [j]	0.88	Lower bioavail: 9	1.13	Lower bioavail: 10	1.25	Lower bioavail: 8	1.00
	Higher bioavail: 6 [k]	0.75	Higher bioavail: 7	0.88	Higher bioavail: 8	1.0	Higher bioavail: 7	0.88

[a] All values are taken from WHO/FAO (2004) unless otherwise stated.
[b] Values for EAR are adjusted for an assumed bioavailability (WHO/FAO 2004). Thus, EAR refers to intake of the nutrients and not the physiological need for the absorbed nutrient.
[c] All SDs were calculated based on EAR and CV (SD = CV*EAR/100). CV is assumed to be 10 percent for all micronutrients except 15 percent for niacin (IOM 2000a), 20 percent for vitamin A (IOM 2000a), and 12.5 percent for zinc (IZiNCG 2004), 9.4 percent and 30 percent for iron, for pregnant and lactating women, respectively (IOM 2000a).
[d] One µg RE is equal to 1 µg all-trans-retinol, 6 µg β-carotene and 12 µg α-carotene or β-cryptoxanthin (WHO/FAO 2004). Note also the EAR for vitamin A refers to intake adequate to prevent the appearance of deficiency-related syndromes (WHO/FAO 2004).
[e] EAR taken from WHO/FAO (2004).
[f] EAR back-calculated from RNI (Recommended Nutrient Intake) (WHO/FAO 2004).
[g] This is not an EAR, but rather AI from IOM (1997). Following Foote et al. (2004), we calculate probabilities of adequacy to be 0 percent when intake ≤ 1/4 of the AI; 25 percent for intakes > 1/4 and ≤ 1/2 of the AI; 50 percent for intakes > 1/2 and ≤ 3/4 of the AI; 75 percent for intakes > 3/4 and ≤ AI; and 100 percent for intakes above the AI.
[h] EAR for iron intake, as presented in IOM (2000a, page 347). IOM estimates that bioavailability is 18 percent in the first trimester and 25 percent in the second and third. As information on month of pregnancy will not be available in most data sets, a weighted average of 23 percent absorption was used for all pregnant women.
[i] Gives EAR for iron for two levels of absorption for lactating women, based on IOM (2006). According to WHO/FAO (2004), either a very low (5 percent) or low (10 percent) absorption level can be assumed in a developing country setting.
[j] This is the estimated median requirement of zinc to be used for diets with a lower bioavailability (unrefined, cereal based diets), as suggested by IZiNCG (2004).
[k] This is the estimated median requirement of zinc to be used for diets with a higher bioavailability (mixed or refined vegetarian diets), as suggested by IZiNCG (2004).

Table A1-2. PA of Iron (mg/d) and Associated Ranges of Usual Intake in Adult Women Not Using Oral Contraceptives (OC) [a]

PA	Total absorbed iron	10% bioavailability	5% bioavailability
0	<0.796	<7.96	<15.91
0.04	0.796-0.879	7.96-8.79	15.91-17.59
0.07	0.880-0.981	8.80-9.81	17.60-19.65
0.15	0.982-1.120	9.82-11.20	19.66-22.42
0.25	1.121-1.237	11.21-12.37	22.43-24.76
0.35	1.238-1.343	12.38-13.43	24.77-26.88
0.45	1.344-1.453	13.44-14.53	26.89-29.08
0.55	1.454-1.577	14.54-15.77	29.09-31.56
0.65	1.578-1.734	15.78-17.34	31.57-34.69
0.75	1.735-1.948	17.35-19.48	34.70-38.98
0.85	1.949-2.349	19.49-23.49	38.99-47.01
0.92	2.350-2.789	23.50-27.89	47.02-55.79
0.96	2.790-3.281	27.90-32.81	55.80-65.63
1	>3.28	>32.81	>65.63

[a] This table was adapted from Table G-7 in IOM (2006), which gives PA for various levels of iron intake, assuming 18 percent absorption. In order to construct the table above, the associated level of *absorbed* iron was back-calculated from Table G-7. The table above presents usual intake levels to achieve the same amount of absorbed iron, but adjusted for absorption at two lower levels (10 percent and 5 percent).

Table A1-3. PA of Iron (mg/d) and Associated Ranges of Usual Intake in Adolescent Girls (15-18 Years) Not Using Oral Contraceptives (OC) [a]

PA	Total absorbed iron	10% bioavailability	5% bioavailability
0	<0.833	<8.33	<16.67
0.04	0.833-0.911	8.33-9.11	16.67-18.22
0.07	0.912-1.010	9.12-10.10	18.23-20.20
0.15	1.011-1.136	10.11-11.36	20.21-22.72
0.25	1.137-12.37	11.37-12.37	22.73-24.73
0.35	1.238-1.330.	12.38-13.30	24.74-26.60
0.45	1.331-1.424	13.31-14.24	26.61-28.49
0.55	1.425-1.526	14.25-15.26	28.50-30.53
0.65	1.526-1.647	15.27-16.47	30.54-32.94
0.75	1.648-1.805	16.48-18.05	32.95-26.11
0.85	1.806-2.077	18.06-20.77	36.12-41.54
0.92	2.078-2.354	20.78-23.54	41.55-47.09
0.96	2.355-2.664	23.55-26.64	47.10-53.28
1	>2.664	>26.64	>53.28

[a] This table was adapted from Table G-6 in IOM (2006), which gives PA for various levels of iron intake, assuming 18 percent absorption. In order to construct the table above, the associated level of *absorbed* iron was back-calculated from Table G-6. The table above presents usual intake levels to achieve the same amount of absorbed iron, but adjusted for absorption at two lower levels (10 percent and 5 percent).

DISCUSSION ON THE SELECTION OF EAR AND CV

Vitamin A

According to WHO/FAO,[57] the CV for vitamin A requirements is unknown. IOM, however, has used 20 percent. The WDDP uses the EAR of WHO/FAO with a CV of 20 percent. For adolescents (ages 15-18), WHO/FAO give a range for the EAR of 330-400 µg/d. The WDDP uses the mid-point of this range.

