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Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Bamako, Mali Site

Gina Kennedy, Nadia Fanou, Chiara Seghieri and Inge D. Brouwer

December 2009

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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, which will be published in 2010:

Mary Arimond, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa C. 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. *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 C. Daniels. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Metropolitan Cebu, Philippines Site*.

This report presents the results for the Mali site.

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 a collaboration among researchers 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.

Acknowledgements

Data collection was carried out in the framework of the European Union FONIO Specific Targeted Research Project/International Cooperation (EU/STREP/INCO project N° 0015403). Funding for this report was provided by the United States Agency for International Development (USAID) through the Food and Nutrition Technical Assistance II Project (FANTA-2) and its predecessor project, FANTA, at FHI 360.

We are grateful to the study participants for allowing the teams into their homes and participating in data collection, and to all the interviewers for their commitment during fieldwork. We are also grateful to Lidwien van der Heijden and Romain Dossa for their support during training, data collection and analysis. We would like to acknowledge Yara Koreissi for her support during the fieldwork and Yara Koreissi and Esmée Doets for their work on the Mali food composition table (FCT) used in this study. We would also like to thank Mary Arimond, Megan Deitchler and the editorial staff at FANTA-2 for their technical and editorial assistance on our report.

Acronyms and Abbreviations

AI	Adequate Intake
AUC	Area under the curve
BLUP	Best linear unbiased predictor
BMI	Body mass index
CI	Confidence interval
cm	Centimeters
CPS/MS	Cellule de Planification et de Statistique du Ministère de la Santé
CV	Coefficient of variation
DHS	Demographic and Health Surveys
DNSI	Direction Nationale de la Statistique et de l'Informatique
DRI	Dietary Reference Intakes
DRPSI-ATP	Direction Regionale de la Planification, de la Statistique, de l'Informatique, de l'Aménagement du Territoire et de la Population
EAR	Estimated average requirement
EU/STREP/INCO project	European Union Specific Targeted Research Project/International Cooperation project
FANTA	Food and Nutrition Technical Assistance Project
FANTA-2	Food and Nutrition Technical Assistance II Project
FAO	Food and Agriculture Organization of the United Nations
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
g	Gram(s)
h	Hour(s)
IFPRI	International Food Policy Research Institute
ILSI	International Life Sciences Institute
IML	International Minilist
IRD	Institute of Research for Development
IZiNCG	International Zinc Nutrition Consultative Group
kcal	Kilocalorie(s)
kg	Kilogram(s)
μg	Microgram(s)
mg	Milligram(s)
MPA	Mean probability of adequacy
MPAT	Ministère du Plan et de l'Amenagement du Territoire
NPNL	Non-pregnant non-lactating
OC	Oral contraceptives

ORC Macro	Opinion Research Corporation Macro International, Inc.
PA	Probability of adequacy
R1	Round 1 of data collection (first observation day)
R2	Round 2 of data collection (second observation day)
RAE	Retinol activity equivalent
RE	Retinol equivalent
RF	Retention factors
RNI	Recommended nutrient intake
ROC	Receiver-operating characteristic
SD	Standard deviation
SEM	Standard error of the mean
TACAM	*Table de Composition d'aliments du Mali* (food composition table for Mali)
UK	United Kingdom
UNICEF	United Nations Children's Fund
US	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USDA Release	United States Department of Agriculture National Nutrient Database for Standard Reference Release
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. When grain- or tuber-based staple foods dominate and diets lack vegetables, fruits and animal-source foods, risk for a range of micronutrient deficiencies is high. Women of reproductive age constitute one vulnerable group. While information on micronutrient deficiencies is scarce, it is clear that poor micronutrient status among women is a global problem and is most severe for poor women. Information about dietary patterns for women across countries is also scarce, but the Demographic and Health Surveys (DHS) have recently begun to fill this information void.

The broad objective of this study, carried out under FANTA's Women's Dietary Diversity Project (WDDP), is to use an existing data set with dietary intake data from 24-hour (24-h) recalls to analyze the relationship between simple indicators of dietary diversity – such as could be derived from the DHS – and diet quality for women. Adequate diet quality is defined here as a diet that delivers 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 and balance. However, because low intakes remain the dominant problem in many of the poorest regions, focus in this work is on micronutrient adequacy only.

Dietary diversity – i.e., the number of foods consumed across and within food groups over a reference period – is widely recognized as a key dimension of diet quality. There is ample evidence from developed countries showing that dietary diversity is indeed strongly associated with nutrient adequacy. There is less evidence from developing countries, but the few available studies of adult women have also supported the association between diversity and nutrient adequacy.

OBJECTIVES

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

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 diet quality
4. Test and compare the performance of various indicators

As a secondary objective, the WDDP also aimed to characterize micronutrient adequacy for women of reproductive age in each study site.

Indicator performance in just one site is not sufficient to address the broader objective of developing indicators for global use. Therefore, although site-specific results pertaining to objective four are presented in this report, the results for indicator performance are most useful when considered across multiple sites. This discussion is provided in the WDDP summary report.

METHODS

The data used in this report are a set of women's dietary intake data from a cross-sectional food consumption study undertaken in Bamako, Mali as part of the European Union (EU)-funded FONIO Specific Targeted Research Project/International Cooperation project (EU/STREP/INCO project N° 0015403). Two quantitative 24-h recalls of food consumption among non-pregnant non-lactating (NPNL) women age 15 to 49 were used in this analysis. The dietary recalls were during February, March and April 2007. The sample originally consisted of 108 women: five women dropped out during round one and an additional woman was deleted as an outlier from the first round of data collection. The final sample size for round one was 102 women, with a sub-sample of 96 women in round two.

The WDDP research protocol and addendum to the research protocol were followed in carrying out this research. In summary, eight diversity indicators based on four sets of food groupings (6, 9, 13 and 21 food groups) and each applying a 1 g or 15 g minimum intake criteria were constructed based on the 24-h recall from the first observation day (R1). The probability of adequacy (PA) for 11 micronutrients was constructed taking into account nutrient requirement distributions and inter- and intra-individual variation in intake. The mean probability of adequacy (MPA) was constructed as a summary indicator using the average of the 11 PAs.

The analytical approach consisted of descriptive statistics of dietary patterns and food group scores, correlations and ordinary least squares regressions to assess the relationships between food group scores, estimated usual intake of the micronutrients and MPA. Receiver operating curve (ROC) analysis was used to test the performance of each indicator as a predictor of MPA.

RESULTS

Dietary Patterns and Food Group Indicator Scores

The diet of this urban sample of women in Mali was dominated by starchy staples, mainly refined white rice, refined wheat flour and millet, which provide nearly 50 percent of the total energy in the diet. A substantial proportion of the total dietary energy (32 percent) was provided by fat, mainly consumed as edible vegetable oil. Using information from the most disaggregated food group indicator, most women consumed grains and grain products, vitamin C-rich vegetables, and vitamin A-rich deep yellow/orange/red vegetables (using the 1 g minimum intake criteria). A majority of women also consumed foods from the nuts and seeds, beef, pork, veal, lamb, goat or game meat and all other vegetables food groups. No women consumed soybeans or soy products, cheese, organ meat, chicken or other fowl, insects, and few women consumed any fruit. The food groups most affected by the 15 g minimum intake criteria were vitamin A-rich deep yellow/orange/red vegetables and nuts and seeds. The large whole fish/dried fish/shellfish/other seafood, small fish eaten whole with bones and vitamin A-rich dark green leafy vegetables food groups were also influenced by the 15 g minimum intake.

Dietary diversity scores increased as the food group indicators became more disaggregated. Mean dietary diversity scores ranged from 5.1 to 7.1 for the 1 g indicators and from 4.3 to 5.6 for the 15 g indicators. The median scores ranged from 5-7 food groups for the 1 g indicators and 4-5 food groups for 15 g indicators.

Micronutrient Intake, Adequacy and Food Group's Contribution

Median intakes of riboflavin, niacin, vitamin B12, folate and vitamin A were below the estimated average requirements (EAR) and calcium intake was below the adequate intake (AI). Median intakes were above the EAR for vitamin B6, vitamin C and zinc, and equal to the EAR for thiamin. The estimated probability of adequate intake was < 0.20 for vitamin B12 and folate, ranged from 0.27 to 0.31 for riboflavin, calcium and niacin, and was 0.50 or above for iron, vitamin A, vitamin B6, thiamin, zinc and vitamin C. The sample average MPA for the 11 micronutrients was 0.47. Forty six percent of women had an MPA above 0.5 and 25 percent had an MPA above 0.6.

Due to the large quantities of grains consumed, the starchy staple food group provided the majority of thiamin, vitamin B6, iron and zinc in the diet. Substantial amounts of other micronutrients were provided by different food groups. Legumes and nuts, provided a large percent of niacin and folate intake, dairy, contributed to B12 and calcium intake, all other flesh foods, contributed primarily to B12 intake, vitamin C-rich vegetables contributed to a large percentage of the intake of folate and vitamin C and dark green leafy vegetables contributed the highest percentage intake of vitamin A.

Relationships between Food Group Indicators, Energy Intakes and MPA

In general, there was a trend for higher correlations between food group diversity scores, the estimated usual intake of individual micronutrients and MPA when not controlling for energy intake and when applying the 15 g restriction. The most consistent relationships between the food group scores and individual micronutrients were seen for riboflavin, folate, vitamin B12, vitamin A and calcium. For these nutrients, correlations were positive and significant with all dietary diversity indicators, and remained so after controlling for energy intake. Intakes for all micronutrients except iron were significantly correlated with FGI-21 and FGI-21R when energy intake was not controlled. After controlling for energy, correlations remained significant for riboflavin, folate, vitamin B12, vitamin A, calcium and vitamin C for FGI-21R and for all those micronutrients except vitamin C for FGI-21. All coefficients between the dietary diversity scores and MPA were positive and significant, including when controlling for total energy intake. These results indicate that both dietary energy intake and diversity of the diet influence micronutrient adequacy.

For the most disaggregated food grouping (21 groups), six out of the 15 food groups consumed were correlated with MPA when not controlling for total dietary energy, four remained significantly correlated when total dietary energy was controlled. Dietary diversity indicators were significant predictors of MPA in ordinary least squares regression with age and diversity score in the model. All indictors with the exception of FGI-6 and FGI-13 remained a significant predictor of MPA when total energy intake was included in the model. The model with the highest adjusted R^2 (0.42) when controlling for total energy intake was FGI-6R.

Indicator Performance

For the purpose of assessing an indicator's predictive ability, an area under the curve (AUC) of ≥ 0.70 derived from ROC analysis can be considered to have potential, while an AUC of 0.50 indicates ―no predictive power". All AUC results except for FGI-6 and FGI-13 were above the 0.70 threshold (with a narrow range of 0.72 to 0.75) when using an MPA cutoff > 50 percent. At an MPA cutoff > 60 percent, the AUC results ranged from 0.59 (FGI-13) to 0.71 (FGI-6R) across all eight indicators, with only FGI-6R and FGI-9R above 0.70.

At an MPA > 50 percent, the highest AUC was for FGI-6R (0.75), FGI-9R (0.75), FGI-9 (0.74), FGI-13R (0.74) and FGI-21R (0.74). At an MPA > 60 percent, the highest AUC was for FGI-6R (0.71), FGI-9R (0.70), FGI-13R (0.68) and FGI-21R, (0.68). There were no significant differences in AUC for MPA > 50 percent. At an MPA cutoff > 60 percent, FGI-13 was significantly lower than FGI-6R, FGI-9R and FGI-13R.

Using the MPA cut off of > 50 percent, FGI-6R had the best balance (when favoring specificity) of sensitivity (62 percent) specificity (78 percent) and total misclassification (29 percent) at a cutoff of ≥ 5 food groups. For FGI-9R, the best cutoff was also ≥ 5 food groups where sensitivity was 62 percent, specificity was 75 percent and total misclassification was 31 percent. FGI-21R also performed well at a cutoff of ≥ 6 food groups with a sensitivity of 72 percent, specificity of 71 percent and a total of 28 percent misclassified.

At an MPA cutoff of > 60 percent, FGI-6R and FGI-9R had the best performance. At a cutoff of ≥ 5 food groups, sensitivity for FGI-6R was 64 percent, specificity was 68 percent and total misclassification was 33 percent. At a cutoff of ≥ 5 food groups, FGI-9R had a sensitivity of 64 percent, a specificity of 65 percent and a total misclassification of 35 percent.

CONCLUSION

For FGI-6, the most aggregated diversity indicator, the median number of food groups consumed was five out of six food groups. Although the median number of food groups consumed increased slightly with increasing disaggregation of the food groups, the median diversity scores were far below the highest score possible. For FGI-13 the median score was 6 out of 13 food groups, and for FGI-21, 7 out of 21 food groups (for FGI-21). This indicates that there is overall a lot of diversity across the 6 major food groups, but that this diversity is limited to certain types of food items within these major food groups.

In our Mali sample, the general dietary pattern consisted of one to two meals of a staple food accompanied by a sauce. The sauce ingredients tended to be fairly standard, generally coming from two or three of the six major food groups. Snacks and foods purchased outside the home (e.g. roasted peanuts, some fruits and fruit juices, and fried snacks such as fried potatoes and doughnuts) contributed to increased diversity scores, particularly for the more disaggregated food groupings.

Fats and oils (with the exception of red palm oil), sweetened beverages, alcoholic beverages and coffee and tea do not contribute substantially to micronutrient intake and were therefore excluded from the food groups in the diversity indicators constructed for this study. These foods should not, however, be excluded from guidelines on how to collect information on the diversity of the diet. Due to the pace of the nutrition transition in developing countries, it is important to track the consumption of these foods for program monitoring purposes,

All of the dietary diversity indicators constructed for this analysis were positively and significantly correlated to our summary indicator of micronutrient adequacy, MPA. Results from ROC analysis indicated FGI-6R and FGI-9R to perform very well. FGI-21R and FGI-9R performed nearly as well, although they did not have an AUC above 0.70 at an MPA > 60 percent. It should be noted that the results for all FGI-R indicators were quite similar and that there were no significant differences among the AUCs for these four indicators.

These results demonstrate that dietary diversity scores are useful proxy indicators of adequate intake across a range of key micronutrients, particularly when food consumed in small amounts are excluded from counting in score construction.

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 vegetables, fruits, and animal-source foods, 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. Unfortunately, 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.[1]

Similarly, comparable information about dietary patterns for women across countries is also scarce. The Demographic and Health Surveys (DHS) have recently added questions on mothers' diets in order to begin to fill this information void. The current survey questionnaire includes a set of questions about food groups eaten in the last 24 hours by mothers of young children under three years of age (see **Appendix 5**).[2]

The broad objective of this study, carried out under FANTA-'s Women's Dietary Diversity Project (WDDP), is to use an existing data set with dietary intake data from 24-hour (24-h) recall 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 source foods, fruits and vegetables, and to identify sub-groups 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 one resource-poor setting.

For the purposes of this study, adequate diet quality is defined 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, refined sugars) and balance. But because low intakes remain the dominant problem in many of the poorest regions, our focus in this work is on micronutrient adequacy only.

[1] Kennedy and Meyers 2005.
[2] Appendix 5 excerpts the relevant questions from the model questionnaire; the entire questionnaire is available on the Opinion Research Corporation Macro International, Inc., (ORC Macro) DHS website at: http://www.measuredhs.com/aboutsurveys/dhs/questionnaires.cfm (accessed September 7, 2007).

2. Dietary Diversity

Dietary diversity – i.e., the number of foods consumed across and within food groups over a reference time period – is widely recognized as being a key dimension of diet quality. 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 thus is 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. This report, along with the companion reports from additional sites, 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, the following main objectives were identified for the WDDP:

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 total misclassification) relative to various cutoffs for diet quality, as data allow

As a secondary objective, the WDDP also aimed to characterize micronutrient adequacy for women of reproductive age in each study site.

Indicator performance in just one site is not sufficient to address the broader objective of developing indicators for global use. Therefore, although site-specific results pertaining to objective four are presented in this report, the results for indicator performance are most useful when considered across multiple sites. This discussion is provided in the WDDP summary report.[7]

[7] Arimond et al. 2009b.

4. Mali Study: Original Research Objectives and Context

The data used in this report are a set of women's dietary intake data from a cross-sectional food consumption study undertaken as part of the European Union (EU)-funded FONIO[8] project. The FONIO project was originally designed to determine the role of fonio in dietary patterns and the contribution of fonio to iron and zinc intake and iron status among women of reproductive age living in an urban area of Mali. A secondary objective of the food consumption study was to assess the association between dietary diversity and nutrient adequacy of women of reproductive age. This objective fits within the aim of the WDDP and was thus pursued within that framework. This report follows the analysis protocol established for the WDDP, focusing on dietary intake data collected by a quantitative 24-h recall method. Part of the FONIO project consisted of two 24-h recalls of food consumption among non-pregnant non-lactating (NPNL) women age 15 to 49, and it is this aspect of the FONIO project which is reported here.

4.1. SUMMARY OF REVISIONS

This report has been amended from the original Mali site report submitted to the WDDP in July 2008 due to revisions to the WDDP analysis protocol and improvement of the original data set. Changes in the analysis protocol were discussed with WDDP collaborating researchers and, as described in the revised protocol,[9] include the following amendments:

- Recoding of vitamin A- and vitamin C-rich fruits and vegetables as per the updated definitions of those fruits and vegetables; vitamin A-rich fruits and vegetables were defined as containing ≥ 120 microgram (μg) retinol equivalents (REs)/100 grams (g) (≥ 60 μg retinol activity equivalents [RAEs]/100g) and vitamin C-rich fruits and vegetables were defined as containing ≥ 9 milligrams (mg)/100g
- Reporting of two values of bioavailability for iron and zinc: the low and moderate bioavailability levels
- Revision of the estimated average requirement (EAR) used for zinc; the estimated median zinc requirement and coefficient of variation (CV) suggested by the International Zinc Nutrition Consultative Group (IZiNCG)[10] was used, replacing the EAR from the World Health Organization (WHO)/Food and Agriculture Organization of the United Nations (FAO) used in the original analysis

Improvements specific to the Mali data set since July 2008 include:

- The number of observations for the second observation day (R2) was increased to 96 from the 55 in the original Mali site report. There were fewer R2 observations in the original site report due to a software coding error, which was corrected for the revised report.
- The vitamin B12 values for beef and goat were reviewed in the food composition table (FCT) for Mali, *Table de Composition d'aliments du Mali* (TACAM), resulting in retaining the TACAM values for use in the present analysis.

4.2. DESCRIPTION OF COMMUNITIES WHERE DATA WERE COLLECTED

The research for this study was carried out in Bamako, the capital and biggest city in Mali, which is situated in the south and crossed by the Niger River. Mali has a subtropical-to-arid climate with two seasons: a rainy season from June to September and a dry season from October to May. Annual rainfall varies from 1,300 millimeters (mm) to 1,500 mm in the south; in the north, the average is around 200 mm. Average temperature ranges from 26.6°C to 32.9°C and is higher in the dry season.[11] Bamako comprises six communes divided in 72 quarters. In 2006, 1,690,471 people grouped into 160,425 households lived

[8] EU/STREP/INCO, project N° 0015403.
[9] Arimond et al. 2008b.
[10] 2004.
[11] CPS/MS/DNSI/ORC Macro 2002.

in Bamako. The average household size was 6.3 people, with adult women constituting 22.6 percent of the population.[12]

4.3. NATURE OF SAMPLING AND SURVEY DESIGN

A total of 108 women were selected for the study sampjle using a three-stage cluster sampling method.[13] From the initial sampling frame that included Bamako's 72 quarters, nine quarters were excluded due to overrepresentation of expatriates and international industries. Twelve of the remaining 63 quarters were selected for sampling using probability proportional to size. In each selected quarter, nine households[14] were randomly selected using the random walk method.[15] All women age 15 to 49 living in the selected households were listed. From the list, one apparently healthy NPNL woman, who belonged to a Malian sociolinguistic group and preferably was a food preparer, was selected from each household. Forty-seven percent of the households had only one eligible woman; the rest had two-to-eight eligible women. In the case of unavailability or refusal, the selected women were not replaced.

No weights were applied to any sampling stage. The first stage of the sample is weighted based on probability proportional to size, and an equal number of households were selected for sampling in each quarter at the second stage of sampling, thus the use of sample weights for these stages was not warranted. No weights were applied to the third stage of sample selection. Although weighting at this stage would have helped account for the probability of being selected when more than one woman per household was eligible, this would have been useful only for those results intended to be representative of the population (**Tables N1-N9**). Because the WDDP's primary objective is to assess the validity of dietary diversity indicators as a measure of the micronutrient adequacy of women's diets (**Tables N10-N20a-h**), we elected not to apply sampling weights for the analyses undertaken in this study.

[12] MPAT/DRPSI-ATP/DNSI 2005.
[13] UNICEF 2006.
[14] The household is considered as a group of consumers and may be defined as any person or group of people who share the same living accommodation, who pool some or all of their income and wealth and who take food prepared from a common kitchen or cooking.
[15] Gibson and Ferguson 1999.

5. Methods

Two 24-h dietary recalls were performed over three months: February, March and April 2007. Information on consumption of fortified food products was not collected. However, it is unlikely that this affected the results of the study as most of the fortified foods commonly available in the study area are designed for infants and preschool children.[16]

5.1. TRAINING

For data collection, six local female interviewers who spoke both French and the local language were recruited and trained for 10 days. The interviewers then completed a pretest in two households that were not included in the sample. Before beginning data collection, an information meeting was held with the selected respondents to explain the study's objectives and ensure that the selected woman would be at home and available on the days of the interview. While some bias could be introduced into the study due to this meeting, it was deemed necessary to clearly explain the purpose of the study, obtain informed consent and ensure the women's full participation.

5.2. DATA COLLECTION FOR 24-HOUR RECALL AND CALCULATION OF NUTRIENT INTAKES

Two 24-h recalls were collected on separate days, with a minimum of two days and a maximum of 11 days between the two recall days. Weekends and special event days were excluded. The subject's daily food intake was assessed by a quantitative 24-h recall method adapted to the context of eating from shared plates, which involved asking the respondent to use known-weight utensils on the recall day to help them visualize the amount of food consumed.[17] Individual portion sizes were assessed in terms of household measures. Data were collected by the trained local interviewers through semi-structured interviews using questionnaires with specific probes to help the respondents remember all foods consumed throughout the day. Each interviewer completed three 24-h recalls per day. To minimize potential interviewer's bias, dietary intake data were collected from each woman by different interviewers for the first and second rounds of 24-h recall.

A standardized format for data collection was followed. First, the subjects were asked to name all the food and drinks consumed during the preceding day, including snacks and any food or beverages consumed outside the home. Then they were asked to describe the foods and beverages consumed, including ingredients and cooking methods of mixed dishes, and the place and the time of consumption. Finally, the amounts of all foods, beverages, ingredients of mixed dishes consumed were estimated either in household units or in monetary value. The total amount of the cooked food and the amount consumed by the respondents were measured in household units to derive the proportion consumed by the respondent from the total volume of the dish.

To convert ingredients from monetary value to weight equivalent, all ingredients and their monetary values were listed. Three to five food vendors were randomly selected from each of the three most frequented markets of the study area for a total of nine to 15 vendors. For each ingredient, the prices and weights of different portions sold were recorded from each vendor. The average weight for each monetary unit (e.g., 100 CFA francs, 200 CFA francs) for each ingredient was derived and then used to convert the ingredient's monetary value to gram equivalent.[18] For example, a woman might have reported consuming one third of a baguette from the market at a cost of 85 CFA francs. The weight of a purchase of 85 CFA francs of baguette was averaged from the sampled baguette vendors.

[16] Lactating women often eat the leftovers of their babies' porridges, some of which might be fortified. No lactating women were selected for this study. Although it cannot be stated conclusively, the impact of consumption of fortified children's porridge in our sample of NPNL women is expected to be minimal.
[17] Gibson and Ferguson 1999.
[18] The average monetary equivalent converted into g was considered more accurate than using the recalled weight equivalent of the purchase as recalled by the respondent. This is because of the non-standardized packaging and portion sizes at local markets. In addition, some ingredients are purchased only by monetary unit, not by weight.

Five women (three on the first recall day and two on the second day) could not name the ingredients of the dishes eaten because the meal was prepared outside of the home. To estimate the amount of ingredients eaten from mixed dishes with unknown amounts of ingredients, three standardized recipes of these foods were determined. Three women (different from the subjects) who lived in the study area and were known for their cooking skills were asked to prepare the mixed dish using the recipes. All the raw ingredients, their amounts, the total uncooked weight, the total cooked weight and volume were recorded. An average amount of ingredients used in the three recipes was determined and used for the five cases.

Food weights were measured using digital dietary scales,[19] with a maximum range of 10 kilograms (kg) to the nearest 2 g. Food intake was computed by the VBS Food Calculation System version 3.[20]

5.3. ANTHROPOMETRY

Anthropometric measurements were taken on about two-thirds of the sample (n=65) using WHO standardized procedures.[21] Body weight and height were measured early in the morning from fasting subjects. Weight was measured using a SECA platform spring balance model 761 (graduation 0.5 kg, measuring range 150 kg). The scale was placed on a horizontal surface and calibrated using a standard weight at the beginning of data collection and every 15 measurements thereafter. Subjects were weighed wearing a minimum of clothing.[22] Weights were recorded to the nearest 0.1 kg.

Height was measured with a body measuring tape label MZ10017 (measuring range 2,200 mm, graduation 1 mm). The women were measured while standing without shoes on a horizontal surface against a wall with their heels together, chins tucked in, bodies stretched upward to full extent, heads in the Frankfurt plane and heels, buttocks and shoulders touching the wall to which the measuring tape was attached. Height was recorded to the nearest 0.1 centimeter (cm).

Body mass index (BMI) was calculated as [weight/height^2 (kg/m^2)]. Chronic energy deficiency and overweight/obesity were assessed using BMI cutoffs of < 18.5 and ≥ 25.0, respectively.

5.4. FOOD COMPOSITION TABLE

The food composition values used in this study are based on the FONIO FCT which relied primarily on the FCT for Mali, the Table de Composition d'aliments (TACAM).[23, 24] Energy values in the FONIO FCT are calculated based on the following coefficients: 4 kilocalories (kcal)/g for protein, 3.75 kcal/g for carbohydrate and 9 kcal/g for fat.

The TACAM was used as the primary source of information for the FONIO FCT because it was thought to most accurately represent the foods available in the Malian context and the nutrient composition of those foods. In the framework of the FONIO project, a pilot evaluation of the TACAM, based on the United States Department of Agriculture (USDA) expert systems approach was undertaken by Doets.[25] The study concluded that the TACAM values are in acceptable range for scientific purposes. However, the quality evaluation study did recommend the replacement of 18 nutrient values in the FCT due to an insufficient level of confidence in the TACAM value. The study also added missing values for zinc (four foods), vitamin C (four foods), calcium (one food) and retinol (two foods). **Appendix 8** provides a table of the revised and additional values recommended by Doets and adopted for this study.

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[19] Soehnle, Plateau Art Nr 65086 (22 pounds [lb]).
[20] Bas Nutrition Software, Arnhem, The Netherlands, www.bware.nl.
[21] WHO 1995.
[22] Gibson 2005.
[23] Barikmo et al. 2004.
[24] A detailed description of the development of the FONIO FCT appears elsewhere (Koreissi 2007).
[25] Doets 2007.

The nutrients in the FONIO FCT were expressed primarily in raw form. For the purpose of this study, cooked nutrient values were obtained from the TACAM for all staple foods. However, vitamin B6 values reported for cooked staples in the TACAM are very low, so vitamin B6 values for cooked staples from USDA and the International Mini List (IML), which is part of the WorldFood Dietary Assessment System software package,[26] were used instead. To account for nutrient losses during cooking for other foods, such as fish, meat and vegetables, USDA Table of Nutrient Retention Factors Release (USDA Release) 6[27] were applied to the nutrient values of the raw foods.

The FONIO FCT included information on all macronutrients, moisture, calcium, iron, zinc, vitamin C, retinol and beta carotene. Nutrient values for thiamin, riboflavin, niacin, vitamin B6, vitamin B12 and folate were added to the FONIO FCT for the purpose of this study. Values for these nutrients were first taken from TACAM.[28] If TACAM did not contain a value, the value was obtained from USDA Release 20[29] and, if necessary, from the IML.[30] When USDA nutrient values were very different from nutrient values from other sources (e.g., vitamin A in sweet potatoes) or when no suitable food match was found (e.g., fakouhoye leaves), nutrient values were taken from the IML instead of USDA. REs were calculated as the sum of retinol and beta carotene, using the following conversions: 1 µg retinol = 1 µg RE and 1 µg beta carotene = 0.167 µg RE, as recommended by WHO/FAO.[31] Nutrient values taken from sources other than the TACAM were adjusted to account for differences in moisture content.[32]

5.5. DATA ENTRY

Food intake was computed using the VBS Food Calculation System version 3,[33] which includes KOMEET, VBS MANAGER, ORION and FOOD GROUPS. Data on nutrient composition were entered into VBS MANAGER, and food intake was entered into KOMEET software. Each respondent's food intake was matched to nutrient values for that food item using a unique food code identifier. Nutrient intake by food group was analyzed using ORION and FOOD GROUPS software.

The food intake data were entered in duplicate, and each individual food intake record was double-checked for accuracy. During double data entry, errors were noted. For example, an extra digit was attributed to one record of peanut butter consumption. In another case, some foods were assigned to raw nutrient values when the weight of the cooked form of the food was recorded on the survey form. Several errors of this type were corrected during the double data entry process.

5.6. IMPLEMENTATION OF THE PROTOCOL

The WDDP research protocol and addendum to the research protocol,[34] were followed in carrying out this research. In summary, eight diversity indicators based on four sets of food groupings (6, 9, 13 and 21 food groups, shown in **Table A**) and each applying a 1 g or 15 g minimum intake criteria were constructed based on the 24-h recall from the first observation day (R1). The probability of adequacy (PA) for 11 micronutrients was constructed taking into account nutrient requirement distributions and inter- and intra-individual variation in intake. The mean probability of adequacy (MPA) was constructed as a summary indicator using the average of the 11 PAs.

Descriptive statistics, correlations, regressions and performance of each indicator are discussed in **Section 6**.

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[26] WorldFood Dietary Assessment System, version 2.0, no date.
[27] 2007.
[28] Vitamin B12 values reported for beef and goat in TACAM were high; however, after quality evaluation, it was determined that they were within acceptable range (personal communication, Doets, 2008).
[29] 2008.
[30] WorldFood Dietary Assessment System, no date.
[31] 2002.
[32] IML tables do not report moisture content. The moisture content for foods taken from IML was estimated based on the closest food match from USDA.
[33] Bas Nutrition Software, Arnhem, The Netherlands, www.bware.nl
[34] Arimond et al. 2008a and Arimond et al. 2008b.

Table A. 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	Vitamin A-rich dark green leafy vegetables Other vitamin A-rich vegetables and fruits	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits	Vitamin A-rich dark green leafy vegetables Vitamin A-rich deep yellow/orange/red vegetables Vitamin A-rich fruits
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 FGIs were constructed. Grams of intake were assessed based on foods as eaten (e.g., raw, cooked).
[b] —Vitamin A-rich" is defined as > 60 RAE/100g; —vitamin C-rich" is defined as > 9 mg/100g; these represent 15 percent of the NRV.

5.7. EXCLUSION FROM THE SAMPLE

Of the 108 original women in the sample, five did not complete R1 of the 24-h recall, leaving 103 women in the sample for R1. Outliers for energy and vitamin A intake were reviewed, and each original survey form was rechecked for these women.

All 103 records from the first round were used in the analysis for the following reasons: The data were recently collected and the principal investigator is participating in the WDDP and could provide first-hand information and observations on the validity of the records; all records were double-checked for accuracy, and all errors identified were corrected. As a result, there is a high level of confidence in the accuracy of the information.

After analysis, one woman was excluded from the sample because she appeared to be a real outlier. Inclusion of this woman seemed to confuse the relationship between the dietary diversity indicators and MPA. Therefore, all results presented here are based on a final sample of 102 NPNL women age 15 to 49. Exceptions are the anthropometric results presented in **Table N1**, which are based on a sub-sample of 64 women, and results incorporating data from the 24-h recall for the second day, which are based on a sub-sample of 96 women.

5.8. BIOAVAILABILITY FOR IRON AND ZINC

Each study team participating in the WDDP was asked to select one of two levels of bioavailability for iron and zinc, based on the diet of the sample. For iron, the levels of bioavailability to choose from were 5 or 10 percent; for zinc, the levels were low (25 percent) or moderate (34 percent) bioavailability.

WHO/FAO[35] provides guidance on factors influencing dietary iron absorption. Factors that increase dietary iron absorption include presence of dietary heme sources in the diet and ascorbic acid content. Factors that inhibit non-heme iron absorption are phytate and phenolic compounds including tea, coffee, cocoa, red wine, calcium and soy.

The User's Guide to the WorldFood Dietary Assessment System, version 2.0,[36] provides the following guidance on non-heme iron bioavailability.

Table B. Estimated Percentage Bioavailability of Non-Heme Iron (at basal requirement level)

	Meat/fish/poultry protein, g/1,000 kcal		
Ascorbic acid mg/1,000 kcal	< 9	9-27	> 27
< 35	5%	10%	15%
35-105	10%	10%	15%
> 105	15%	15%	15%
< 35	5%	10%	15%

For this urban Mali sample, we selected a bioavailability factor of 10 percent for iron for the following reasons: i) 60 percent of the women in the sample consumed some form of heme iron from meat or fish; ii) vitamin C intake was high enough to meet the EAR; iii) the phytate content of meals is moderate, with the dietary staples mainly consumed in highly polished forms (white rice and milled millet); and iv) median ascorbic acid intake was 28 mg/1,000 kcal and median meat intake was 20 g/1,000 kcal, corresponding to a non-heme iron availability of 10 percent in the IML table above.[37]

Based on the below guidance for determining the bioavailabity of zinc in the diet[38] the average diet of women in the Mali sample best fits the category of moderate zinc bioavailability (34 percent). Diets are generally mixed, containing both animal and vegetable sources and not primarily based on unrefined grains.

[35] 2002.
[36] Accessed at www.fao.org/infoods/software/wfood2.
[37] FAO/WHO 2002
[38] WHO/FAO 2004.

Table C. Criteria for Categorizing Diets According to Their Potential Zinc Bioavailability [a]

Nominal Category	Principal Dietary Characteristics
High availability	• Refined diets low in cereal fiber, low in phytic acid and with phytate-zinc (molar) ratio < 5 • Adequate protein content principally from non-vegetable sources, such as meat and fish • Includes semisynthetic formula diets based on animal protein
Moderate availability	Mixed diets containing animal or fish protein and lacto-ovo, ovovegetarian or vegan diets not based primarily on unrefined cereal grains or high-extraction-rate flours. Phytate-zinc molar ratio ranging from 5 to 15 or not exceeding 10 if more than 50 percent of the energy intake comes from unfermented, unrefined cereal grains and flours and the diet is fortified with inorganic calcium salts (> 1 g Ca^{2+}/ day). Availability of zinc improves when the diet includes animal or other protein sources or milks.
Low availability	Diets high in unrefined, unfermented and ungerminated cereal grain,[b] especially when fortified with inorganic calcium salts and when intake of animal protein is negligible. Phytate-zinc molar ratio of total diet exceeds 15.[c] High-phytate soya-protein products constitute the primary protein source. Diets in which, singly or collectively, approximately 50percent of the energy intake is accounted for by the following high-phytate foods: high-extraction-rate (90 percent +) wheat, rice, maize, grains and flours, oatmeal, and millet; chapatti flours and *tanok*; and sorghum, cowpeas, pigeon peas, grams, kidney beans, blackeye beans, and groundnut flours. High intakes of inorganic calcium salts (> 1 g Ca^{2+}/ day), either as supplements or as adventitious contaminants (e.g., from calcareous geophagia), potentiate the inhibitory effects; low intakes of animal protein exacerbate these effects.

[a] Source of this table is WHO/FAO 2004.
[b] Germination of such grains or fermentation (e.g., leavening) of many flours can reduce antagonistic potency; the diet should then be classified as moderate availability.
[c] Vegetable diets with phytate-zinc ratios exceeding 30 are not unknown; for such diets, an assumption of 10 percent availability of zinc or less may be justified, especially if the intake of protein is low, calcium salts is excessive, or both (e.g., calcium salts providing > 1.5 g Ca^{2+}/day).

5.9. INDICATOR CONSTRUCTION

Eight food group dietary diversity indicators (FGI) were constructed as recommended in the WDDP analysis protocol. The set of indicators classify food items eaten into 6, 9, 13 and 21 food groups and applying a minimum consumption requirement of 1 g or 15 g. The following abbreviations are used to describe each indicator:

- 6 food groups, 1 g minimum intake: FGI-6
- 6 food groups, 15 g minimum intake: FGI-6R
- 9 food groups, 1 g minimum intake: FGI-9
- 9 food groups, 15 g minimum intake: FGI-9R
- 13 food groups, 1 g minimum intake: FGI-13
- 13 food groups, 15 g minimum intake: FGI-13R
- 21 food groups, 1 g minimum intake: FGI-21
- 21 food groups, 15 g minimum intake: FGI-21R

In cases where a food item could be classified into either the vitamin A- or vitamin C-rich food group, the food was classified into the vitamin A-rich food group. Revisions made to the protocol since the first analysis of the Mali sample included a change in the criteria to classify a food as vitamin-A or vitamin C-rich. **Appendix 2** shows the reclassification of fruits and vegetables in comparison with the first analysis and report.

Changes in the definition of vitamin A- and vitamin C-rich fruits and vegetables had the following effect:

- For FGI-6, the percentage of women consuming vitamin A-rich fruits and vegetables increased from 54 to 92.
- For FGI-9, the percentage of women consuming other vitamin A-rich fruits and vegetables increased from 24 to 86 percent.

- For FGI-13, the percentage of women consuming vitamin A-rich deep yellow/orange/red vegetables increased from 17 to 82 percent; vitamin A-rich fruits increased from 8 to 12 percent; and all other fruits and vegetables decreased from 99 to 60 percent.
- For FGI-21, no women consumed ―all other fruits" as all fruits consumed were defined as either rich in vitamin A or vitamin C.

The increase in consumption of vitamin A-rich deep yellow/orange/red vegetables was mainly due to the change in definition of tomato paste from ―all other vegetables" to ―vitamin A-rich vegetables." Consumption of vitamin C-rich vegetables increased due to the change in classification of garlic and onion from ―other vegetables" to ―vitamin C-rich vegetables."

5.10. ANALYTICAL APPROACH AND STATISTICAL METHODS

The statistical methods described in the WDDP analysis protocol were adopted for analysis of the data reported here.[39] We completed the following six main tasks as desribed in the protocol:

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 5.9**);
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
3. Assessed distributions of variables and transformed as needed to approximate normal distributions;[40]
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. Regression diagnostics were performed, including assessment of normality of residuals and heteroskedasticity tests. In cases where regression diagnostics indicated violation of assumptions regression results are not presented.

[39] Arimond et al. 2008a, Arminod et al. 2008b.
[40] Distributions of the food group diversity variables were considered acceptable (approximately normal) for use without transformation in correlations and regressions. There were only two exceptions to normality distribution tests, but no FGI failed both tests that were conducted.

6. Results

The results presented in this section are organized as follows:

- Characteristics of women, and energy and macronutrient intakes
- Description of dietary patterns
- Distributions of micronutrient intakes and food group diversity scores
- Micronutrient intakes and adequacy
- Contributions of food groups to nutrient intakes
- Relationship between diversity indicators and estimated intakes of individual micronutrients
- Relationship between energy from specific food groups and mean probability of adequacy
- Relationship between diversity indicators and total energy intake
- Relationship between diversity indicators and mean probability of adequacy
- Performance of diversity indicators using selected cutoffs for mean probability of adequacy

6.1. CHARACTERISTICS OF WOMEN, AND ENERGY AND MACRONUTRIENT INTAKES

Descriptive statistics are presented in **Table N1**. Mean age in the sample was 31 years, with 16 percent of the sample comprising adolescents (age 15-18). Literacy rate, defined as having attended primary school or Islamic school, was 65 percent. In the sub-sample of women whose anthropometric measurements were taken, the prevalence of chronic energy deficiency (BMI < 18.5) was 17 percent, while 28 percent of the women were overweight/obese (BMI ≥ 25.0). Mean energy intake was 2,054 (717 standard deviation [SD]) kcal, with 11 percent of dietary energy from protein, 57 percent from carbohydrate and 32 percent from fat. This macronutrient composition is within acceptable limits for carbohydrate and protein and above recommendations for percentage of dietary energy from fat.[41]

6.2. DESCRIPTION OF DIETARY PATTERNS

The diet of this urban sample of women in Mali is dominated by starchy staples, mainly refined white rice, refined wheat flour and millet. A substantial proportion of the total dietary energy is provided by fat, mainly consumed as edible vegetable oil. The majority of women consumed three meals per day; some also consumed snacks. A typical breakfast consists of millet porridge or bread. Lunch and dinner consisted of a starchy staple served with a sauce typically made from vegetables and fish or meat. The most common staples consumed for lunch and dinner were rice, bread and millet, and the sauce ingredients most frequently used were peanut butter, onions, tomatoes, garlic, dried okra, hot peppers, fish and green leaves such as sweet potato leaves, shallot leaves or amaranth leaves. In addition some women in the sample ate green salad (raw lettuce and tomatoes with oil and vinegar), and others consumed an urban type of energy-dense snack such as millet doughnuts, croissants or fried potatoes. Very few women consumed fruit; those who did ate bananas (n=4) and papayas (n=4) most often.

In terms of food variety (total number of individual food items eaten), the lowest number of different foods consumed by any woman in one day was 11 while the highest was 27 (results not shown).

Dietary patterns are described in **Tables N3-N7**. **Tables N3a-d** show the proportion of women who consumed each food group during R1. **Table N3a** shows results when foods are categorized into 6 major groups; **Table N3b** shows 9 sub-groups; **Table N3c** shows 13 sub-groups; and **Table N3d** shows 21 sub-groups. **Tables N3a-d** and **Figure A** illustrate differences between the 1 g minimum consumption cutoff and the 15 g cutoff.

Focusing on the most disaggregated group (**Table N3d**), most women consumed foods from grains and grain products, vitamin C-rich vegetables, and vitamin A-rich deep yellow/orange/red vegetables (using the 1 g limit). More than half of the women ate foods from the groups of nuts and seeds (using the 1 g limit); beef, pork, veal, lamb, goat, game meat; large whole fish/dried fish/shellfish/other seafood; and all

[41] WHO/FAO 2003.

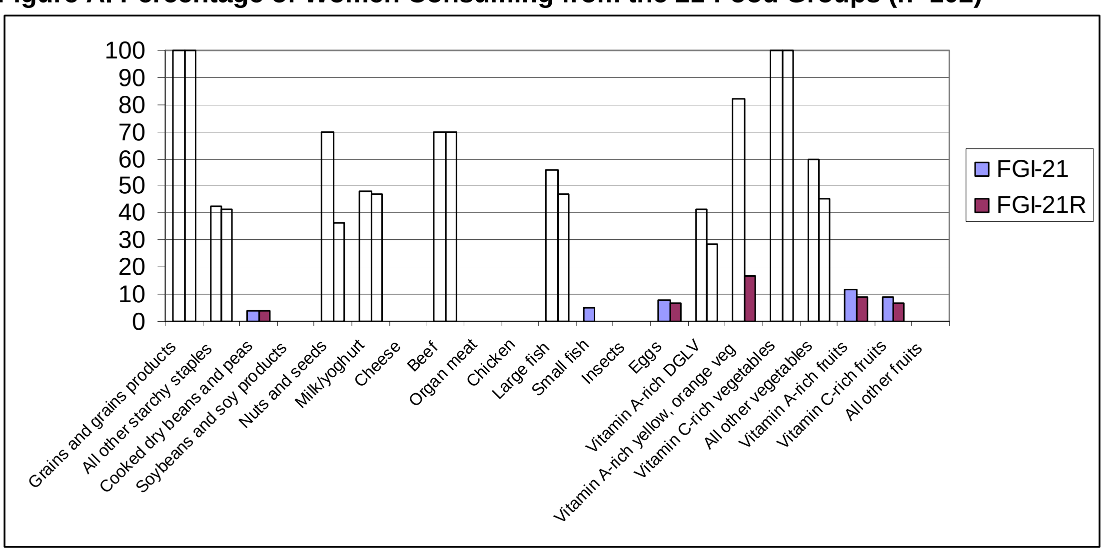
other vegetables. Nearly half of the women consumed milk or yogurt (**Figure A**). For the food groups grains and grain products, milk/yogurt and vitamin C-rich vegetables, there were no substantial differences between the 1 g limit and the 15 g limit. Thus, those who ate 1 g from these groups tended also to eat at least 15 g of the foods. For the remaining food groups commonly consumed, there was a difference between the percentage consuming 1 g as compared to 15 g of the food group.

The food groups most affected by the 15 g limit were vitamin A-rich deep yellow/orange/red vegetables, and nuts and seeds. The food groups large whole fish/dried fish/shellfish/other seafood, small fish eaten whole with bones and vitamin A-rich dark green leafy vegetables were also influenced by the 15 g minimum intake. In the vitamin A-rich deep yellow/orange/red vegetable group, tomato paste was a common ingredient in sauce accompanying staple foods, but the amount consumed rarely exceeded 15 g. The difference in the nuts and seeds group was almost entirely due to the frequent consumption of fermented African locust bean seed, which is often added to sauce for flavoring and used in very small amounts. In the small fish eaten whole with bones group, the percentage of women consuming dropped from 5 to 0 when the 15 g limit was applied.

In the most aggregated group, every food group but dairy was consumed by at least half of the women, using the 1 g limit. Dairy was consumed by 48 percent of the women. In the 9 and 13 group scores, no women consumed organ meat. In the 21 group score, no women consumed soybeans or soy products, cheese, organ meat, chicken or other fowl, insects, or all other fruits. So the maximum scores possible were 6, 8, 12 and 15. Using the 1 g limit, four of the 15 groups consumed for FGI-21 were consumed by less than 10 percent of women in the sample: beans and peas; small fish with bones; eggs; and vitamin C rich fruits. The remaining 11 food groups were consumed by 12 to 100 percent of women in the sample. The food groups infrequently consumed are important to keep in mind for interpreting data in later tables.

Rice (consumed by 90 percent of women), bread (consumed by 49 percent of women) and millet products (consumed by 42 percent) were the foods most commonly consumed in the grain and grain product group. In the vitamin C-rich vegetable food group, tomatoes and onions were consumed by 90 percent or more of the women, followed by cabbage, 58 percent. In the vitamin A-rich deep yellow/orange/red vegetable food group, tomato paste was consumed by 79 percent of the women. Beef was the only food consumed from the beef, pork, veal, lamb, goat and game meat group. Fermented African locust bean seeds (consumed by 53 percent of women) and groundnut products (consumed by 23 percent of women) were the two foods consumed in the nuts and seeds groups. In the "all other foods group" (not included in the dietary diversity scores), sugar was consumed by 77 percent and oil by 76 percent. Coffee and green tea were also frequently consumed.

Figure A. Percentage of Women Consuming from the 21-Food Groups (n=102)



Tables N4a-d describe the average quantities consumed from each food group, for all women in the sample and for only those consuming the food group. **Table N4a** shows that for the 6 food group —the most aggregated group – starchy staples and other fruits and vegetables were consumed by all women. Starchy staples (e.g., grains) were eaten in large amounts, with a mean intake of 804 g. This intake provided an average of 948 kcal, nearly 50 percent of the total energy in the diet. The next largest contributor to dietary energy was legumes and nuts (consumed by 73 percent of women), mainly due to the high energy density and frequent consumption of peanut butter. Mean intake of other fruits and vegetables was 243 g, but due to lower energy density, these foods contributed an average of 94 kcal. Mean intake of meat, fish or eggs was 72 g (73 g among the 98 percent of women who consumed), which contributed an average of 146 kcal (149 kcal among the 98 percent of women who consumed) to the diet.

Table N4d shows that for the 21 food group - the most disaggregated group - grains and grain products accounted for 43 percent of total dietary energy intake for all women in the sample, followed by nuts and seeds, red meat, and milk and yogurt. The amount of vitamin C-rich vegetables (tomatoes, cabbage and hot peppers) consumed stood out in the more disaggregated list, although their contribution to dietary energy intake is rather low. Disaggregation of the animal-source food groups shows beef was consumed in larger quantities (42 g) than large fish (25 g), with the former contributing more to total energy intake.

Table N5 presents mean and median dietary diversity scores for the eight dietary diversity indicators, and **Table N6** shows the percentage of observations at each score for each indicator. Overall, dietary diversity scores increased as the food groups comprising the indicators became more disaggregated. Mean dietary diversity scores ranged from 5.1 to 7.1 for the 1 g indicators and slightly lower, from 4.3 to 5.6 for the 15 g indicators. The median scores ranged from 5-7 food groups for the 1 g indicators and 4-5 food groups for 15 g indicators. The range of dietary diversity scores for FGI-21 and FGI-21R was 3-11 and 2-10, respectively. With the exception of FGI-13R and FGI-21R, the mean scores using the revised protocol were higher than those reported previously.

Cross-tabulations of dietary diversity scores against the individual food groups provide a picture of how diets diversify (**Tables N7a-h**). At the extreme ends of the distribution some of the scores contain very few observations. To minimize misinterpretation of results due to scores with small sample size, only those scores with a sample size of 10 or more observations are included in the interpretation of these tables. For FGI-6 and FGI-6R (**Tables N7a-b**), this includes scores of 4 to 6 and 3 to 5, respectively. **Table N7a** shows starchy staples, other animal-source foods, vitamin A-rich fruits and vegetables, and other fruits and vegetables were consumed by at least 50 percent of women with an FGI-6 of 4. Legumes and nuts and dairy were consumed by at least 50 percent of women with scores of 5 or 6. There was a large difference between FGI-6 and FGI-6R results are for legumes and nuts, dairy, and vitamin A-rich fruits and vegetables, which were not consumed by more than 50 percent of women until a score of 5 on FGI-6R.

Tables N7g-h provide results for FGI-21 and FGI-21R. The range of scores with more than 10 observations was 6 to 9 and 4 to 7, respectively. At a score of 6 for FGI-21, the food groups consumed by 50 percent or more of the women were grains and grain products; nuts and seeds; beef, pork, veal, lamb, goat or game meat; vitamin A-rich deep yellow/orange/red vegetables; vitamin C-rich vegetables; and all other vegetables. At a score of 7, all other starchy staples were also consumed by the majority of women. Milk and yogurt, and large fish were consumed by 50 percent or more at a score of 8, and vitamin A-rich dark green leafy vegetables at a score of 9. At a score of 4 on FGI-21R, grains and grain products, beef and vitamin C-rich vegetables were consumed by 50 percent or more of the women. As FGI-21R scores increased, the following food groups were consumed by a majority of the women: at a score of 5, all other starchy staples and large fish, and at a score of 6 and 7, nuts and seeds, milk and yogurt and all other vegetables. In summary, for FGI-21 and FGI-21R, as diets diversified, beef, pork, veal, lamb, goat and game meat was the first food group to be added to the diet and was not affected by the 15 g minimum consumption requirement. The food groups that seemed to be most affected by the 15 g limit were nuts and seeds, large whole fish/dried fish/shellfish and other seafood and vitamin A-rich dark green leafy vegetables.

6.3. DISTRIBUTIONS OF MICRONUTRIENT INTAKES AND FOOD GROUP DIVERSITY SCORES

Intake distributions and intra-individual standard deviation distributions for most micronutrients were skewed (see **Figures N1-N22**). Nutrient intake distributions were transformed for further analyses (Box-Cox lambda values in **Table N8**).

6.4. MICRONUTRIENT INTAKES AND ADEQUACY

Table N8 shows that median micronutrient intakes were below the EAR for riboflavin, niacin, vitamin B12, folate, vitamin A and the adequate intake (AI) for calcium. Median intakes were above the EAR for vitamin B6, vitamin C and zinc, and equal to the EAR for thiamin. The probability of adequate intake (PA) for the sample was < 0.20 for vitamin B12 and folate, ranged from 0.27 to 0.31 for riboflavin, calcium and niacin, and was 0.50 or above for iron, vitamin A, vitamin B6, thiamin, zinc and vitamin C. The sample MPA for the 11 micronutrients was 0.47; using the lower bioavailability for iron and zinc dropped the range of PA from the sample to 0.07-0.81 and lowered the MPA to 0.41.

6.5. CONTRIBUTIONS OF FOOD GROUPS TO NUTRIENT INTAKES

Tables N9a-d show the contribution of each of the 6, 9, 13 and 21 food groups to nutrient intake. Each food group's contribution to nutrient intake depends on both the quantity consumed and the nutrient density of the food items in the group. Women in the sample consumed large quantities of grains (an average of 747 g). As a result, this food group makes a large contribution to the intake of many micronutrients, even though the food items in this group are not considered among the highest food sources for any given micronutrient. Other food groups have such high levels of micronutrients that even small amounts contribute substantially to micronutrient intake. For example, although women ate only small quantities of dark green leafy vegetables (an average intake of 30 g), those foods made a considerable contribution to vitamin A intake because they are rich in beta carotene.

A summary of the food groups and the individual food items contributing to intake of the 11 micronutrients selected for focus in the WDDP appears below. **Appendix 3** provides more detailed information on the nutrient composition values of the food items discussed below.

- Median zinc intake exceeded the EAR. The majority of zinc intake came from grains, particularly millet, which is high in zinc and was consumed in some form by 21 percent of women. Milk and yogurt and other animal-source foods each contributed an additional 20 percent to zinc intake.
- Median vitamin C intake also exceeded the EAR. An average of 212 g of vitamin C-rich vegetables including tomatoes, hot peppers, sweet peppers and fried, dried shallots were consumed. All women consumed vitamin C-rich vegetables, which contributed to 67 percent of vitamin C intake. The ―all other starchy staples" group, which mainly comprises boiled or fried potatoes, contributed most of the remainder (15 percent) of total vitamin C intake.
- Median vitamin A intake did not meet the EAR. Vitamin A intake came primarily from dark green leafy vegetables (36 percent), and milk and yogurt (20 percent). Vitamin A-rich deep yellow/orange/red vegetables and vitamin C-rich vegetables each contributed an additional 12 percent.
- The median PA for thiamin was 0.5, indicating that median intake was about equal to the EAR. The primary source of thiamin was grains, followed by nuts and seeds.
- Median iron intake was 14 g, and the median PA was 0.55. Forty percent of iron intake came from grains (due to the large volume consumed), with wheat and millet both being moderate sources, depending on type of dish consumed. The next largest contributors to iron intake were nuts and seeds (namely, peanut butter) and vitamin C-rich vegetables. Nine percent of iron intake came from beef and 5 percent from large fish.[42] Median niacin intake was slightly below the EAR,

[42] This result at first seemed rather surprising. Iron content is 3.6 mg/100 g for beef, 0.05/100 g for cooked catfish and 4.1 mg/100 g for Nile perch. The iron content of wheat, millet and peanut butter is on about the same level as that of

with a median PA of 0.06. Most of the niacin in the diet came from the nuts and seeds, grains and beef groups.

- Median riboflavin intake was below the EAR, and the median PA was 0.05. The majority of riboflavin came from grains, and milk and yogurt, none of which, with the exception of powdered milk, are a rich source of riboflavin.
- Calcium intake was quite low, with a median PA of 0.25. The majority of calcium intake was provided by milk and yogurt (43 percent), and vitamin C-rich vegetables (17 percent). Some dark green leafy vegetables are a rich source of calcium; 11 percent of calcium intake came from this group, in spite of the small quantities consumed.
- Median vitamin B6 intake exceeded the EAR. The main contributors to vitamin B6 intake were grains (due to the volume consumed), other starchy staples and vitamin C-rich vegetables.
- Folate intake was much lower than the EAR.[43] One third of folate came from the vitamin C-rich vegetable group (tomatoes, in particular), followed by nuts and seeds (13 percent) and vitamin A-rich dark green leafy vegetables (12 percent). Cowpeas were also a significant source of folate but were infrequently consumed.
- Median vitamin B12 intake was 1.3 µg, below the EAR of 2.0 µg. Nearly equal proportions of vitamin B12 were obtained from milk/yogurt, beef and large fish. Although consumption of these products seemed considerable for a developing country context, the amounts consumed were not sufficient to meet the EAR. In addition, the TACAM tables report a vitamin B12 value for beef that is substantially lower than values for similar beef cuts in other food composition tables. However, a quality evaluation of B12 values in the TACAM concluded that the values were within an acceptable range and therefore no substitution was recommended.[44]

6.6. RELATIONSHIP BETWEEN DIVERSITY INDICATORS AND ESTIMATED INTAKES OF INDIVIDUAL MICRONUTRIENTS

Table N10 shows the correlation between the eight dietary diversity indicators and estimated intake of individual nutrients.

- In general, there was a trend for more significant relationships when not controlling for energy intake. The most consistent relationships were seen for riboflavin, folate, vitamin B12, vitamin A and calcium. For these nutrients, the correlations with all dietary diversity indicators were positive and significant, and remained so after controlling for energy intake. After controlling for energy, correlations became smaller and so energy in part explains the relationship between dietary diversity and micronutrient intakes.
- Estimated intakes for all micronutrients except iron were significantly correlated with FGI-21 and FGI-21R when energy intake was not controlled. After controlling for energy, correlations remained significant for riboflavin, folate, vitamin B12, vitamin A, calcium and vitamin C for FGI-21R and for all those micronutrients except vitamin C for FGI-21.
- Zinc was positively correlated with all dietary diversity indicators when not controlling for energy and with FGI-6, FGI-6R and FGI-9 when controlling for energy.
- Vitamin C was negatively correlated with FGI-6 and FGI-9. The correlation became positive and significant, when food groups were more disaggregated into 21 groups.
- Estimated iron intake was significantly correlated only with FGI-9 when not controlling for energy.
- Vitamin B6 correlations were significant for FGI-6R, FGI-13R, FGI-21 and FGI-21R when not controlling for energy.

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beef and fish, but the former are consumed in much greater quantities and by a larger percentage of the women in the sample. Although smoked and dried fish have very high iron content, these foods were much less commonly consumed.

[43] The PA for folate was 0 for all women. Three women on day one had intake values above (or nearly equal to) the EAR of 320 (586 µg, 384 µg and 275 µg, respectively); however, their values for day two were very low, (57 µg, 83 µg and 93 µg, respectively). In general, folate values in the TACAM table are low for most foods, particularly staple foods.

[44] Personal communication, Doets 2008.

6.7. RELATIONSHIP BETWEEN ENERGY FROM SPECIFIC FOOD GROUPS AND MEAN PROBABILITY OF ADEQUACY

Correlations between MPA and dietary energy for the 6, 9, 13 and 21 food groups are presented in **Tables N11a-d**. Using the most aggregated grouping, correlations between dietary energy and MPA are significant for four out of six food groups without controlling for total dietary energy and for two out of six when total dietary energy is controlled. Dietary energy from the vitamin A-rich fruits and vegetables group and other fruits and vegetables group was not significantly correlated with MPA in either test. Only the starchy staples and dairy food groups still had significant correlations with MPA when controlling for total energy. However, the relationship between MPA and the starchy staples group became negative when controlling for energy.

Using the most disaggregated grouping, six (grains and grain products; all other starchy stables; nuts and needs; vitamin C-rich vegetables; milk/yogurt; and vitamin A-rich dark green leafy vegetables) out of a possible 15 food groups were correlated with MPA when not controlling for total dietary energy, and four (grains and grain products; milk/yogurt; eggs and vitamin A-rich dark green leafy vegetables) were significant when total dietary energy is controlled. For the eggs and vitamin A-rich dark green leafy vegetables groups, the correlation coefficient increased when controlling for energy, while for the grains and grain products food group, the coefficient changed from positive to negative.

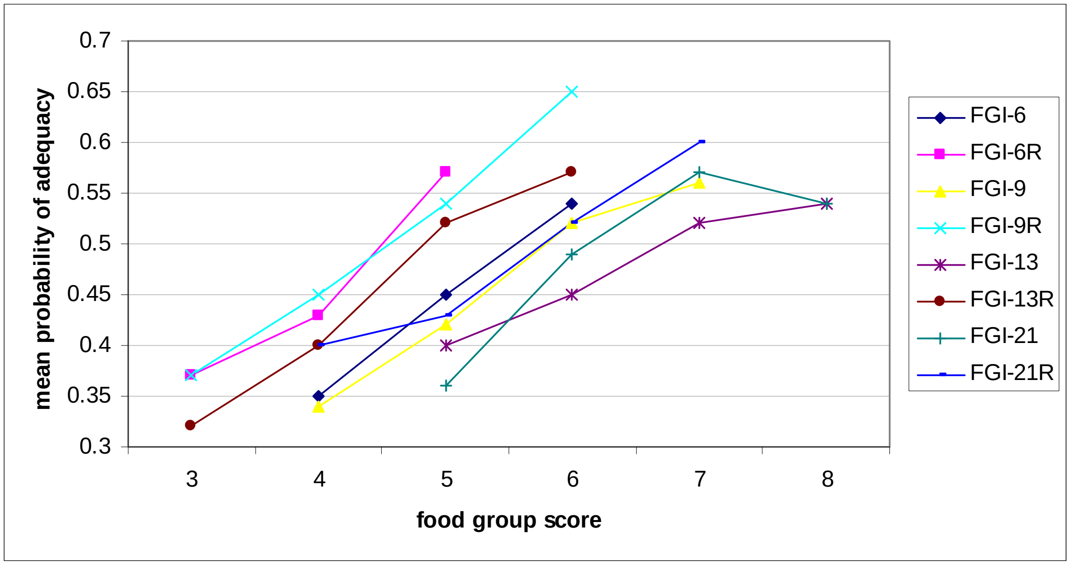
6.8. RELATIONSHIP BETWEEN DIVERSITY INDICATORS AND TOTAL ENERGY INTAKE

Total energy intake by dietary diversity indicator and the correlation between those two parameters appear in **Tables N12** and **N13**, respectively. Dietary energy intake increased rather consistently with increasing dietary diversity scores for each dietary diversity indicator; however, there was no entirely linear relationship at either extreme end of the scores. This is likely due in part to the smaller sample sizes at the tails of the distribution. The correlation coefficients between energy intake and the dietary diversity indicators ranged from 0.18 to 0.26, with significant coefficients for FGI-6, FGI-6R, FGI-9, FGI-13R and FGI-21R.

6.9. RELATIONSHIP BETWEEN DIVERSITY INDICATORS AND MEAN PROBABILITY OF ADEQUACY

Tables N14 and **N15** show the relationship between the dietary diversity indicators and MPA. The relationship between the dietary diversity scores and MPA demonstrated a general linear relationship (see **Figure B**). All coefficients between the dietary diversity scores and MPA were positive and significant. The coefficients ranged from 0.30 (FGI-13) to 0.50 (FGI-6R). For the majority of the relationships, the correlation coefficients decreased slightly when controlling for energy intake.

Figure B. Mean Probability of Adequacy by Food Group Scores for Various Diversity Indicators [a]



[a] Only scores with 10 or more observations are plotted.

The relationships between the dietary diversity indicators and MPA were also analyzed by different linear regression models. These analyses are presented in **Tables N16a-b**. Results for FGI-13 and FGI-13R were excluded from table N16a when energy was added to the model, due to non normality of residuals. The dietary diversity indicators were significant predictors of MPA in all regressions when not controlling for energy. When controlling for energy and excluding height from the model (table 16b), all indicators except FGI-6 and FGI-13 were significant predictors of MPA. Neither a woman's age nor height was significantly associated with MPA. In the model excluding height, the adjusted R^2 ranged from 0.09 for FGI-13 to 0.25 for FGI-6R when not controlling for energy. The regression results controlling for energy were higher, with adjusted R^2 ranging from 0.36 (FGI-13) to 0.42 (both FGI-6R and FGI-9R).

6.10. PERFORMANCE OF DIVERSITY INDICATORS USING SELECTED CUTOFFS FOR MEAN PROBABILITY OF ADEQUACY

Table N17 shows that 46 percent of the women had an MPA > 50 percent, 25 percent had an MPA > 60 percent and 11 percent had an MPA > 70 percent. The percentages of women above MPA cutoffs of 70 percent and higher are low enough, particularly given this study's small sample size, to indicate that MPA cutoffs of 70 percent and higher should be excluded from an analysis of indicator performance.

For the purpose of assessing an indicator's predictive potential, an area under the curve (AUC) of ≥ 0.70 derived from receiver-operating characteristic (ROC) analysis can be considered to have potential, while an AUC of 0.50 indicates "no predictive power." For Mali, all AUC results except for FGI-6 and FGI-13 were above the 0.70 threshold (with a narrow range of 0.72 to 0.75) when using an MPA cutoff > 50 percent, indicating that FGI-6R, FGI-9R, FGI-9R, FGI-13R, FGI-21 and FGI-21R have some potential predictive power at this cut-point (**Table N18**). At an MPA cutoff > 60 percent, the AUC results ranged from 0.59 (FGI-13) to 0.71 (FGI-6R) across all eight indicators, with only FGI-6R and FGI-9R above 0.70. At the MPA cutoff > 70 percent, the AUC results were similar, ranging from 0.54 to 0.78. Since only 11 women had an MPA > 70 percent, these results will not be further interpreted.

For both of the MPA cutoffs > 50 percent and > 60 percent, the p value indicated a significant difference between a neutral diagonal line and the AUC obtained with the dietary diversity indicators. The exceptions were FGI-6, FGI-13 and FGI-21 at the MPA cutoff > 60 percent. At an MPA > 50 percent, the highest AUC was 0.75 for both FGI-6R and FGI-9R, followed by FGI-9, FGI-13R and FGI-21R at 0.74. At an MPA > 60 percent, the highest AUC was for FGI-6R (0.71) followed by FGI-9R (0.70) and then both FGI-13R and FGI-21R, (0.68). In looking at AUCs that are significantly different from one another (**Table**

N19), there were no significant differences among the indicators for MPA > 50 percent. At an MPA cutoff > 60 percent, FGI-13 was significantly lower than FGI-6R, FGI-9R and FGI-13R.

Sensitivity, specificity and total misclassification are presented in **Tables N20a-h**. Sensitivity indicates the proportion of those with better MPA identified correctly by the chosen cutoff applied to the score. Specificity is the proportion of those with a lower MPA who are correctly identified using the cutoff for each score. For the purposes of the WDDP – to develop indicators to assess diet quality for women at a population level – it is reasonable to aim for a balance between sensitivity and specificity, but to favor specificity when trade-offs must be made.[45] This would err on the side of classifying women with lower MPA correctly.

Based on the results in **Table N18** neither FGI-6 nor FGI-13 had AUC ≥ 0.70 at any MPA cutoff, therefore these two indicators could be considered the worst performers. FGI-6R and FGI-9R had the highest AUC at an MPA > 50 percent. The best sensitivity/specificity balance (favoring specificity) was at a cutoff of ≥ 5 food groups for FGI-6R where sensitivity was 62 percent, specificity was 78 percent and total misclassified was 29 percent. For FGI-9R, the best cutoff was ≥ 5 food groups where sensitivity was 62 percent, specificity was 75 percent and total misclassified was 31 percent. FGI-21R also performed well at a cutoff of ≥ 6 food groups with a sensitivity of 72 percent, specificity of 71 percent and a total of 28 percent misclassified.

At an MPA cutoff of > 60 percent, FGI-6R and FGI-9R seemed to have the best performance. At a cutoff of ≥ 5 food groups, sensitivity for FGI-6R was 64 percent, specificity was 68 percent and the total misclassified was 33 percent. At a cutoff of ≥ 5 food groups, FGI-9R had a sensitivity of 64 percent, a specificity of 65 percent and a total of 35 percent misclassified.

[45] Arimond et al. 2009a.

7. Summary and Discussion

The results of this study indicate that dietary diversity indicators, particularly those that apply a 15 g minimum consumption requirement, can be used as a proxy indicator to assess the micronutrient adequacy of the diet of NPNL women of reproductive age in urban Mali.

7.1. DIETARY PATTERNS

Results from this urban sample of women in Mali indicate that energy intake and macronutrient distributions were within acceptable ranges, with intake of total dietary energy and percentage of dietary energy from fat tending to exceed the higher acceptable ranges. This is also reflected in the average BMI and percentage of women with a BMI classified as overweight or obese.

Roughly 50 percent of dietary energy came from starchy staples. This is lower than for most other WDDP sites. In the Mali sample, food items not counted in any of the dietary diversity indicators, such as fats and oils, accounted for 20 percent of total dietary energy intake. The large proportion of energy provided by fats and oils partly explains the results reported in **Tables N12** and N**13**, where the dietary diversity indicators and total energy intake were not always strongly or significantly correlated.

7.2. MICRONUTRIENT INTAKES AND ADEQUACY

The MPA of women in the Mali sample was 0.47, higher than the MPA for most other WDDP sites. In the Mali sample there was a wide variation in PA for individual micronutrients, ranging from 0-0.96. Estimated prevalence of PA was lowest for folate, vitamin B12, riboflavin and calcium and was highest for zinc, vitamin C and vitamin B6.

Intakes for thiamin, riboflavin, folate, calcium and vitamin B12 were low while vitamin C intake was high. Iron and zinc intakes were high among urban women in Mali due in part to increased intake of animal-source foods and millet, which is one of the most frequently consumed staples and is also a good source of zinc. Bioavailability of iron and zinc for this urban sample of women was assessed at 10 percent for iron and 34 percent for zinc. It should be noted that the use of these higher bioavailability factors, in comparison with five and 25 percent for iron and zinc, respectively, changed the estimated prevalence of PA of iron from 0.07 to 0.54 and of zinc from 0.81 to 0.96.