Calcium

WHO/FAO's EAR for calcium is quite high, and based on WDDP working group discussions, the justification for these high levels does not appear to be strong/persuasive. The group therefore proposed to use the method described in Foote et al.,[58] which takes the AI of 1,000 mg/d as a starting point (or 1,300 mg/d for adolescents). The DRI include AI when insufficient evidence is available to set an EAR and CV. The AI is an observed estimate of nutrient intake by a defined group of healthy people. Some seemingly healthy individuals may require higher intakes and some individuals may be at low risk on even lower intakes. The AI is believed to cover their needs, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.[59] An individual with a usual intake of calcium at or above AI can be assumed to have an AI. Foote et al.[60] estimated probabilities of adequacy as follows:

0 percent when intake ≤ 1/4 of the AI,
25 percent for intakes > 1/4 and ≤ 1/2 of the AI,
50 percent for intakes > 1/2 and ≤ 3/4 of the AI,
75 percent for intakes > 3/4 and ≤ AI,
100 percent for intakes above the AI.

The AI is the same for pregnant and lactating women and adolescents and for NPNL women (1,000 mg/d for women and 1,300 mg/d for adolescents).

Iron

For estimating the probability of AI of iron for NPNL women the WDDP used a modified version of the PA tables in IOM.[61] The table is based on an assumption of 18 percent absorption, which is higher than expected in most developing country settings. The WDDP adjusted the table to find the PA for the two levels of absorption: five percent and ten percent. The tables above (one for adult women and one for adolescents) are thus entirely based on IOM.[62] Each researcher must select an assumed level of absorption (five percent or ten percent), based on his/her own expertise/knowledge of the local food intake.

For pregnant and lactating women, CVs have been given by the IOM. We therefore used the usual method of EAR for estimating PA for these two groups.

For pregnant women, the WDDP used the EAR suggested by IOM, because WHO/FAO[63] does not provide a requirement level for pregnant women. However, WHO and FAO state that iron absorption can increase up to approximately four times NPNL levels by the third trimester. Therefore, using IOM requirements – which assume 18 percent absorption in first trimester and 25 percent absorption in

[57] 2004.
[58] 2004.
[59] IOM 1997.
[60] 2004.
[61] Table I-6 and I-7; 2000b.
[62] 2000b.
[63] 2004.

second and third trimesters – seems reasonable, in the absence of more specific guidance from WHO and FAO on absorption during pregnancy.

For lactating women, IOM gives an EAR for iron intake of 6.5 mg/d, assuming 18 percent absorption. We calculated the EAR of absorbed iron (6.5 mg times 18/100) as 1.17 mg/d. This is similar to the WHO/FAO EAR for lactating women (1.1 mg/day).[64] In the table above, we give EARs for two levels of absorption (five percent and ten percent). Researchers should apply the same levels of absorption as used for NPNL women. This study used coefficient of variation from IOM (30 percent) for lactating women.

Zinc

IZiNCG recently presented revised dietary zinc requirements, including EAR.[65] It also estimated a CV for the requirement distribution of 12.5 percent, indicating a narrower requirement distribution than implied by the WHO/FAO[66] CV of 25 percent. Hotz[67] assessed the internal validity of these new requirements and found that they predicted zinc status. They also yielded similar estimates of prevalence of zinc deficiency as did biochemical indicators, including among pregnant and non-pregnant women. Therefore, we adopted these requirements for the purposes of the WDDP.

As with the WHO/FAO requirements, researchers must choose a requirement depending on an assumption for absorption, which is based on knowledge of diet patterns and likely bioavailability. For mixed or refined vegetarian diets (with a phytate to zinc molar ratio of 4-18) an absorption level of 34 percent is suggested. For high phytate, unrefined cereal-based diets (molar ratio greater than 18), an absorption level of 25 percent is suggested.[68] Note that the level of absorption IZiNCG suggests for high phytate diets (25 percent) is considerably higher than the absorption level suggested by the WHO/FAO requirements document (15 percent).

[64] WHO/FAO 2004, page 265.
[65] IZiNCG 2004.
[66] 2004.
[67] 2007.
[68] IZiNCG 2004.

Appendix 2. Summary of Tests Comparing Area Under the Curve for Food Group Diversity Indicators

The results of tests comparing AUC are summarized in the following table. The table shows all significant differences between AUC for different FGI for NPNL women, by study site.

In interpreting the results below, note that sample sizes (larger in Bangladesh and far larger in the Philippines) influence the size of AUC differences that are detected as significantly different.

Study Site	Cutoff of MPA > 0.50	Cutoff of MPA > 0.60	Cutoff of MPA > 0.70
Burkina Faso	AUC for FGI-13R greater than for FGI-13 AUC for FGI-21R greater than for FGI-6, FGI-6R, FGI-13	AUC for FGI-13R greater than for FGI-13 AUC for FGI-21R greater than for all others except FGI-9, FGI-13R	AUC for FGI-21R greater than for FGI-6, FGI-6R, FGI-9R
Mali	No significant differences between AUC	AUC for FGI-6R, FGI-9R, FGI-13R, each greater than for FGI-13	AUC for FGI-6 greater than for FGI-9, FGI-13, FGI-21, FGI-21R AUC for FGI-6R greater than for all others except FGI-6 AUC for FGI-13, FGI-21 lower than for all others; difference between FGI-13 and FGI-21 not significant AUC for FGI-9R greater than for FGI-9, FGI-21R
Mozambique	AUC for FGI-21 greater than for FGI-6, FGI-9, FGI-13 AUC for FGI-21R greater than for all except FGI-13, FGI-21	AUC for FGI-21 greater than for FGI-6, FGI-9, FGI-13 AUC for FGI-21R greater for all others except FGI-21	AUC for FGI-21 greater than for FGI-6, FGI-6R, FGI-9, FGI-13 AUC for FGI-21R greater for all except for FGI-21
Bangladesh	AUC for FGI-6 is lower than all others AUC for FGI-9R is greater than for FGI-9 AUC for FGI-13R is greater than for FGI-9, FGI-13, FGI-21 (all 1 g indicators)	AUC for FGI-6 lower than all others except for FGI-21 AUC for FGI-13R greater than for FGI-6, FGI-6R, FGI-21	AUC for FGI-6 lower than for all except for FGI-9R, FGI-21R
Philippines	AUC for FGI-6 lower than all except for FGI-6R AUC for FGI-6R lower than for FGI-9R, FGI-13R, FGI-21, FGI-21R AUC for FGI-21R greater than for all othersAUC for FGI-9R greater than for FGI-13AUC for FGI-21 greater than for FGI-9, FGI-13	AUC for FGI-6 lower than all others except FGI-6R, FGI-13 AUC for FGI-6R lower than for FGI-9R, FGI-13R, FGI-21, FGI-21R AUC for FGI-21R greater than for all othersAUC for FGI-9 greater than for FGI-13 AUC for FGI-21 greater than for FGI-9 and FGI-13	AUC for FGI-6 lower than all except for FGI-6R AUC for FGI-6R lower than for FGI-9R, FGI-13R, FGI-21R AUC for FGI-21R greater than for all others AUC for FGI-9R greater than for FGI-9, FGI-13 AUC for FGI-13R greater than for FGI-13 AUC for FGI-21 greater than for FGI-13