7.3. RELATIONSHIPS BETWEEN FOOD GROUP DIVERSITY, DIET QUALITY AND ENERGY INTAKE

The relationship between dietary diversity indicators and intake of individual micronutrients was not as consistent as the results seen for some other WDDP sites. For the Mali sample, the most consistent results were with riboflavin, folate, vitamin B12, vitamin A and calcium, which were significantly correlated with every indicator tested. For zinc, correlations were more significant with the less aggregated indicators, while the opposite was true for vitamin C intake. Those micronutrients with a consistently significant relationship with all eight indicators were derived for the most part from a wide set of food groups, with no single food group dominating more than 50 percent of intake (except for vitamin B12, which was dominated by dairy and other animal source food groups).

All dietary diversity indicators, except FGI-13 and FGI-13R in the model including height and total energy intake, were positively and significantly associated with MPA in linear regression models. The explanatory power of the model increased when energy intake was added to the model.

7.4. INDICATOR PERFORMANCE

The aim for choosing an MPA cutoff is to arrive at a probability level of nutrient adequacy that "can comfortably be described as reasonably adequate."[46] An MPA cutoff > 50 percent does not fit this definition. A cutoff > 60 percent comes closer, but ideally one would choose an even higher MPA, perhaps > 75 percent or > 80 percent. The mean MPA in the Mali dataset was 0.47, and while 11 percent of the sample had an MPA above 70 percent, because of the small sample size, this represents only 11 women. Using the less ideal MPA cutoff of > 60 percent, FGI-6R and FGI-9R were the only indicators above an AUC of 0.70. In terms of balance between sensitivity and specificity, the best cutoff for FGI-6R and FGI-9R was ≥ 5 food groups.

7.5. IMPLICATIONS FOR OPERATIONALIZING FOOD GROUP DIVERSITY

When evaluating what MPA cutoff to use for an indicator of the quality of the diet, it must be considered whether the MPA cutoff used will allow the indicator to focus on a positive outcome (adequate probability of micronutrient intake) or an undesirable outcome (likelihood that the diet is insufficient in micronutrients). Given the Mali study's small sample size, it was not possible to draw conclusions about an indicator that would really maximize the potential for a positive outcome (MPA cutoff > 75 or > 80 percent). This should be taken into consideration when deciding how to interpret the chosen indicator.

Our results concur with those from other WDDP sites: The 15 g restricted indicators performed slightly better, indicating that for data collection purposes, it is better to exclude items used in small amounts, such as food flavorings. In the context of Mali, these items include *soumbala* (African locust bean seed), dried okra powder, hot peppers and small dried fish.

Judging each indicator based on a combined performance of results, including the Pearson correlation coefficients, linear regressions, AUC and maximizing the balance between sensitivity and specificity, FGI-6R and FGI-9R consistently ranked the highest, with FGI-13R and FGI-21R usually ranking second or third, depending on the test result considered. When trying to choose a cutoff point for operationalizing the indicators, a cutoff of ≥ 5 food groups would be the consistent choice for both FGI-6R and FGI-9R at either an MPA of > 50 percent or > 60 percent. At an MPA > 50 percent, FGI-21R had the best balance of sensitivity and specificity at a cutoff of ≥ 6 food groups. Our results indicate that the best cutoff to operationalize an indicator would be ≥ five or ≥ six food groups, with ≥ five being better for the more aggregated scores of FGI-6R and FGI-9R and ≥ six being better for FGI-13R and FGI-21R.

7.6. GENERALIZABILITY

The data used in this study were collected only a year before this report was written. They seem to accurately reflect the dietary patterns of urban women in developing countries undergoing the nutrition transition. Aspects of the nutrition transition characterized by Mendez and Popkin[47] are noted in this data set. For example, staple foods are still a predominant part of the diet, the diet is sufficient or even abundant in terms of energy intake, yet micronutrient intake remains below requirements. The diet is also characterized by substantial amounts of fat, primarily from vegetable oil, fried foods and moderate intake of animal-source foods. One third of the sample of women with anthropometric data were overweight or obese, another indication of the nutrition transition in this population.

[46] Arimond et al. 2009a.
[47] 2004.

8. Conclusions

The overall level of dietary diversity in this sample of urban NPNL women of reproductive age living in Bamako was rather high, particularly when looking at the most aggregated indicators (1 g limit), where the median intake of food groups was five out of six food groups (FGI-6). Diversity dropped off as indicators became more disaggregated, reaching a median food group score of 6 out of 13 (for FGI-13) and 7 out of 21 food groups (for FGI-21). This indicates that there is overall a lot of diversity across the 6 major food groups, but that this diversity is limited to certain food items within these major food groups. The dietary pattern is primarily driven by consumption of one to two main meals that consist of a staple accompanied by a sauce. The sauce ingredients tend to be quite standard, generally coming from two to three of the six major food groups. Snacks and foods purchased outside the home were important supplements to the diversity, with roasted peanuts, some fruits and fruit juices, and fried snacks such as fried potatoes and doughnuts contributing to increasing diversity scores, particularly at the more disaggregated levels.

The exclusion of fats and oils as a food group in the dietary diversity indicators might partially explain the lack of correlation seen between some of the indicators and total energy intake, but it is unlikely to influence the relationship between micronutrient adequacy. However, due to the pace of the nutrition transition in developing countries, monitoring consumption of fats and oils is important and should not be excluded from guidelines on how to collect information on the diversity of the diet.

All of the dietary diversity indicators constructed for this analysis were positively and significantly correlated to our indicator of micronutrient adequacy. The results of the ROC analysis showed FGI-6R and FGI-9R to have a slight advantage of the rest. FGI-21R and FGI-9R performed nearly as well as FGI-6R, although they did not have an AUC above 0.70 at an MPA > 60 percent. It should be noted that the results for all FGI-R indicators were quite similar and that there were no significant differences among the AUCs for these four indicators.

These results demonstrate that dietary diversity scores are useful proxy indicators of adequate intake across a range of key micronutrients, particularly when foods consumed in small amounts are excluded from counting in the score.

References

Arimond, M., L. E. Torheim, D. Wiesmann, M. Joseph, and A. Carriquiry. 2009a. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Results from Rural Bangladesh Site*. Washington, DC: FANTA at FHI 360.

Arimond, M., D. Wiesmann, E. Becquey, A. Carriquiry, M. Daniels, M. Deitchler, N. Fanou, E. Ferguson, M. Joseph, G. Kennedy, Y. Martin-Prével, and L. E. Torheim. 2009b. *Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets in Resource-Poor Areas: Summary of Results from Five Sites*. Washington, DC: FANTA at FHI 360.

Arimond, M., D. Wiesmann, L. E. Torheim, M. Joseph, and A. Carriquiry. Revised March 2008a. *Validation of Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Background and Research Protocol.* Washington, DC: FANTA at FHI 360.

---. October 2008b. *Validation of Dietary Diversity as a Measure of the Micronutrient Adequacy of Women's Diets: Addendum to Research Protocol.* Washington, DC: FANTA at FHI 360.

Barikmo, I., F. Ouattara and A. Oshaug. 2004. *Table de composition d'aliments du Mali*. Oslo: Akershus University College.

CPS/MS/DNSI/ORC Macro. 2002. *Enquête Démographique et de Santé au Mali 2001* (EDSM-III). Calverton, Maryland: CPS/MS/DNSI/ORC Macro.

Doets, E. 2008. Personal Communication. Unpublished report ―Qality evaluation of two types of beef and mutton meat." Communication received September 24, 2008.

---. 2007. *Quality Evaluation and update of the Food Composition Table of Mali* (TACAM, 2004). Masters Thesis. Wageningen University and Research Center.

FAO/WHO. 2002. *Human Vitamin and Mineral Requirements.* Report of a joint FAO/WHO Expert consultation. Geneva: WHO and Rome: FAO.

Gibson, R., and E. Ferguson. 1999. *An Interactive 24-Hour Recall for Assessing the Adequacy of Iron and Zinc Intakes of Developing Countries*. Washington, DC: USAID and ILSI..

Gibson, R. F. 2005. *Principles of nutritional assessment*. 2nd ed. Oxford, UK: Oxford University Press.

Holland, B., A. A. Welch, I. D. Unwin, D. H. Buss, A. A. Paul, and D. A. T. Southgate. 1991. *McCance & Widdowson's The Composition of Foods, 5th ed.* Cambridge, MA: The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.

IZiNCG. 2004. ―Assessment of the Risk of Zinc Deficiency in Populations and Options for Its Control." *Food and Nutrition Bulletin* 25: S99-203.

Koreissi, Y., N. Fanou and I. Brouwer. 2007. *Development of the fonio food composition table.* Montpellier, France: EU/STREP/INCO.

Mendez, M., and B. Popkin. 2004. *Globalization, urbanization and nutritional change in the developing world in Globalization of food systems in developing countries: Impact on food security and nutrition.* Rome: FAO.

MPAT/DRPSI-ATP/DNSI. November 2005. *Annuaire statistique du district de Bamako : 2004*. Bamako, Mali: MPAT/DRPSI-ATP/DNSI.

USDA, Agricultural Research Service. 2008. *USDA National Nutrient Database for Standard Reference, Release 20*. Available from Nutrient Data Laboratory Home Page, http://www.ars.usda.gov/ba/bhnrc/ndl (accessed January 2008).

---. 2007. *USDA Table of Nutrient Retention Factors, Release 6*. Nutrient Data Laboratory Home Page, http://www.ars.usda.gov/ba/bhnrc/ndl (accessed January 2008).

UNICEF, Division of Policy and Planning. 2006. *Monitoring the Situation of Children and Women: Multiple indicator cluster survey manual*. New York: UNICEF.

WHO. 1995. *Physical status: The use and interpretation of anthropometry*. Geneva: WHO.

WHO/FAO. 2004. *Vitamin and Mineral Requirements in Human Nutrition*. Report of a joint FAO/WHO expert consultation. 2nd edition. Geneva: WHO and Rome: FAO,

---. 2003. *Diet, Nutrition and the Prevention of Chronic Diseases*. Report of a joint WHO/FAO expert consultation. Geneva: WHO.

WorldFood Dietary Assessment System. *Users Guide to the WorldFood Dietary Assessment System*, version 2.0. http://www.fao.org/infoods/software/wfood2.doc (accessed on August 6, 2008).

Appendix 1. Tables and Figures, Non-Pregnant, Non-Lactating Women

Table N1. Description of Sample, NPNL Women, R1 (n=102)

	n	Mean	SD	Median	Range
Age (year)	102	31.5	10.5	30	15-49
Height (cm)	64	166	5.9	165.6	155-188
Weight (kg)	64	65.0	14.8	63.3	41-100
BMI	64	23.6	5.6	22.7	16.6-41.1
Education (% literate)[a]	102	65.1			
	n	**Percent**			
BMI <16	0	0			
16≤BMI≤16.9	3	4.7			
17≤BMI≤18.49	8	12.5			
18.5≤BMI≤24.9	35	54.7			
25≤BMI≤29.9	11	17.2			
BMI ≥30	7	10.9			

[a] Percent of Women who reached at least primary school level or went to Islamic school.

Table N2. Energy and Macronutrient Intakes, NPNL Women, R1 (n=102)

	Mean	SD	Median	Range	Percent of kcal
Energy (kcal)	2054.0	716.5	2023.9	525-4150	
Protein (g)	57.7	25.6	53.9	12.6-136.0	11
Total carbohydrate (g)	310.1	112.3	319.6	106.6-605.6	57
Total fat (g)	73.2	34.8	71.6	1.7-181.0	32

Table N3a. Percent of Women Who Consumed 6 Major Food Groups, NPNL Women, R1 (n=102)

Food groups	≥ 1 g	≥ 15 g
All starchy staples	100	100
All legumes and nuts	73	39
All dairy	48	47
Other animal source foods	98	95
Vitamin A-rich fruits and vegetables [a]	92	47
Other fruits and vegetables	100	100

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g in the form eaten.

Table N3b. Percent of Women Who Consumed 9 Sub-Food Group, NPNL Women, R1 (n=102)

Food groups	≥ 1 g	≥ 15 g
All starchy staples	100	100
All legumes and nuts	73	39
All dairy	48	47
Organ meat	0	0
Eggs	8	7
Flesh foods and other miscellaneous small animal protein	98	95
Vitamin A-rich dark green leafy vegetables [a]	41	28
Other vitamin A-rich vegetables and fruits [a]	86	25
Other fruits and vegetables	100	100

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g in the form eaten.

Table N3c. Percent of Women Who Consumed 13 Sub-Food Groups, NPNL Women, R1 (n=102)

Food groups	≥ 1 g	≥ 15 g
All starchy staples	100	100
All legumes and nuts	73	39
All dairy	48	47
Organ meat	0	0
Eggs	8	7
Small fish eaten whole with bones	5	0
All other flesh foods and miscellaneous small animal protein	98	95
Vitamin A-rich dark green leafy vegetables [a]	41	28
Vitamin A-rich deep yellow/orange/red vegetables [a]	82	17
Vitamin C-rich vegetables [b]	100	100
Vitamin A-rich fruits [a]	12	9
Vitamin C-rich fruits [b]	9	7
All other fruits and vegetables	60	45

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g in the form eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g in the form eaten.

Table N3d. Percent of Women Who Consumed 21 Sub-Food Groups, NPNL Women, R1 (n=102)

Food groups	≥ 1 g	≥ 15 g
Grains and grains products	100	100
All other starchy staples	42	41
Cooked dry beans and peas	4	4
Soybeans and soy products	0	0
Nuts and seeds	70	36
Milk/yogurt	48	47
Cheese	0	0
Beef, pork, veal, lamb, goat, game meat	70	70
Organ meat	0	0
Chicken, duck, turkey, pigeon, guinea hen, game birds	0	0
Large whole fish/dried fish/shellfish and other seafood	56	47
Small fish eaten whole with bones	5	0
Insects, Grubs, snakes, rodents and other small animal	0	0
Eggs	8	7
Vitamin A-rich dark green leafy vegetables [a]	41	28
Vitamin A-rich deep yellow/orange/red vegetables [a]	82	17
Vitamin C-rich vegetables [b]	100	100
All other vegetables	60	45
Vitamin A-rich fruits [a]	12	9
Vitamin C-rich fruits [b]	9	7
All other fruits	0	0

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g in the form eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g in the form eaten.

Table N4a. Summary of Food Group Intake (FGI-6) for All Observation Days and for Days When the Food was Consumed, NPNL Women

	All (n = 102)					Among those who consume			
Food group	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)	Percent consuming	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)
All starchy staples	803.5	948.2	828.5	880.0	100	803.5	948.2	828.5	880.0
All legumes and nuts	41.9	217.1	3.0	12.8	73	57.8	299.3	47.0	116.3
All dairy	74.5	94.0	0.0	0.0	48	155.1	195.7	94.0	171.1
Other animal source foods	71.7	145.8	65.5	132.0	98	73.1	148.7	66.5	133.1
Vitamin A-rich fruits and vegetables [a]	41.3	24.5	11.5	8.2	92	44.8	26.6	15.5	10.3
Other fruits and vegetables	243.2	94.2	225.5	77.2	100	243.2	94.2	225.5	77.2

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N4b. Summary of Food Group Intake (FGI-9) for All Observation Days and for Days When the Food was Consumed, NPNL Women

	All (n = 102)					Among those who consume			
Food group	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)	Percent consuming	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)
All starchy staples	803.5	948.2	828.5	880.0	100	803.5	948.2	828.5	946.0
All legumes and nuts	41.9	217.1	3.0	12.8	73	57.8	299.3	47.0	116.3
All dairy	74.5	94.0	0.0	0.0	48	155.1	195.7	94.0	171.3
Organ meat	0.0	0.0	0.0	0.0	0				0.0
Eggs	4.1	5.8	0.0	0.0	8	52.3	74.1	57.5	81.6
Flesh foods and other miscellaneous small animal protein	67.6	140.0	59.5	121.1	98	68.9	142.8	60.5	120.3
Vitamin A-rich dark green leafy vegetables [a]	30.0	9.1	0.0	0.0	41	72.8	22.0	87.5	20.5
Other vitamin A-rich vegetables and fruits [a]	11.3	15.4	5.0	4.5	86	13.1	17.9	5.0	9.5
Other fruits and vegetables	243.2	94.2	225.5	77.2	100	243.2	94.2	225.5	82.6

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N4c. Summary of Food Group Intake (FGI-13) for All Observation Days and for Days When the Food was Consumed, NPNL Women

Food group	All (n = 102) Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)	Percent consuming	Among those who consume Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)
All starchy staples	803.5	948.2	828.5	880.0	100	803.5	948.2	828.5	880.0
All legumes and nuts	41.9	217.1	3.0	12.8	73	57.8	299.3	47.0	116.3
All dairy	74.5	94.0	0.0	0.0	48	155.1	195.7	94.0	171.1
Organ meat	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Eggs	4.1	5.8	0.0	0.0	8	52.3	74.1	57.5	81.5
Small fish eaten whole with bones	0.3	0.8	0.0	0.0	5	6.2	15.8	5.0	12.7
All other flesh foods and miscellaneous small animal protein	67.3	139.2	59.0	121.1	98	68.6	142.0	59.5	121.9
Vitamin A-rich dark green leafy vegetables [a]	30.0	9.1	0.0	0.0	41	72.8	22.0	87.5	21.0
Vitamin A-rich deep yellow/orange/red vegetables [a]	7.5	4.9	5.0	4.5	82	9.1	5.9	5.0	4.5
Vitamin C-rich vegetables [b]	212.2	79.7	209.5	74.5	100	212.2	79.7	209.5	74.5
Vitamin A-rich fruits [a]	3.8	10.5	0.0	0.0	12	31.9	89.5	20.0	69.8
Vitamin C-rich fruits [b]	14.7	11.6	0.0	0.0	9	166.7	131.9	42.0	18.0
All other fruits and vegetables	16.2	2.9	11.0	1.7	60	27.1	4.8	24.0	3.7

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N4d. Summary of Food Group Intake (FGI-21) for All Observation Days and for Days When the Food was Consumed, NPNL Women

	All (n=102)					Among those who consume			
Food group	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)	Percent consuming	Mean amount (g)	Mean energy (kcal)	Median amount (g)	Median energy (kcal)
Grains and grain products	742.7	883.8	775.5	787.3	100	742.7	883.8	775.5	787.3
All other starchy staples	60.8	64.4	0.0	0.0	42	144.2	152.7	124.0	125.5
Cooked dry beans and peas	5.2	4.7	0.0	0.0	4	133.5	119.0	121.5	108.3
Soybeans and soy products	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Nuts and seeds	36.7	212.4	2.0	8.5	70	52.7	305.2	25.0	143.5
Milk/yogurt	74.5	94.0	0.0	0.0	48	155.1	195.7	94.0	171.1
Cheese	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Beef, pork, veal, lamb, goat, game meat	42.3	99.0	41.5	97.1	70	60.8	142.2	52.0	121.7
Organ meat	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Chicken, duck, turkey, pigeon, guinea hen, game birds	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Large whole fish/dried fish/shellfish and other seafood	25.0	40.2	12.0	18.6	56	44.7	72.0	35.0	55.6
Small fish eaten whole with bones	0.3	0.8	0.0	0.0	5	6.2	15.8	5.0	12.7
Insects, grubs, snakes, rodents and other small animal	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Eggs	4.1	5.8	0.0	0.0	8	52.3	74.1	57.5	81.5
Vitamin A-rich dark green leafy vegetables [a]	30.0	9.1	0.0	0.0	41	72.8	22.0	87.5	21.0
Vitamin A-rich deep yellow/orange/red vegetables [a]	7.5	4.9	5.0	4.5	82	9.1	5.9	5.0	4.5
Vitamin C-rich vegetables [b]	212.2	79.7	209.5	74.5	100	212.2	79.7	209.5	74.5
All other vegetables	16.2	2.9	11.0	1.7	60	27.1	4.8	24.0	3.7
Vitamin A-rich fruits [a]	3.8	10.5	0.0	0.0	12	31.9	89.5	20.0	69.8
Vitamin C-rich fruits [b]	14.7	11.6	0.0	0.0	9	166.7	131.9	42.0	18.0
All other fruits	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N5. Diversity Scores for Various Diversity Indicators, NPNL Women, R1

Indicator	Number of food groups and level	Mean	SD	Median	Range
FGI-6	6 major food groups	5.1	0.7	5.0	3-6
FGI-6R [a]	6 major food groups	4.3	0.9	4.0	2-6
FGI-9	9 food sub-groups	5.5	1.0	6.0	3-8
FGI-9R [a]	9 food sub-groups	4.4	1.1	4.0	2-7
FGI-13	13 food sub-groups	6.4	1.3	6.0	3-10
FGI-13R [a]	13 food sub-groups	4.9	1.3	5.0	2-9
FGI-21	21 food sub-groups	7.1	1.5	7.0	3-11
FGI-21R [a]	21 food sub-groups	5.6	1.6	5.0	2-10

[a] "R" indicates that at least 15 g must be consumed in order for the food group/sub-group to —count" in the score.

Table N6. Percent of Observation Days at Each Food Group Diversity Score, NPNL Women, R1

Number of food groups eaten	Diversity indicators							
	FGI-6	FGI-6R	FGI-9	FGI-9R	FGI-13	FGI-13R	FGI-21	FGI-21R
1	0	0	0	0	0	0	0	0
2	0	2	0	2	0	1	0	1
3	2	16	2	16	2	10	1	7
4	14	42	10	40	5	31	5	18
5	56	32	37	28	15	28	8	26
6	28	8	35	11	36	19	20	25
7			15	4	24	7	32	13
8			1	0	15	4	15	7
9			0	0	3	1	16	3
10					1	0	2	2
11					0	0	2	0
12					0	0	0	0
13					0	0	0	0
14							0	0
15							0	0
16							0	0
17							0	0
18							0	0
19							0	0
20-21							0	0

Table N7a. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-6 - 1 g Minimum)

	Number of food groups eaten					
	1	2	3	4	5	6
Percent (number) of observation days at each diversity score	0 (0)	0 (0)	2 (2)	14 (14)	56 (57)	28 (29)
Food groups	**Percent of observation days on which each food group was consumed**					
All starchy staples	--	--	100	100	100	100
All legumes and nuts	--	--	0	21	74	100
All dairy	--	--	50	7	32	100
Other animal source foods	--	--	50	93	100	100
Vitamin A-rich fruits and vegetables [a]	--	--	0	79	95	100
Other fruits and vegetables	--	--	100	100	100	100

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N7b. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-6R - 15 g Minimum)

	Number of food groups eaten					
	1	**2**	**3**	**4**	**5**	**6**
Percent (number) of observation days at each diversity score	0 (0)	2 (2)	16 (16)	42 (43)	32 (33)	8 (8)
Food groups	**Percent of observation days on which each food group was consumed**					
All starchy staples	--	100	100	100	100	100
All legumes and nuts	--	0	6	30	55	100
All dairy	--	0	6	30	79	100
Other animal source foods	--	0	88	98	100	100
Vitamin A-rich fruits and vegetables [a]	--	0	0	42	67	100
Other fruits and vegetables	--	100	100	100	100	100

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N7c. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-9 - 1 g Minimum)

	Number of food groups eaten								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Percent (number) of observation days at each diversity score	0 (0)	0 (0)	2 (2)	10 (10)	37 (38)	35 (36)	15 (15)	1 (1)	0 0
Food groups	**Percent of observation days on which each food group was consumed**								
All starchy staples	--	--	100	100	100	100	100	100	--
All legumes and nuts	--	--	0	30	66	92	80	100	--
All dairy	--	--	50	10	32	56	93	100	--
Organ meat	--	--	0	0	0	0	0	0	--
Eggs	--	--	0	0	0	6	33	100	--
Flesh foods and other miscellaneous small animal protein	--	--	50	90	100	100	100	100	--
Vitamin A-rich dark green leafy vegetables [a]	--	--	0	10	18	53	93	100	--
Other vitamin A-rich vegetables and fruits [a]	--	--	0	60	84	94	100	100	--
Other fruits and vegetables	--	--	100	100	100	100	100	100	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N7d. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-9R - 15 g Minimum)

	Number of food groups eaten							
	1	2	3	4	5	6	7	8-9
Percent (number) of observation days at each diversity score	0 (0)	2 (2)	16 (16)	40 (41)	28 (28)	11 (11)	4 (4)	0 (0)
Food groups	**Percent of observation days on which each food group was consumed**							
All starchy staples	--	100	100	100	100	100	100	--
All legumes and nuts	--	0	6	32	57	73	50	--
All dairy	--	0	6	29	75	91	100	--
Organ meat	--	0	0	0	0	0	0	--
Eggs	--	0	0	0	4	36	50	--
Flesh foods and other miscellaneous small animal protein	--	0	88	98	100	100	100	--
Vitamin A-rich dark green leafy vegetables [a]	--	0	0	20	32	73	100	--
Other vitamin A-rich vegetables and fruits [a]	--	0	0	22	32	27	100	--
Other fruits and vegetables	--	100	100	100	100	100	100	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N7e. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-13 - 1 g Minimum)

	Number of food groups eaten									
	1-2	3	4	5	6	7	8	9	10	11-13
Percent (number) of observation days at each diversity score	0 (0)	2 (2)	4.9 (5)	14.7 (15)	36.3 (37)	23.5 (24)	14.7 (15)	2.9 (3)	1 (1)	0 (0)
Food groups	**Percent of observation days on which each food group was consumed**									
All starchy staples	--	100	100	100	100	100	100	100	100	--
All legumes and nuts	--	0	0	67	76	88	73	100	100	--
All dairy	--	50	20	27	32	58	93	67	100	--
Organ meat	--	0	0	0	0	0	0	0	0	--
Eggs	--	0	0	0	3	8	27	0	100	--
Small fish eaten whole with bones	--	0	0	0	3	0	13	67	0	--
All other flesh foods and miscellaneous small animal protein	--	50	100	93	100	100	100	100	100	--
Vitamin A-rich dark green leafy vegetables [a]	--	0	20	20	30	58	67	67	100	--
Vitamin A-rich deep yellow/orange/red vegetables [a]	--	0	60	67	87	92	87	100	100	--
Vitamin C-rich vegetables [b]	--	100	100	100	100	100	100	100	100	--
Vitamin A-rich fruits [a]	--	0	0	7	8	8	27	67	0	--
Vitamin C-rich fruits [b]	--	0	0	0	0	17	20	33	100	--
All other fruits and vegetables	--	0	0	20	62	71	93	100	100	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten

Table N7f. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-13R - 15 g Minimum)

	Number of food groups eaten									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10-13**
Percent (number) of observation days at each diversity score	0 (0)	1 (1)	10 (10)	31 (32)	28 (28)	19 (19)	7 (7)	4 (4)	1 (1)	0 (0)
Food groups										
All starchy staples	--	100	100	100	100	100	100	100	100	--
All legumes and nuts	--	0	10	19	54	63	57	50	0	--
All dairy	--	0	10	28	43	79	86	100	100	--
Organ meat	--	0	0	0	0	0	0	0	0	--
Eggs	--	0	0	0	4	11	14	50	100	--
Small fish eaten whole with bones	--	0	0	0	0	0	0	0	0	--
All other flesh foods and miscellaneous small animal protein	--	0	70	97	100	100	100	100	100	--
Vitamin A-rich dark green leafy vegetables [a]	--	0	0	19	21	47	57	75	100	--
Vitamin A-rich deep yellow/orange/red vegetables [a]	--	0	0	13	11	21	29	75	100	--
Vitamin C-rich vegetables [b]	--	100	100	100	100	100	100	100	100	--
Vitamin A-rich fruits [a]	--	0	0	3	11	11	29	25	0	--
Vitamin C-rich fruits [b]	--	0	0	0	7	5	29	25	100	--
All other fruits and vegetables	--	0	10	22	50	63	100	100	100	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten

Table N7g. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-21 - 1 g Minimum)

	Number of food groups eaten										
	1-2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12-21**
Percent (number) of observation days at each diversity score	0	1	5	8	20	32	15	16	2	2	0
	0	(1)	(5)	(8)	(20)	(33)	(15)	(16)	(2)	(2)	(0)
Food groups	**Percent of observation days on which each food group**										
Grains and grains products	--	100	100	100	100	100	100	100	100	100	--
All other starchy staples	--	0	20	13	25	52	27	69	100	100	--
Cooked dry beans and peas	--	0	0	0	5	3	0	13	0	0	--
Soybeans and soy products	--	0	0	0	0	0	0	0	0	0	--
Nuts and seeds	--	0	0	50	75	76	73	75	100	100	--
Milk/yogurt	--	0	40	38	25	42	73	63	100	100	--
Cheese	--	0	0	0	0	0	0	0	0	0	--
Beef, pork, veal, lamb, goat, game meat	--	0	40	25	60	82	73	88	100	50	--
Organ meat	--	0	0	0	0	0	0	0	0	0	--
Chicken, duck, turkey, pigeon, guinea hen, game birds	--	0	0	0	0	0	0	0	0	0	--
Large whole fish/dried fish/shellfish and other seafood	--	100	40	63	45	42	73	69	100	100	--
Small fish eaten whole with bones	--	0	0	0	5	0	13	13	0	0	--
Insects, grubs, snakes, rodents and other small animal	--	0	0	0	0	0	0	0	0	0	--
Eggs	--	0	0	0	0	3	20	19	0	50	--
Vitamin A-rich dark green leafy vegetables [a]	--	0	0	13	25	39	47	88	0	100	--
Vitamin A-rich deep yellow/orange/red vegetables [a]	--	0	60	63	80	85	80	100	100	100	--
Vitamin C-rich vegetables [b]	--	100	100	100	100	100	100	100	100	100	--
All other vegetables	--	0	0	25	55	58	80	88	50	100	--
Vitamin A-rich fruits [a]	--	0	0	13	0	12	20	6	100	50	--
Vitamin C-rich fruits [b]	--	0	0	0	0	6	20	13	50	50	--
All other fruits	--	0	0	0	0	0	0	0	0	0	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N7h. Percent of Observation Days on Which Different Food Groups were Consumed by Food Group Diversity Score, NPNL Women, R1 (FGI-21R - 15 g Minimum)

	Number of food groups eaten										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11-21**
Percent (number) of observation days at each diversity score	0 0	1 (1)	7 (7)	18 (18)	26 (26)	25 (25)	13 (13)	7 (7)	3 (3)	2 (2)	0 (0)
Food groups	**Percent of observation days on which each food group**										
Grains and grains products	--	100	100	100	100	100	100	100	100	100	--
All other starchy staples	--	0	0	11	50	32	77	57	100	100	--
Cooked dry beans and peas	--	0	0	0	4	4	0	14	33	0	--
Soybeans and soy products	--	0	0	0	0	0	0	0	0	0	--
Nuts and seeds	--	0	14	17	39	52	39	57	0	50	--
Milk/yogurt	--	0	0	39	27	60	62	86	100	100	--
Cheese	--	0	0	0	0	0	0	0	0	0	--
Beef, pork, veal, lamb, goat, game meat	--	0	43	56	58	92	85	71	100	50	--
Organ meat	--	0	0	0	0	0	0	0	0	0	--
Chicken, duck, turkey, pigeon, guinea hen, game birds	--	0	0	0	0	0	0	0	0	0	--
Large whole fish/dried fish/shellfish and other seafood	--	0	29	39	50	40	54	86	33	100	--
Small fish eaten whole with bones	--	0	0	0	0	0	0	0	0	0	--
Insects, grubs, snakes, rodents and other small animal	--	0	0	0	0	0	0	0	0	0	--
Eggs	--	0	0	0	0	8	8	29	33	50	--
Vitamin A-rich dark green leafy vegetables [a]	--	0	0	6	27	32	39	57	67	100	--
Vitamin A-rich deep yellow/orange/red vegetables [a]	--	0	0	0	12	12	39	29	100	50	--
Vitamin C-rich vegetables [b]	--	100	100	100	100	100	100	100	100	100	--
All other vegetables	--	0	14	28	27	52	77	71	100	100	--
Vitamin A-rich fruits [a]	--	0	0	6	4	12	15	0	33	50	--
Vitamin C-rich fruits [b]	--	0	0	0	4	4	8	43	0	50	--
All other fruits	--	0	0	0	0	0	0	0	0	0	--

[a] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[b] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N8. HIGH BIOAVAILABILITY Mean and Median Nutrient Intake and PA, NPNL Women [a]

Nutrient	Mean	SD	Median	EAR	SD [b]	PA (Mean)	PA (Median)	Lambda (Box-Cox transformation)
Energy	2,054	717	2,024					
Protein (all sources) (% of kcal)	11	5	11					
Total carbohydrate (% of kcal)	57	20	61					
Total fat (% of kcal)	32	15	32					
Thiamin (mg/d)	1.0	0.50	0.90	0.9 [c]	0.09	0.59	0.67	0.33
Riboflavin (mg/d)	0.8	0.40	0.70	0.9 [c, g]	0.09	0.28	0.05	0.18
Niacin (mg/d)	10.6	6.50	8.30	11 [c, g]	1.65	0.31	0.06	0.18
Vitamin B6 (mg/d)	1.2	0.50	1.20	1.1 [c, g]	0.11	0.67	0.89	0.27
Folate (µg/d)	131.4	82.50	119.10	320 [c, g]	32.0	0.00	0.00	0.21
Vitamin B12 (µg/d)	1.5	1.00	1.30	2.0 [h]	0.2	0.17	0.00	0.32
Vitamin C (mg/d)	62.6	34.50	58.40	38 [c]	3.8	0.88	1.00	0.52
Vitamin A (RE/d)	358	295.30	244.60	270 [h, g]	54.0	0.50	0.43	0.31
Calcium (mg/d)	443.9	318.30	374.50	1,000 [e, g]	--	0.27	0.25	0.08
Iron (mg/d)	16.1	8.80	14.20	-- [f]	--	0.54	0.55	0.09
Zinc (mg/d)	10.2	5.8	8.8	6.0 [d, g]	0.75	0.96	1.00	0.10
MPA across 11 micronutrients	0.471	0.183	0.483					

[a] Mean and median nutrient intakes are for first observation day (R1); PA are based on estimated usual intake, calculated using repeat observations for a subset of the sample.
Thus, PA incorporate information from both rounds of data collection.
[b] All SD calculated based on EAR and CV, which was assumed to be 10 percent for all micronutrients (FAO/WHO 2002 requirements), except 15 percent for niacin (IOM 2000), 20 percent for vitamin A (IOM 2000) and 12.5 percent for zinc (IZiNCG 2004).
[c] EAR back calculated from RNI values of WHO/FAO 2004 requirements.
[d] This is the estimated median requirement of zinc to be used for diets with higher bioavailability as suggested by IZiNCG (2004).
[e] Not an EAR, but rather AI from IOM (1997). Following Foote et al. (2004), PA are calculated 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.
[f] PA for iron intake are estimated using IOM tables (2000a, page 347), adult women. According to WHO/FAO (2004). Bioavailability of 10 percent was used for our study.
[g] For adolescents group (15-18 years old, n=16), value of 0.8±0.08 was used for riboflavin, 12±1.2 for niacin, 7.0±0.88 for zinc (30 percent bioavailability), 365±73 for vitamin A, 330±33 for folate, 1.0±0.1 for B6, and 1300 AI for calcium.
[h] EAR taken from WHO/FAO 2004.

Table N9a. Percent Contribution of Food Groups (FGI-6) to Intake of Energy, Protein and Nutrients, NPNL Women, R1 [a]

Food groups (%)	Energy	Protein	CHO	Total fat	Thiamin	Riboflavin	Niacin	Vitamin B6	Folate	Vitamin B12	Vitamin C	Vitamin A	Calcium	Iron	Zinc
All starchy staples	46.2	36.2	67.2	12.5	58.9	26.8	20.7	48.0	14.9	0.2 [c]	15.8	4.6	12.0	42.5	40.6
All legumes and nuts	10.6	16.7	2.2	23.3	11.7	6.6	37.8	8.7	21.3	0.0	0.0	0.1	5.8	18.4	9.7
All dairy	4.6	8.8	2.1	7.5	5.0	29.4	4.4	3.6	5.0	30.4	0.9	20.2	43.4	0.3	19.5
Other animal source foods	7.1	28.8	0.0	12.0	8.9	13.7	21.6	10.3	4.5	66.2	0.4	2.1	7.8	14.5	21.4
Vitamin A-rich fruits /vegetables[b]	1.2	1.6	0.9	1.6	3.5	8.3	3.7	5.5	14.1	0.0	9.1	54.8	11.3	7.0	1.6
Other fruits and vegetables	4.6	6.2	6.5	0.6	10.1	13.3	10.1	22.2	37.1	0.0	71.0	16.5	17.9	14.7	6.8

[a] Percents may not sum to 100 due to nutrient contributions from foods not included in any of the groups comprising the diversity indicators (e.g., fats, sweets, alcohol).
[b] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[c] This value comes from butter croissant (0.16 mcg/100 g).

Table N9b. Percent Contribution of Food Groups (FGI-9) to Intake of Energy, Protein and Nutrients, NPNL Women, R1 [a]

Food groups (%)	Energy	Protein	CHO	Total fat	Thiamin	Riboflavin	Niacin	Vitamin B6	Folate	Vitamin B12	Vitamin C	Vitamin A	Calcium	Iron	Zinc
All starchy staples	46.2	36.2	67.2	12.5	58.9	26.8	20.7	48.0	14.9	0.2 [c]	15.8	4.6	12.0	42.5	40.6
All legumes and nuts	10.6	16.7	2.2	23.3	11.7	6.6	37.8	8.7	21.3	0.0	0.0	0.1	5.8	18.4	9.7
All dairy	4.6	8.8	2.1	7.5	5.0	29.4	4.4	3.6	5.0	30.4	0.9	20.2	43.4	0.3	19.5
Organ meat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eggs	0.3	0.9	0.0	0.6	0.4	1.5	0.1	0.5	0.6	4.1	0.0	1.7	0.4	0.5	0.6
Flesh foods and other miscellaneous small animal protein	6.8	28.0	0.0	11.4	8.6	12.1	21.5	9.8	4.0	62.1	0.4	0.4	7.4	14.0	20.8
Vitamin A-rich dark green leafy vegetables [b]	0.4	1.2	0.5	0.1	2.3	7.3	2.1	3.3	12.2	0.0	6.4	35.7	10.6	5.8	1.2
Other vitamin A-rich vegetables and fruits [b]	0.8	0.4	0.4	1.5	1.1	1.0	1.6	2.2	1.9	0.0	2.8	19.2	0.6	1.2	0.4
Other fruits and vegetables	4.6	6.2	6.5	0.6	10.1	13.3	10.1	22.2	37.1	0.0	71.0	16.5	17.9	14.7	6.8

[a] Percents may not sum to 100 due to nutrient contributions from foods not included in any of the groups comprising the diversity indicators (e.g., fats, sweets, alcohol).
[b] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[c] This value comes from butter croissant (0.16 mcg/100 g).

Table N9c. Percent Contribution of Food Groups (FGI-13) to Intake of Energy, Protein and Nutrients, NPNL Women, R1 [a]

Food groups (%)	Energy	Protein	CHO	Total fat	Thiamin	Riboflavin	Niacin	Vitamin B6	Folate	Vitamin B12	Vitamin C	Vitamin A	Calcium	Iron	Zinc
All starchy staples	46.2	36.2	67.2	12.5	58.9	26.8	20.7	48.0	14.9	0.2 [d]	15.8	4.6	12.0	42.5	40.6
All legumes and nuts	10.6	16.7	2.2	23.3	11.7	6.6	37.8	8.7	21.3	0.0	0.0	0.1	5.8	18.4	9.7
All dairy	4.6	8.8	2.1	7.5	5.0	29.4	4.4	3.6	5.0	30.4	0.9	20.2	43.4	0.3	19.5
Organ meat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eggs	0.3	0.9	0.0	0.6	0.4	1.5	0.1	0.5	0.6	4.1	0.0	1.7	0.4	0.5	0.6
Small fish eaten whole w/bones	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.5	0.0	0.0	0.7	0.1	0.1
All other flesh foods misc. small animal protein	6.8	27.7	0.0	11.4	8.5	12.1	21.3	9.6	3.9	61.6	0.4	0.4	6.7	13.9	20.8
Vitamin A-rich dark green leafy vegetables [b]	0.4	1.2	0.5	0.1	2.3	7.3	2.1	3.3	12.2	0.0	6.4	35.7	10.6	5.8	1.2
Vitamin A-rich deep yellow/orange/red vegetables [b]	0.2	0.4	0.3	0.0	1.1	0.8	1.5	2.1	1.8	0.0	0.6	11.6	0.5	1.0	0.4
Vitamin C-rich vegetables [c]	3.9	5.5	5.5	0.5	8.8	11.7	8.8	17.0	33.0	0.0	66.5	12.3	17.1	14.1	6.2
Vitamin A-rich fruits [b]	0.5	0.0	0.1	1.4	0.1	0.1	0.1	0.1	0.1	0.0	2.1	7.5	0.1	0.1	0.0
Vitamin C-rich fruits [c]	0.6	0.4	0.9	0.0	0.5	0.6	0.8	3.9	2.2	0.0	2.7	0.6	0.3	0.1	0.3
All other fruits and vegetables	0.1	0.3	0.2	0.0	0.9	1.0	0.5	1.3	1.9	0.0	1.8	3.5	0.5	0.6	0.4

[a] Percents may not sum to 100 due to nutrient contributions from foods not included in any of the groups comprising the diversity indicators (e.g., fats, sweets, alcohol).
[b] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[c] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.
[d] This value comes from butter croissant (0.16 mcg/100 g).

Table N9d. Percent Contribution of Food Groups (FGI-21) to Intake of Energy, Protein and Nutrients, NPNL Women, R1 [a]

Food groups (%)	Energy	Protein	CHO	Total fat	Thiamin	Riboflavin	Niacin	Vitamin B6	Folate	Vitamin B12	Vitamin C	Vitamin A	Calcium	Iron	Zinc
Grains and grain products	43.0	34.7	62.7	11.1	53.0	24.8	14.7	35.1	8.8	0.2[d]	0.8	3.3	10.5	40.3	39.4
All other starchy staples	3.1	1.5	4.5	1.4	5.9	2.0	5.9	12.9	6.1	0.0	15.0	1.3	1.5	2.2	1.2
Cooked dry beans and peas	0.2	0.7	0.2	0.0	1.1	0.4	0.2	0.4	8.3	0.0	0.0	0.0	0.3	0.8	0.7
Soybeans and soy products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuts and seeds	10.3	16.0	1.9	23.3	10.6	6.2	37.5	8.3	13.0	0.0	0.0	0.1	5.6	17.6	9.0
Milk/yogurt	4.6	8.8	2.1	7.5	5.0	29.4	4.4	3.6	5.0	30.4	0.9	20.2	43.4	0.3	19.5
Cheese	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beef, pork, veal, lamb, goat, game meat	4.8	13.2	0.0	10.4	6.9	8.4	14.4	4.3	1.6	30.6	0.0	0.0	1.0	9.4	17.0
Organ meat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chicken, duck, turkey, pigeon, guinea hen, game birds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Large whole fish/dried fish/shellfish, other seafood	2.0	14.5	0.0	1.0	1.7	3.7	6.9	5.3	2.3	31.1	0.4	0.4	5.7	4.5	3.8
Small fish eaten whole w/bones	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.5	0.0	0.0	0.7	0.1	0.1
Insects, grubs, snakes, rodents and other small animal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eggs	0.3	0.9	0.0	0.6	0.4	1.5	0.1	0.5	0.6	4.1	0.0	1.7	0.4	0.5	0.6
Vitamin A-rich dark green leafy vegetables [b]	0.4	1.2	0.5	0.1	2.3	7.3	2.1	3.3	12.2	0.0	6.4	35.7	10.6	5.8	1.2
Vitamin A-rich deep yellow/orange/red vegetables [b]	0.2	0.4	0.3	0.0	1.1	0.8	1.5	2.1	1.8	0.0	0.6	11.6	0.5	1.0	0.4
Vitamin C-rich vegetables [c]	3.9	5.5	5.5	0.5	8.8	11.7	8.8	17.0	33.0	0.0	66.5	12.3	17.1	14.1	6.2
All other vegetables	0.1	0.3	0.2	0.0	0.9	1.0	0.5	1.3	1.9	0.0	1.8	3.5	0.5	0.6	0.4
Vitamin A-rich fruits [b]	0.5	0.0	0.1	1.4	0.1	0.1	0.1	0.1	0.1	0.0	2.1	7.5	0.1	0.1	0.0
Vitamin C-rich fruits [c]	0.6	0.4	0.9	0.0	0.5	0.6	0.8	3.9	2.2	0.0	2.7	0.6	0.3	0.1	0.3
All other fruits	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] Percents may not sum to 100 due to nutrient contributions from foods not included in any of the groups comprising the diversity indicators (e.g., fats, sweets, alcohol).
[b] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[c] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.
[d] This value comes from butter croissant (0.16 mcg/100 g).

Table N10. Correlation between Food Group Diversity Scores and the PA of Individual Micronutrients, With and Without Controlling for Total Energy Intake, NPNL Women [a, b]

	FGI-6		FGI-6R		FGI-9		FGI-9R		FGI-13		FGI-13R		FGI-21		FGI-21R	
Nutrients	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	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy	Not controlling for energy	Controlling for energy
Total energy	0.205 *		0.261**		0.203 *		0.192		0.168	-0.001	0.209 *	0.011	0.204 *	0.089	0.217 *	0.083
Thiamin	0.188	0.015	0.256**	0.055	0.205 *	0.055	0.187	0.037	0.149	-0.001	0.209 *	0.011	0.204 *	0.089	0.217 *	0.083
Riboflavin	0.444 ***	0.417 ***	0.511***	0.464 ***	0.438 ***	0.41 ***	0.481 ***	0.474***	0.359 ***	0.332 **	0.414 ***	0.356***	0.36 ***	0.321 **	0.382 ***	0.336 ***
Niacin	0.199 *	0.094	0.386***	0.296 **	0.259 **	0.174	0.278 **	0.207*	0.187	0.107	0.236 *	0.122	0.222 *	0.14	0.233 *	0.14
Vitamin B6	0.067	-0.109	0.252*	0.1	0.091	-0.073	0.191	0.08	0.151	0.047	0.256 **	0.136	0.212 *	0.118	0.274 **	0.189
Folate	0.287 **	0.22 *	0.495***	0.436 ***	0.344 ***	0.287 **	0.471 ***	0.44***	0.302 **	0.255 **	0.421 ***	0.363***	0.362 ***	0.317 **	0.443 ***	0.402 ***
Vitamin B12	0.381 ***	0.331 ***	0.382***	0.309 **	0.375 ***	0.325 ***	0.392 ***	0.349***	0.302 **	0.258 **	0.352 ***	0.288**	0.328 ***	0.28 **	0.349 ***	0.297 **
Vitamin C	-0.048	-0.126	0.088	0.001	-0.017	-0.092	0.093	0.032	0.11	0.058	0.19	0.123	0.195 *	0.144	0.249 *	0.197 *
Vitamin A	0.457 ***	0.425 ***	0.613***	0.581 ***	0.536 ***	0.51 ***	0.652 ***	0.635***	0.497 ***	0.475 **	0.591 ***	0.563***	0.537 ***	0.514 ***	0.604 ***	0.582 ***
Calcium	0.473 ***	0.448 ***	0.512***	0.461 ***	0.436 ***	0.401 ***	0.469 ***	0.451***	0.341 ***	0.305 **	0.412 ***	0.352***	0.337 ***	0.288 **	0.375 ***	0.324 ***
Iron	0.124	-0.001	0.171	0.014	0.24 *	0.149	0.111	-0.008	0.157	0.07	0.108	-0.043	0.188	0.097	0.11	-0.018
Zinc	0.29 **	0.212 *	0.336***	0.218 *	0.285 **	0.206 *	0.24 *	0.148	0.209 *	0.127	0.247 *	0.113	0233 *	0.144	0.235 *	0.126

[a] Usual intake of energy and individual nutrients are estimated by the BLUP following the method described in Arimond et al. 2008. Diversity scores are from R1 data; BLUP calculation incorporates information from both rounds.
[b] A "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$, and *** indicates $p < 0.001$.

Table N11a. Correlation between Energy from 6 Major Food Groups and the MPA, With and Without Controlling for Total Energy Intake, NPNL Women [a]

Major food groups	Correlation between MPA and energy from each food group [b]		Partial correlation coefficients for energy from each food group (controlling for total energy) [b]	
All starchy staples	**0.393**	***	**-0.248**	*
All legumes and nuts	0.346	***	0.077	
All dairy	0.332	***	0.209	*
Other animal source foods	0.235	*	0.122	
Vitamin A-rich fruits and vegetables [c]	0.153		0.122	
Other fruits and vegetables	0.165		-0.043	

[a] Energy from food groups is from R1; MPA is based on estimated usual intake, calculated using repeat observations for a subset of the sample.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N11b. Correlation between Energy from 9 Sub-Food Groups and the MPA, With and Without Controlling for Total Energy Intake, NPNL Women [a]

Major food groups	Correlation between MPA and energy from each food group [b]		Partial correlation coefficients for energy from each food group (controlling for total energy)	
All starchy staples	**0.393**	***	**-0.248**	*
All legumes and nuts	0.346	***	0.077	
All dairy	0.332	***	0.209	*
Organ meat	--		--	
Eggs	0.132		0.245	*
Flesh foods and other miscellaneous small animal protein	0.205	*	0.063	
Vitamin A-rich dark green leafy vegetables [c]	0.28	**	0.321	**
Other vitamin A-rich vegetables and fruits [c]	0.052		0.001	
Other fruits and vegetables	0.165		-0.043	

[a] Energy from food groups is from R1; MPA is based on estimated usual intake, calculated using repeat observations for a subset of the sample.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.

Table N11c. Correlation between Energy from 13 Sub-Food Groups and the MPA, With and Without Controlling for Total Energy Intake, NPNL Women [a]

Major food groups	Correlation between MPA and energy from each food group [b]		Partial correlation coefficients for energy from each food group (controlling for total energy)	
All starchy staples	**0.393**	***	**-0.248**	*
All legumes and nuts	0.346	***	0.077	
All dairy	0.332	***	0.209	*
Organ meat	--		--	
Eggs	0.132		0.245	*
Small fish eaten whole with bones	0.065		0.054	
All other flesh foods and miscellaneous small animal protein	0.202	*	0.061	
Vitamin A-rich dark green leafy vegetables [c]	0.28	**	0.321	**
Vitamin A-rich deep yellow/orange/red vegetables [c]	0.008		-0.036	
Vitamin C-rich vegetables [d]	0.229	*	-0.028	
Vitamin A-rich fruits [c]	0.05		0.004	
Vitamin C-rich fruits [d]	0.035		-0.042	
All other fruits and vegetables	0.173		0.06	

[a] Energy from food groups is from R1; MPA is based on estimated usual intake, calculated using repeat observations for a subset of the sample.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[d] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N11d. Correlation between Energy from 21 Sub-Food Groups (FGI-21) and the MPA, With and Without Controlling for Total Energy Intake, NPNL Women [a]

Major food groups	Correlation between MPA and energy from each food group [b]		Partial correlation coefficients for energy from each food group (controlling for total energy)	
Grains and grain products	**0.351**	***	**-0.283**	**
All other starchy staples	0.196	*	0.134	
Cooked dry beans and peas	-0.004		-0.009	
Soybeans and soy products	--		--	
Nuts and seeds	0.345	***	0.077	
Milk/yogurt	0.332	***	0.209	*
Cheese	--		--	
Beef, pork, veal, lamb, goat, game meat	0.169		0.125	
Organ meat	--		--	
Chicken, duck, turkey, pigeon, guinea hen, game birds	--		--	
Large whole fish/dried fish/shellfish and other seafood	0.044		-0.103	
Small fish eaten whole with bones	0.065		0.054	
Insects, grubs, snakes, rodents and other small animal	--		--	
Eggs	0.132		0.245	*
Vitamin A-rich dark green leafy vegetables [c]	0.28	**	0.321	**
Vitamin A-rich deep yellow/orange/red vegetables [c]	0.008		-0.036	
Vitamin C-rich vegetables [d]	0.229	*	-0.028	
All other vegetables	0.173		0.06	
Vitamin A-rich fruits [c]	0.05		0.004	
Vitamin C-rich fruits [d]	0.03		-0.042	
All other fruits	**--**		**--**	

[a] Energy from food groups is from R1; MPA is based on estimated usual intake, calculated using repeat observations for a subset of the sample.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Vitamin A-rich fruits and vegetables are defined as those with ≥ 120 RE/100 g as eaten.
[d] Vitamin C-rich fruits and vegetables are defined as those with ≥ 9 mg/100 g as eaten.

Table N12. Total Energy Intake (kcal) by Food Group Diversity Scores, NPNL Women, R1 [a]

Number of food groups eaten	Diversity indicators															
	FGI-6		FGI-6R		FGI-9		FGI-9R		FGI-13		FGI-13R		FGI-21		FGI-21R	
	Median total energy intake (range)															
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	1618	(885-2741)	--	--	1618	(885-2741)	--	--	1592	(885-2047)	--	--	1584	(885-2047)
4	1684	(885-2345)	1998	(678-2990)	1684	(885-2345)	2010	(678-2990)	1323	(885-2077)	1773	(678-2990)	1804	(885-2077)	1769	(678-2345)
5	2031	(882-4116)	2362	(851-4150)	2021	(922-4116)	2336	(851-4150)	1764	(1291-4116)	2317	(851-4150)	1914	(886-4116)	1989	(882-4116)
6	2324	(678-4150)	2616	(863-3175)	2200	(678-4150)	2400	(1157-3514)	1988	(678-4150)	2268	(1278-3450)	1664	(678-2669)	2205	(1242-4150)
7					2268	(863-3514)	--	--	2296	(882-3450)	2771	(1157-3514)	2078	(882-4150)	2714	(851-3514)
8					--	--	--	--	2205	(851-3514)	--	--	2437	(1461-3514)	2523	(1157-2846)
9					--	--	--	--	--	--	--	--	2362	(863-3175)	--	--
10									--	--	--	--	--	--	--	--
11									--	--	--	--	--	--	--	--
12									--	--	--	--	--	--	--	--
13									--	--	--	--	--	--	--	--
14													--	--	--	--
15													--	--	--	--
16													--	--	--	--
17													--	--	--	--
18													--	--	--	--
19													--	--	--	--
20													--	--	--	--
21													--	--	--	--

[a] A dash (--) indicates fewer than five observations. Dark shading indicates fewer than ten observations.

Table N13. Relationship between Food Group Diversity Scores and Total Energy Intake, NPNL Women [a]

	Food group diversity score		Total energy intake		Correlation coefficient [b]	
	(mean)	(median)	(mean)	(median)		
FGI-6	5.1	5.0	2054	2024	0.205	*
FGI-6R [c]	4.3	4.0	2054	2024	0.261	**
FGI-9	5.5	6.0	2054	2024	0.203	*
FGI-9R [c]	4.4	4.0	2054	2024	0.192	
FGI-13	6.4	6.0	2054	2024	0.168	
FGI-13R [c]	4.9	5.0	2054	2024	0.230	*
FGI-21	7.1	7.0	2054	2024	0.184	
FGI-21R [c]	5.6	5.0	2054	2024	0.202	*

[a] Food group diversity scores and mean and median energy intakes are from first observation day; BLUP for energy intake (calculated using repeat observations for a subset of the sample) is used for correlation analysis.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Refers to minimum intake of 15 g for each of the food groups/sub-food groups.

Table N14. MPA by Food Group Diversity Scores, NPNL Women [a, b]

Number of food groups eaten	Diversity indicators															
	FGI-6		FGI-6R		FGI-9		FGI-9R		FGI-13		FGI-13R		FGI-21		FGI-21R	
	Median MPA (range)															
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	0.37	(0.09-0.52)	--	--	0.37	(0.09-0.52)	--	--	0.32	(0.09-0.52)	--	--	0.28	(0.14-0.52)
4	0.35	(0.13-0.66)	0.43	(0.12-0.77)	0.34	(0.18-0.66)	0.45	(0.12-0.77)	0.36	(0.28 –0.66)	0.40	(0.12-0.77)	0.42	(0.28-0.66)	0.40	(0.09-0.66)
5	0.45	(0.09-0.80)	0.57	(0.23-0.86)	0.42	(0.12-0.80)	0.54	(0.23-0.86)	0.40	(0.12-0.80)	0.52	(0.23-0.85)	0.37	(0.12-0.80)	0.43	(0.13-0.80)
6	0.54	(0.12-0.86)	0.58	(0.28-0.82)	0.52	(0.09-0.86)	0.65	(0.50-0.82)	0.45	(0.09-0.85)	0.57	(0.18-0.86)	0.36	(0.12-0.63)	0.52	(0.29-0.86)
7					0.56	(0.28-0.79)	--	--	0.52	(0.14-0.86)	0.64	(0.35-0.74)	0.49	(0.09-0.86)	0.60	(0.18-0.82)
8					--	--	--	--	0.54	(0.28-0.69)	--	--	0.57	(0.32-0.79)	0.64	(0.35-0.78)
9					--	--	--	--	--	--	--	--	0.54	(0.28-0.78)	--	--
10									--	--	--	--	--	--	--	--
11									--	--	--	--	--	--	--	--
12									--	--	--	--	--	--	--	--
13									--	--	--	--	--	--	--	--
14													--	--	--	--
15													--	--	--	--
16													--	--	--	--
17													--	--	--	--
18													--	--	--	--
19													--	--	--	--
20													--	--	--	--
21													--	--	--	--

[a] Food group diversity scores are from first observation day; MPA is based on estimated usual intake, calculated using repeat observations for a subset of the sample.
[b] A dash (--) indicates fewer than five observations. Dark shading indicates fewer than ten observations.

Table N15. Relationship between MPA and Food Group Diversity Scores, NPNL Women[a]

	Food group diversity score		MPA		Correlation Coefficient [b]		Partial correlation controlling for total energy intake [b]	
	(mean)	(median)	(mean)	(median)				
FGI-6	5.1	5.0	0.47	0.48	0.316	**	0.251	*
FGI-6R [c]	4.3	4.0	0.47	0.48	0.500	***	0.479	***
FGI-9	5.5	6.0	0.47	0.48	0.363	***	0.327	***
FGI-9R [c]	4.4	4.0	0.47	0.48	0.454	***	0.481	***
FGI-13	6.4	6.0	0.47	0.48	0.299	**	0.266	**
FGI-13R [c]	4.9	5.0	0.47	0.48	0.418	***	0.383	***
FGI-21	7.1	7.0	0.47	0.48	0.343	***	0.315	**
FGI-21R [c]	5.6	5.0	0.47	0.48	0.414	***	0.406	***

[a] Food group diversity scores are from first observation day, MPA is based on the first observation day and repeat observations for a subset of the sample. BLUP for energy intake (calculated using repeat observations for a subset of the sample) is used for correlation analysis.
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Refers to minimum intake of 15 g for each of the food groups/sub-food groups.

Table N16a. Results of Ordinary Least Squares Regression Analysis of the Determinants of MPA (height included in the model), NPNL Women [a,b]

	FGI-6		FGI-6R		FGI-9		FGI-9R		FGI-13 [d]		FGI-13R [d]		FGI-21		FGI-21R	
	Not controlling for energy															
	B	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**
Constant	-1.091	0.685	-0.519	0.608	-0.830	0.681	-0.548	0.633	-0.900	0.719	-0.894	0.633	-0.856	0.690	-0.790	0.629
Woman's height	0.006	0.004	0.003	0.004	0.005	0.004	0.004	0.004	0.007	0.004	0.006	0.004	0.006	0.004	0.006	0.004
Age	-0.003	0.002	-0.003	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002
Dietary diversity score	0.120 **	0.035	0.122 ***	0.024	0.085 **	0.027	0.099 ***	0.023	0.048 *	0.021	0.083 ***	0.018	0.049 **	0.017	0.067 ***	0.015
Adjusted R^2	0.183 **		0.314 ***		0.159 **		0.256 ***		0.098 *		0.271 ***		0.144 **		0.273 ***	
	Controlling for energy															
	B	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**	**B**	**Standard error**
Constant	-0.844	0.584	-0.564	0.538	-0.771	0.560	-0.588	0.539					-0.738	0.575	-0.722	0.549
Woman's height	0.005	0.003	0.003	0.003	0.004	0.003	0.003	0.003					0.005	0.003	0.004	0.003
Age	-0.002	0.002	-0.002	0.002	-0.001	0.002	-0.002	0.002					-0.001	0.002	-0.001	0.002
Dietary diversity score	0.057	0.032	0.074 **	0.024	0.053 *	0.023	0.062 **	0.021					0.024	0.015	0.039 **	0.015
Total energy intake [c]	0.146 ***	0.030	0.124 ***	0.030	0.150 ***	0.028	0.136 ***	0.028					0.151 ***	0.029	0.131 ***	0.030
Adjusted R^2	0.410 ***		0.462 ***		0.431 ***		0.460 ***						0.406 ***		0.446 ***	

[a] Food group diversity scores are from first observation day, MPA is based on the first observation day and repeat observations for a subset of the sample
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Total energy intake (kcal)/1000.
[d] Residuals did not meet assumptions of Shapiro-wilk test when controlling for energy when height is included in the model.

Table N16b. Results of Ordinary Least Squares Regression Analysis of the Determinants of MPA (height not included in the model), NPNL Women [a,b]

	FGI-6		FGI-6R		FGI-9		FGI-9R		FGI-13		FGI-13R		FGI-21		FGI-21R	
	Not controlling for energy															
	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error
Constant	0.149	0.137	0.113	0.096	0.176	0.122	0.199 *	0.093	0.292	0.113	0.253 **	0.092	0.016 *	0.108	0.275	0.088
Age	-0.003	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002
Dietary diversity score	0.082 **	0.025	0.101 ***	0.018	0.065 ***	0.018	0.076 ***	0.016	0.039 **	0.014	0.055 ***	0.013	0.001 **	0.012	0.045 ***	0.011
Adjusted R^2	0.113 **		0.252 ***		0.127 ***		0.201 ***		0.086 *		0.165 ***		0.109 **		0.162 ***	
	Controlling for energy															
	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error	B	Standard error
Constant	0.045	0.117	0.011	0.086	0.002	0.106	0.03	0.084	0.097	0.099	0.083	0.083	0.082	0.095	0.1	0.081
Age	-0.002	0.001	-0.002	0.001	-0.001	0.001	-0.002	0.001	-0.001	0.001	-0.001	0.002	-0.001	0.001	-0.001	0.001
Dietary diversity score	0.04	0.022	0.063 ***	0.017	0.041 *	0.016	0.049 ***	0.014	0.02	0.012	0.031 **	0.012	0.020 *	0.01	0.025 *	0.01
Total energy intake [c]	0.137 ***	0.022	0.117 ***	0.022	0.136 ***	0.021	0.127 ***	0.021	0.141 ***	0.021	0.13 ***	0.021	0.138 ***	0.021	0.13 ***	0.022
Adjusted R^2	0.365 ***		0.422 ***		0.387 ***		0.417 ***		0.362 ***		0.388 ***		0.37 ***		0.385 ***	

[a] Food group diversity scores are from first observation day, MPA is based on the first observation day and repeat observations for a subset of the sample
[b] "*" indicates a coefficient that is statistically significant at $p < 0.05$; ** indicates $p < 0.01$ and *** indicates $p < 0.001$.
[c] Total energy intake (kcal)/1000.

Table N17. Percent of Observation Days Above Selected Cut-Off(s) for MPA, NPNL Women [a]

	Percent	(number)
Women with MPA >50%	46	(47)
Women with MPA >60%	25	(25)
Women with MPA >70%	11	(11)
Women with MPA >80%	4	(4)
Women with MPA >90%	0	(0)

[a] MPA is based on the first observation day and repeat observations for a subset of the sample.

Table N18. MPA: Performance of Diversity Scores, NPNL Women [a]

	Range	AUC	p-value [b]	SEM [c]	95% CI [d]
			MPA >50% (first cut-off)		
FGI-6	3.0-6.0	0.673	0.003	0.047	0.581-0.765
FGI-6R [e]	2.0-6.0	0.753	0.000	0.044	0.667-0.840
FGI-9	3.0-8.0	0.736	0.000	0.047	0.644-0.827
FGI-9R [e]	2.0-7.0	0.753	0.000	0.045	0.665-0.840
FGI-13	3.0-10.0	0.679	0.002	0.051	0.579-0.779
FGI-13R [e]	2.0-9.0	0.738	0.000	0.048	0.644-0.831
FGI-21	3.0-11.0	0.718	0.000	0.050	0.620-0.816
FGI-21R [e]	2.0-10.0	0.743	0.000	0.049	0.647-0.838
			MPA >60% (second cut-off)		
FGI-6	3.0-6.0	0.624	0.062	0.058	0.510-0.739
FGI-6R [e]	2.0-6.0	0.709	0.002	0.051	0.609-0.809
FGI-9	3.0-8.0	0.653	0.022	0.058	0.540-0.766
FGI-9R [e]	2.0-7.0	0.695	0.003	0.052	0.593-0.798
FGI-13	3.0-10.0	0.589	0.181	0.062	0.468-0.710
FGI-13R [e]	2.0-9.0	0.683	0.006	0.055	0.575-0.792
FGI-21	3.0-11.0	0.618	0.076	0.060	0.501-0.736
FGI-21R [e]	2.0-10.0	0.676	0.008	0.057	0.565-0.787
			MPA >70% (third cut-off)		
FGI-6	3.0-6.0	0.643	0.122	0.071	0.505-0.782
FGI-6R [e]	2.0-6.0	0.777	0.003	0.063	0.653-0.900
FGI-9	3.0-8.0	0.689	0.041	0.069	0.554-0.825
FGI-9R [e]	2.0-7.0	0.751	0.007	0.063	0.627-0.874
FGI-13	3.0-10.0	0.539	0.670	0.077	0.388-0.691
FGI-13R [e]	2.0-9.0	0.660	0.084	0.073	0.517-0.803
FGI-21	3.0-11.0	0.581	0.382	0.075	0.434-0.728
FGI-21R [e]	2.0-10.0	0.677	0.056	0.067	0.546-0.808

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.
[b] P-value for test of null hypothesis that area=0.5 (―neutral" diagonal line on ROC graph).
[c] Standard error of the mean.
[d] Confidence interval.
[e] Refers to minimum intake of 15 g for each food groups/sub-food groups.

Table N19. MPA: Tests Comparing of AUC for Various Diversity Scores, NPNL Women [a, b]

		FGI-6	FGI-6R [d]	FGI-9	FGI-9R [d]	FGI-13	FGI-13R [d]	FGI-21	FGI-21R [d]
MPA > 50% (first cutoff)									
	AUC [c]	0.673	0.753	0.736	0.753	0.679	0.738	0.718	0.743
		P-values							
FGI-6	0.673								
FGI-6R [d]	0.753	0.064							
FGI-9	0.736	0.078	0.678						
FGI-9R [d]	0.753	0.074	0.948	0.663					
FGI-13	0.679	0.890	0.115	0.084	0.104				
FGI-13R [d]	0.738	0.174	0.539	0.967	0.546	0.135			
FGI-21	0.718	0.334	0.461	0.584	0.447	0.122	0.629		
FGI-21R [d]	0.743	0.157	0.757	0.873	0.762	0.148	0.835	0.452	
MPA > 60% (second cutoff)									
		FGI-6	**FGI-6R [d]**	**FGI-9**	**FGI-9R [d]**	**FGI-13**	**FGI-13R [d]**	**FGI-21**	**FGI-21R [d]**
	AUC [c]	0.624	0.709	0.653	0.695	0.589	0.683	0.618	0.676
		P-values							
FGI-6	0.624								
FGI-6R [d]	0.709	0.081							
FGI-9	0.653	0.512	0.203						
FGI-9R [d]	0.695	0.173	0.364	0.300					
FGI-13	0.589	0.496	**0.030**	0.089	**0.044**				
FGI-13R [d]	0.683	0.237	0.422	0.492	0.677	**0.018**			
FGI-21	0.618	0.909	0.111	0.342	0.164	0.344	0.170		
FGI-21R [d]	0.676	0.290	0.411	0.613	0.608	0.065	0.807	0.137	
MPA > 70% (third cutoff)									
		FGI-6	**FGI-6R [d]**	**FGI-9**	**FGI-9R [d]**	**FGI-13**	**FGI-13R [d]**	**FGI-21**	**FGI-21R [d]**
	AUC [c]	0.763	0.823	0.579	0.774	0.404	0.681	0.392	0.621
		P-values							
FGI-6	0.763								
FGI-6R [d]	0.823	0.556							
FGI-9	0.579	**0.000**	**0.007**						
FGI-9R [d]	0.774	0.911	**0.001**	**0.028**					
FGI-13	0.404	**0.000**	**0.001**	**0.018**	**0.003**				
FGI-13R [d]	0.681	0.371	**0.014**	0.203	0.096	**0.001**			
FGI-21	0.392	**0.000**	**0.000**	**0.000**	**0.000**	0.860	**0.001**		
FGI-21R [d]	0.621	**0.020**	**0.002**	0.440	**0.021**	**0.035**	0.355	**0.000**	

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.
[b] P-value for test of null hypothesis that area under the curve is equal for the 2 indicators. P-values <0.05 are in bold type.
[c] Area under the curve.
[d] Refers to minimum intake of 15 g for each food groups/sub-food groups.