Appendix 3. Indicator Characteristics for Three Best Candidate Food Group Diversity Indicators (FGI-9R, FGI-13R, FGI-21R), by Study Site

Table A3-1. Indicator Characteristics for FGI-9R, Burkina Faso

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
130	≥ 1	100.0	0.0	72.3	0.0	72
130	≥ 2	100.0	0.0	72.3	0.0	72
125	≥ 3	100.0	5.3	68.5	0.0	69
98	≥ 4	88.9	29.8	50.8	3.1	54
56	≥ 5	66.7	66.0	24.6	9.2	34
19	≥ 6	36.1	93.6	4.6	17.7	22
2	≥ 7	5.6	100.0	0.0	26.2	26
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.60		
130	≥ 1	100.0	0.0	84.6	0.0	85
130	≥ 2	100.0	0.0	84.6	0.0	85
125	≥ 3	100.0	4.5	80.8	0.0	81
98	≥ 4	100.0	29.1	60.0	0.0	60
56	≥ 5	60.0	60.0	33.8	6.2	40
19	≥ 6	30.0	88.2	10.0	10.8	21
2	≥ 7	5.0	99.1	0.8	14.6	15
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.70		
130	≥ 1	100.0	0.0	90.8	0.0	91
130	≥ 2	100.0	0.0	90.8	0.0	91
125	≥ 3	100.0	4.2	86.9	0.0	87
98	≥ 4	100.0	27.1	66.2	0.0	66
56	≥ 5	58.3	58.5	37.7	3.8	42
19	≥ 6	16.7	85.6	13.1	7.7	21
2	≥ 7	0.0	98.3	1.5	9.2	11
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-2. Indicator Characteristics for FGI-9R, Mali

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
102	≥ 1	100.0	0.0	53.9	0.0	54
102	≥ 2	100.0	0.0	53.9	0.0	54
100	≥ 3	100.0	3.6	52.0	0.0	52
84	≥ 4	97.9	30.9	37.3	1.0	38
43	≥ 5	61.7	74.5	13.7	17.6	31
15	≥ 6	27.7	96.4	2.0	33.3	35
4	≥ 7	4.3	96.4	2.0	44.1	46
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.60		
102	≥ 1	100.0	0.0	75.5	0.0	76
102	≥ 2	100.0	0.0	75.5	0.0	76
100	≥ 3	100.0	2.6	73.5	0.0	74
84	≥ 4	100.0	23.4	57.8	0.0	58
43	≥ 5	64.0	64.9	26.5	8.8	35
15	≥ 6	28.0	89.6	7.8	17.6	26
4	≥ 7	0.0	94.8	3.9	24.5	28
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.70		
102	≥ 1	100.0	0.0	89.2	0.0	89
102	≥ 2	100.0	0.0	89.2	0.0	89
100	≥ 3	100.0	2.2	87.3	0.0	87
84	≥ 4	100.0	19.8	71.6	0.0	72
43	≥ 5	81.8	62.6	33.3	2.0	35
15	≥ 6	36.4	87.9	10.8	6.9	18
4	≥ 7	0.0	95.6	3.9	10.8	15
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-3. Indicator Characteristics for FGI-9R, Mozambique

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
103	≥ 1	100.0	0.0	38.8	0.0	39
103	≥ 2	100.0	0.0	38.8	0.0	39
97	≥ 3	100.0	15.0	33.0	0.0	33
60	≥ 4	69.8	60.0	15.5	18.4	34
9	≥ 5	14.3	100.0	0.0	52.4	52
1	≥ 6	1.6	100.0	0.0	60.2	60
0	≥ 7	–	–	–	–	–
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.60		
103	≥ 1	100.0	0.0	54.4	0.0	54
103	≥ 2	100.0	0.0	54.4	0.0	54
97	≥ 3	100.0	10.7	48.5	0.0	49
60	≥ 4	70.2	51.8	26.2	13.6	40
9	≥ 5	14.9	96.4	1.9	38.8	41
1	≥ 6	0.0	98.2	1.0	45.6	47
0	≥ 7	–	–	–	–	–
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.70		
103	≥ 1	100.0	0.0	75.7	0.0	76
103	≥ 2	100.0	0.0	75.7	0.0	76
97	≥ 3	100.0	7.7	69.9	0.0	70
60	≥ 4	68.0	44.9	41.7	7.8	50
9	≥ 5	16.0	93.6	4.9	20.4	25
1	≥ 6	0.0	98.7	1.0	24.3	25
0	≥ 7	–	–	–	–	–
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-4. Indicator Characteristics for FGI-9R,Bangladesh