Table N20a. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-6) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 50%			
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
102	≥ 3	100.0	0.0	53.9	0.0	53.9
100	≥ 4	100.0	3.6	52.0	0.0	52.0
86	≥ 5	93.6	23.6	41.2	2.9	44.1
29	6	42.6	83.6	8.8	26.5	35.3
			MPA > 60%			
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
102	≥ 3	100.0	0.0	75.5	0.0	75.5
100	≥ 4	100.0	2.6	73.5	0.0	73.5
86	≥ 5	92.0	18.2	61.8	2.0	63.7
29	6	44.0	76.6	17.6	13.7	31.4
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
102	≥ 3	100.0	0.0	89.2	0.0	89.2
100	≥ 4	100.0	2.2	87.3	0.0	87.3
86	≥ 5	100.0	17.6	73.5	0.0	73.5
29	6	45.5	73.6	23.5	5.9	29.4

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20b. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-6R) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 50%			
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
100	≥ 3	100.0	3.6	52.0	0.0	52.0
84	≥ 4	97.9	30.9	37.3	1.0	38.2
41	≥ 5	61.7	78.2	11.8	17.6	29.4
8	6	12.8	96.4	2.0	40.2	42.2
			MPA > 60%			
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
100	≥ 3	100.0	2.6	73.5	0.0	73.5
84	≥ 4	100.0	23.4	57.8	0.0	57.8
41	≥ 5	64.0	67.5	24.5	8.8	33.3
8	6	16.0	94.8	3.9	20.6	24.5
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
100	≥ 3	100.0	2.2	87.3	0.0	87.3
84	≥ 4	100.0	19.8	71.6	0.0	71.6
41	≥ 5	81.8	64.8	31.4	2.0	33.3
8	6	27.3	94.5	4.9	7.8	12.7

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20c. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-9) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 50%		
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
102	≥ 3	100.0	0.0	53.9	0.0	53.9
100	≥ 4	100.0	3.6	52.0	0.0	52.0
90	≥ 5	95.7	18.2	44.1	2.0	46.1
52	≥ 6	72.3	67.3	17.6	12.7	30.4
16	≥ 7	27.7	94.5	2.9	33.3	36.3
1	≥ 8	2.1	100.0	0.0	45.1	45.1
0	9	--	--	--	--	--
				MPA > 60%		
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
102	≥ 3	100.0	0.0	75.5	0.0	75.5
100	≥ 4	100.0	2.6	73.5	0.0	73.5
90	≥ 5	96.0	14.3	64.7	1.0	65.7
52	≥ 6	72.0	55.8	33.3	6.9	40.2
16	≥ 7	24.0	87.0	9.8	18.6	28.4
1	≥ 8	0.0	98.7	1.0	24.5	25.5
0	9	--	--	--	--	--
				MPA > 70%		
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
102	≥ 3	100.0	0.0	89.2	0.0	89.2
100	≥ 4	100.0	2.2	87.3	0.0	87.3
90	≥ 5	100.0	13.2	77.5	0.0	77.5
52	≥ 6	81.8	52.7	42.2	2.0	44.1
16	≥ 7	27.3	85.7	12.7	7.8	20.6
1	≥ 8	0.0	98.9	1.0	10.8	11.8
0	9	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20d. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-9R) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 50%		
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
100	≥ 3	100.0	3.6	52.0	0.0	52.0
84	≥ 4	97.9	30.9	37.3	1.0	38.2
43	≥ 5	61.7	74.5	13.7	17.6	31.4
15	≥ 6	27.7	96.4	2.0	33.3	35.3
4	≥ 7	4.3	96.4	2.0	44.1	46.1
0	≥ 8	--	--	--	--	--
0	9	--	--	--	--	--
				MPA > 60%		
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
100	≥ 3	100.0	2.6	73.5	0.0	73.5
84	≥ 4	100.0	23.4	57.8	0.0	57.8
43	≥ 5	64.0	64.9	26.5	8.8	35.3
15	≥ 6	28.0	89.6	7.8	17.6	25.5
4	≥ 7	0.0	94.8	3.9	24.5	28.4
0	≥ 8	--	--	--	--	--
0	9	--	--	--	--	--
				MPA > 70%		
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
100	≥ 3	100.0	2.2	87.3	0.0	87.3
84	≥ 4	100.0	19.8	71.6	0.0	71.6
43	≥ 5	81.8	62.6	33.3	2.0	35.3
15	≥ 6	36.4	87.9	10.8	6.9	17.6
4	≥ 7	0.0	95.6	3.9	10.8	14.7
0	≥ 8	--	--	--	--	--
0	9	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20e. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-13) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 50%			
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
102	≥ 3	100.0	0.0	53.9	0.0	53.9
100	≥ 4	100.0	3.6	52.0	0.0	52.0
95	≥ 5	97.9	10.9	48.0	1.0	49.0
80	≥ 6	89.4	30.9	37.3	4.9	42.2
43	≥ 7	57.4	70.9	15.7	19.6	35.3
19	≥ 8	27.7	89.1	5.9	33.3	39.2
4	≥ 9	4.3	96.4	2.0	44.1	46.1
1	≥10	2.1	100.0	0.0	45.1	45.1
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--
			MPA > 60%			
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
102	≥ 3	100.0	0.0	75.5	0.0	75.5
100	≥ 4	100.0	2.6	73.5	0.0	73.5
95	≥ 5	96.0	7.8	69.6	1.0	70.6
80	≥ 6	88.0	24.7	56.9	2.9	59.8
43	≥ 7	52.0	61.0	29.4	11.8	41.2
19	≥ 8	24.0	83.1	12.7	18.6	31.4
4	≥ 9	4.0	96.1	2.9	23.5	26.5
1	≥10	0.0	98.7	1.0	24.5	25.5
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
102	≥ 3	100.0	0.0	89.2	0.0	89.2
100	≥ 4	100.0	2.2	87.3	0.0	87.3
95	≥ 5	100.0	7.7	82.4	0.0	82.4
80	≥ 6	90.9	23.1	68.6	1.0	69.6
43	≥ 7	45.5	58.2	37.3	5.9	43.1
19	≥ 8	9.1	80.2	17.6	9.8	27.5
4	≥ 9	9.1	96.7	2.9	9.8	12.7
1	≥10	0.0	98.9	1.0	10.8	11.8
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20f. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-13R) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 50%			
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
101	≥ 3	100.0	1.8	52.9	0.0	52.9
91	≥ 4	97.9	18.2	44.1	1.0	45.1
59	≥ 5	78.7	60.0	21.6	9.8	31.4
31	≥ 6	46.8	83.6	8.8	24.5	33.3
12	≥ 7	19.1	94.5	2.9	37.3	40.2
5	≥ 8	6.4	96.4	2.0	43.1	45.1
1	≥ 9	2.1	100.0	0.0	45.1	45.1
0	≥10	--	--	--	--	--
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--
			MPA > 60%			
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
101	≥ 3	100.0	1.3	74.5	0.0	74.5
91	≥ 4	100.0	14.3	64.7	0.0	64.7
59	≥ 5	80.0	49.4	38.2	4.9	43.1
31	≥ 6	48.0	75.3	18.6	12.7	31.4
12	≥ 7	20.0	90.9	6.9	19.6	26.5
5	≥ 8	4.0	94.8	3.9	23.5	27.5
1	≥ 9	0.0	98.7	1.0	24.5	25.5
0	≥10	--	--	--	--	--
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
101	≥ 3	100.0	1.1	88.2	0.0	88.2
91	≥ 4	100.0	12.1	78.4	0.0	78.4
59	≥ 5	81.8	45.1	49.0	2.0	51.0
31	≥ 6	54.5	72.5	24.5	4.9	29.4
12	≥ 7	9.1	87.9	10.8	9.8	20.6
5	≥ 8	0.0	94.5	4.9	10.8	15.7
1	≥ 9	0.0	98.9	1.0	10.8	11.8
0	≥10	--	--	--	--	--
0	≥ 11	--	--	--	--	--
0	≥ 12	--	--	--	--	--
0	13	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20g. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-21) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 50%			
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
102	≥ 3	100.0	0.0	53.9	0.0	53.9
101	≥ 4	100.0	1.8	52.9	0.0	52.9
96	≥ 5	97.9	9.1	49.0	1.0	50.0
88	≥ 6	91.5	18.2	44.1	3.9	48.0
68	≥ 7	83.0	47.3	28.4	7.8	36.3
35	≥ 8	53.2	81.8	9.8	21.6	31.4
20	≥ 9	31.9	90.9	4.9	31.4	36.3
4	≥10	6.4	98.2	1.0	43.1	44.1
2	≥11	2.1	98.2	1.0	45.1	46.1
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--
			MPA > 60%			
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
102	≥ 3	100.0	0.0	75.5	0.0	75.5
101	≥ 4	100.0	1.3	74.5	0.0	74.5
96	≥ 5	96.0	6.5	70.6	1.0	71.6
88	≥ 6	92.0	15.6	63.7	2.0	65.7
68	≥ 7	84.0	39.0	46.1	3.9	50.0
35	≥ 8	48.0	70.1	22.5	12.7	35.3
20	≥ 9	24.0	81.8	13.7	18.6	32.4
4	≥10	0.0	94.8	3.9	24.5	28.4
2	≥ 11	0.0	97.4	2.0	24.5	26.5
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--

(continued)

Table N20g (continued). Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-21) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
102	≥ 3	100.0	0.0	89.2	0.0	89.2
101	≥ 4	100.0	1.1	88.2	0.0	88.2
96	≥ 5	100.0	6.6	83.3	0.0	83.3
88	≥ 6	90.9	14.3	76.5	1.0	77.5
68	≥ 7	90.9	36.3	56.9	1.0	57.8
35	≥ 8	36.4	65.9	30.4	6.9	37.3
20	≥ 9	18.2	80.2	17.6	8.8	26.5
4	≥10	0.0	95.6	3.9	10.8	14.7
2	≥ 11	0.0	97.8	2.0	10.8	12.7
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

Table N20h. Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-21R) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
				MPA > 50%		
102	≥ 1	100.0	0.0	53.9	0.0	53.9
102	≥ 2	100.0	0.0	53.9	0.0	53.9
101	≥ 3	100.0	1.8	52.9	0.0	52.9
94	≥ 4	97.9	12.7	47.1	1.0	48.0
76	≥ 5	87.2	36.4	34.3	5.9	40.2
50	≥ 6	72.3	70.9	15.7	12.7	28.4
25	≥ 7	40.4	89.1	5.9	27.5	33.3
12	≥ 8	19.1	94.5	2.9	37.3	40.2
5	≥ 9	6.4	96.4	2.0	43.1	45.1
2	≥10	2.1	98.2	1.0	45.1	46.1
0	≥11	--	--	--	--	--
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--
				MPA > 60%		
102	≥ 1	100.0	0.0	75.5	0.0	75.5
102	≥ 2	100.0	0.0	75.5	0.0	75.5
101	≥ 3	100.0	1.3	74.5	0.0	74.5
94	≥ 4	100.0	10.4	67.6	0.0	67.6
76	≥ 5	92.0	31.2	52.0	2.0	53.9
50	≥ 6	68.0	57.1	32.4	7.8	40.2
25	≥ 7	44.0	81.8	13.7	13.7	27.5
12	≥ 8	16.0	89.6	7.8	20.6	28.4
5	≥ 9	0.0	93.5	4.9	24.5	29.4
2	≥10	0.0	97.4	2.0	24.5	26.5
0	≥11	--	--	--	--	--
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--

(continued)

Table N20h (continued). Sensitivity/Specificity Analysis of the Relationship between Food Group Diversity (FGI-21R) and MPA by Diversity Cut-Offs, NPNL Women [a]

N	Cutoff	Sensitivity	Specificity	Proportion of false positives	Proportion of false negatives	Total proportion misclassified
			MPA > 70%			
102	≥ 1	100.0	0.0	89.2	0.0	89.2
102	≥ 2	100.0	0.0	89.2	0.0	89.2
101	≥ 3	100.0	1.1	88.2	0.0	88.2
94	≥ 4	100.0	8.8	81.4	0.0	81.4
76	≥ 5	100.0	28.6	63.7	0.0	63.7
50	≥ 6	72.7	53.8	41.2	2.9	44.1
25	≥ 7	45.5	78.0	19.6	5.9	25.5
12	≥ 8	9.1	87.9	10.8	9.8	20.6
5	≥ 9	0.0	94.5	4.9	10.8	15.7
2	≥10	0.0	97.8	2.0	10.8	12.7
0	≥11	--	--	--	--	--
0	≥12	--	--	--	--	--
0	≥13	--	--	--	--	--
0	≥14	--	--	--	--	--
0	≥15	--	--	--	--	--
0	≥16	--	--	--	--	--
0	≥17	--	--	--	--	--
0	≥18	--	--	--	--	--
0	≥19	--	--	--	--	--
0	≥20	--	--	--	--	--
0	21	--	--	--	--	--

[a] Diversity scores are from a single (R1) observation day. MPA is calculated based on both observation days.

FIGURES

Histograms of intakes for 11 micronutrients (R1 data): Figures N1-N11

Histograms for intra-individual SDs of intake, based on data from two rounds: Figures N12-N22

Histograms for FGIs (R1 data): Figures N23-N30

Histograms of PA for 11 micronutrients, based on data from two rounds: Figures N31-N41

Histogram of MPA, based on data from two rounds: Figure N42

Figure N1. Distribution of Thiamin Intakes, NPNL Women

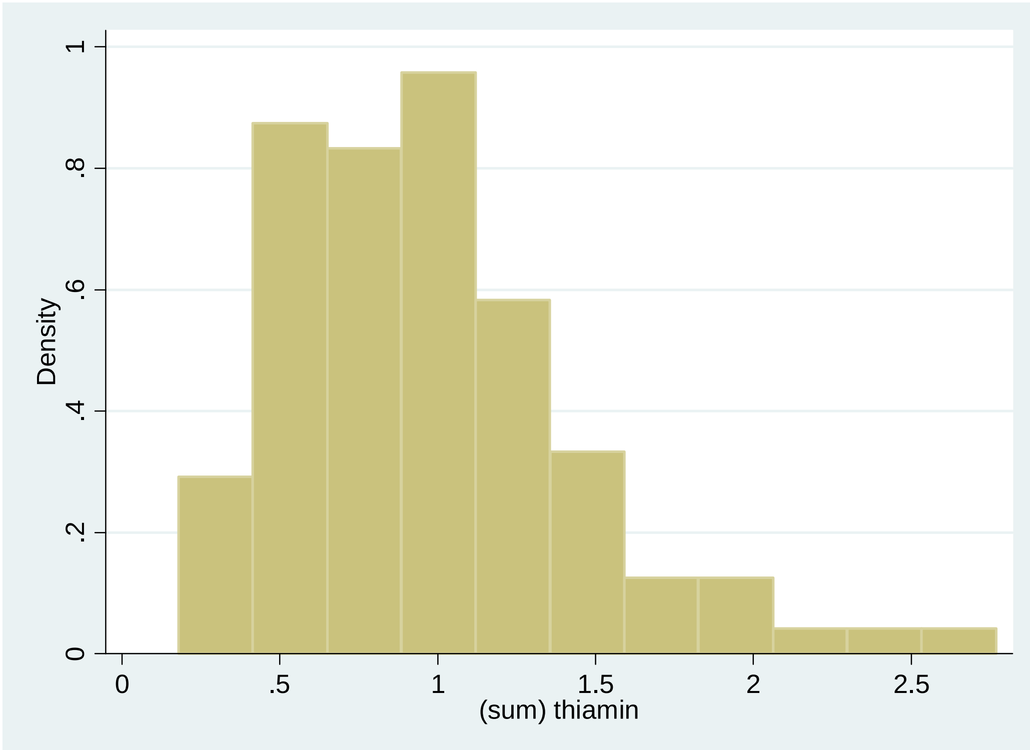


Figure N2. Distribution of Riboflavin Intakes, NPNL Women

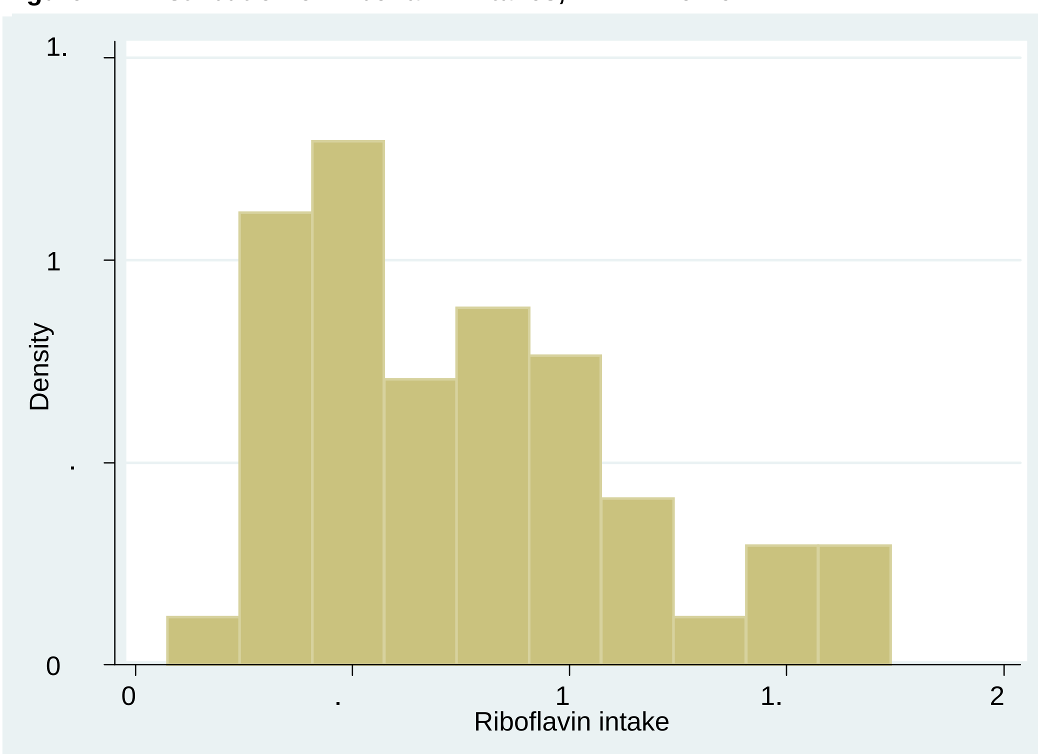


Figure N3. Distribution of Niacin Intakes, NPNL Women

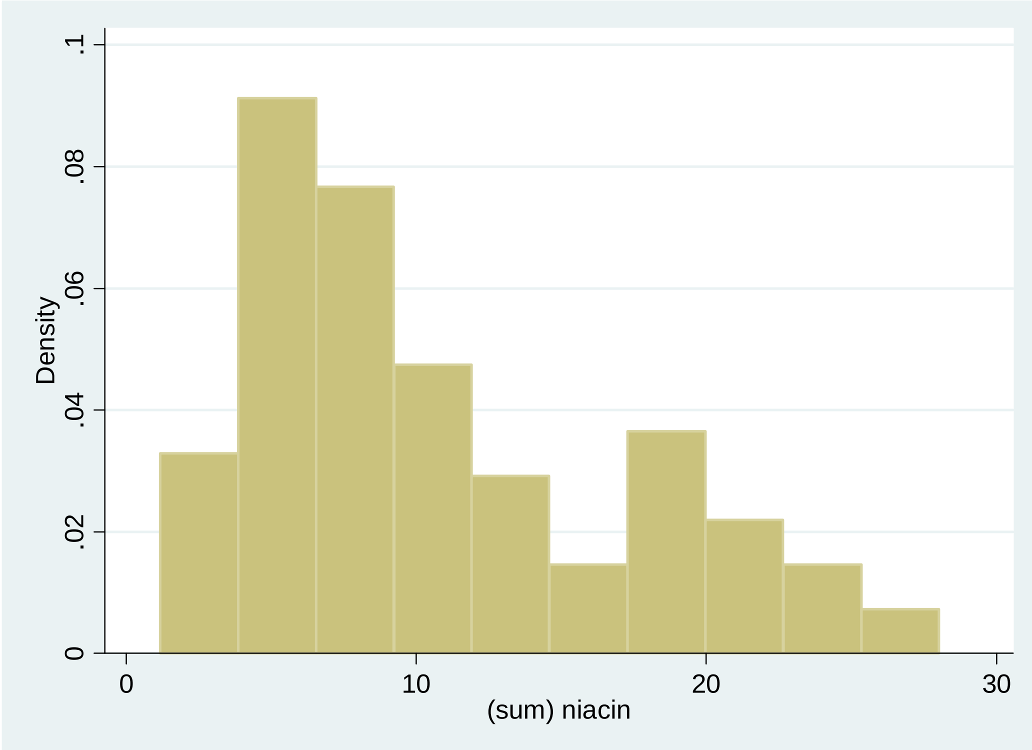


Figure N4. Distribution of Vitamin B6 Intakes, NPNL Women

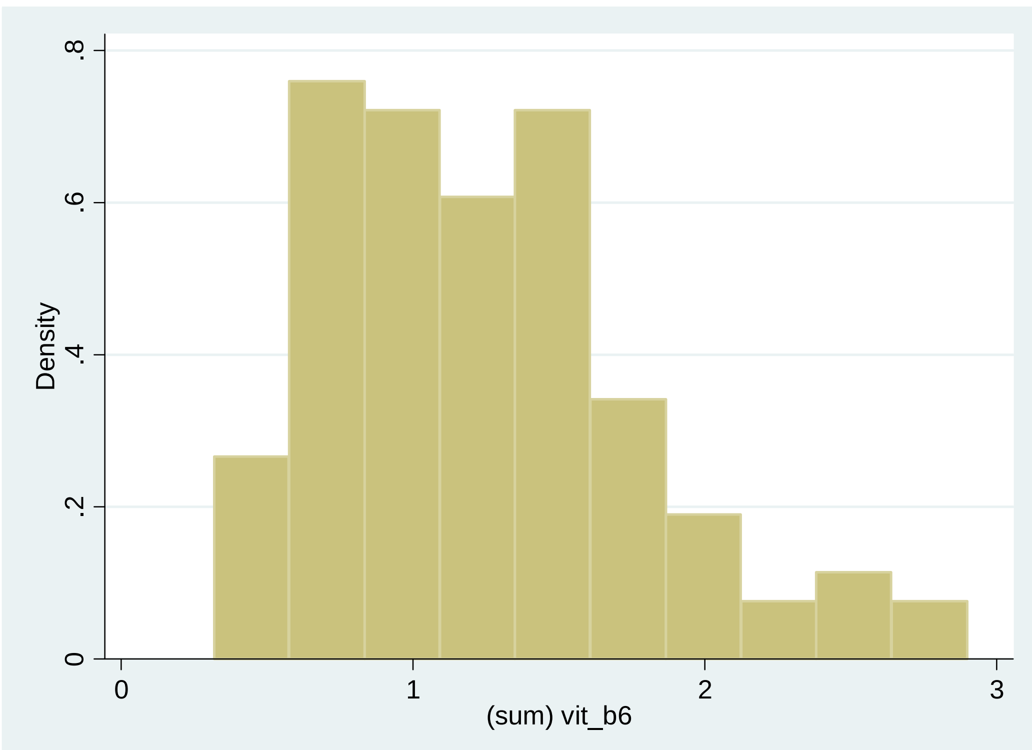


Figure N5. Distribution of Folate Intakes, NPNL Women

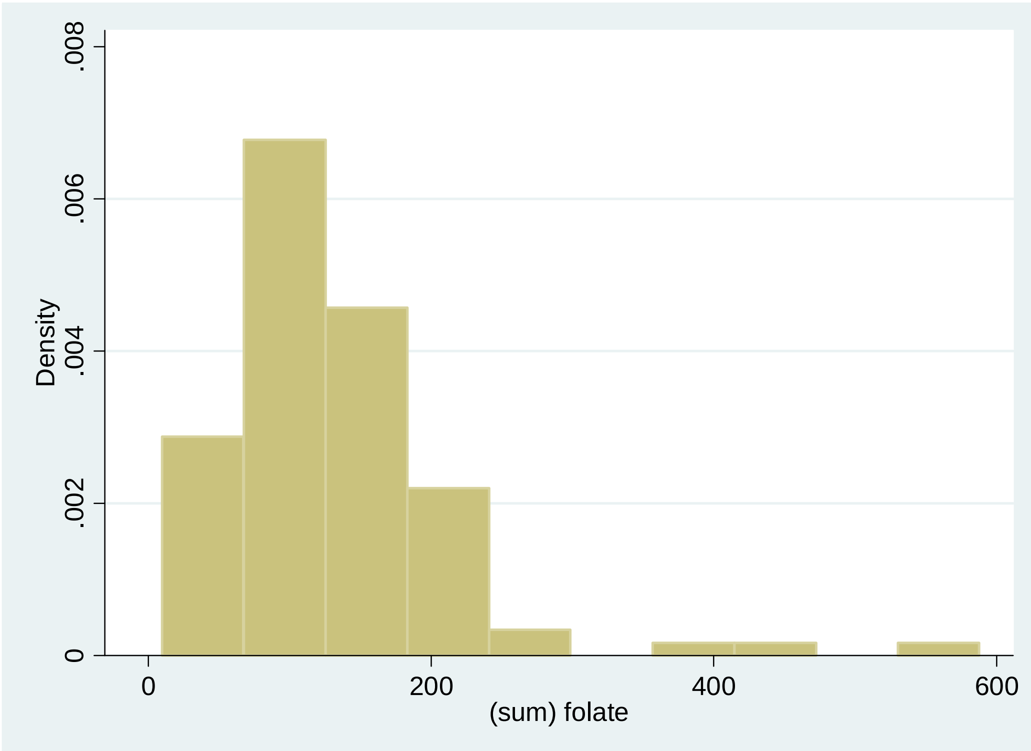


Figure N6. Distribution of Vitamin B12 Intakes, NPNL Women

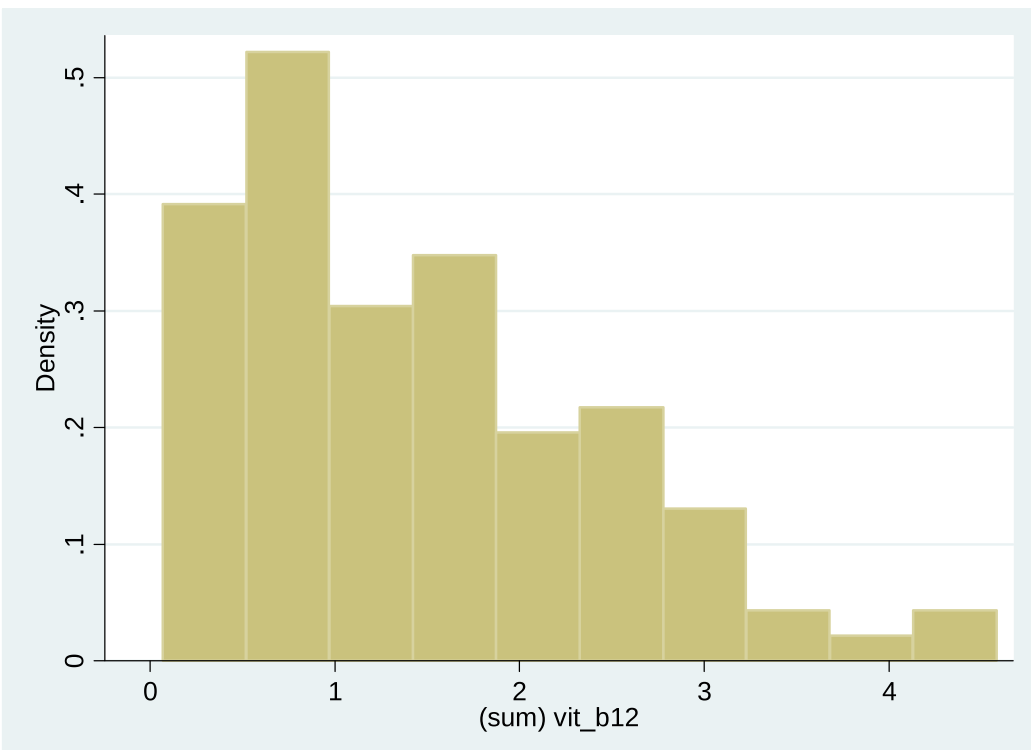


Figure N7. Distribution of Vitamin C Intakes, NPNL Women

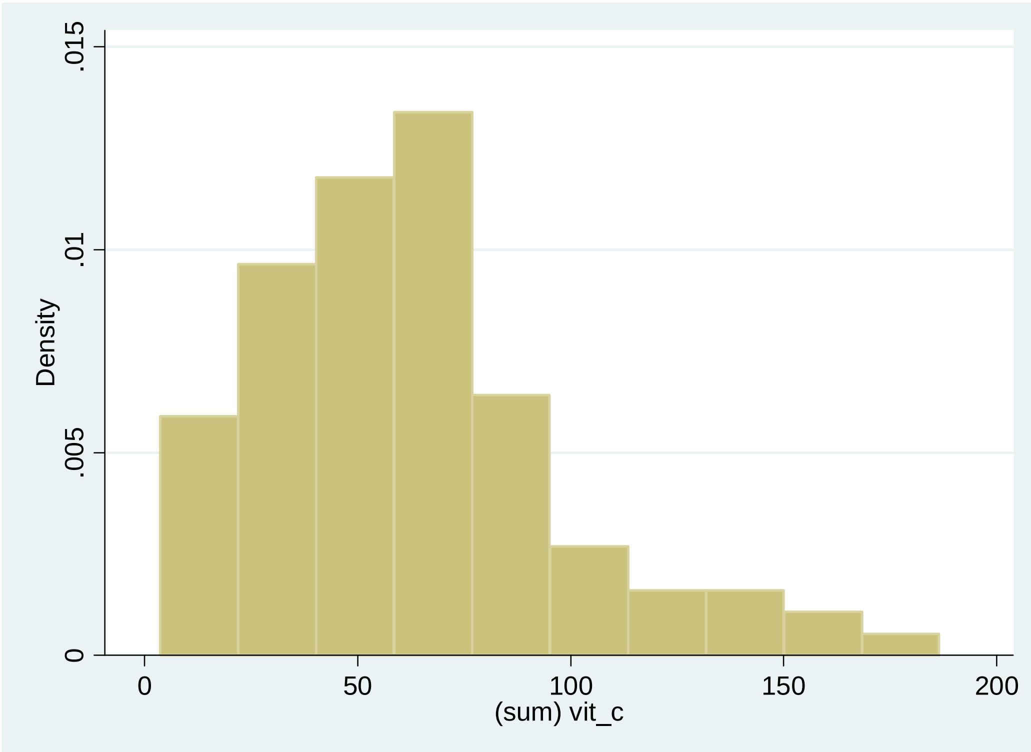


Figure N8. Distribution of Vitamin A Intakes, NPNL Women

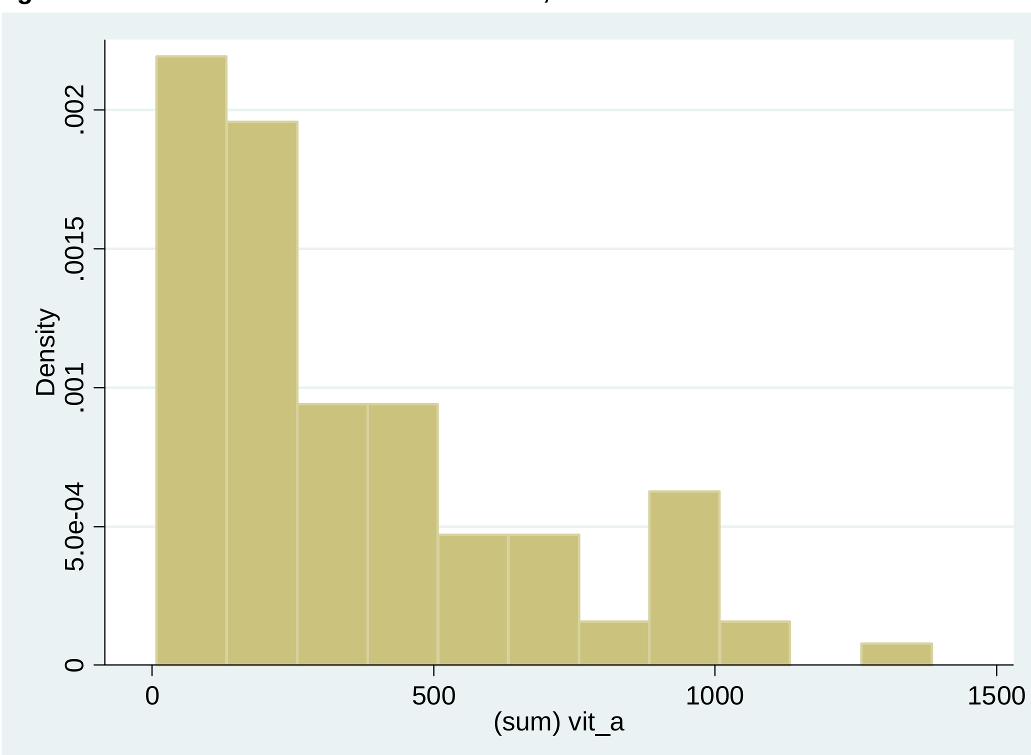


Figure N9. Distribution of Calcium Intakes, NPNL Women

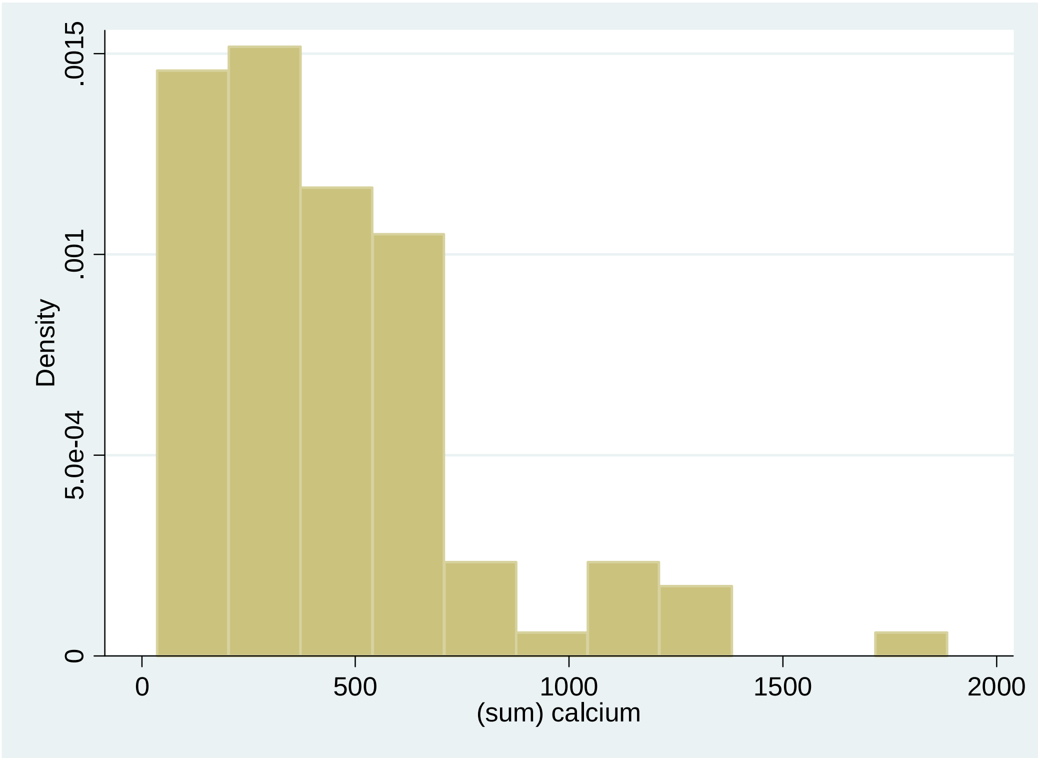


Figure N10. Distribution of Iron Intakes, NPNL Women

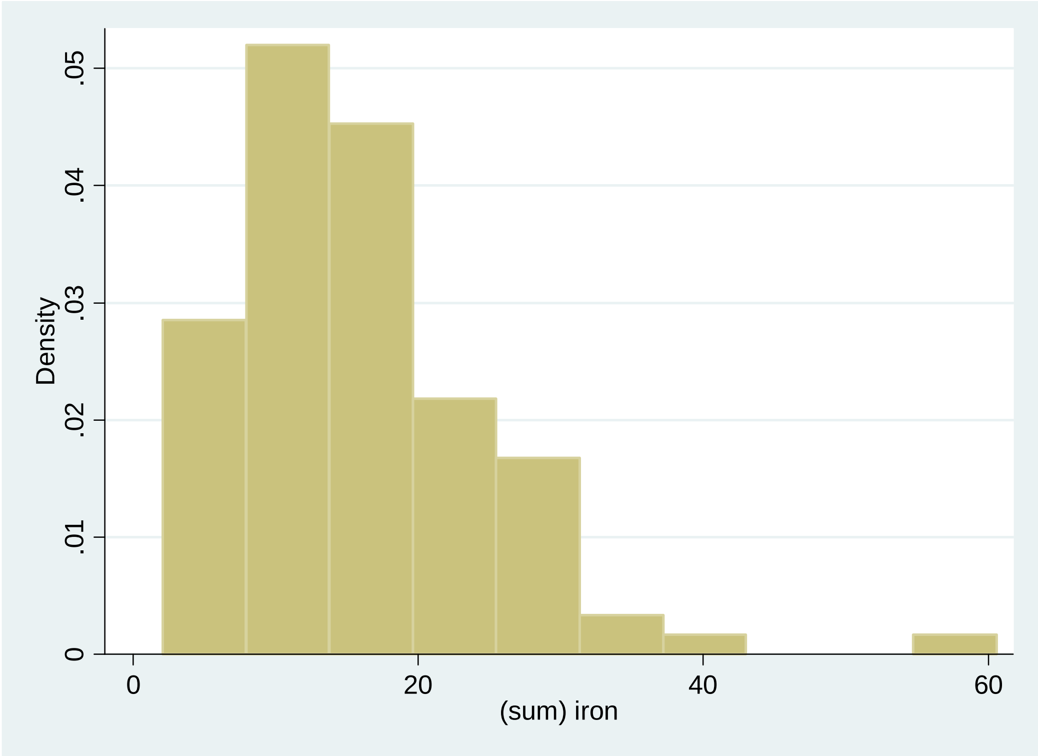


Figure N11. Distribution of Zinc Intakes, NPNL Women

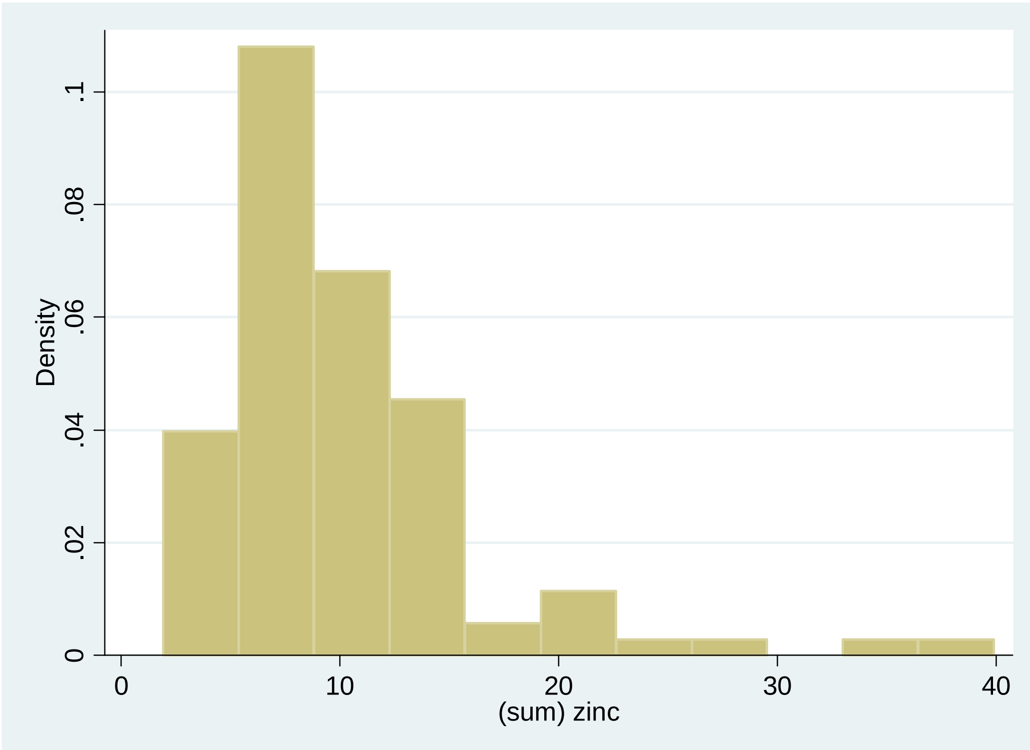


Figure N12. Intra-Individual SD of Thiamin Intakes, NPNL Women

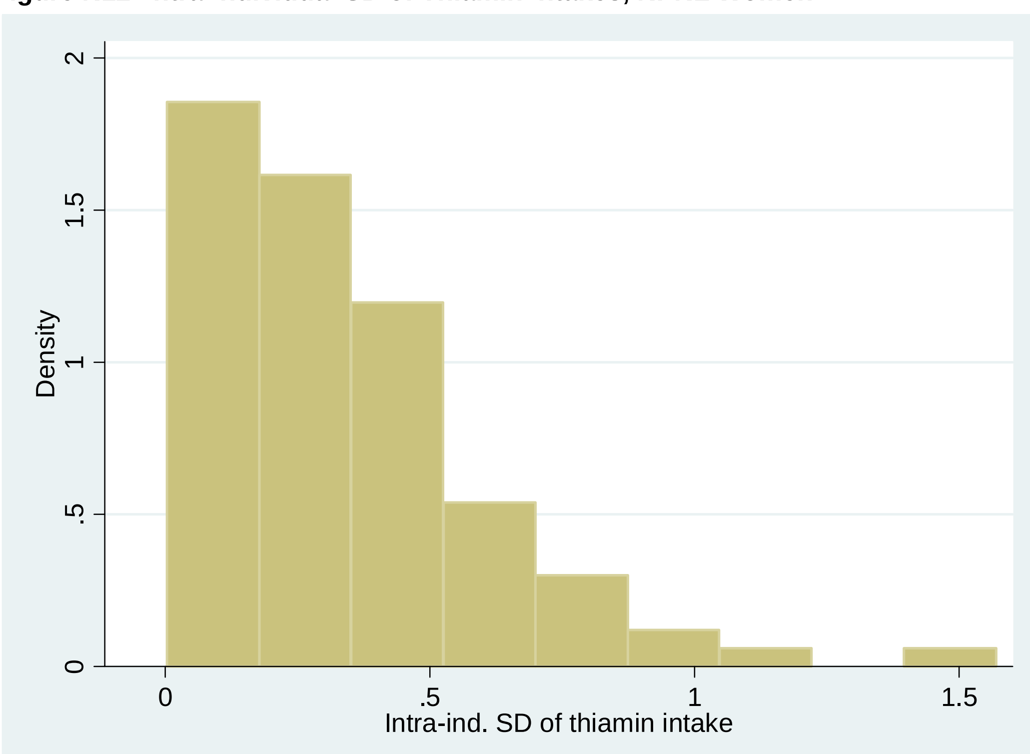


Figure N13. Intra-Individual SD of Riboflavin Intakes, NPNL Women

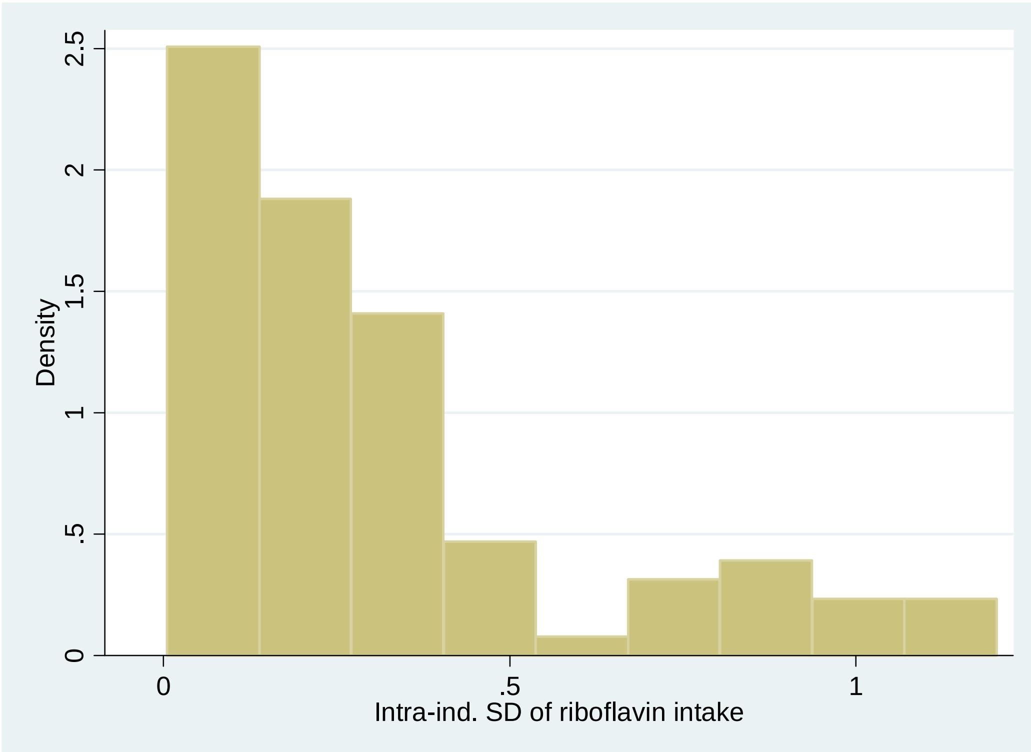


Figure N14. Intra-Individual SD of Niacin Intakes, NPNL Women

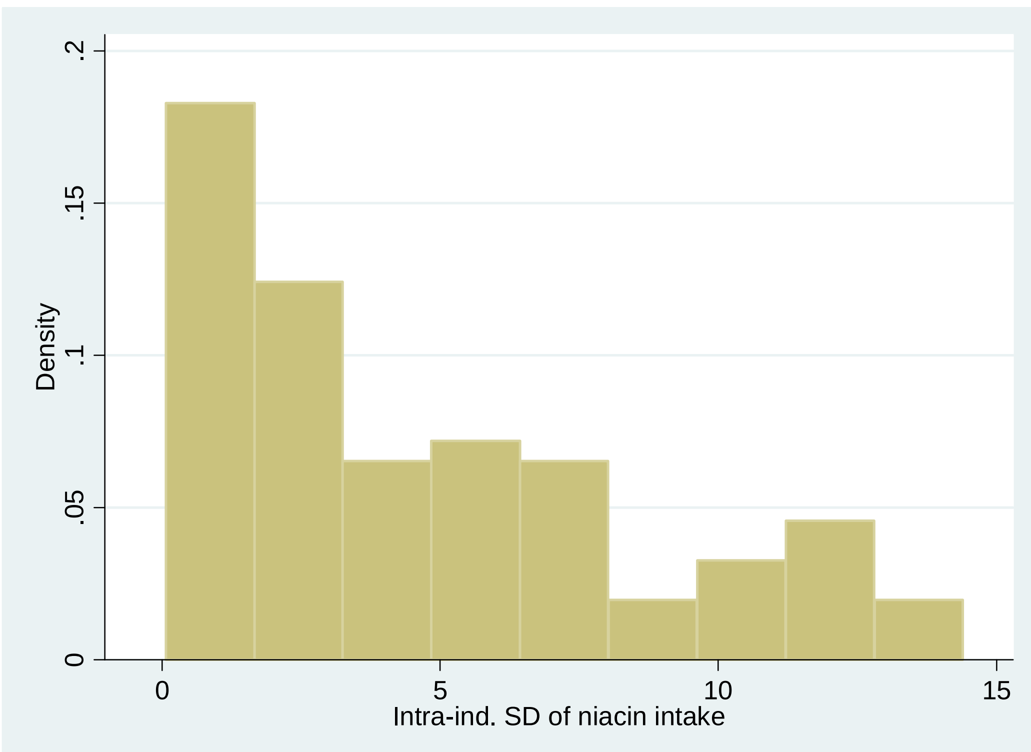


Figure N15. Intra-Individual SD of Vitamin B6 Intakes, NPNL Women

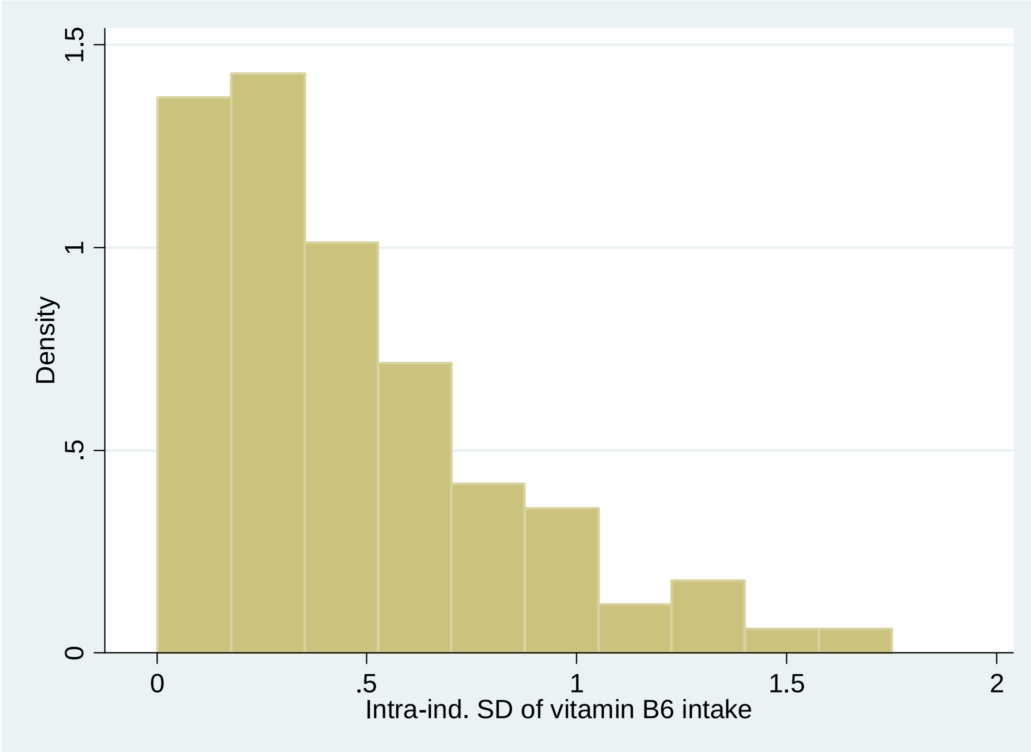


Figure N16. Intra-Individual SD of Folate Intakes, NPNL Women

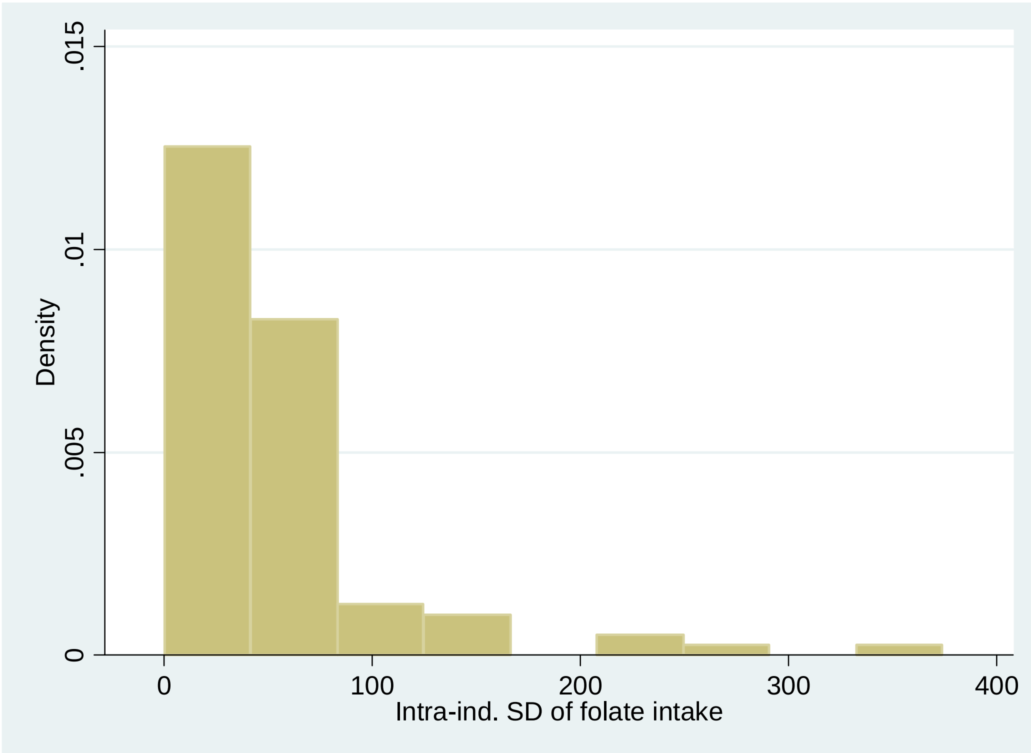


Figure N17. Intra-Individual SD of Vitamin B12 Intakes, NPNL Women

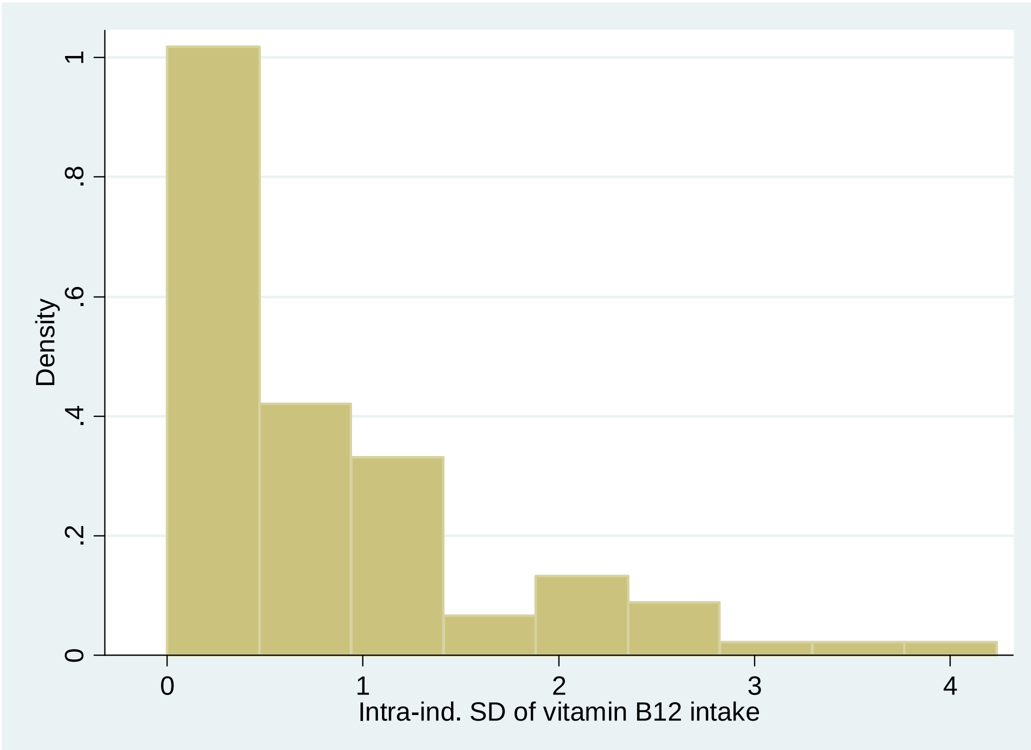


Figure N18. Intra-Individual SD of Vitamin C Intakes, NPNL Women