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
299	≥ 1	100.0	0.0	80.3	0.0	80
297	≥ 2	100.0	0.8	79.6	0.0	80
251	≥ 3	100.0	20.0	64.2	0.0	64
160	≥ 4	83.1	53.8	37.1	3.3	41
63	≥ 5	44.1	84.6	12.4	11.0	23
11	≥ 6	5.1	96.7	2.7	18.7	21
1	≥ 7	0.0	99.6	0.3	19.7	20
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.60		
299	≥ 1	100.0	0.0	93.0	0.0	93
297	≥ 2	100.0	0.7	92.3	0.0	92
251	≥ 3	100.0	17.3	76.9	0.0	77
160	≥ 4	95.2	49.6	46.8	0.3	47
63	≥ 5	66.7	82.4	16.4	2.3	19
11	≥ 6	14.3	97.1	2.7	6.0	9
1	≥ 7	0.0	99.6	0.3	7.0	7
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.70		
299	≥ 1	100.0	0.0	96.0	0.0	96
297	≥ 2	100.0	0.7	95.3	0.0	95
251	≥ 3	100.0	16.7	79.9	0.0	80
160	≥ 4	91.7	48.1	49.8	0.3	50
63	≥ 5	66.7	80.8	18.4	1.3	20
11	≥ 6	25.0	97.2	2.7	3.0	6
1	≥ 7	0.0	99.7	0.3	4.0	4
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-5. Indicator Characteristics for FGI-9R,Philippines

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
1798	≥ 1	100.0	0.0	73.2	0.0	73
1776	≥ 2	100.0	1.7	72.0	0.0	72
1307	≥ 3	85.5	32.0	49.8	3.9	54
729	≥ 4	56.8	65.4	25.3	11.6	37
277	≥ 5	28.8	89.5	7.7	19.1	27
67	≥ 6	9.3	98.3	1.2	24.3	26
8	≥ 7	1.5	99.9	0.1	26.4	27
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.60		
1798	≥ 1	100.0	0.0	84.2	0.0	84
1776	≥ 2	100.0	1.5	83.0	0.0	83
1307	≥ 3	87.3	30.1	58.9	2.0	61
729	≥ 4	60.6	63.2	31.0	6.2	37
277	≥ 5	34.2	88.1	10.0	10.4	20
67	≥ 6	12.0	97.8	1.8	13.9	16
8	≥ 7	1.4	99.7	0.2	15.6	16
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–
				MPA > 0.70		
1798	≥ 1	100.0	0.0	92.5	0.0	93
1776	≥ 2	100.0	1.3	91.3	0.0	91
1307	≥ 3	90.3	28.7	66.0	0.7	67
729	≥ 4	70.1	61.8	35.3	2.2	38
277	≥ 5	41.0	86.7	12.3	4.4	17
67	≥ 6	14.9	97.2	2.6	6.3	9
8	≥ 7	2.2	99.7	0.3	7.3	8
0	≥ 8	–	–	–	–	–
0	9	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-6. Indicator Characteristics for FGI-13R,Burkina Faso

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
130	≥ 1	100	0	72.3	0.0	72
130	≥ 2	100	0	72.3	0.0	72
126	≥ 3	100	4	69.2	0.0	69
101	≥ 4	89	27	53.1	3.1	56
67	≥ 5	78	59	30.0	6.2	36
29	≥ 6	50	88	8.5	13.8	22
9	≥ 7	17	97	2.3	23.1	25
1	≥ 8	3	100	0.0	26.9	27
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.60		
130	≥ 1	100	0	84.6	0.0	85
130	≥ 2	100	0	84.6	0.0	85
126	≥ 3	100	4	81.5	0.0	82
101	≥ 4	100	26	62.3	0.0	62
67	≥ 5	80	54	39.2	3.1	42
29	≥ 6	50	83	14.6	7.7	22
9	≥ 7	15	95	4.6	13.1	18
1	≥ 8	0	99	0.8	15.4	16
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.70		
130	≥ 1	100	0	90.8	0.0	91
130	≥ 2	100	0	90.8	0.0	91
126	≥ 3	100	3	87.7	0.0	88
101	≥ 4	100	25	68.5	0.0	69
67	≥ 5	92	53	43.1	0.8	44
29	≥ 6	42	80	18.5	5.4	24
9	≥ 7	8	93	6.2	8.5	15
1	≥ 8	0	99	0.8	9.2	10
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-7. Indicator Characteristics for FGI-13R,Mali

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
102	≥ 1	100	0	53.9	0.0	54
102	≥ 2	100	0	53.9	0.0	54
101	≥ 3	100	2	52.9	0.0	53
91	≥ 4	98	18	44.1	1.0	45
59	≥ 5	79	60	21.6	9.8	31
31	≥ 6	47	84	8.8	24.5	33
12	≥ 7	19	95	2.9	37.3	40
5	≥ 8	6	96	2.0	43.1	45
1	≥ 9	2	100	0.0	45.1	45
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.60		
102	≥ 1	100	0	75.5	0.0	76
102	≥ 2	100	0	75.5	0.0	76
101	≥ 3	100	1	74.5	0.0	75
91	≥ 4	100	14	64.7	0.0	65
59	≥ 5	80	49	38.2	4.9	43
31	≥ 6	48	75	18.6	12.7	31
12	≥ 7	20	91	6.9	19.6	27
5	≥ 8	4	95	3.9	23.5	28
1	≥ 9	0	99	1.0	24.5	26
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.70		
102	≥ 1	100	0	89.2	0.0	89
102	≥ 2	100	0	89.2	0.0	89
101	≥ 3	100	1	88.2	0.0	88
91	≥ 4	100	12	78.4	0.0	78
59	≥ 5	82	45	49.0	2.0	51
31	≥ 6	55	73	24.5	4.9	29
12	≥ 7	9	88	10.8	9.8	21
5	≥ 8	0	95	4.9	10.8	16
1	≥ 9	0	99	1.0	10.8	12
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-8. Indicator Characteristics for FGI-13R,Mozambique