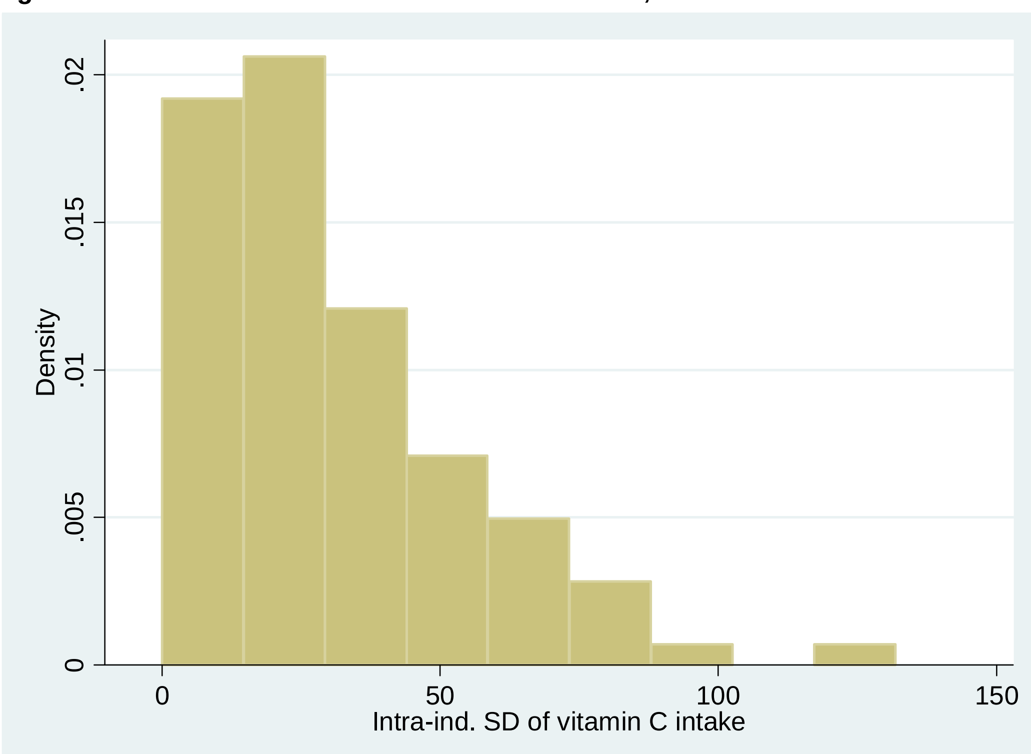


Figure N19. Intra-Individual SD of Vitamin A Intakes, NPNL Women

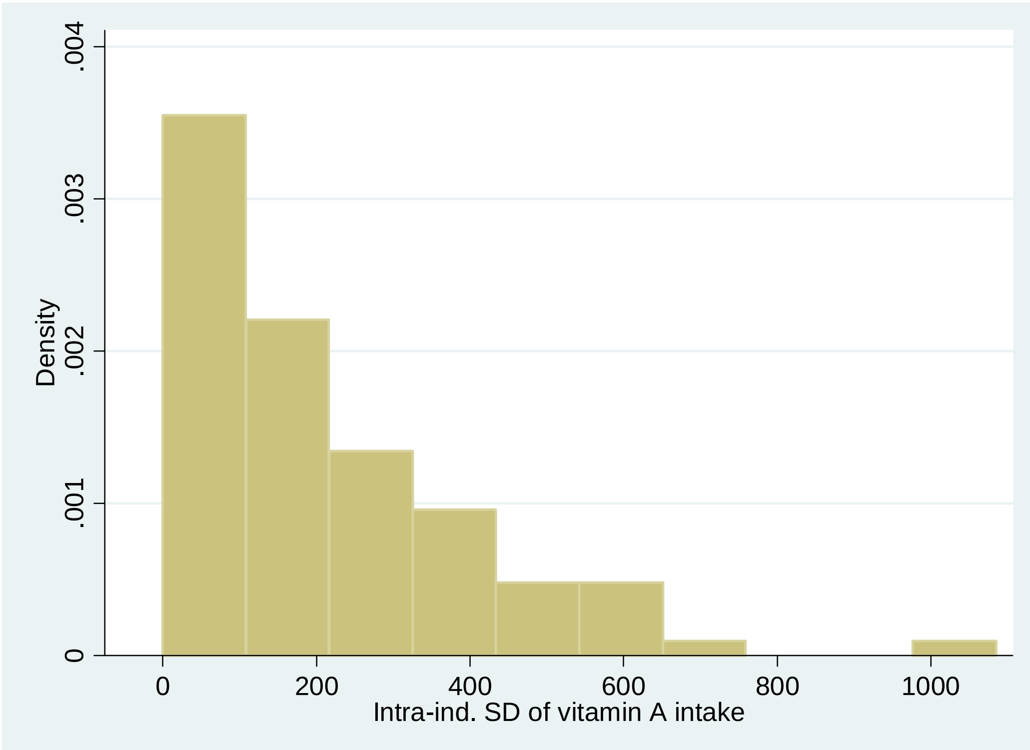


Figure N20. Intra-Individual SD of Calcium Intakes, NPNL Women

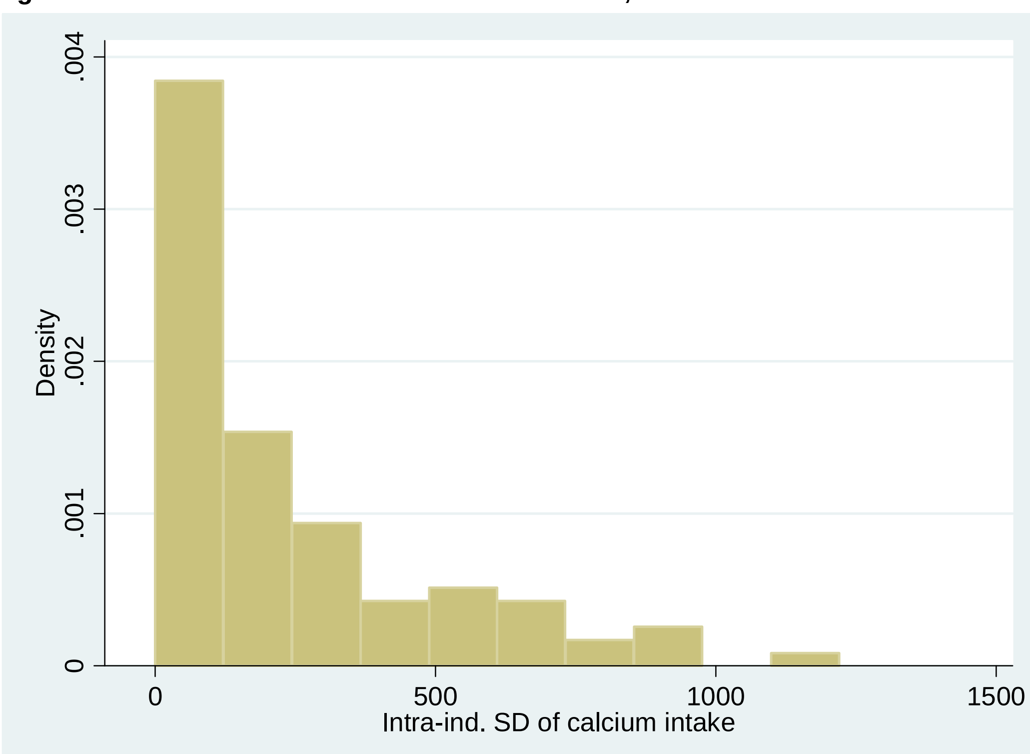


Figure N21. Intra-Individual SD of Iron Intakes, NPNL Women

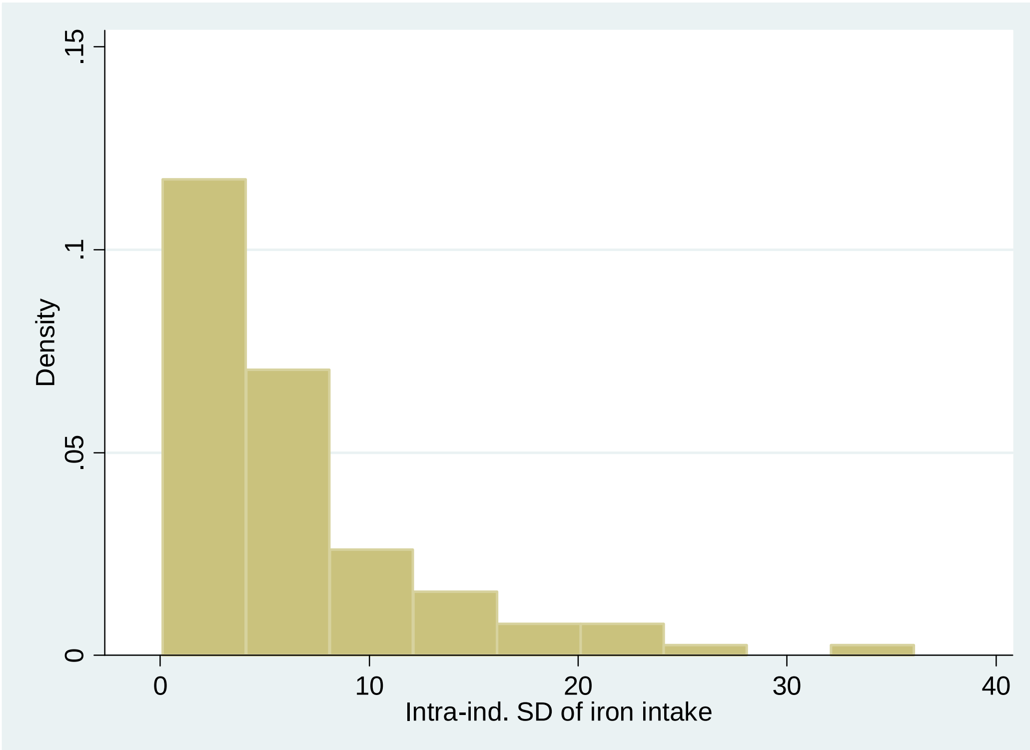


Figure N22. Intra-Individual SD of Zinc Intakes, NPNL Women

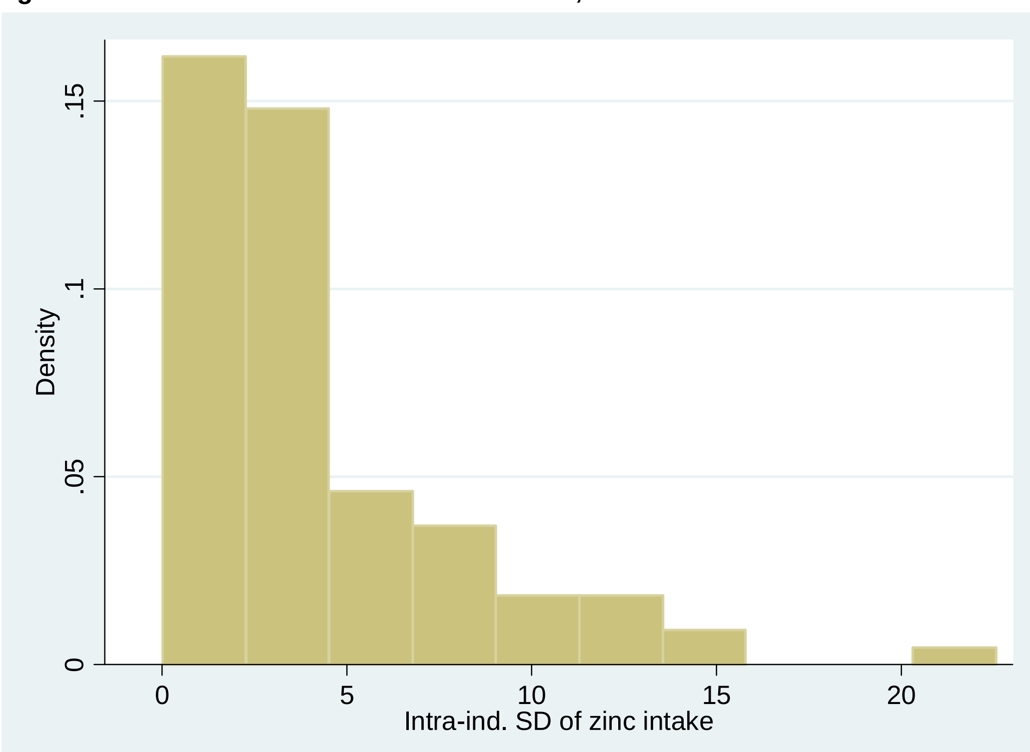


Figure N23. Distribution of Scores for FGI-6, NPNL Women

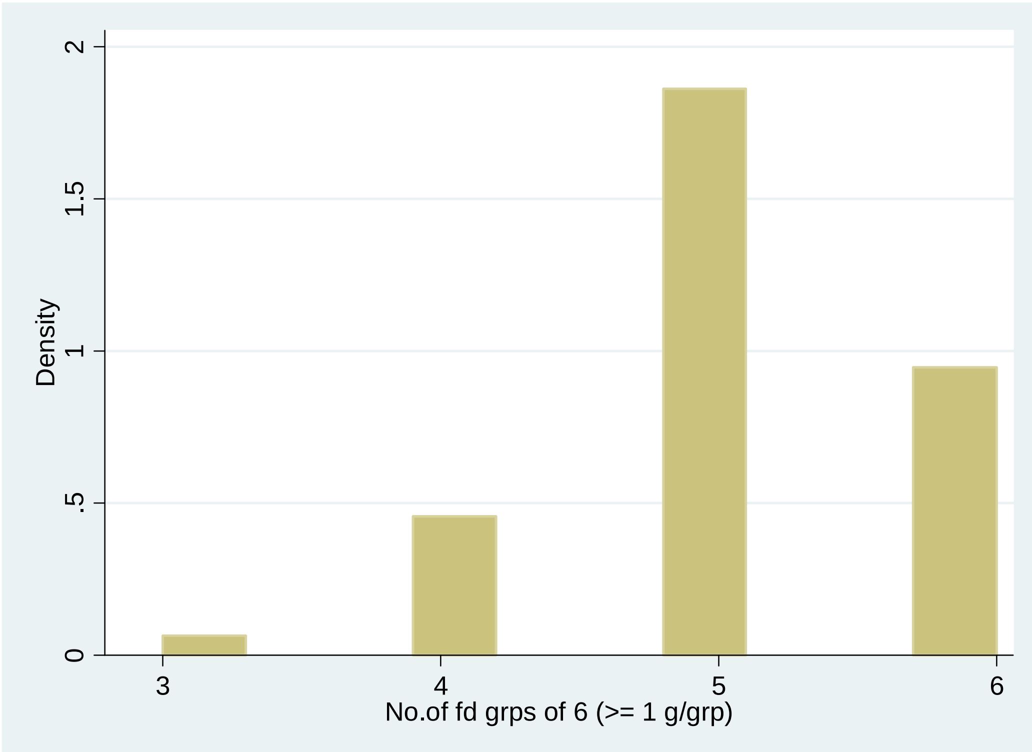


Figure N24. Distribution of Scores for FGI-6R, NPNL Women

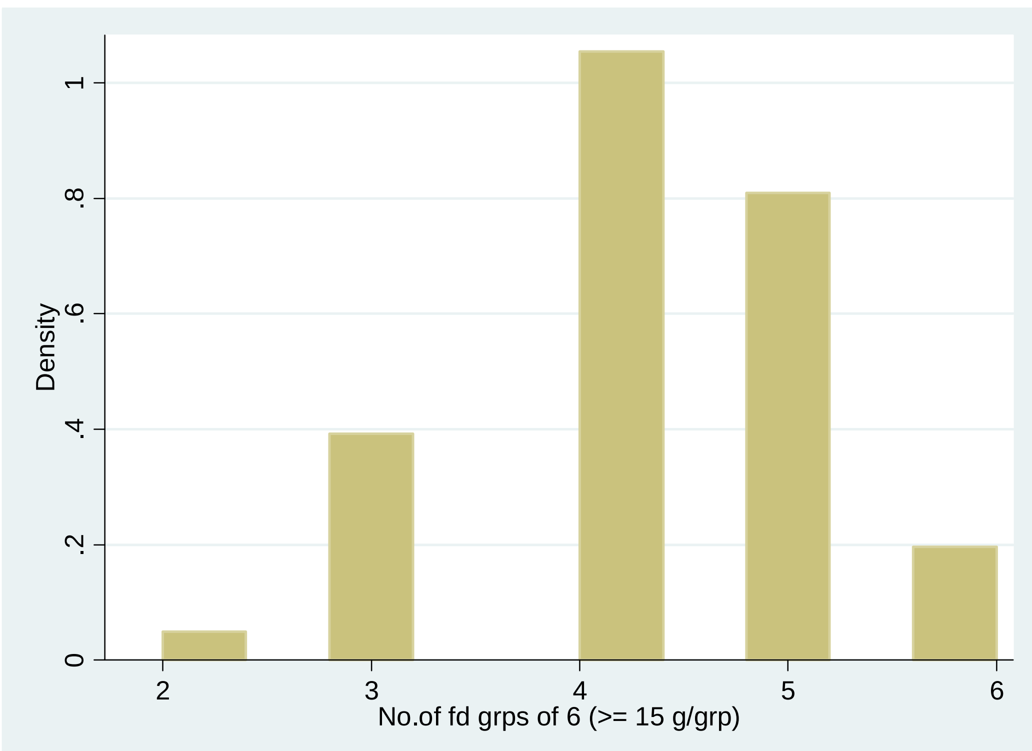


Figure N25. Distribution of Scores for FGI-9, NPNL Women

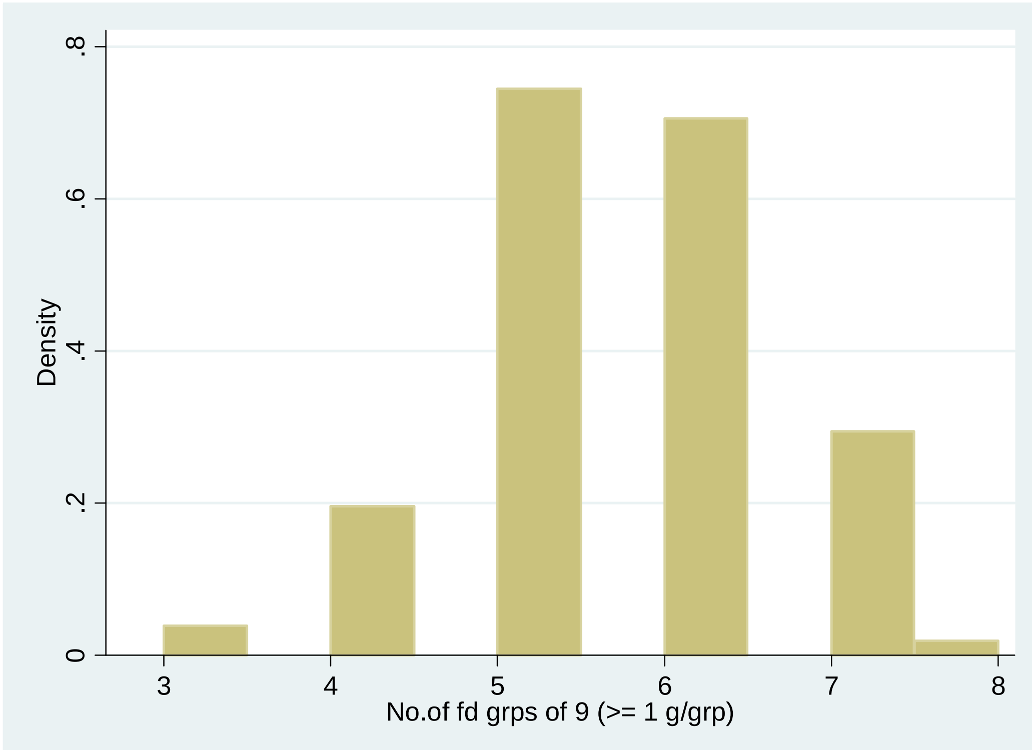


Figure N26. Distribution of Scores for FGI-9R, NPNL Women

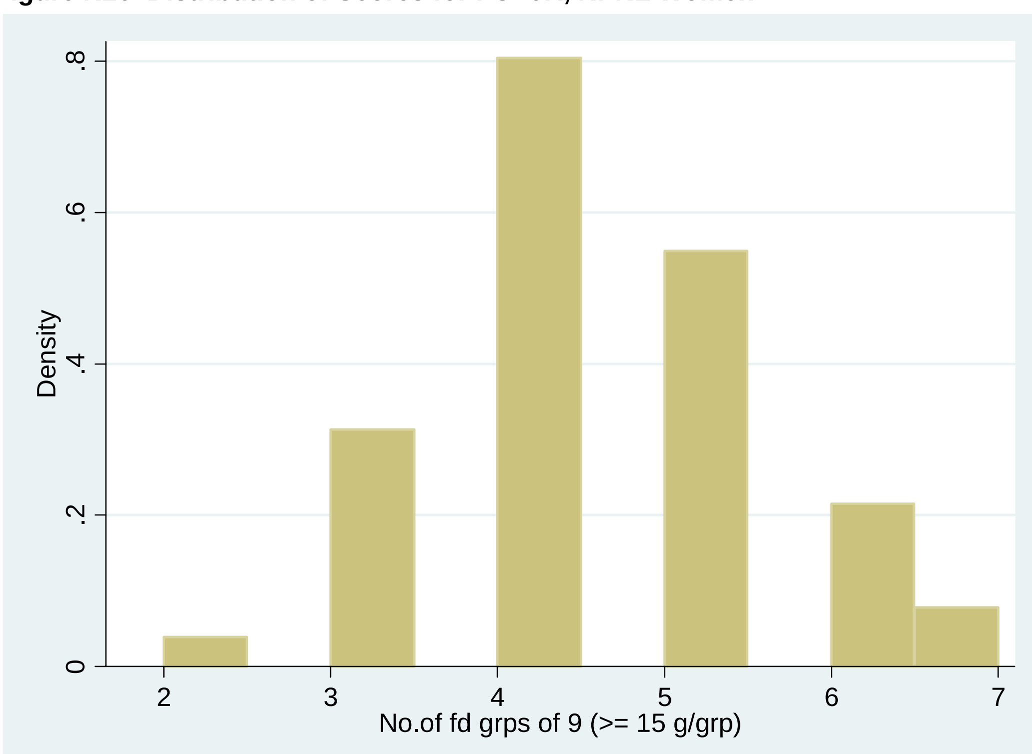


Figure N27. Distribution of Scores for FGI-13, NPNL Women

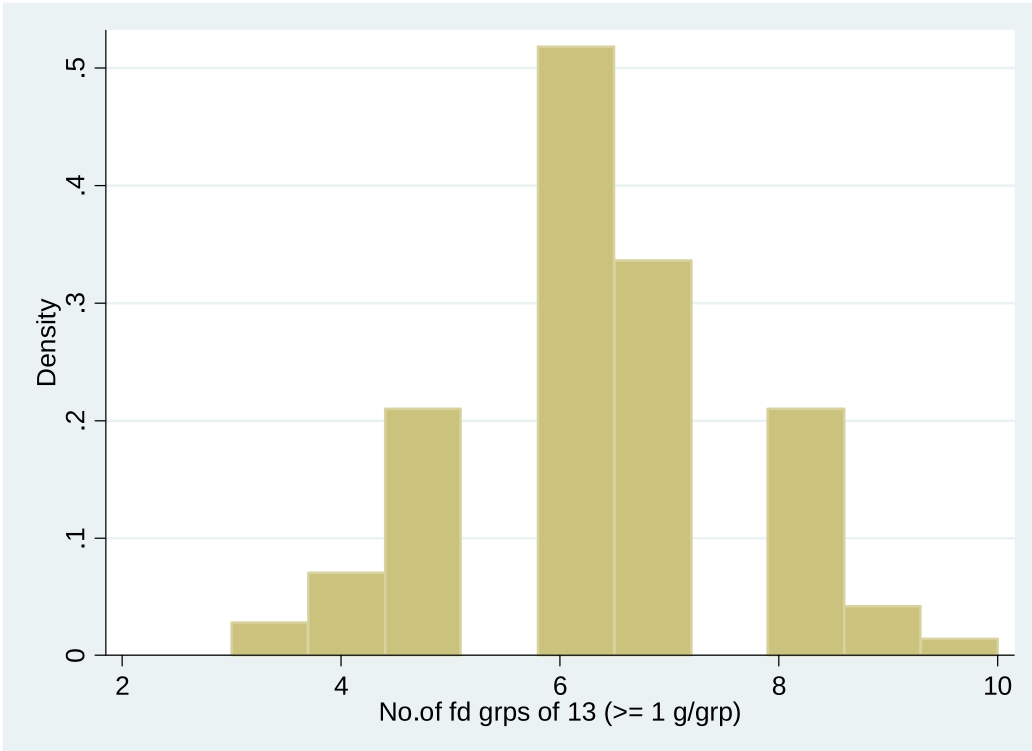


Figure N28. Distribution of Scores for FGI-13R, NPNL Women

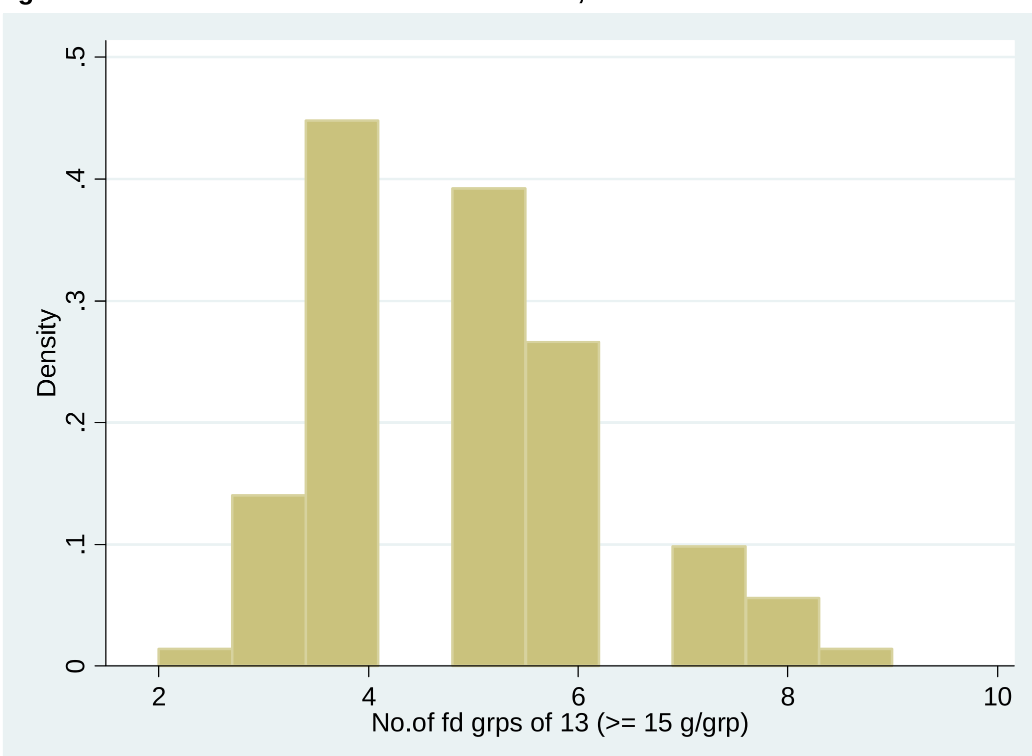


Figure N29. Distribution of Scores for FGI-21, NPNL Women

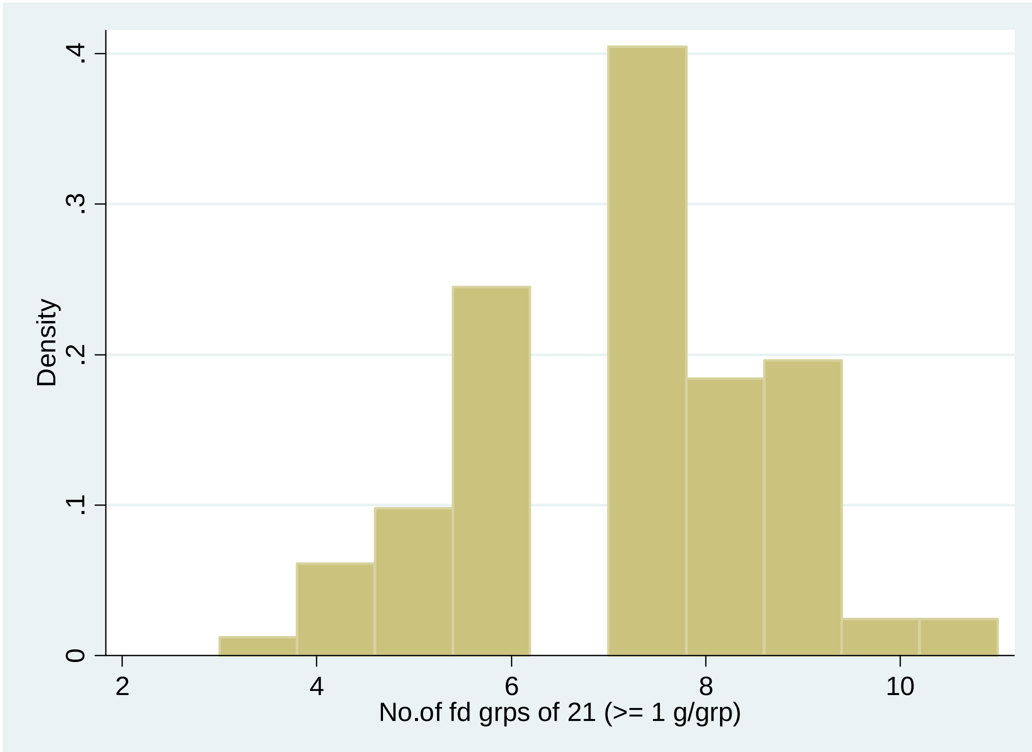


Figure N30. Distribution of Scores for FGI-21R, NPNL Women

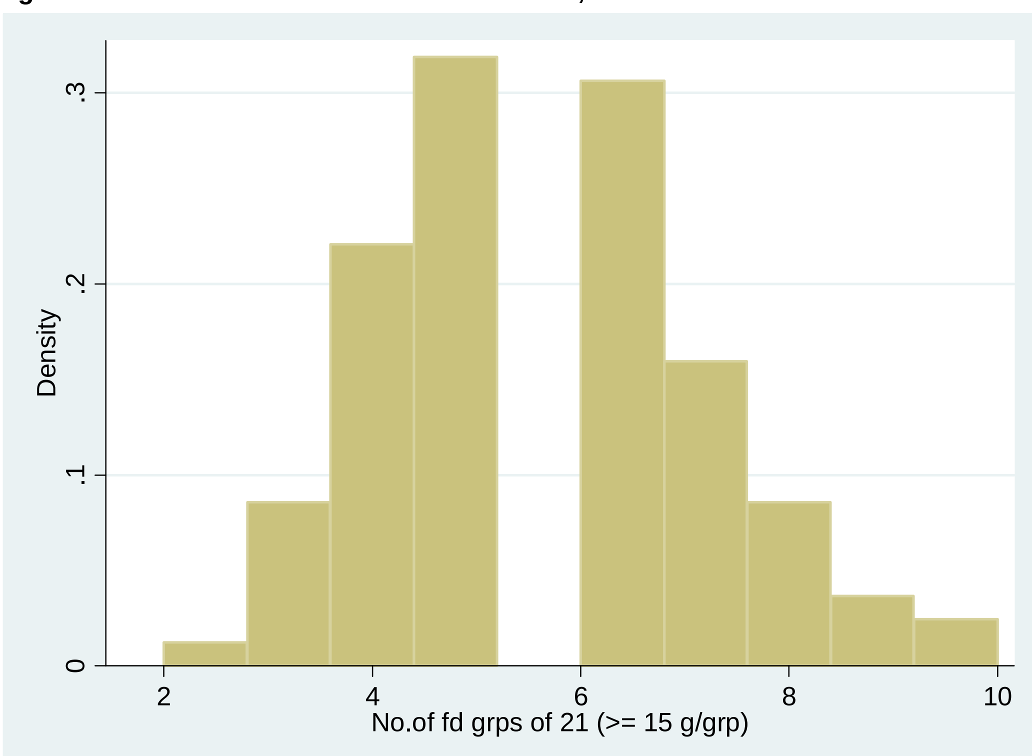


Table N6. Percent of Observation Days at Each Food Group Diversity Score, NPNL Women, R1

Number of food groups eaten	Diversity indicators							
	FGI-6	**FGI-6R**	**FGI-9**	**FGI-9R**	**FGI-13**	**FGI-13R**	**FGI-21**	**FGI-21R**
1	0	0	0	0	0	0	0	0
2	0	2	0	2	0	1	0	1
3	2	16	2	16	2	10	1	7
4	14	42	10	40	5	31	5	18
5	56	32	37	28	15	28	8	26
6	28	8	35	11	36	19	20	25
7			15	4	24	7	32	13
8			1	0	15	4	15	7
9			0	0	3	1	16	3
10					1	0	2	2
11					0	0	2	0
12					0	0	0	0
13					0	0	0	0
14							0	0
15							0	0
16							0	0
17							0	0
18							0	0
19							0	0
20-21							0	0