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
103	≥ 1	100	0	38.8	0.0	39
103	≥ 2	100	0	38.8	0.0	39
96	≥ 3	98	15	33.0	1.0	34
67	≥ 4	76	53	18.4	14.6	33
22	≥ 5	30	93	2.9	42.7	46
6	≥ 6	10	100	0.0	55.3	55
1	≥ 7	2	100	0.0	60.2	60
0	≥ 8	–	–	–	–	–
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.60		
103	≥ 1	100	0	54.4	0.0	54
103	≥ 2	100	0	54.4	0.0	54
96	≥ 3	98	11	48.5	1.0	50
67	≥ 4	79	46	29.1	9.7	39
22	≥ 5	32	88	6.8	31.1	38
6	≥ 6	9	96	1.9	41.7	44
1	≥ 7	0	98	1.0	45.6	47
0	≥ 8	–	–	–	–	–
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.70		
103	≥ 1	100	0	75.7	0.0	76
103	≥ 2	100	0	75.7	0.0	76
96	≥ 3	100	9	68.9	0.0	69
67	≥ 4	80	40	45.6	4.9	51
22	≥ 5	32	82	13.6	16.5	30
6	≥ 6	8	95	3.9	22.3	26
1	≥ 7	0	99	1.0	24.3	25
0	≥ 8	–	–	–	–	–
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-9. Indicator Characteristics for FGI-13R,Bangladesh

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
299	≥ 1	100	0	80.3	0.0	80
295	≥ 2	100	2	78.9	0.0	79
250	≥ 3	98	20	64.2	0.3	65
165	≥ 4	85	52	38.5	3.0	42
83	≥ 5	61	80	15.7	7.7	23
23	≥ 6	14	94	5.0	17.1	22
9	≥ 7	3	97	2.3	19.1	21
1	≥ 8	0	100	0.3	19.7	20
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.60		
299	≥ 1	100	0	93.0	0.0	93
295	≥ 2	100	1	91.6	0.0	92
250	≥ 3	100	18	76.6	0.0	77
165	≥ 4	95	48	48.5	0.3	49
83	≥ 5	91	77	21.4	0.7	22
23	≥ 6	19	93	6.4	5.7	12
9	≥ 7	5	97	2.7	6.7	9
1	≥ 8	0	100	0.3	7.0	7
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.70		
299	≥ 1	100	0	96.0	0.0	96
295	≥ 2	100	1	94.6	0.0	95
250	≥ 3	100	17	79.6	0.0	80
165	≥ 4	92	46	51.5	0.3	52
83	≥ 5	92	75	24.1	0.3	24
23	≥ 6	25	93	6.7	3.0	10
9	≥ 7	8	97	2.7	3.7	6
1	≥ 8	0	100	0.3	4.0	4
0	≥ 9	–	–	–	–	–
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-10. Indicator Characteristics for FGI-13R,Philippines

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
1798	≥ 1	100	0	73.2	0.0	73
1772	≥ 2	100	2	71.7	0.0	72
1313	≥ 3	86	32	50.1	3.9	54
783	≥ 4	59	62	27.8	11.0	39
388	≥ 5	36	84	11.9	17.1	29
144	≥ 6	17	95	3.4	22.2	26
42	≥ 7	6	99	0.8	25.3	26
7	≥ 8	1	100	0.1	26.5	27
1	≥ 9	0	100	0.0	26.8	27
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.60		
1798	≥ 1	100	0	84.2	0.0	84
1772	≥ 2	100	2	82.8	0.0	83
1313	≥ 3	87	30	59.3	2.1	61
783	≥ 4	63	60	33.6	5.9	40
388	≥ 5	42	82	15.0	9.2	24
144	≥ 6	22	95	4.6	12.4	17
42	≥ 7	7	99	1.2	14.7	16
7	≥ 8	1	100	0.2	15.6	16
1	≥ 9	0	100	0.0	15.7	16
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–
				MPA > 0.70		
1798	≥ 1	100	0	92.5	0.0	93
1772	≥ 2	100	2	91.1	0.0	91
1313	≥ 3	90	28	66.4	0.8	67
783	≥ 4	72	59	38.2	2.1	40
388	≥ 5	51	81	17.8	3.7	22
144	≥ 6	28	94	6.0	5.4	11
42	≥ 7	8	98	1.7	6.8	9
7	≥ 8	2	100	0.2	7.3	8
1	≥ 9	1	100	0.0	7.4	7
0	≥10	–	–	–	–	–
0	≥11	–	–	–	–	–
0	≥12	–	–	–	–	–
0	13	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-11. Indicator Characteristics for FGI-21R,Burkina Faso

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
130	≥ 1	100	0	72.3	0.0	72
130	≥ 2	100	0	72.3	0.0	72
126	≥ 3	100	4	69.2	0.0	69
107	≥ 4	89	20	57.7	3.1	61
73	≥ 5	83	54	33.1	4.6	38
48	≥ 6	75	78	16.2	6.9	23
15	≥ 7	25	94	4.6	20.8	25
5	≥ 8	11	99	0.8	24.6	25
1	≥ 9	3	100	0.0	26.9	27
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–
				MPA > 0.60		
130	≥ 1	100	0	84.6	0.0	85
130	≥ 2	100	0	84.6	0.0	85
126	≥ 3	100	4	81.5	0.0	82
107	≥ 4	100	21	66.9	0.0	67
73	≥ 5	90	50	42.3	1.5	44
48	≥ 6	80	71	24.6	3.1	28
15	≥ 7	30	92	6.9	10.8	18
5	≥ 8	10	97	2.3	13.8	16
1	≥ 9	0	99	0.8	15.4	16
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

(continued)

Table A3-11 (continued). Indicator Characteristics for FGI-21R,Burkina Faso

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.70		
130	≥ 1	100	0	90.8	0.0	91
130	≥ 2	100	0	90.8	0.0	91
126	≥ 3	100	3	87.7	0.0	88
107	≥ 4	100	20	73.1	0.0	73
73	≥ 5	100	48	46.9	0.0	47
48	≥ 6	83	68	29.2	1.5	31
15	≥ 7	25	90	9.2	6.9	16
5	≥ 8	17	98	2.3	7.7	10
1	≥ 9	0	99	0.8	9.2	10
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-12. Indicator Characteristics for FGI-21R,Mali

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
102	≥ 1	100	0	53.9	0.0	54
102	≥ 2	100	0	53.9	0.0	54
101	≥ 3	100	2	52.9	0.0	53
94	≥ 4	98	13	47.1	1.0	48
76	≥ 5	87	36	34.3	5.9	40
50	≥ 6	72	71	15.7	12.7	28
25	≥ 7	40	89	5.9	27.5	33
12	≥ 8	19	95	2.9	37.3	40
5	≥ 9	6	96	2.0	43.1	45
2	≥ 10	2	98	1.0	45.1	46
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

(continued)

Table A3-12 (continued). Indicator Characteristics for FGI-21R,Mali

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.60		
102	≥ 1	100	0	75.5	0.0	76
102	≥ 2	100	0	75.5	0.0	76
101	≥ 3	100	1	74.5	0.0	75
94	≥ 4	100	10	67.6	0.0	68
76	≥ 5	92	31	52.0	2.0	54
50	≥ 6	68	57	32.4	7.8	40
25	≥ 7	44	82	13.7	13.7	28
12	≥ 8	16	90	7.8	20.6	28
5	≥ 9	0	94	4.9	24.5	29
2	≥ 10	0	97	2.0	24.5	27
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–
				MPA > 0.70		
102	≥ 1	100	0	89.2	0.0	89
102	≥ 2	100	0	89.2	0.0	89
101	≥ 3	100	1	88.2	0.0	88
94	≥ 4	100	9	81.4	0.0	81
76	≥ 5	100	29	63.7	0.0	64
50	≥ 6	73	54	41.2	2.9	44
25	≥ 7	46	78	19.6	5.9	26
12	≥ 8	9	88	10.8	9.8	21
5	≥ 9	0	95	4.9	10.8	16
2	≥ 10	0	98	2.0	10.8	13
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-13. Indicator Characteristics for FGI-21R,Mozambique

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
103	≥ 1	100	0	38.8	0.0	39
103	≥ 2	100	0	38.8	0.0	39
99	≥ 3	100	10	35.0	0.0	35
76	≥ 4	86	45	21.4	8.7	30
45	≥ 5	60	83	6.8	24.3	31
14	≥ 6	22	100	0.0	47.6	48
7	≥ 7	11	100	0.0	54.4	54
1	≥ 8	2	100	0.0	60.2	60
0	≥ 9	–	–	–	–	–
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–
				MPA > 0.60		
103	≥ 1	100	0	54.4	0.0	54
103	≥ 2	100	0	54.4	0.0	54
99	≥ 3	100	7	50.5	0.0	51
76	≥ 4	87	38	34.0	5.8	40
45	≥ 5	66	75	13.6	15.5	29
14	≥ 6	26	96	1.9	34.0	36
7	≥ 7	11	96	1.9	40.8	43
1	≥ 8	2	100	0.0	44.7	45
0	≥ 9	–	–	–	–	–
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

(continued)

Table A3-13 (continued). Indicator Characteristics for FGI-21R,Mozambique

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.70		
103	≥ 1	100	0	75.7	0.0	76
103	≥ 2	100	0	75.7	0.0	76
99	≥ 3	100	5	71.8	0.0	72
76	≥ 4	88	31	52.4	2.9	55
45	≥ 5	68	64	27.2	7.8	35
14	≥ 6	32	92	5.8	16.5	22
7	≥ 7	12	95	3.9	21.4	25
1	≥ 8	4	100	0.0	23.3	23
0	≥ 9	–	–	–	–	–
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-14. Indicator Characteristics for FGI-21R,Bangladesh

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
299	≥ 1	100	0	80.3	0.0	80
297	≥ 2	100	1	79.6	0.0	80
271	≥ 3	98	11	71.2	0.3	72
211	≥ 4	88	34	53.2	2.3	56
132	≥ 5	75	63	29.4	5.0	34
67	≥ 6	46	83	13.4	10.7	24
25	≥ 7	19	94	4.7	16.1	21
7	≥ 8	5	98	1.3	18.7	20
2	≥ 9	0	99	0.7	19.7	20
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

(continued)

Table A3-14 (continued). Indicator Characteristics for FGI-21R,Bangladesh

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.60		
299	≥ 1	100	0	93.0	0.0	93
297	≥ 2	100	1	92.3	0.0	92
271	≥ 3	100	10	83.6	0.0	84
211	≥ 4	95	31	63.9	0.3	64
132	≥ 5	95	60	37.5	0.3	38
67	≥ 6	62	81	18.1	2.7	21
25	≥ 7	24	93	6.7	5.4	12
7	≥ 8	0	98	2.3	7.0	9
2	≥ 9	0	99	0.7	7.0	8
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–
				MPA > 0.70		
299	≥ 1	100	0	96.0	0.0	96
297	≥ 2	100	1	95.3	0.0	95
271	≥ 3	100	10	86.6	0.0	87
211	≥ 4	92	30	66.9	0.3	67
132	≥ 5	92	58	40.5	0.3	41
67	≥ 6	75	80	19.4	1.0	20
25	≥ 7	33	93	7.0	2.7	10
7	≥ 8	0	98	2.3	4.0	6
2	≥ 9	0	99	0.7	4.0	5
0	≥ 10	–	–	–	–	–
0	≥ 11	–	–	–	–	–
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Table A3-15. Indicator Characteristics for FGI-21R,Philippines

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.50		
1798	≥ 1	100	0	73.2	0.0	73
1769	≥ 2	100	2	71.6	0.0	72
1547	≥ 3	97	18	60.0	0.7	61
1108	≥ 4	83	46	39.3	4.4	44
647	≥ 5	59	72	20.3	11.1	31
335	≥ 6	34	87	9.6	17.8	27
164	≥ 7	20	95	3.8	21.5	25
59	≥ 8	9	99	0.9	24.4	25
20	≥ 9	3	100	0.3	26.0	26
5	≥ 10	1	100	0.1	26.6	27
1	≥ 11	0	100	0.0	26.8	27
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–
				MPA > 0.60		
1798	≥ 1	100	0	84.2	0.0	84
1769	≥ 2	100	2	82.6	0.0	83
1547	≥ 3	98	16	70.6	0.3	71
1108	≥ 4	87	43	47.9	2.1	50
647	≥ 5	63	69	26.0	5.8	32
335	≥ 6	41	86	12.2	9.4	22
164	≥ 7	25	94	5.1	11.8	17
59	≥ 8	11	98	1.6	14.1	16
20	≥ 9	4	99	0.5	15.2	16
5	≥ 10	1	100	0.1	15.6	16
1	≥ 11	0	100	0.0	15.7	16
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