Figure N31. Distribution of PA for Thiamin, NPNL Women

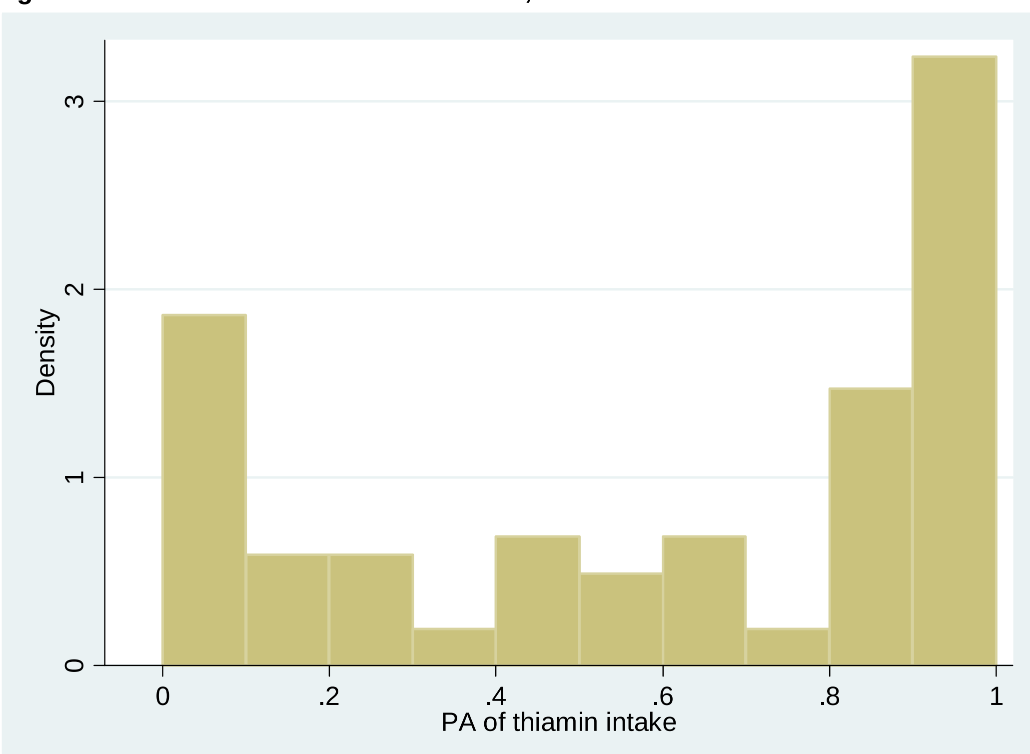


Figure N32. Distribution of PA for Riboflavin, NPNL Women

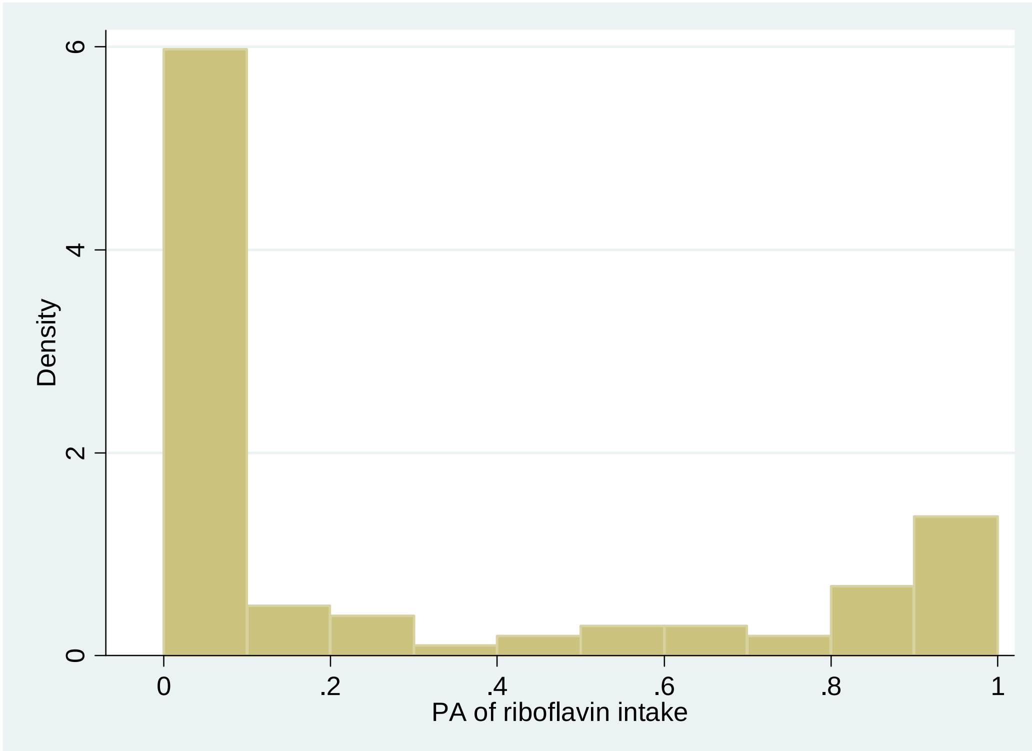


Figure N33. Distribution of PA for Niacin, NPNL Women

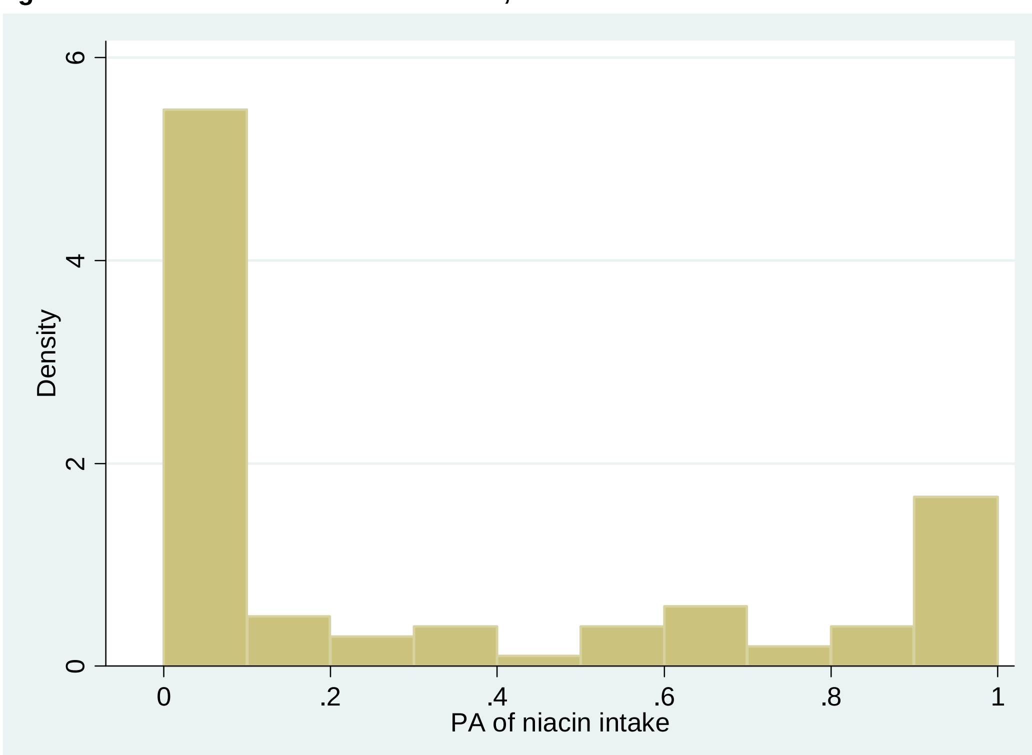


Figure N34. Distribution of PA for Vitamin B6, NPNL Women

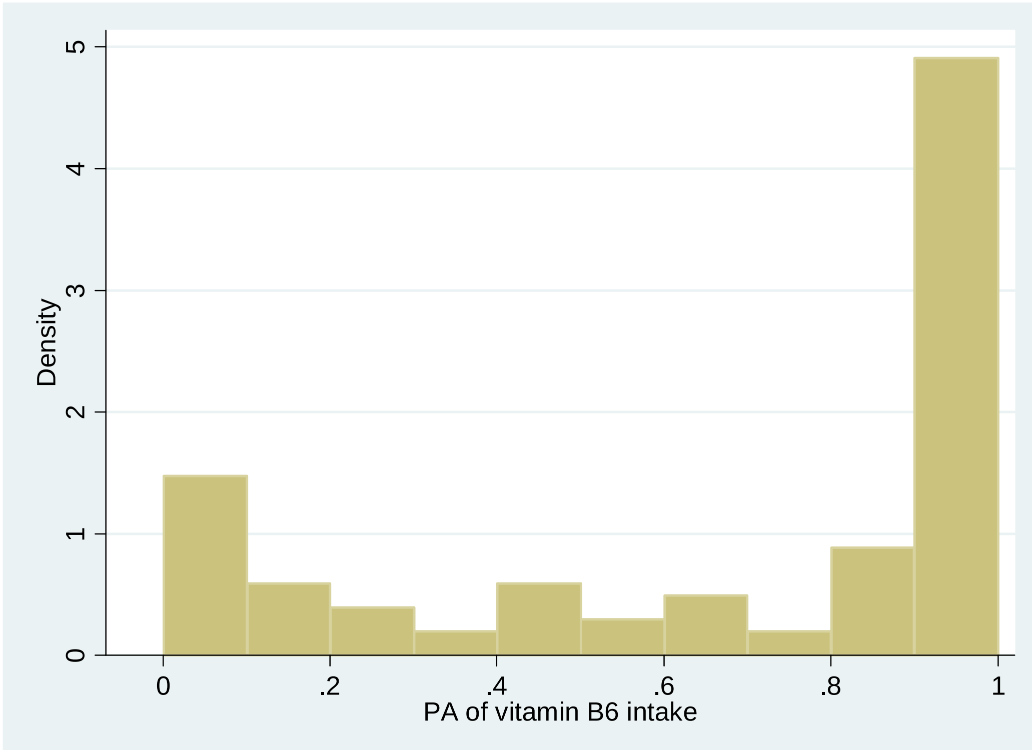


Figure N35. Distribution of PA for Folate, NPNL Women

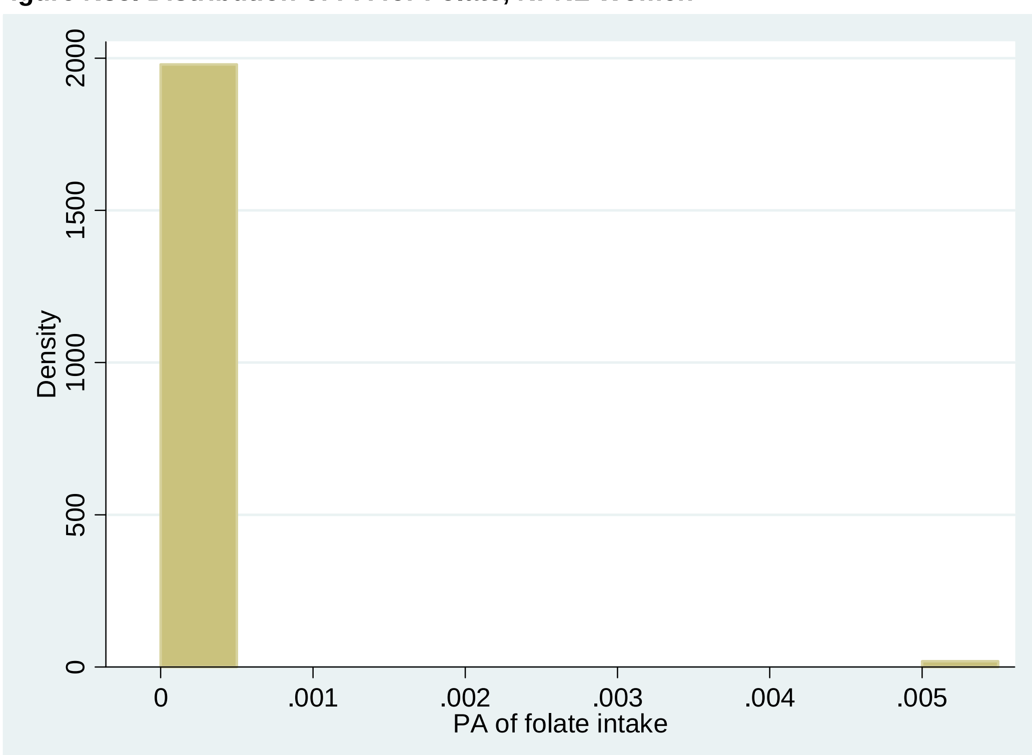


Figure N36. Distribution of PA for Vitamin B12, NPNL Women

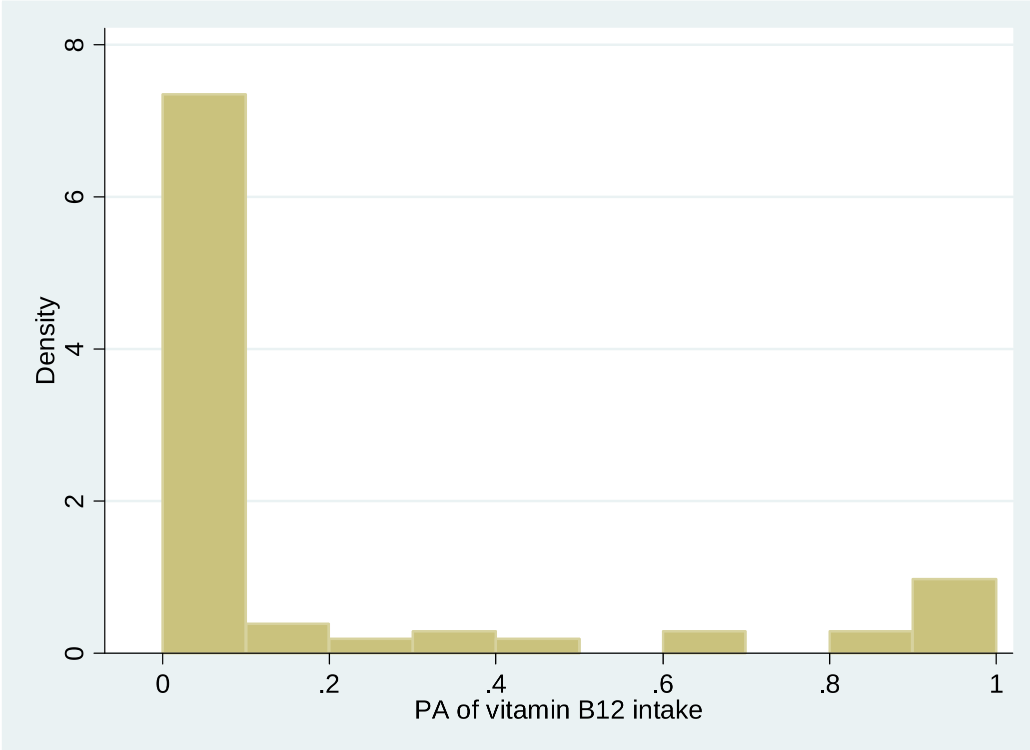


Figure N37. Distribution of PA for Vitamin C, NPNL Women

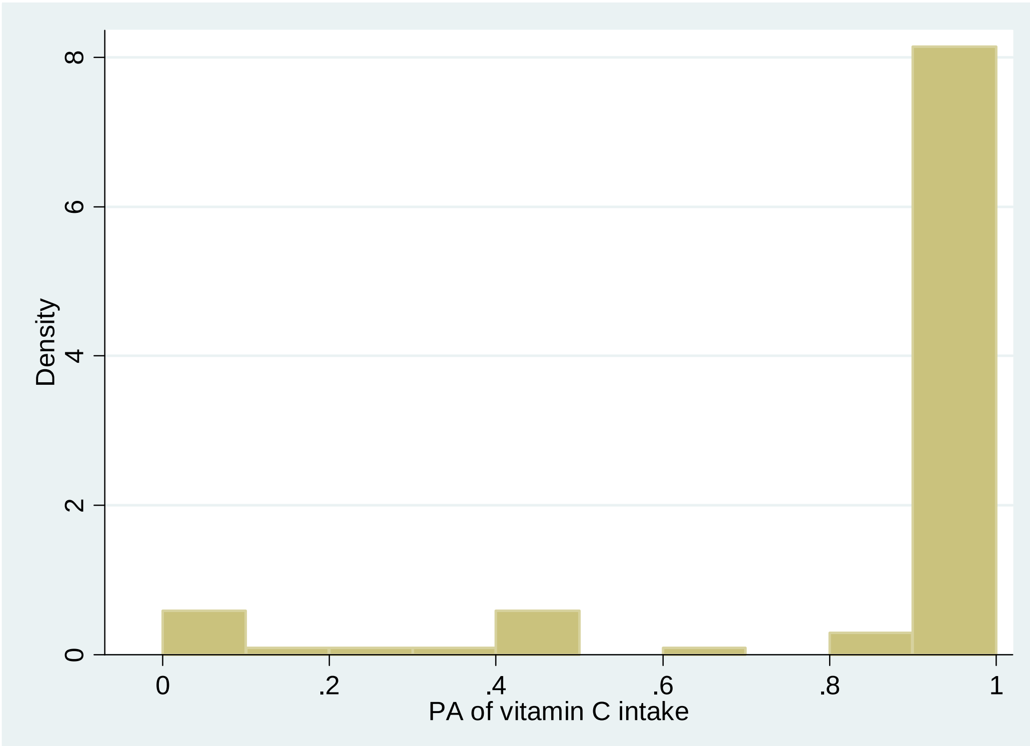


Figure N38. Distribution of PA for Vitamin A, NPNL Women

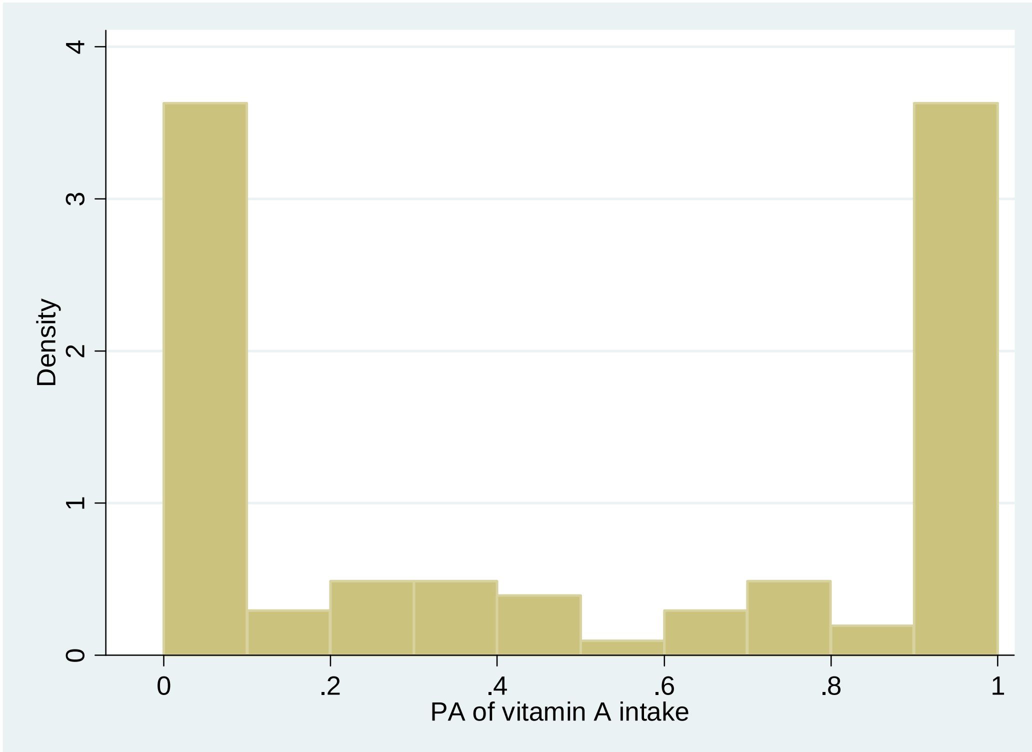


Figure N39. Distribution of PA for Calcium, NPNL Women

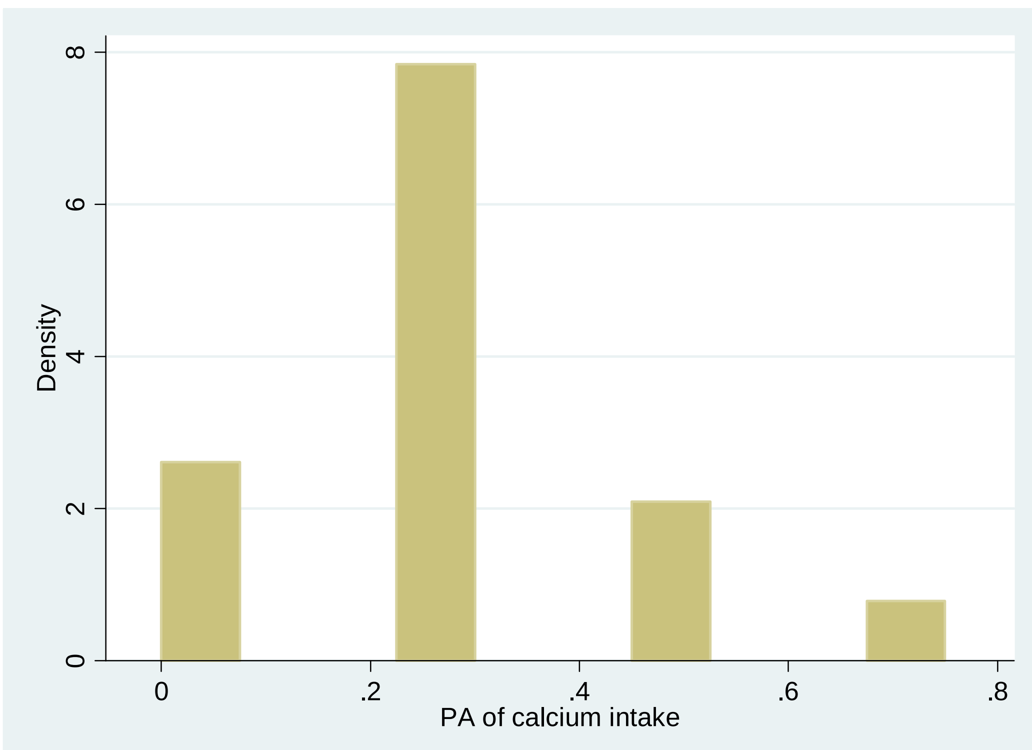


Figure N40. Distribution of PA for Iron, NPNL Women

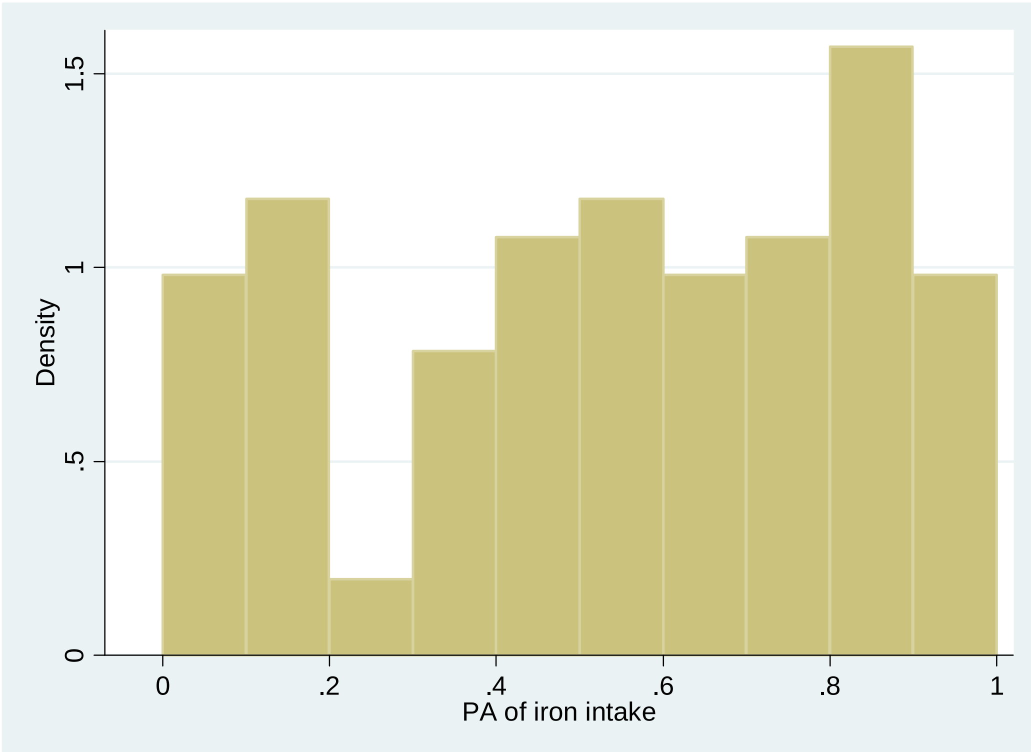


Figure N41. Distribution of PA for Zinc, NPNL Women

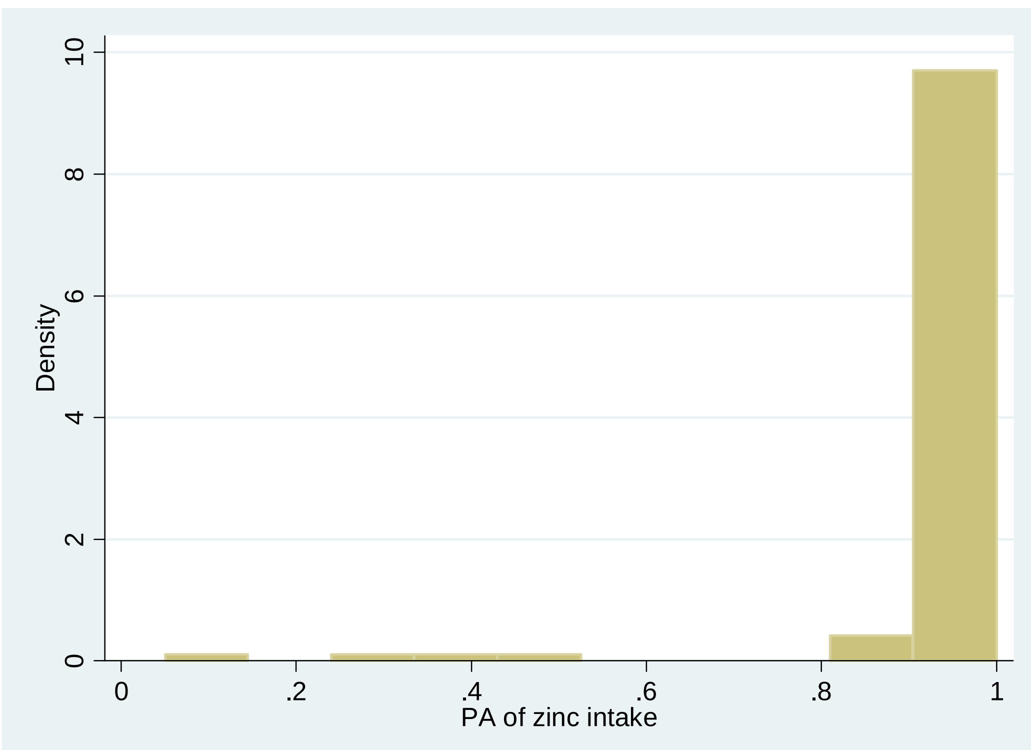
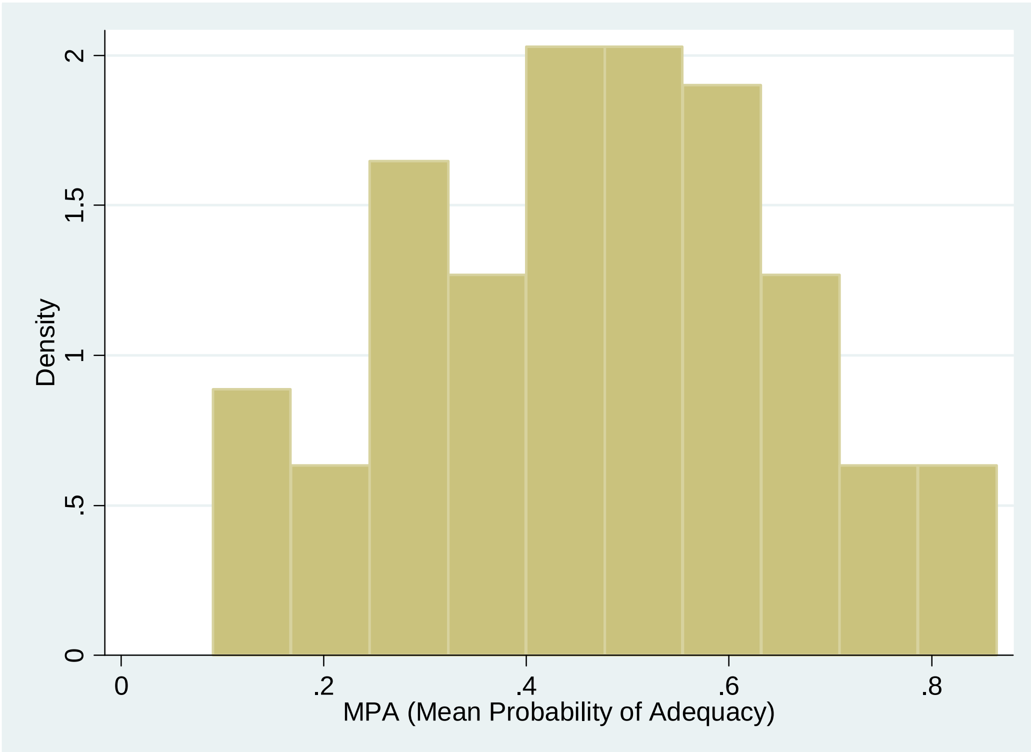


Figure N42. Distribution of MPA across 11 Micronutrients, NPNL Women



Appendix 2. Classification of Food Items to Food Groups, Using the Original and Revised WDDP Analysis Protocol

Food name	Vitamin A > 260 RE and Vitamin C > 18	Vitamin A ≥ 120 RE and Vitamin C ≥ 9.0
Lettuce raw	Vitamin A-rich dark green leafy vegetables	
Amaranth leaves cooked	Vitamin A-rich dark green leafy vegetables	
Baobab leaves dried with RF [a]	Vitamin A-rich dark green leafy vegetables	
Bean leaves raw with RF [a]	Vitamin A-rich dark green leafy vegetables	
Fakouhoye leaves dried with RF [a]	Vitamin A-rich dark green leafy vegetables	
Green leaves dark with RF [a]	Vitamin A-rich dark green leafy vegetables	
Shallot leaves with RF [a]	Vitamin A-rich dark green leafy vegetables	
Sweet potato leaves raw with RF [a]	Vitamin A-rich dark green leafy vegetables	
Celery leaves raw	Vitamin A-rich dark green leafy vegetables	
Celery leaves cooked	Vitamin A-rich dark green leafy vegetables	
Bay laurel leaves dried with RF [a]	Vitamin A-rich dark green leafy vegetables	
Parsley leaves raw with RF [a]	Vitamin A-rich dark green leafy vegetables	
Carrot raw	Vitamin A-rich yellow/orange/red vegetables	Vitamin A-rich yellow/orange/red vegetables
Carrot cooked	Vitamin A-rich yellow/orange/red vegetables	Vitamin A-rich yellow/orange/red vegetables
Cabbage cooked	Vitamin C-rich vegetables	
Sweet pepper green raw	Vitamin C-rich vegetables	
Sweet pepper green raw with RF [a]	Vitamin C-rich vegetables	
Tomato raw	Vitamin C-rich vegetables	
Tomato cooked	Vitamin C-rich vegetables	
Onion dried	Vitamin C-rich vegetables	

(continued)

Food name	Vitamin A > 260 RE and Vitamin C > 18	Vitamin A ≥ 120 RE and Vitamin C ≥ 9.0
Shallot fried dried	Vitamin C-rich vegetables	
Pepper hot	Vitamin C-rich vegetables	
Tomato bitter raw with RF [a]	Other vegetables	
Coourgette zucchini cooked	Other vegetables	Vitamin C-rich vegetables
Cuncumber raw	Other vegetables	Vitamin C-rich vegetables
Eggplant cooked	Other vegetables	
Beans french green cooked	Other vegetables	Vitamin C-rich vegetables
Okra pods dried powder	Other vegetables	Vitamin C-rich vegetables
Onion shallot mature bulbs raw	Other vegetables	Vitamin C-rich vegetables
Onion shallot mature bulbs raw with RF [a]	Other vegetables	Vitamin C-rich vegetables
Pumpkin squash cooked	Other vegetables	
Garlic raw	Other vegetables	Vitamin C-rich vegetables
Garlic raw with RF [a]	Other vegetables	Vitamin C-rich vegetables
Celery leaves raw	Other vegetables	
Celery leaves cooked	Other vegetables	
Tomato paste	Other vegetables	Vitamin A rich yellow/orange/red vegetables
Mango ripe	Vitamin A-rich fruit	
Citrus orange raw	Vitamin C-rich fruit	
Papaya ripe raw	Vitamin C-rich fruit	
Orange juice (100%)	Vitamin C-rich fruit	
Banana ripe	Other fruit	Vitamin C-rich fruit
Pineapple juice (100%)	Other fruit	Vitamin C-rich fruit
Red palm oil	Vitamin A-rich fruit	

[a] RF is used as an abbreviation for retention factor

Appendix 3. Summary of Food Items and Food Groups with Substantial Contribution to the Intake of Individual Micronutrients

Nutrient	21 food	Primary individual food items consumed	Composition/100g [a]
Zinc	Grains	Rice	0.4 mg
		Wheat (bread, pasta)	0.7-1.4 mg
		Millet	0.33- 2.9 mg
	Milk	Fresh whole milk	0.5 mg
		Powdered milk	3.3 mg
		Curdled milk	4 mg
Vitamin C	Vitamin C-rich vegetables	Tomato (raw/cooked)	22 mg
		Hot pepper	34 mg
		Sweet pepper	102-120 mg
		Dried shallot	27 mg
		Onion	11 mg
		Dried okra	9.35 mg
	All other starchy staples	Potato	7-20 mg
Vitamin A	Vitamin A-rich dark green leafy vegetables	Lettuce	325 mcg
		Shallot leaves	1090 mcg
		Parsley	640 mcg
		Other leaves (Amaranth, Baobab, Fakouhoye, Sweet potato, bean)	278-1,951 mcg
	Milk/yogurt	Fresh whole milk	40 mcg
		Powdered milk	457 mcg
		Curdled milk	42 mcg
	Vitamin A-rich yellow/orange/red vegetables	Carrot	951 mcg
Thiamin	Grains	Rice	0.05 mg
		Wheat (bread, pasta)	.02-0.22 mg
		Millet	.02-0.8 mg
Iron	Grains	Rice	0.12 mg
		Wheat (bread, pasta)	0.5-3.0 mg
		Millet	0.67-5.8 mg
	Nuts/seeds	Peanut butter	5.1mg
		African locust been seed	79.0 mg
	Vitamin C rich-vegetables	Onion	0.8 mg
		Dried okra	33 mg
Niacin	Nuts/seeds	Peanut butter	8.0-10.0 mg
		African locust been seed	10.4 mg

(continued)

Nutrient	21 food	Primary individual food items consumed	Composition/100g[a]
Riboflavin	Grains	Rice	0.01 mg
		Wheat (bread, pasta)	0.09-0.02 mg
		Millet	0.02-0.12 mg
	Milk/yogurt	Fresh whole milk	0.18 mg
		Powdered milk	1.2 mg
		Curdled milk	0.14 mg
Calcium	Milk/yogurt	Fresh whole milk	145.0 mg
		Powdered milk	1,000 mg
		Curdled milk	143.0 mg
	Vitamin C-rich vegetables	Onion	27 mg
		Dried okra	75 mg
Vitamin B12	Milk/yogurt	Fresh whole milk	0.44 mcg
		Powdered milk	3.2 mcg
		Curdled milk	0.37 mcg
	Fish	Fish, fresh	1.6 mcg
		Fish, smoked	2.3 mcg
		Fish, dried	1.3-2.3 mcg
	Beef	Beef	1.05 mcg [b]
Vitamin B6	Grains	Rice	.05 mg
		Wheat (bread, pasta)	.07 mg
		Millet	.14-.22 mg
	All other starchy staples	Potato boiled	0.27 mg
		Potato fried	0.23 mg
	Vitamin C-rich vegetables	Tomato (raw/cooked)	0.05-0.06 mg
		Hot pepper	0.23 mg
		Sweet pepper	0.27 mg
		Dried shallot	1.4 mg
		Onion	0.06 mg
		Dried okra	0.38 mg
Folate	Vitamin C-rich vegetables	Tomato (raw/cooked)	24-48 mcg
		Hot pepper	14 mcg
		Sweet pepper	30 mcg
		Dried shallot	137 mcg
		Onion	12 mcg
		Dried okra	75 mcg

[a] Values from the FCT used for the present study.
[b] This value is low with respect to similar values on average of 3mcg/100g reported in USDA tables.

Appendix 4. Tables for Second Observation Day

Table A4-2. Energy and Macronutrient Intakes, R2 (n=96)

	Mean	SD	Median	Range	Percent of kcal
Energy (kcal)	2,233.1	739.8	2,241.5	702-4,662	
Protein (g)	63.5	28.1	60.0	13-179	11.3
Total carbohydrate (g)	358.1	121.8	358.0	103-701	60.8
Total fat (g)	70.5	36.8	64.0	4-182	27.9

Table A4-8. Mean and Median Nutrient Intake, R2 (n=96) [a]

Nutrient	Mean	SD	Median	EAR	SD [b]
Energy	2,233.1	739.8	2,241.5		
Protein (all sources) (% of kcal)	11.3	3.1	10.9		
Total carbohydrate (% of kcal)	60.8	11.0	59.6		
Total fat (% of kcal)	27.9	10.5	28.8		
Thiamin (mg/d)	1.08	0.45	1.05	0.9 [c]	0.09
Riboflavin (mg/d)	0.86	0.50	0.75	0.9 [c, g]	0.09
Niacin (mg/d)	10.16	5.81	8.72	11 [c, g]	1.65
Vitamin B6 (mg/d)	1.31	0.56	1.22	1.1 [c, g]	0.11
Folate (µg/d)	130.12	72.69	116.85	320 [c, g]	32.0
Vitamin B12 (µg/d)	1.66	1.46	1.29	2.0 [h]	0.2
Vitamin C (mg/d)	61.61	39.98	54.50	38 [c]	3.8
Vitamin A (RE/d)	389.57	323.92	297.10	270 [h, g]	54.0
Calcium (mg/d)	514.54	386.62	401.00	1,000 [e, g]	--
Iron (mg/d)	18.79	10.32	16.00	-- [f]	
Zinc (mg/d)	10.85	5.52	10.00	6.0 [d, g]	0.75
MPA across 11 micronutrients	.468				

[a] Mean and median nutrient intakes are for first observation day; probabilities of adequacy are based on estimated usual intake, calculated using repeat observations for a subset of the sample.
Thus, probabilities of adequacy incorporate information from both rounds of data collection.
[b] All SD calculated based on EAR and CV, which was assumed to be 10 percent for all micronutrients (FAO/WHO 2002 requirements), except 15 percent for niacin (IOM 2000), 20 percent for vitamin A (IOM 2000) and 12.5 percent for zinc (IZiNCG 2004).
[c] EAR back calculated from RNI values of WHO/FAO 2004 requirements.
[d] This is the estimated median requirement of zinc to be used for diets with higher bioavailability as suggested by IZiNCG (2004).
[e] Not an EAR, but rather AI from IOM (1997). Following Foote et al. (2004), PA are calculated 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.
[f] PA for iron intake are estimated using IOM tables (2000a, page 347), adult women. According to WHO/FAO (2004). Bioavailability of 10 percent was used for our study.
[g] For adolescents group (15-18 years old, n=16), value of 0.8±0.08 was used for riboflavin, 12±1.2 for niacin, 7.0±0.88 for zinc (30 percent bioavailability), 365±73 for vitamin A, 330±33 for folate, 1.0±0.1 for B6, and 1300 AI for calcium.
[h] EAR taken from WHO/FAO 2004.

Appendix 5. Women's Food Group Recall in DHS 5

579 Now I would like to ask you about (other) liquids or foods that (NAME FROM 577)/you may have had yesterday during the day or night. I am interested in whether your child/you had the item even if it was combined with other foods. **(15)**

Did (NAME FROM 577)/you drink (eat):		CHILD			MOTHER		
		YES	NO	DK	YES	NO	DK
a) Milk such as tinned, powdered, or fresh animal milk?	**a**	1	2	8	1	2	8
b) Tea or coffee?	**b**	1	2	8	1	2	8
c) Any other liquids?	**c**	1	2	8	1	2	8
d) Bread, rice, noodles, or other foods made from grains? **(16)**	**d**	1	2	8	1	2	8
e) Pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside? **(17)**	**e**	1	2	8	1	2	8
f) White potatoes, white yams, manioc, cassava, or any other foods made from roots?	**f**	1	2	8	1	2	8
g) Any dark green, leafy vegetables? **(18)**	**g**	1	2	8	1	2	8
h) Ripe mangoes, papayas, or [INSERT ANY OTHER LOCALLY AVAILABLE VITAMIN A-RICH FRUITS]?	**h**	1	2	8	1	2	8
i) Any other fruits or vegetables?	**i**	1	2	8	1	2	8
j) Liver, kidney, heart, or other organ meats?	**j**	1	2	8	1	2	8
k) Any meat, such as beef, pork, lamb, goat, chicken, or duck?	**k**	1	2	8	1	2	8
l) Eggs?	**l**	1	2	8	1	2	8
m) Fresh or dried fish or shellfish?	**m**	1	2	8	1	2	8
n) Any foods made from beans, peas, lentils, or nuts?	**n**	1	2	8	1	2	8
o) Cheese, yogurt, or other milk products?	**o**	1	2	8	1	2	8
p) Any oil, fats, or butter, or foods made with any of these?	**p**	1	2	8	1	2	8
q) Any sugary foods such as chocolates, sweets, candies, pastries, cakes, or biscuits?	**q**	1	2	8	1	2	8
r) Any other solid or semi-solid foods?	**r**	1	2	8	1	2	8

[15] A separate category for any foods made with red palm oil, palm nut, or palm nut pulp sauce must be added in countries where these items are consumed. A separate category for any grubs, snails, insects or other small protein food must be added in countries where these items are eaten. Items in each food group should be modified to include only those foods that are locally available and/or consumed in the country. Local terms should be used.

[16] Grains include millet, sorghum, maize, rice, wheat, or other local grains. Start with local foods (e.g., ugali, nshima, fufu, chapatti) then follow with bread, rice, noodles, etc.

[17] Items in this category should be modified to include only vitamin A rich tubers, starches, or yellow/orange/red vegetables that are consumed in the country.

[18] These include cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, amaranth leaves or other dark green, leafy vegetables.

Source: ORC Macro DHS website at: http://www.measuredhs.com/aboutsurveys/dhs/questionnaires.cfm. Accessed September 7, 2007.

Appendix 6: 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 A6-1. 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] 5% bioavail: 23.40	3.51 7.02
Zinc (mg/d)	Lower bioavail: 7 [j] Higher bioavail: 6 [k]	0.88 0.75	Lower bioavail: 9 Higher bioavail: 7	1.13 0.88	Lower bioavail: 10 Higher bioavail: 8	1.25 1.0	Lower bioavail: 8 Higher bioavail: 7	1.00 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 A6-2. 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 A6-3. 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,[48] 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.,[49] 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.[50] An individual with a usual intake of calcium at or above AI can be assumed to have an AI. Foote et al.[51] 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.[52] 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.[53] 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[54] 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

[48] 2004.
[49] 2004.
[50] IOM 1997.
[51] 2004.
[52] Table I-6 and I-7; 2000b.
[53] 2000b.
[54] 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).[55] 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.[56] It also estimated a CV for the requirement distribution of 12.5 percent, indicating a narrower requirement distribution than implied by the WHO/FAO[57] CV of 25 percent. Hotz[58] 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.[59] 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).

[55] WHO/FAO 2004, page 265.
[56] IZiNCG 2004.
[57] 2004.
[58] 2007.
[59] IZiNCG 2004.

Appendix 7. Mean and Median Nutrient Intake and Probability of Adequacy When Low Bioavailability is Assumed for Iron and Zinc [a]

Nutrient	Mean	SD	Median	EAR	SD [b]	PA (Mean)	PA (Median)	Lambda (Box-Cox transformation)
Energy	2,054	717	2,024					
Protein (all sources) (% of kcal)	11	5	11					
Total carbohydrate (% of kcal)	57	20	61					
Total fat (% of kcal)	32	15	32					
Thiamin (mg/d)	1	0.50	0.90	0.9 [c]	0.09	0.59	0.67	0.33
Riboflavin (mg/d)	0.8	0.40	0.70	0.9 [c, g]	0.09	0.28	0.05	0.18
Niacin (mg/d)	10.6	6.50	8.30	11 [c, g]	1.65	0.31	0.06	0.18
Vitamin B6 (mg/d)	1.2	0.50	1.20	1.1 [c]	0.11	0.67	0.89	0.27
Folate (µg/d)	131.4	82.50	119.10	320 [d, g]	32.0	0.00	0.00	0.21
Vitamin B12 (µg/d)	1.5	1.00	1.30	2.0 [d]	0.2	0.17	0.00	0.32
Vitamin C (mg/d)	62.6	34.50	58.40	38 [c]	3.8	0.88	1.00	0.52
Vitamin A (RE/d)	358	295.30	244.60	270 [d, g]	54.0	0.50	0.43	0.31
Calcium (mg/d)	443.9	318.30	374.50	1,000 [e]	--	0.27	0.25	0.08
Iron (mg/d)	16.1	8.80	14.20	-- [f]	--	0.07	0.00	0.09
Zinc (mg/d)	10.2	5.8	7.0	7.0 [g, h]	0.88	0.81	1.00	0.10
MPA across 11 micronutrients	0.414	0.184	0.415					

[a] Mean and median nutrient intakes are for first observation day (R1); PA are based on estimated usual intake, calculated using repeat observations for a subset of the sample. Thus, PA incorporate information from both rounds of data collection.

[b] All SD calculated based on EAR and CV, which was assumed to be 10 percent for all micronutrients except 15 percent for niacin, 20 percent for vitamin A (IOM 2000a) and 12.5 percent for zinc (WHO/FAO 2004 requirements).

[c] EAR back calculated from RNI values of WHO/FAO 2004 requirements

[d] Values directly taken from WHO/FAO 2004 requirements.

[e] Not an EAR. but rather AI from IOM (1997). Following Foote et al. (2004), PA are calculated 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.

[f] PA for iron intake are estimated using IOM tables (2000a, page 347), adult women. According to WHO/FAO (2004). Bioavailability of 5 percent was used in this table.

[g] For adolescents group (15-18 years old, n=16), value of 0.8±0.08 was used for riboflavin, 12±1.2 for niacin, 9.0±1.13 for zinc (30 percent bioavailability), 365±73 for vitamin A, 330±33 for folate, 1.0±0.1 for B6 and 1300 AI for calcium.

[h] This is the estimated median requirement of zinc to be used for diets with lower bioavailability as suggested by IZiNCG (2004).

Appendix 8. Summary of Doets Study Findings: Nutrients Replaced After Quality Evaluation and Missing Values Added

Table 4.2 Summary of Results of Evaluation Step 2 and 3 (Decision Trees and Comparisons) and Consequences

Food Item	Moisture	Prot	Fat	Carb	Fiber	Ca	Fe	Zn	B-carotene	Retinol	Vit C[a]
CEREALS											
Fonio	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	Replaced	TACAM 2	TACAM 4	TACAM 4		TACAM 4
Mais	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	TACAM 2	TACAM 4		TACAM 4
Macaroni	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1		TACAM 4
Rice	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	TACAM 2	TACAM 4		TACAM 4
Sorghum	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	TACAM 2	TACAM 4		TACAM 4
Wheat	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	Replaced	Replaced		TACAM 3
Millet	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	Replaced	TACAM 4		Updated
ROOTS & TUBERS											
Sweet potato	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 4	TACAM 3	Replaced	Updated	TACAM 4		TACAM 3
Nuts & Legumes											
African locust bean seed	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	TACAM 2	TACAM 2	TACAM 1		Updated
Groundnuts	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 4	TACAM 3	Updated	TACAM 3	Replaced		Replaced
MILK & PRODUCTS											
Milk	TACAM 3	TACAM 3	TACAM 3	Replaced	TACAM 3	TACAM 3	TACAM 3	Updated	TACAM 3	TACAM 3	TACAM 3
Fish & Products											
Catfish	TACAM 4	TACAM 4	TACAM 4	TACAM 4	TACAM 4	Updated	Updated	Updated		Updated	
Threadfin	TACAM 4	TACAM 4	TACAM 4	TACAM 1	TACAM 4	TACAM 4	TACAM 4	Updated		Updated	
EGGS & MEAT											
Egg	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	Replaced	TACAM 3	
Goat	TACAM 4	TACAM 4	TACAM 4	TACAM 4	TACAM 4	TACAM 4	TACAM 4	TACAM 4		TACAM 4	
Beef	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	Updated	Replaced	Replaced	
VEGETABLES											
Okra	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 2	Replaced	TACAM 2	TACAM 1		Updated
Pumpkin	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	Replaced	Updated	Replaced		TACAM 3
Carrot	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3		TACAM 3
Tomato	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3		TACAM 3
FRUITS											
Orange	TACAM 3	TACAM 3	Replaced	TACAM 3	Replaced	TACAM 3	TACAM 3	TACAM 3	TACAM 3		TACAM 3
Mango	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	Replaced	TACAM 3	TACAM 3	TACAM 3		TACAM 3
Banana	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	TACAM 3	Replaced	TACAM 3	TACAM 3		TACAM 3
GREEN LEAVES											
Fakhouhoye	TACAM 2	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1	TACAM 1		TACAM 1
Onion	TACAM 2	TACAM 2	TACAM 2	TACAM 2	TACAM 2	TACAM 2	TACAM 2	TACAM 2	TACAM 2		Updated

-TACAM 1= TACAM – value is accepted after evaluation step 1, decision trees
-TACAM 2= TACAM – value is accepted after evaluation step 1 and 2, decision trees and comparison.
-TACAM 3= TACAM – value is accepted after evaluation step 2, comparison
-TACAM 4= TACAM – No value was available for comparison
-Replaced = TACAM – value is replaced after evaluation step1 and/or 2
-Updated = No TACAM value existed, new value added
= Food does not contain the specific nutrient

Quality evaluation and update of the food composition table of Mali