(continued)

Table A3-15 (continued). Indicator Characteristics for FGI-21R,Philippines

N [a]	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 0.70		
1798	≥ 1	100	0	92.5	0.0	93
1769	≥ 2	100	2	90.9	0.0	91
1547	≥ 3	97	15	78.8	0.2	79
1108	≥ 4	90	41	54.9	0.7	56
647	≥ 5	70	67	30.8	2.2	33
335	≥ 6	49	84	15.0	3.8	19
164	≥ 7	33	93	6.7	5.0	12
59	≥ 8	13	98	2.3	6.5	9
20	≥ 9	4	99	0.8	7.2	8
5	≥ 10	3	100	0.1	7.2	7
1	≥ 11	1	100	0.0	7.4	7
0	≥ 12	–	–	–	–	–
0	≥ 13	–	–	–	–	–
0	≥ 14	–	–	–	–	–
0	≥ 15	–	–	–	–	–
0	≥ 16	–	–	–	–	–
0	≥ 17	–	–	–	–	–
0	≥ 18	–	–	–	–	–
0	≥ 19	–	–	–	–	–
0	≥ 20	–	–	–	–	–
0	21	–	–	–	–	–

[a] N = Number in the sample that meet the cutoff.

Appendix 4. Comparing the Probability Approach to the Estimated Average Requirement Cut-Point Method

We assessed prevalence of adequacy using the probability approach, as described in **Section 5**. We employed this approach because for analytic purposes, we needed to assign a probability to each individual woman. When the objective is to provide population-level estimates only, there is a simpler approach, called the EAR cut-point method, which may be applied.[69]

As a form of triangulation, this appendix presents results from both methods, for comparison. We were interested in triangulating because the syntax developed for our project[70] included a methodological innovation: to allow comparison of usual intake distributions with requirement distributions. We simulated each requirement distribution then transformed using the same Box-Cox transformation parameter as had been selected for the micronutrient.

Like the probability approach, the EAR cut-point method requires that the intake distribution be adjusted for intra-individual variability to estimate "usual" intake. In our study, the usual intake is estimated by the BLUP (see **Section 5.7**).

In order to apply the cut-point method, certain other assumptions must be met:[71]

1. There must be an EAR established for the nutrient; this is not true in the case of calcium.
2. Intakes should be independent of requirements. This is not always the case (e.g., for energy), but is considered to be true for micronutrients.
3. Variability in intakes among individuals in the group should be greater than the variability in requirements. Since little data is available for variability in requirements in any population, this is hard to establish. However, for example, in the US, variability in intakes has been shown to far exceed best estimates of variability in requirements.
4. The distribution of requirements is approximately symmetrical; this is not true for iron for menstruating women.

The method works best when actual prevalence is neither very low (e.g., < 8-10 percent) nor very high (e.g., > 90-92 percent). Above or below these true prevalences, the cut-point method may produce biased estimates; the closer the true prevalence is to 50 percent, the less biased the estimate provided by the EAR cut-point method will be.

Once usual intake has been estimated, the EAR cut-point method is calculated very simply as the proportion of the group with usual intakes below the median requirement (EAR).

In the tables presented in this appendix, estimated prevalence of adequacy is presented as calculated for our work ("PA" column) and using the EAR cut-point method (BLUP column). Results are presented for all micronutrients except calcium (no EAR) and iron (skewed requirement distribution). For some micronutrients where the PA is estimated as ≤ 8 percent or ≥ 92 percent, cut-point methods may be biased; these rows are shaded in gray.

As an exercise, we also present several columns that incorrectly apply the cut-point method to unadjusted intake distributions. We show an estimated prevalence when one day's intake data is used (first column). In addition, for the three sites where a second recall was available for most or all women (Burkina Faso, Mali and Philippines), the second column shows results when an average across observation days is used. For these same three sites, the third column shows results when the average is used but the distribution is transformed to approximate normal. We wanted to explore these incorrect methods because such results are sometimes reported in the literature and we wished to see the impact varying

[69] IOM 2000a.
[70] See Joseph 2007.
[71] IOM 2000a.

methods (both incorrect and correct) in our data sets. However, our main comparison is between the correct EAR cut-point method (prevalence estimates in column labeled "BLUP") and the probability approach (prevalence estimate in column labeled "PA"). We also constructed a "quasi-MPA" — without calcium and iron — to see how well this agreed across methods.

For simplicity, results are shown for NPNL women only. In summary, for the main comparison of interest (BLUP and PA columns in the following tables), the two methods agree very well in all five sites.

At the level of individual micronutrients, estimates of prevalence of adequacy differed by 0-3 percentage points, with two exceptions. In Burkina Faso, the estimated prevalence of adequate vitamin B12 intake differed by 6 percentage points, but the PA for this was extremely low and the EAR cut-point method likely to be biased. The other exception was for zinc in the Philippines, where there was a 14 percentage point difference between the estimates. We have no explanation for the difference in these two estimates.

The "quasi-MPA" is the average of the PA across the 9 nutrients for which the EAR cut-point method is appropriate. At the level of this summary variable, agreement was excellent, with differences of 0.00 – 0.02 across all five sites.

As expected, agreement was not as good between the PA and incorrect approaches to the EAR cut-point method (using single day intakes or average intakes across days). Most differences in prevalence estimates for individual nutrients were in the 0-10 percentage point range, but some exceeded this. Only one difference exceeded 15 percentage points. At the level of the quasi-MPA, differences between the PA and these incorrect approaches ranged from 0.01 – 0.09 with most below 0.05.

EAR Cut-Point Method: Burkina Faso

	Round 2 Only	Average of 3 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.53	0.57	0.47	0.47	0.49
Riboflavin	0.29	0.25	0.20	0.14	0.16
Niacin	0.32	0.29	0.21	0.17	0.19
Vitamin B6	0.65	0.70	0.62	0.72	0.70
Folate	0.27	0.23	0.18	0.15	0.15
Vitamin B12	0.11	0.14	1.00	0.00	0.06
Vitamin C	0.61	0.73	0.68	0.69	0.70
Vitamin A	0.62	0.83	0.68	0.74	0.73
Zinc	0.72	0.71	0.68	0.71	0.70
Quasi-MPA	0.46	0.49	0.52	0.42	0.43
			Difference from PA		
Thiamin	0.04	0.08	-0.02	-0.02	–
Riboflavin	0.13	0.09	0.04	-0.02	–
Niacin	0.13	0.10	0.02	-0.02	–
Vitamin B6	-0.05	0.00	-0.08	0.02	–
Folate	0.12	0.08	0.03	0.00	–
Vitamin B12	0.05	0.08	0.94	-0.06	–
Vitamin C	-0.09	0.03	-0.02	-0.01	–
Vitamin A	-0.11	0.10	-0.05	0.01	–
Zinc	0.02	0.01	-0.02	0.01	–
Quasi-MPA	0.03	0.06	0.09	-0.01	–

EAR Cut-Point Method: Mali

	Round 1 Only	Average of 2 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.52	0.64	0.57	0.62	0.59
Riboflavin	0.31	0.35	0.29	0.25	0.28
Niacin	0.38	0.40	0.35	0.33	0.31
Vitamin B6	0.55	0.67	0.61	0.68	0.67
Folate	0.03	0.02	0.00	0.00	0.00
Vitamin B12	0.25	0.28	0.24	0.16	0.17
Vitamin C	0.76	0.82	0.79	0.86	0.88
Vitamin A	0.48	0.60	0.51	0.51	0.50
Zinc	0.82	0.90	0.90	0.95	0.96
Quasi-MPA	0.46	0.52	0.47	0.48	0.48
			Difference from PA		
Thiamin	-0.07	0.05	-0.02	0.03	–
Riboflavin	0.03	0.07	0.01	-0.03	–
Niacin	0.07	0.09	0.04	0.02	–
Vitamin B6	-0.12	0.00	-0.06	0.01	–
Folate	0.03	0.02	0.00	0.00	–
Vitamin B12	0.08	0.11	0.07	-0.01	–
Vitamin C	-0.12	-0.06	-0.09	-0.02	–
Vitamin A	-0.02	0.10	0.01	0.01	–
Zinc	-0.14	-0.06	-0.06	-0.01	–
Quasi-MPA	-0.03	0.04	-0.01	0.00	–

EAR Cut-Point Method: Mozambique

	Round 1 Only	Average of 2 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.62	–	–	0.67	0.68
Riboflavin	0.52	–	–	0.45	0.45
Niacin	0.49	–	–	0.50	0.49
Vitamin B6	0.81	–	–	0.90	0.90
Folate	0.48	–	–	0.47	0.45
Vitamin B12	0.22	–	–	0.25	0.26
Vitamin C	0.82	–	–	0.89	0.90
Vitamin A	0.77	–	–	0.88	0.86
Zinc	0.69	–	–	0.78	0.76
Quasi-MPA	0.60			0.64	0.64
		Difference from PA			
Thiamin	-0.06	–	–	-0.01	–
Riboflavin	0.07	–	–	0.00	–
Niacin	0.00	–	–	0.01	–
Vitamin B6	-0.09	–	–	0.00	–
Folate	0.03	–	–	0.02	–
Vitamin B12	-0.04	–	–	-0.01	–
Vitamin C	-0.08	–	–	-0.01	–
Vitamin A	-0.09	–	–	0.02	–
Zinc	-0.07	–	–	0.02	–
Quasi-MPA	-0.04	–	–	0.00	–

EAR Cut-Point Method: Bangladesh

	Round 1 only	Average of 2 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.17	–	–	0.07	0.09
Riboflavin	0.24	–	–	0.12	0.15
Niacin	0.33	–	–	0.29	0.30
Vitamin B6	0.71	–	–	0.82	0.82
Folate	0.12	–	–	0.01	0.02
Vitamin B12	0.24	–	–	0.20	0.20
Vitamin C	0.53	–	–	0.50	0.52
Vitamin A	0.56	–	–	0.55	0.53
Zinc	0.83	–	–	0.90	0.92
Quasi-MPA	0.41	–	–	0.38	0.39
		Difference from PA			
Thiamin	0.08	–	–	-0.02	–
Riboflavin	0.09	–	–	-0.03	–
Niacin	0.03	–	–	-0.01	–
Vitamin B6	-0.11	–	–	0.00	–
Folate	0.10	–	–	-0.01	–
Vitamin B12	0.04	–	–	0.00	–
Vitamin C	0.01	–	–	-0.02	–
Vitamin A	0.03	–	–	0.02	–
Zinc	-0.09	–	–	-0.02	–
Quasi-MPA	0.02	–	–	-0.01	–

EAR Cut-Point Method: Philippines

	Round 1 Only	Average of 2 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.19	0.18	0.15	0.12	0.12
Riboflavin	0.17	0.15	0.13	0.10	0.11
Niacin	0.59	0.62	0.58	0.60	0.60
Vitamin B6	0.48	0.49	0.45	0.45	0.45
Folate	0.48	0.48	0.47	0.46	0.47
Vitamin B12	0.69	0.78	0.73	0.78	0.78
Vitamin C	0.20	0.23	0.17	0.13	0.13
Vitamin A	0.43	0.47	0.40	0.38	0.38
Zinc	0.38	0.38	0.36	0.34	0.48
Quasi-MPA	0.40	0.42	0.38	0.37	0.39

Difference from PA

	Round 1 Only	Average of 2 Rounds	Average, Box-Cox Transformed	BLUP	PA
Thiamin	0.07	0.06	0.03	0.00	–
Riboflavin	0.06	0.04	0.02	-0.01	–
Niacin	-0.01	0.02	-0.02	0.00	–
Vitamin B6	0.03	0.04	0.00	0.00	–
Folate	0.01	0.01	0.00	-0.01	–
Vitamin B12	-0.09	0.00	-0.05	0.00	–
Vitamin C	0.07	0.10	0.04	0.00	–
Vitamin A	0.05	0.09	0.02	0.00	–
Zinc	-0.10	-0.10	-0.12	-0.14	–
Quasi-MPA	0.01	0.03	-0.01	-0.02	–